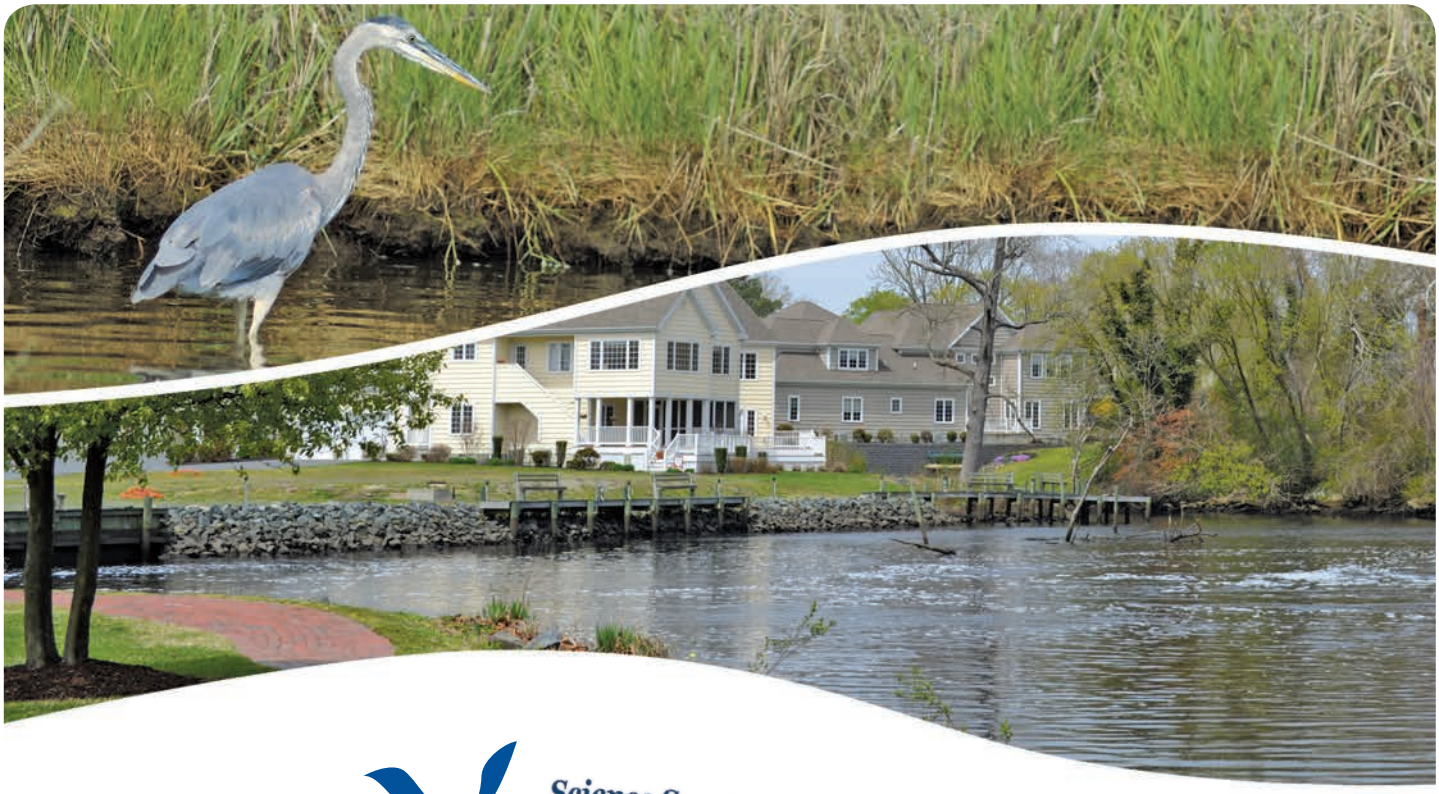

Sea Grant Delaware

Science Serving the Delaware Coast

Performance Review Panel | August 2015

PROGRAM INTRODUCTION

Since 1976, the Delaware Sea Grant College Program (DESG) has worked to promote the wise use, conservation, and management of marine and coastal resources through high-quality research, education, and outreach activities that benefit the public and our environment. Our motto is *"Science Serving the Delaware Coast,"* and to achieve that goal we operate as a fully integrated Sea Grant program where top-quality research supports a broad range of education and outreach efforts that in turn help to identify new research needs.

In Delaware and within our national networks our Sea Grant program is recognized as a leading neutral, science-based organization, backed by the strength and reputation of the University of Delaware. Our team provides research and outreach leadership and support to address environmental and policy challenges across our state and region. We identify and leverage federal and private funding, forge partnerships, and facilitate public engagement to identify pressing societal issues and work toward solutions.

The entire state of Delaware is considered coastal; no part of it is more than eight miles from tidal waters. With only three counties and a land area of 1,982 square miles, it is the second smallest state in the nation, yet Delaware is the sixth most densely populated state (as estimated by the U.S. Census Bureau in July 2013), with population estimates quickly approaching one million people. The combination of state population density and proximity to East Coast urban centers means that there is tremendous pressure to balance resource use among multiple sectors.

DESG understands the importance of the coast to businesses, industries, communities, homeowners and beach-goers; DESG-sponsored research shows that coast-related activities in southern Delaware alone contribute more than $6.8 billion to the state economy.

We also know the challenges involved in maintaining a healthy environment and ensuring that society continues to benefit from our natural resources. Thanks to strong stakeholder engagement across these sectors, DESG is able to deliver science-based information about coastal resources and processes that informs state and local decision-makers, assists resource managers, helps local businesses, protects the safety of citizens, and enhances marine literacy across all ages.

The 2009–2013 DESG Strategic Plan identified four focus areas and a cross-cutting focus: Healthy Coastal Ecosystems; Sustainable Coastal Development; Safe and Sustainable Seafood Supply; Hazard Resilience in Coastal Communities; and Ocean and Environmental Literacy. In our program summary reports for each focus area, we provide examples that demonstrate our contributions to science and society through a combination of research, extension, education, and communication.

Formal input on DESG's focus areas is provided by our state Sea Grant Advisory Council; key stakeholders from public sector agencies, business and industry groups, nonprofit organizations, educational groups and community leaders; and through surveys of stakeholder groups to assess needs and solicit ideas for programming. Built on partnerships and priorities from our stakeholders, the DESG Strategic Plan describes measurable objectives and specific performance measures that address the challenges identified by major stakeholders.

Our successes are reflected in our ability to catalyze partnerships, which enable us to stretch every dollar and maximize our research and outreach resources. We build relationships that address stakeholder needs and make a difference in the lives of Delawareans and the nation.

HEALTHY COASTAL ECOSYSTEMS (HCE)

State resource managers are faced with an array of environmental problems and issues related to point and nonpoint source pollution from municipal, industrial, and agricultural sources. Current issues of concern include reduced water quality, including macroalgal and toxic algal blooms and possible contamination, declining fishery stocks, and habitat loss due to sea level rise and development. These environmental problems and trends pose a serious long-term threat to Delaware's coastal ecosystems and, if left unchecked, will impact public health, economic stability, and overall quality of life in Delaware's coastal communities.

GOAL: Science and policy research in support of ecosystem sustainability. Emphasis is on ecosystem processes and relationships between coastal stressors and long-term human and ecosystem health and on programs that provide lifelong opportunities to enhance understanding and promote stewardship.

The work of Delaware Sea Grant supports the management of valuable coastal and marine resources. Specific areas of interest in the Healthy Coastal Ecosystems focus area include: research in support of baseline data that informs ecosystem-based planning and management approaches; development of regional coastal observing systems to advance our capability to make predictions about human impacts and environmental changes on coastal resources; development of new technologies, methods, and polices to address water quality degradation; innovation and demonstration of best practices in support of citizens and businesses with specific mitigation and restoration problems; and efforts to enhance lifelong learning to promote ecosystem stewardship and informed decision making.

Meeting Our Strategic Outcomes: The 2009–2013 Delaware Sea Grant (DESG) Strategic Plan set forth seven outcomes for Healthy Coastal Ecosystems. Research projects, selected through a biennial, competitive peer-review process, comprise much of our program investment in the Healthy Coastal Ecosystem focus area. Research relevance to societal concerns is always considered during our selection process, and translation of those research findings to resource management and policy can take many years to develop. Stories highlighted below represent the most significant science and societal progress towards addressing our strategic plan.

SEA GRANT LEADS EFFORTS TO IMPROVE WATER QUALITY IN COASTAL DELAWARE.

Sea Grant efforts vital to Delaware beaches achieving #1 ranking in U.S. Delaware's ocean beaches are the state's most important recreational resource and a key stimulus for the state's $7 billion coastal economy. When Delaware Department of Natural Resources and Environmental Control (DNREC), Office of Shellfish and Recreational Waters, upgraded the recreation water sampling protocol for its 24 coastal beach sampling program, they turned to DESG to analyze beach samples for bacteria and provide a harmful algal bloom monitoring component. DESG's Citizen Monitoring Program laboratory staff provided analytical lab support, with increased beach sampling, and added newly developed methods for harmful algal bloom monitoring to support the state's marine beach water monitoring program. Both the increased sample frequency and harmful

algal bloom monitoring support helped earn Delaware beaches not only the highest rating at most of the popular ocean beaches in Rehoboth Beach and Dewey Beach, but also a #1 ranking in the nation out of 30 states for 2011, 2012 and 2013 based on Natural Resources Defense Council (NRDC) criteria (The *best in nation* ranking has been used by the Governor's office, local chambers of commerce and coastal towns to promote coastal tourism and the state's clean, safe beaches).

Community addresses water quality challenges with Sea Grant training and support. The Town of South Bethany is an intensely developed coastal community, with an extensive system of man-made canals connected to a poorly flushed bay with low tidal exchange. The community has experienced massive fish kills, harmful algal bloom outbreaks and macroalgae accumulation caused by nutrient input, low dissolved oxygen and poor flushing. Over the last 20 years, with support of DESG and other collaborators, the community has initiated more than a dozen water quality studies and demonstration projects to support the community goals of restoring "fishable, swimmable" waters. DESG's Citizen Monitoring Program, managed by DESG, has been very engaged for 25 years, having as many as a dozen active canal monitoring sites manned by community volunteers. To extend limited staff resources, DESG staff have trained and supported the Town of South Bethany Canal Water Quality Committee to collect, manage and report their own data and to conduct citizen science initiatives. The town is implementing restoration strategies (i.e., diffusers, bioretention, rain gardens, and oyster gardens) designed to improve the quality of water in their canals.

Oyster recruitment in Delaware's Inland Bays spearheaded by Sea Grant. Oysters are a keystone species in the health of coastal estuaries because of the important ecological services they provide. Examples include water filtration and clarity, nutrient cycling and sequestration, and habitat formation and refuge for other bottom dwelling invertebrates and juvenile fishes. Native Inland Bays oyster populations, reduced to negligible levels by MSX and Dermo disease, have been the subject of an ongoing stock enhancement and restoration program conducted by the Delaware Center for the Inland Bays (CIB), a National Estuary Program (NEP) member organization, DESG, and coastal resident volunteers since 2003. From the program's inception, DESG has provided technical guidance, educational programming, and facilities support for oyster spat production for the CIB Oyster Gardening Program. DESG has also provided technical advisement for Delaware State University graduate students and their oyster restoration related field research projects. A network of coastal resident volunteer gardeners from more than 100 sites around the bays cultivate up to 50 bushels of juvenile oysters from hatchery produced disease resistant stocks annually for field restoration work. Over 300 bushels of juvenile and adult oysters have been transplanted to restoration sites around the Inland Bays. Natural oyster recruitment attributed to oyster gardening and restoration activities has been observed in the Little Assawoman Bay and Indian River Bay. This citizen volunteer-based oyster restoration program and associated research and demonstration work guided by DESG has educated hundreds of coastal residents about the ecological value and importance of oysters in the estuary, and has contributed to the development and passage of legislation in 2013 to further increase Inland Bays oyster populations via commercial aquaculture.

Lewes Board of Public Works turns to Sea Grant for solutions to nutrient management permit challenge. Faced with a regulatory permit deadline for its wastewater treatment plant, the City of Lewes Board of Public Works (BPW) needed economical options for creating a required nutrient offset program. The Delaware Department of Natural Resources and Environmental Control recruited DESG to assist Lewes BPW with development of a short-term annual nutrient reduction program to satisfy the discharge permit requirements. DESG worked closely with staff from the BPW to identify and select the relocation of poultry manure as an annual nutrient reduction strategy. Subsequently, DESG arranged and facilitated meetings between BPW, the Delaware Nutrient Management Program, and a private agricultural operation to initiate manure relocation. Approximately 350 tons of poultry manure was transported at a cost of $3,500 to a site outside the watershed of Delaware's Inland Bays, an "estuary of national significance." Relocation of ~25,300 pounds of nitrogen and ~20,190 pounds of phosphorus was achieved based on an analysis of the manure sample completed by the Delaware Department of Agriculture's Compliance Section. Ultimately, the discharge permit was amended to also accept this short-term strategy as the long-term offset, since the required nutrient reductions had been far exceeded. Compared to costly wastewater treatment plant upgrades, the nutrient offset strategy brokered by DESG was an extremely cost-effective method that helped the City of Lewes maintain its needed discharge permit while also protecting water quality.

Sea Grant leads watershed restoration partnership. The Broadkill River Watershed has sustained increased pressure from residential and commercial development over the last decade. When the Delaware Department of Natural Resources and Environmental Control (DNREC) Watershed Assessment Branch needed stakeholder input to develop a watershed plan, they turned to DESG to develop and lead a public engagement process with watershed residents. Over two years, DESG created a Tributary Action Team that learned about the issues and challenges facing the watershed and provided recommendations to DNREC for development of a Broadkill River Watershed Pollution Control Strategy in 2012. To assist in implementing the strategy, DESG staff coordinated a variety of education and restoration efforts, with a focus on urban stormwater, to clean and restore the watershed. DESG staff served as the project coordinator for a multi-partner *Milton Rain Gardens* project, developing six rain gardens adjacent to the Broadkill River in the heart of downtown Milton—at the public library, elementary school, town boat ramp and commercial properties. Working with many community partners, DESG-led efforts have supported state watershed restoration efforts by restoring ecosystem function and reducing the stormwater impacts in an urbanized riverfront community.

Delaware NEMO supports stormwater education and tools. Stormwater is one of the major sources of nonpoint source pollution in coastal Delaware. A growing population and the urbanization of this region has resulted in some areas with greater than 10 percent impervious surface coverage, a level at which a decrease in water quality is cited to occur. More than a decade ago, DESG led efforts to create a Delaware NEMO (Nonpoint Education for Municipal Officials) affiliate to the National NEMO Network. NEMO is a collection of

university-based outreach education programs across the U.S., inspired by the original NEMO program at the University of Connecticut, that educate local land-use decision-makers about protecting water quality as communities grow. DESG has provided funding, technical support and conducted education programs to assist coastal towns in managing stormwater through statewide NEMO partnerships. Rain gardens are a relatively simple and inexpensive way to create or restore watershed function at the parcel level. DESG has led or partnered with many local groups to create awareness and enhance acceptance of rain gardens as a stormwater management practice. Through demonstration gardens at the University of Delaware Hugh R. Sharp Campus (n=2), and at sites in Milton (n=6) and Lewes (n=1), DESG has worked with many local partners and provided accompanying education programs, including a rain garden workshop for professional landscapers. Partnering with other Mid-Atlantic Sea Grant programs and the regional Rain Garden for the Bays, DESG provided support to adapt Connecticut NEMO's free Rain Garden app, giving homeowners and business owners the tools to design and create their own rain gardens. DESG leadership has provided NEMO based education and tools to raise awareness about stormwater quality and to instruct communities on how they can take steps to reduce impacts.

Water quality research team looks to Sea Grant outreach specialists to develop and guide participatory modeling process. Sea Grant researchers from Virginia, Maryland and Delaware developed an online tool that connected three different water quality models to provide communities information about how land use affects the health of Delmarva's coastal bays. Specifically, Delaware researchers conducted a suite of field experiments to measure nitrogen processing along the shores of Delaware's Inland Bays to parametrize nitrogen removal via dentrification in sub-tidal sediments. Working with scientists from Maryland and Virginia, a DESG scientist assisted with refinement of the nitrogen loading model to validate it's effectiveness in estimating nitrogen loading to the shallow coastal systems of the Delmarva region. The research team was interested in soliciting feedback on their models

from potential users (i.e., resource managers, community planners), but was unsure how to do so. DESG Marine Advisory Specialists (MAS), who are trained facilitators, were approached to develop and facilitate an end-user engagement strategy involving participants from all three states. The specialists organized a number of planning sessions with the researchers to discuss their goals, objectives and anticipated outcomes. The agreed upon engagement strategy included two participatory modeling workshops. During one workshop MAS specialists utilized the *weTable* (touch-table) technology to engage the end-users in a high-tech/high-touch activity to involve participants in the modeling efforts. Researchers obtained valuable feedback and input from the workshops, which was critical to making the water quality tool useful for practitioners. The online version of the tool launched in the summer of 2015.

Sea Grant uses monitoring systems aboard ferries to study water quality of Delaware Bay. Through a partnership with the Delaware River Basin Authority (DRBA) that operates the Cape May, NJ–Lewes, DE ferry, DESG acquired and installed an automated water quality monitoring system on two of the vessels, and has identified ecosystem-scale productivity patterns at the mouth of the Delaware Bay. Monitoring data for the Delaware Bay is very limited, so the ferry-mounted systems provide unique and consistent measurements of dissolved nutrients and oxygen that would otherwise remain unknown for this section of the bay. The DRBA contributed the engineering and inspection work, while DESG provided the scientific leadership, equipment, maintenance and calibration, and data analysis. Results have been published in

the scientific literature, and made available to resource managers. Most recently, the program is applying data uplink capabilities to provide real-time access on the internet. Carbon dioxide and pH sensors have been added, providing researchers with data necessary to measure changes in acidification. The shipboard atmospheric monitoring system is also undergoing an upgrade with data being made available live through the internet as well. With the new equipment and additional monitoring capabilities, the partnership has expanded to include the National Weather Service that will be incorporating the data into their weather reporting systems.

SEA GRANT RESEARCH ENHANCES MANAGEMENT DECISION-MAKING IN DELAWARE.

Molecular analysis of coastal waters allows researchers to identify viable, but unculturable-microbes that can be vectors for disease. Through a series of competitively awarded research proposals, DESG researchers analyzed coastal waters for a number of harmful bacteria. *H. pylori* were identified in 17–34 percent of coastal water samples, positively correlated with salinity. *H. pylori* is a recognized cause of peptic ulcers. *H. pylori* was not only found to be present, but likely viable, though approximately 20 percent of those identified were considered pathogenic. Research also delineated the contributions of contamination from humans and wildlife, including gulls, migrating shorebirds and dolphins. The research highlighted the need for monitoring even in coastal waters that were not necessarily considered contaminated. These are important research findings for health and safety management of coastal waters not only in Delaware, but globally.

New microelectrode proves a critical tool for geochemists worldwide. Groundbreaking research that provided a new tool for the examination of fine scale geochemical cycling was funded by DESG and published in 1995. During the reporting period the gold amalgam microelectrode has been used extensively in the coastal waters and marshes of Delaware Bay, as well as in the Black Sea, Mediterranean Sea, on expeditions of the submersible *Alvin,* and around the world's oceans. The probe allows researchers to determine the redox state of all chemical species simultaneously on a submillimeter scale; it has fundamentally changed the way geochemistry in coastal systems is studied. Trace element speciation work, and descriptions of chemical and microbial processes in metal and sulfur cycling have catalyzed improved understanding of the fundamental chemistry of aquatic systems. The work has led to the designation of an American Chemical Society Fellow, AAAS Fellow, and numerous other national and international awards. DESG has continued to ensure this global tool is applied to Delaware waters through a series of investigations into coastal water quality in and around the state.

Critical work in beach swash zones important for beach nourishment strategies. Turbulent, high energy swash zones are notoriously difficult to study, but DESG funded engineering researchers have developed tools and techniques for capturing sediment movement data over extended time periods on very small scales. Through a series of competitively funded research proposals, engineering researchers designed, refined, and made portable a system for fine scale GPS-based imagery for use in the swash zone to estimate net sediment transport and measure that transport over tidal and lunar cycles. The data and associated simulation models, also partially funded by DESG, provide coastline resource managers with tools to understand sediment flow along Delaware's coast. Beach nourishment projects are an enormous expense in Delaware along both the Atlantic and Delaware Bay coasts. Resource managers not only have cutting edge, locally-based published research upon which to build their nourishment strategies, but access to leaders in the field of geomorphology who are available for consultation.

Sea Grant research informs state planning for sea level rise. Documented acceleration of sea level rise—with state officials anticipating approximately a foot of sea level rise over the next 100 years—is alarming when the extensive coverage of low-lying coastal marshes along Delaware's coast are considered. Nearly 371,000 acres of contiguous tidal wetlands surround the Delaware Bay. Studies indicate that the proportion of wetlands that were degraded increased from 25 percent in 1984 to an alarming 54 percent in 1993. The future of these critical ecosystems is in question and competitive research has been funded by DESG at all marsh system scales. Remote sensing studies provide a system-wide view of elevation and vegetation type that have been used by wetland managers for determining trends in marsh acreage. Within individual marshes, sediment geochronology work has provided surface accretion estimates over 100-year time scales, and incorporated carbon estimates to determine carbon sink rates in the marsh sediments. One coastal marsh, with extensive drainage ditching common along the east coast, has been heavily instrumented to monitor mm-scale movements of particulates over multiple tidal cycles to determine the physics of particle motion across such a complex system, and estimate tidal import/export of particulates between the marsh and estuary. Techniques for using long-wave infrared imagery were developed and verified that allow for more accurate determination of the water line in marsh-tidal creek system. Another mathematical modeling team is using those fine scale data to constrain and validate a theoretical model of sediment transport that is ultimately intended for application across east coast marshes generally. These studies have applied new technology to marsh systems, developed new algorithms for data analysis and interpretation, and results have been published and disseminated widely across the scientific and natural resource management communities in fields such as hydrogeology, civil and environmental engineering, sedimentology, remote sensing and marsh ecology.

SUSTAINABLE COASTAL DEVELOPMENT (SCD)

Delaware continues to experience significant population growth and development, especially along its coastal zone and associated watersheds. This rapid development and urbanization of the coastal zone has resulted in an explosion in the number of residents, visitors, homes and infrastructure exposed to coastal processes, beach erosion, and storm hazards. Although coastal communities need sustainable development policies, many small towns and communities throughout Delaware, especially in Sussex County, do not have professional, experienced land-use planners on staff. Although state law requires local communities and counties to develop comprehensive land use plans that balance growth with environmental quality, results have been slow to materialize. Working farms and coastal vistas are quickly filling with subdivisions and supporting infrastructure.

GOAL: Research and outreach that provide information and techniques that enhance waterfront-related economic activities. This includes engagement of coastal communities in planning processes that support the efforts of community leaders to identify and pursue sustainable economic development, and recognition of the need to balance the multiple uses of these resources.

Meeting Our Strategic Outcomes: The 2009–2013 Delaware Sea Grant Strategic Plan set forth eight outcomes for Sustainable Coastal Development. The outcome stories noted below highlight the most significant science and societal progress towards addressing our strategic plan.

SEA GRANT RESEARCH AND OUTREACH IMPROVE SUSTAINABILITY OF COASTAL COMMUNITIES.

Community excitement builds around Sea Grant design concept and early implementation stages for waterfront revitalization in Laurel, DE. "Help us bring people and jobs back to downtown Laurel!" This was the plea for assistance that community members in Laurel, DE shared with DESG. The town once enjoyed a thriving downtown economy around the waters of Broad Creek; however, Laurel's waterfront and commercial district had deteriorated over the past few decades. In response, DESG facilitated a public engagement process to hear the community's desires for the revitalization of the downtown area. The community's "wish list" included a beautifully landscaped river walk, a pocket-style neighborhood featuring Victorian-era architecture, a mixed use commercial/residential area that would serve as a gathering place, an active play area for children, a kayak launch and an environmental education area. DESG turned the community's thoughts and aspirations into a conceptual site plan and visual images with the help of a landscape design professor from the University of Delaware. Subsequently, the site plan and artist renderings were presented to the citizens of Laurel in a report titled, *Broad Creek Greenway and Waterfront Redevelopment*. The community enthusiastically accepted the site design called "The Ramble," which focused on improving Laurel's economy, as well as the environmental health of Broad Creek. DESG is now helping the community implement the revitalization plan, which includes geotechnical and environmental site assessments, a new website, a community branding initiative, a nature-based tourism study, and supporting community events.

Sea Grant fills planning void and delivers community engagement strategies for master plan development. A staff resignation in the state's planning office left two local municipalities searching for assistance to develop master plans to meet Chesapeake Watershed Implementation Plan requirements. DESG was promptly called into action. Initiated in 2012, DESG coordinated and facilitated public workshops with leaders and stakeholders of the towns of Bridgeville and Greenwood to determine how and where the towns would grow, in the context of water-quality challenges. DESG led this participatory process using the *weTable* (touch-table) technology along with DESG's Community Land Use Model based on the CommunityVIZ platform. This high-tech/high-touch process provided useful geographic information, instantaneous data, comparative analysis and a visual representation of land use density that helped participants identify and define planning areas, as well as growth, economic development and sustainability strategies. The result was a long-term growth scenario designed to protect water quality. Subsequently, DESG produced a master plan for the two communities that was adopted by both towns. Adhering to the master plan will yield many sustainable benefits for the towns and their citizens, for water quality and the natural environment and for farmers and agribusinesses, as well as the taxpayers of Delaware. Sea Grant's land use model and *weTable* process have been adopted for use by a number of state agencies and programs, including the Delaware Office of State Planning Coordination and the Delaware Department of Natural Resources and Environmental Control. In addition, DESG assumed national and regional leadership in training others to implement these participatory processes in public workshops.

ECONOMIC VITALITY IN COASTAL COMMUNITIES IS ENHANCED THROUGH SEA GRANT EFFORTS.

Sea Grant leads economic revitalization efforts in working waterfront community. When DESG asked the question, "What is being done to aid Delaware's traditional maritime communities?" it became apparent that there was an opportunity for action. In response, DESG piloted its Working Waterfronts Initiative in Bowers Beach to determine what could be done to improve economic conditions in this bayside hamlet. DESG conducted stakeholder interviews and identified numerous community challenges, including the expansion of day-use tourism attractions. DESG then led the community in a "strategic doing" process to deliver on their expressed needs. With assistance from DESG, new beach directional signage and three new information kiosks were installed, the public boat ramp area was restriped, a community newsletter was published, a grant to produce interpretive/wayside exhibits that feature the maritime heritage and culture of the town was obtained, a zoning ordinance to permit development of a commercial district in an area more conducive to attracting tourism was adopted and a conceptual plan was developed to repurpose a portion of a 5-acre asphalt parking area into a greenway and park, just to name a few. The newly organized "Bowers Beach Community Improvement Committee" was also established to continue to implement additional actions for the town. These completed projects and activities have improved the town's quality of life, and aided in the potential for expanded day-use tourism opportunities in this Delaware Bayshore community.

Sea Grant leads Mid-Atlantic charter boat fisheries education and outreach. In 2003, DESG participated in a National Sea Grant supported regional Mid-Atlantic States (NY–NC) Charter Boat Fisheries Initiative to develop business-oriented programs for the charter industry. Between 2004–2011 DESG and Maryland Sea Grant organized six additional bi-state workshops covering important aspects of operating a charter boat business: ownership structure, finance and accounting, liability and insurance, planning and management, marketing, safety at sea, seafood handling and quality assurance. The programs also included a safety/regulatory update from the U.S. Coast Guard, regional and state regulatory updates, and reviews of current research for targeted sport fish species. More than 250 charter boat captains from five states (DE, MD, VA, NJ and PA) participated in the workshops and subsequent formation of Limited Liability Corporations (LLC), improved marketing practices, and more efficient insurance coverage were cited as significant business changes by a majority of the attending captains. The financial crisis of 2007–2008 had a devastating effect on the recreational charter fishing industry and significantly decreased workshop attendance. As a result DESG discontinued the programs in 2012. The program legacy includes web resources that supported the workshops, which remain available online (730 visitor sessions, 1,200 page views), and greatly enhanced, ongoing communication between state and regional fishery managers and charter captains regarding fishing regulations and policies.

Sea Grant contributes to expansion of high-speed connectivity to support economic development in Southern Delaware. High-speed connectivity (i.e., broadband) is essential for a region to compete in an economy based increasingly on entrepreneurship and innovation. Advanced broadband fuels economic development that helps both businesses and households, but in rural Delaware, it's not a given that connections will be fast or reliable enough. Some of the more rural areas still struggle with connectivity, which results in negative impacts on farms, families and businesses. DESG, in collaboration with the University of Delaware's Institute for Public Administration (IPA), has been working with community stakeholders and state agencies to analyze the state of broadband provision in Delaware and plan for necessary improvements. Recent activities have focused on facilitating efforts by the Sussex Broadband Work Group and the Sussex Economic Development Action Committee to determine site-specific demands for enhanced broadband infrastructure and Internet services and work toward implementing these improvements. DESG and IPA also partnered with the Delaware Department of Technology and Information to map the availability of broadband services across Delaware, provided digital literacy trainings, and facilitated stakeholder working groups as they planned for enhanced broadband in the region. As a result, broadband providers and innovators have increased activity, primarily in western and central Sussex County, to install broadband infrastructure and technologies. Broadband installation will provide businesses, governments, and households with access to a host of timesaving, educational and commercially valuable applications made possible by the rapid transfer of data.

Sea Grant leads local and national tourism efforts. Tourism generates economic benefits for coastal communities both in Delaware and nationally. Sussex County, DE attracts 7 million visitors each year and direct visitor spending is estimated to be $750,000,000. Nationally, 2.6 million workers are employed in the coastal tourism and recreation sectors in the 30 coastal and Great Lakes states, and generate $223 billion in GDP. Through the University of Delaware's Sustainable Coastal Communities Initiative (SCCI), led by DESG, we have funded research on heritage tourism in Sussex County and hosted a series of workshops to assist businesses in developing heritage tourism itineraries. DESG has provided seed funding to help market heritage tourism efforts in the county and to help stimulate and enhance economic opportunities. Tour operators have begun offering tours in rural communities in Western Sussex County to provide visitors with the opportunity to view local historic and heritage sites. As a direct result of Sea Grant involvement, tour operators have enhanced their tour offerings and realized increased economic gains. Realizing the importance of coastal tourism nationally, DESG partnered with Hawaii Sea Grant colleagues to convene a coastal and marine tourism roundtable session in 2011 to begin the process of renewing Sea Grant's interest in sustainable coastal tourism. After the successful roundtable, with 40 Sea Grant colleagues participating, a subset of individuals drafted a policy white paper which serves as a blueprint for Sea Grant programs nationally to better identify techniques and tools for working with their local tourism sectors. Numerous Sea Grant programs collectively contributed to the successful roundtable and subsequent drafting of the white paper, helping to refocus Sea Grant activities relative to marine and coastal tourism nationwide and to receive more attention in national and state strategic planning efforts.

Sea Grant informs adoption of offshore wind energy along East Coast of the U.S. A 2015 U.S. Department of Energy report predicts that wind power will contribute 35 percent of our nation's energy by 2050. DESG is among a handful of Sea Grant programs that are investing in sustainable energy work and one of a select few focusing on wind energy. DESG has had a major role in environmental research, social science research, policy analysis and education informing the growing offshore wind industry regionally, nationally and internationally. An early Sea Grant funded research project during this reporting period demonstrated a supportive willingness to pay for clean energy among Delawareans, and inspired Delaware to consider offshore wind as an alternative energy source to fossil-fuels. The work inspired the University of Delaware to partner with Gamesa Technology Inc. to erect a 2-megawatt land-based wind turbine on the UD Hugh R. Sharp campus along the coast in Lewes, Delaware. Operational since June 2010, the turbine has provided enough electricity annually to power the campus, and on average, 50 local homes, and is used as a research and education platform for industry, policy makers, and the local community, among other audiences. To communicate the value of renewable energy to diverse audiences, DESG produced public service announcements, media pitches, printed publications, and websites, along with curricula about wind energy. A DESG developed educational field trip program for local first graders used the UD turbine to expose hundreds of children to science and technology while complementing a science kit curriculum used in Delaware schools called "Catching the Wind" by Engineering is Elementary. DESG-supported public perception and policy studies help sustain interest in East Coast wind power development and show support for offshore wind development. Similarly, surveys and monitoring of the offshore lease tract intended for a commercial scale wind farm provide data necessary for siting considerations. DESG funded researchers, past and present, are among the leading experts in offshore wind regionally/nationally, and when championing offshore wind, draw heavily from DESG research findings, outreach methods and education materials.

SAFE AND SUSTAINABLE SEAFOOD SUPPLY (SSSS)

Delaware's coastal waters are rich in fish and shellfish harvested for their recreational and commercial value, although the commercial fishing sector in Delaware is relatively small in comparison to other neighboring states.

GOAL: 1 Research and outreach that catalyze new product innovations to keep the domestic seafood industry financially competitive and environmentally responsible. **2** Development of protocols and training for innovative food safety procedures that reduce risk and enhance consumer knowledge about seafood.

Meeting Our Strategic Outcomes: The 2009–2013 Delaware Sea Grant Strategic Plan set forth ten outcomes for Safe and Sustainable Seafood Supply. The outcome stories noted below highlight the most significant science and societal progress towards addressing our strategic plan.

SEA GRANT TECHNICAL ASSISTANCE VITAL FOR DELAWARE AQUACULTURE EFFORTS.

Sea Grant contributions assist in aquaculture industry start-up. Maintaining healthy populations of bivalve shellfish for their ecological, recreational and commercial value to Delaware's Inland Bays is a top priority of the Delaware Center for the Inland Bays (CIB), a National Estuary Program (NEP) member organization. Fifteen years of applied research, demonstration, and technology transfer work guided by DESG leadership and technical support, in cooperation with the CIB and Delaware State University, documented the value and benefit of shellfish aquaculture as a means to improve the quality of the Inland Bays estuary and to enhance local seafood production and economic development. During 2012, DESG participated in a CIB initiated shellfish aquaculture public and private sector stakeholder work group to conduct spatial planning for bottom lease siting and to draft statutory code and regulatory language to reinstate a bottom leasing system for commercial shellfish aquaculture for the Inland Bays. DESG educated coastal community audiences about shellfish aquaculture through workshops, media interviews, public presentations, a white paper *Shellfish Aquaculture in Delaware's Inland Bays: Status, Opportunities and Constraints* and two websites. Commercial shellfish aquaculture legislation (HB 160) was signed into law on August 28, 2013. Technical guidance and leadership provided by DESG to demonstrate the ecological benefits of shellfish aquaculture helped facilitate a new legislative policy that will significantly increase Inland Bays shellfish (oyster) populations and associated ecological services and economic benefits, thus accomplishing a CIB priority for improving the health and stewardship of the Inland Bays estuary.

SEA GRANT RESEARCH AND OUTREACH ACTIVITIES SUPPORT SEAFOOD BUSINESS AND INDUSTRY.

Sea Grant led HACCP training helps lower the incidence of foodborne illness nationwide. The safety of seafood produced and imported to the U.S. is a national priority. To help ensure the safety of seafood products, the Food and Drug Administration (FDA) requires compliance with federal HACCP regulations. DESG, along with other Sea Grant colleagues, has conducted

national and international training for over 200 seafood professionals, including regulators and industry personnel, to meet the requirements of the FDA Seafood HACCP Regulation. Without DESG efforts in leading HACCP, there would be critical lapses in training and issues with the industry processing seafood safely. The Centers for Disease Control (CDC) data show that HACCP training has lowered the incidence of foodborne illnesses in the U.S. In addition, as a member of the Seafood HACCP Alliance (SHA) (a national steering committee) DESG has assisted in training future instructors throughout the U.S. and internationally and played a major role in improving the SHA training materials.

Sea Grant research and development results in a practical alternative recipe for eel and conch bait. Delaware Bay experienced significant declines in horseshoe crab populations in the 1990s. Population declines were attributed largely to harvests of horseshoe crabs for eel and conch bait, estimated at 350,000 (8–15 percent of the total population) annually. Reducing the harvest of female horseshoe crabs was necessary to ensure the long-term viability of the populations. In 2001 landings were capped, and in 2006 harvest of female horseshoe crabs was banned by both New Jersey and Delaware. DESG funded research and partnered with DuPont, Delaware State University and the Delaware Biotechnology Institute to investigate the chemical cue that makes female horseshoe crabs so irresistible to eel and conch; DESG worked with the fishing community to make sure the solution was practical. DESG researchers analyzed the potential compounds that attract eels and conch through a series of chemical analyses, laboratory experiments, and field trials. The research supported by DESG resulted in bait being developed using a small amount of a male horseshoe crab that met the cost and use requirements of the fishing community. In the fall of 2012, LaMonica Fine Foods (Millville, NJ) scaled up production of the bait using a proprietary fish attractant for a commercial product. In addition to the publication of the bait recipe, LaMonica's commercial version was made available to the public in 2013.

Sea Grant sponsored contest winner sees increase in sales. Coast Day is Delaware Sea Grant's annual open house and largest outreach event for the general public. One main reason people come to Coast Day is to enjoy the seafood contests, cooking demonstrations and to consume various seafood delicacies. The most popular contest is the Crab Cake Cook-Off and previous winners of this event have used the recognition of winning to help promote their businesses. The 2013 contest winner, for example, promoted his winning entry at his restaurant and increased crab cake sales immediately. Within one week of winning the Cook-off he witnessed an increase in sales. There was an initial $8,200 increase the first month compared to the same month in 2012. He also began shipping crab cakes to distant locations and he began a crab cake take-out service for his customers. Total seafood sales at his restaurant increased $109,000 for the 2014 season compared to 2013, due chiefly to the promotion of award-winning crab cakes.

SEAFOOD HEALTH AND SAFETY MESSAGES REACH TARGET AUDIENCES.

Sea Grant leads stakeholders to reach consensus messages about health benefits of seafood. DESG hosted a seafood conference *(Framing the Message About Seafood)* in 2011 with a goal to reach a consensus among participants on the health benefits of seafood.

Participants included representatives from academia, healthcare professionals, federal and state government and non-government organizations. By the end of the conference, they agreed on a conceptual framework that focused on the amount of seafood individuals eat, whether they are in special risk groups and the source of products that they consume. An existing website (seafoodhealthfacts.org) was used to launch a web-based tool to deliver information to consumers using the framework. The website provides healthcare professionals and the general public with straightforward, science-based information about the pros and cons of including seafood in a balanced diet. DESG manages the site and actively encourages other groups and organizations to include a link to it as a reliable and impartial "go to" resource for seafood information. The website is linked to, or receives, search engine referrals from more than 840 sources, most notably NOAA FishWatch, the Seafood Network Information Center, NOAA Office of Aquaculture, the National Fisheries Institute, SeafoodSource.com and Monterey Bay Aquarium SeaWatch. From the time the new web tool was launched in 2012, page views began to increase significantly. Page views and unique page views increased about 70 percent between February 2013 and January 2014. Visitors represent all 50 states, and the District of Columbia and international visitors represent a total of 137 countries. DESG efforts have resulted in consumers, dieticians, journalists, and others using the website extensively for personal information and to inform their clients about the health benefits of seafood.

Sea Grant targets various public audiences with seafood-related training and educational opportunities. Seafood is a primary source of high-quality protein and provides a variety of nutrients needed for overall health; therefore, it is paramount that consumers and food professionals understand both its benefits and risks. DESG developed and implements a variety of seafood training activities reaching multiple stakeholder groups annually. Examples include a partnership with the Delaware Department of Education (DOE) to offer annual training programs to school food service workers. DESG conducted two training programs and subsequently, DOE assumed responsibility for continuing to provide instruction concerning seafood safety, handling and preparation for Delaware's school food service workers. Another illustration was a nationwide survey conducted by DESG to assess knowledge and attitudes of the medical community regarding seafood safety issues and the benefits and risks of seafood consumption. The results indicated a need and interest to include more about food and seafood safety in future health care providers' training. DESG is in the process of securing funds to work with University faculty to develop a training module or case-based simulations to address this need.

Sea Grant informs fish consumption advisories through enhanced data collection. DESG provided funding for the development and application of a new molecular technique for distinguishing subpopulations of white perch in the Delaware Bay. *Morone americana* is a commercially and recreationally important species with known subpopulations whose contamination levels vary according to their life histories. DESG also facilitated collaboration between the research and state fishery managers that resulted in the sharing of fish tissue samples. Researchers can now provide fisheries managers with specific population distribution to tie to contamination studies. Because white perch also is a species used to monitor fish contaminant levels in the Delaware Estuary south of Trenton, New Jersey, the research is critical to fish consumption guidelines for the Delaware Bay more generally. In the future, fish consumption guidelines may be more specific and allow for more efficient consumption guidelines.

HAZARD RESILIENT COASTAL COMMUNITIES (HRCC)

Much of Delaware's populated coast is vulnerable to the effects of coastal storms (e.g. high winds, wave action, overwash, storm surge), flooding, sea-level rise, and both episodic and chronic shoreline erosion. These coastal hazards can pose threats to communities including people, property, infrastructure, and economies, as well as coastal environments such as beaches, dunes and marshes. If coastal hazards are not considered in the process of community planning and development, homeowners and property may be subject to unnecessary and increased risks.

Climate change effects in Delaware will likely include more extreme weather events (more droughts, more intense rainfall, and more intense storms and flooding), sea level rise and warmer temperatures. Therefore it is critical that Delaware residents and local government officials are prepared with resources, strategies and actions that will increase the resilience of homes, businesses and economies. With coastal areas supporting such large populations, safety of both permanent and temporary residents is key.

GOAL: Science and policy research and outreach that provide an informed basis for assessing the risks associated with living and working in coastal communities. This includes the development of strategies that will help mitigate and adapt to climate change.

Meeting Our Strategic Outcomes: The 2009–2013 Delaware Sea Grant Strategic Plan set forth six outcomes for Hazard Resiliency in Coastal Communities. The outcome stories noted below highlight the most significant science and societal progress towards addressing our strategic plan.

SAFETY AT OCEAN BEACHES IMPROVED DUE TO SEA GRANT RESEARCH AND OUTREACH.

Sea Grant, NOAA, NWS and regional beach patrols collaborate to improve rip current safety. DESG continues its lead role—at the local, state, regional and national level—in supporting initiatives and promoting communication among agencies and communities, and developing collaborative programs that strengthen partnerships and leverage expertise among rip current research scientists, Sea Grant extension specialists and beach patrols. DESG distributed rip current awareness signs to six public beaches and five private beach communities along Delaware's Atlantic coast. DESG also participated in and hosted three rip-related workshops attended by fourteen communities in New Jersey, Delaware, Maryland, Virginia and eight cooperating agencies/organizations (coastal managers, scientists, and National Weather Service forecasters and NOAA National Weather Service Headquarters/OST) to discuss issues related to the science, social science, and future directions of rip current and surf zone safety programs. DESG has continued its lead role in delivering updates on advances in rip current science to NOAA's messaging team, and providing assistance in evaluation of the NOAA/USLA *Break the Grip of the Rip* national campaign.

Sea Grant supported research and outreach investigate surf zone injuries. DESG is coordinating a collaborative project with several organizations—UD's Department of Civil and Environmental Engineering, Delaware DNREC, local beach patrols and Beebe Healthcare—to

seek a better understanding of why surf zone injuries occur so that future accidents can be lessened. This innovative research project involves collecting and analyzing data from both medical records of beachgoers who have been injured and daily environmental data from Delaware's ocean beaches. After three seasons of collecting this data (2010–2013), 1,124 injuries were reported, including three deaths. The injuries occurred during variations in ocean wave, current, beach, and weather patterns. The investigation has shed light on the demographics of who is being injured and the type and severity of their injuries. Additional data is being collected to identify specific trends in the environmental conditions that will accurately predict an increased probability of injury. Positive outcomes of this project include enhanced prediction of surf/ocean conditions that are likely to cause injuries, communication of study results to local beach patrols and the National Weather Service to enhance and improve beach hazard statements, and focused/targeted education and outreach efforts directed to the beach-going public. The surf zone injury project has resulted in the development of education and outreach programs for visitors to Delaware beaches, and has the potential to expand to other states and regions.

SEA GRANT PREPARES COMMUNITIES AND INDIVIDUALS TO PROTECT LIFE AND PROPERTY.

Community participation leads to reduction in flood insurance premiums. Participation in the National Flood Insurance Program's (NFIP) Community Rating System (CRS) is often difficult for community officials because implementation and enforcement of higher regulatory standards can be challenging. Awareness of flood-related impacts to life, property and evacuation routes is also important—often leading to implementation of mitigation actions and endorsement of higher standards. DESG has assumed a leadership role in managing the Delaware CRS User Group, which is comprised of community officials who want to improve their community ratings, stay current on changes in the NFIP and find new ways to help and protect their citizens. As coordinator of the Delaware CRS User Group, DESG works with FEMA Region III, Delaware Department of Natural Resources and Environmental Control (DNREC), and local government officials to enhance community understanding of the NFIP CRS, and encourage adaptation of regulations and standards that go beyond code for personal/property protection and reductions in insurance costs. Eleven CRS-participating municipalities are currently involved in the Delaware User Group, and several non-participating communities are also engaged in sessions to gain knowledge and information before applying to join the CRS program. DESG provides technical support, training opportunities, workshops, information and assistance to communities through coordinated meetings for sharing lessons learned, and ultimately assisting communities in obtaining improved ratings which can result in NFIP flood insurance cost savings for property owners. The average premium reduction for residents in participating Delaware communities is 10 percent (depending upon class rating) compared to zero savings for communities who choose not to participate.

Sea Grant engages communities in adopting hazard mitigation and climate adaptation action plans. DESG has assisted communities statewide in developing a community-based process that enhances local understanding of climate change and natural hazard impacts, and has provided guidance in identification of strategies to build resilience towards these impacts. Two specific projects—in the communities of Lewes and Delaware City—engaged key local stakeholders (city staff, city board/commission members, and regional/state partners), as well as property owners and residents, resulting in final reports and adaptation action plans that were adopted by the Mayors and City Councils of both communities in 2011 and 2014, respectively. The City of Lewes has successfully moved forward with mitigation and adaptation strategies, and

outcomes of this project have been highlighted as best practices by programs at the local, state, regional and national level, including the American Planning Association (APA), Association of State Floodplain Managers (ASFPM), Delaware DNREC's sea-level rise adaptation committee, the Federal Emergency Management Agency (FEMA), Georgetown Climate Center and ICLEI—Local Governments for Sustainability. A positive outcome of hazard mitigation and climate adaptation planning process for both communities has been their success in obtaining DE Coastal Management Assistance Grants to implement several identified priority projects. The City of Lewes procured a $20,000 grant to support an evaluation of existing rules, codes, documents and plans related to floodplain management, building codes, hazard mitigation planning, and improving the city's CRS classification to benefit both private property owners and the community as a whole. The Lewes Mitigation Planning Team has continued to work on a prioritized list of implementation actions as recommended in the plan, and the city's recently updated comprehensive plan, with guidance provided by this project, will fully incorporate mitigation and climate change considerations. Delaware City received a $25,000 grant to support an engineering review of stormwater, drainage and flood issues. Following this project, the community received a FEMA Pre-Disaster Mitigation Grant (~$800,000) for a mitigation project that will address significant flooding issues in the community. Success in obtaining these grants can be attributed in part to the fact that Delaware City embraced and completed the process of developing an adaptation plan that engaged local government officials and citizens in addressing issues related to avoidance, minimization, mitigation and adaptation to coastal hazards and climate change. These adaptation planning initiatives also have resulted in development of a step-wise training program for other communities throughout the state. The award-winning DESG publication, *Natural Hazard and Climate Adaptation Tool Kit for Delaware Communities* is designed to assist communities in identifying planning, mitigation, and adaptation opportunities that will help reduce vulnerabilities to natural hazards and climate impacts. The tool kit guides community officials and residents through a planning process that promotes coordination with other community needs and relies on public input.

Sea Grant-led coastal resiliency training informs Delaware communities. DESG has established a strong foundation of community resiliency training by convening workshops to enhance outreach efforts and improve communication and coordination among local officials and state/federal agencies. Working with partners including Delaware's National Estuarine Research Reserve, Delaware DNREC's Division of Energy and Climate, NOAA's Coastal Services Center, and FEMA's National Disaster Preparedness Training Center (NDPTC), DESG has coordinated and hosted seven major workshops related to coastal vulnerability and sustainability, higher regulatory standards, community responsibilities and the National Flood Insurance Program, climate adaptation and community resiliency. With hundreds of individual attendees and more than 66 participating communities, the training courses have targeted officials in local government, emergency management, environmental resources, public works, regulatory/enforcement, land use planning, hazard mitigation and related fields. Several

workshops have also addressed the issue of flood insurance, providing training and information to more than seven private insurance companies and associated insurance agents. The workshops have provided information on adaptation opportunities, and included discussions of climate science and impacts, determining community vulnerabilities, communicating effectively, identifying adaptation strategies and finding mechanisms to implement those strategies. DESG and partners also have collaborated to develop a flood risk awareness training module specifically targeted to local government officials. DESG has been engaged not only in developing learning objectives/outcomes and course curriculum and modules, but also in providing adaptation planning expertise to the program. This training focuses on review of multiple sources of flood risks to Delaware communities that can be addressed and mitigated through planning, codes, and ordinances. Added benefits to each of these training programs include extended networking among Delaware communities who share interests in flood mitigation planning, adaptation planning and opportunities to collaborate with other local governments in the area.

Sea Grant helps individuals prepare for, respond to, and recover from storms. With funding support from FEMA, DEMA, and Delaware DNREC, DESG wrote and published *Delaware Homeowners Handbook to Prepare for Natural Hazards.* This publication addresses natural hazards in Delaware, including coastal storms, inland flooding, wind, and tornadoes, as well as the topic of climate change and sea-level rise. The information provided allows homeowners to make educated decisions about steps required to protect family and property, including information on family preparedness, flood and wind retrofits, dune management, insurance (NFIP), resources to aid in recovery, and emergency contact information for federal, state, county and local agencies. DESG distributed seven thousand copies by the end of 2013, and supported a second print run of an additional 5,000 handbooks. Copies have been provided to municipal offices throughout the state, municipal power cooperatives, public libraries, homeowners associations, real estate offices, local businesses, emergency management and response agencies, Delaware Legislative Hall and UD Cooperative Extension. This Sea Grant-supported publication informs residents of the precautions they should take to protect themselves and their property, ultimately reducing risk from the threats caused by natural hazards. The success of the handbook would not have been possible without Hawaii Sea Grant who developed the initial handbook, and Mississippi-Alabama Sea Grant who provided templates and graphics. DESG updated the text and template to include East Coast-specific information, as well as a new chapter on climate change impacts. DESG has in turn communicated and collaborated with Woods Hole Sea Grant and New Jersey Sea Grant Consortium regarding shared text, graphics and printing specs for their individual handbook preparation and publication.

OCEAN AND ENVIRONMENTAL LITERACY (OEL) | A Cross-Cutting Theme

The complexity of high-priority marine issues calls for an educated public who can understand the link between science and society and the need for an integrated approach between science and policy. A hallmark of Delaware Sea Grant (DESG) is that it has long recognized this, funding both science and policy research and then facilitating the transfer and application of results by ensuring that outreach objectives are fully integrated into each research priority area. We educate the public about the issues, ensuring that it understands the need for and impacts of our work. DESG works to educate current and future environmental professionals and leaders, enhance marine literacy across all population groups, and provide science-based technical assistance to marine resource users, constituents and stakeholders.

GOAL: Enhance marine literacy across all population groups and provide science-based information to K–12 audiences, marine resource users and the general public.

In our 2009–2013 Strategic Plan, DESG identified Ocean and Environmental Literacy (OEL) as a cross-cutting theme. This action not only served to emphasize DESG's important role in formal and informal education, but also showed that the program's outreach and education objectives are fully integrated into each DESG focus area—Healthy Coastal Ecosystems, Sustainable Coastal Development, Safe and Sustainable Seafood Supply and Hazard Resilience in Coastal Communities.

Working collaboratively with DESG researchers, DESG's Marine Advisory Service (MAS) and Environmental Public Education (EPE) Office serve as a bridge that links OEL across the focus areas.

Meeting Our Strategic Outcomes: The 2009–2013 Delaware Sea Grant Strategic Plan set forth five outcomes for OEL specifically. The outcome stories noted below highlight the most significant science and societal progress towards addressing our strategic plan in the OEL focus area.

TEACHERS AND STUDENTS PARTICIPATE IN EXPERIENTIAL LEARNING OPPORTUNITIES.

Marine science summer program for high school students inspires collegiate marine studies. High school students interested in STEM fields can easily overlook marine sciences as a potential pathway for rewarding careers. The University of Delaware's main campus in Newark and Hugh R. Sharp Campus in Lewes, DE provide unique opportunities for engaging students in a range of marine science activities, including underwater robotics, physical oceanography, biological oceanography, marine chemistry and coastal geology. Since the program's inception in 2008, DESG has consistently provided program support to assist with the operation of the TIDE (Taking an Interest in Delaware's Estuary) Camp. The camp is hosted by the University of Delaware College of Earth, Ocean, and Environment (UD CEOE), which is home to DESG, and supported by Sea Grant. DESG extension specialists and scientists provide programming and supervision of activities for students alongside CEOE faculty. DESG exceeded its target goal of 50 students for its strategic plan, with 66 students having

completed the program. More than one-half of TIDE campers apply to marine or environmental science programs for their undergraduate studies. At least 30 percent apply to the UD as marine science and/or environmental science majors.

Sea Grant increases ocean and environmental literacy through engaging, hands-on programming for students. As we deal with a changing global climate, the importance of an ocean and environmentally literate public, especially K–12 students—the future voters and decision-makers—has never been greater. By providing hands-on ocean and environmental science programs to students of all backgrounds, both on the UD Hugh R. Sharp Campus in Lewes and in schools around the state, DESG has built the capacity of students and teachers to better understand the fragile nature of our planet. Since 2010, DESG educators have reached over 1,300 students, providing engaging, current, ocean and environmental science programming. DESG education personnel work closely with classroom teachers, scouts, clubs, and camp leaders, and the Delaware Department of Education to ensure the most useful, level-appropriate, and engaging content is presented to the students. As indicated by group leaders, program participants gain an understanding of their local and global environment and the importance of scientific research in these arenas, as well as an appreciation for a healthy system and the actions required to achieve it. DESG strives to build a strong stewardship ethic among all program participants, including students, teachers and chaperones. With a more ocean and environmentally literate public, we will witness a positive change in the future of our planet.

Sea Grant integrates climate science into formal, informal and higher education. DESG is a founding partner in the National Science Foundation-funded Maryland Delaware Climate Change Education, Assessment, and Research project (MADE CLEAR) that is embedding climate change science education in formal K–12, informal and higher education settings across both states. The DESG Education Specialist regularly contributes to the professional development academies, provides professional contacts, recruits program participants, and works with the Delaware Department of Education and national professional education organizations on behalf of the project. The DESG Research Coordinator provides management and oversight of the project within Delaware by managing the sub-award to Delaware State University, working closely with the Maryland project manager, and building partnerships with state agencies and institutions. To date, as a result of DESG efforts, 16 of 22 Delaware school districts have MADE CLEAR alumni who are prepared for and are teaching climate change science in their classrooms. A new collaboration with Delaware State Parks has been initiated to reinforce classroom lessons with activities across the state in our parks, and an active research program is learning more about how teachers and students understand and learn about climate change. With heavy involvement of DESG staff, the project is working with the Delaware Department of Education to ensure climate change is included in the statewide science curriculum as the *Next Generation Science Standards* are implemented across the state.

Sea Grant coordinates first National Ocean Sciences Bowl regional competition in Delaware. Gaming and competition are proven methods of learning and building higher level thinking skills. By engaging students in competition in ocean sciences content, they are able to better learn about the ocean, which is not typically a large component of high school science curricula. To facilitate this learning, beginning in 2014, DESG shares coordination responsibilities for the Chesapeake Bay Bowl (CBB), a National Ocean Sciences Bowl regional competition. Hosting the 2014 CBB at the University of Delaware's Hugh R. Sharp Campus in Lewes, DESG welcomed 60 high school students from around the Mid-Atlantic region, including

Delaware, Maryland, Pennsylvania, Virginia and Washington, D.C. To ensure a successful competition, DESG recruited and trained 50 volunteers hailing from universities, state and federal agencies and research laboratories from around the region. The competitors experienced the University of Delaware marine studies campus, including their 146-foot research vessel, Global Visualization Lab, and museum-quality exhibits, and received an opportunity to network with scientists, graduate students and eight DESG staff members. As a result of coordinating the 2014 Chesapeake Bay Bowl, competitors' ocean and environmental literacy grew through competition preparation, and they networked with like-minded peers and potential colleagues and mentors.

RESIDENTS AND VISITORS BECOME MORE INFORMED ON COASTAL AND MARINE ISSUES.

Sea Grant open house reaches thousands annually. In October 2015, DESG will celebrate its 39th annual Coast Day open house, held annually on the University of Delaware's Hugh R. Sharp campus by the coast in Lewes, DE. While the event is co-sponsored by UD's College of Earth, Ocean, and Environment, DESG MAS and EPE staffs are responsible for coordination of the event. The event celebrates the state's ocean and coastal resources, and allows the public a behind-the-scenes look at DESG and UD outreach in the environmental arena with a focus on Sea Grant student and faculty research, and outreach topics. Attendance at the event varies based on weather, however most recently, annual attendance averages 8,000–10,000. In addition to the event itself, supporting contests, advertisements, and signage share related coastal and ocean information with audiences while promoting the event. Event surveys consistently show that 100 percent of respondents rate the educational value of the event as good or excellent, and show that all visitors commit to a behavior change as a result of a call to action at the event.

Sea Grant works with local, state, regional, and national media to inform various audiences. Surveys of Delaware residents show that Delaware residents obtain information about the environment from three primary sources (listed in order of preference): television, newspapers, and the Internet. National trends, which lean slightly more in favor of digital based information sources, still show traditional media as a major source of environmental information for the public. Working with local, state, regional and national news media outlets (broadcast and print) is a major priority for DESG OEL efforts to increase public understanding of the steps that individuals can take to conserve and wisely use coastal, ocean and environmental resources. EPE staff write and actively pitch Sea Grant stories and announcements to media partners, resulting in media placements. In addition, EPE connects journalists with DESG efforts for timely topics like beach safety, climate change, seafood, aquaculture and coastal community resilience. DESG is seen as a go-to source for environmental information by the media in the state of Delaware and Mid-Atlantic region. Seeing an upward trend in digital media, EPE staff have worked with MAS staff and DESG researchers to enhance its web presence and social media accounts, and to provide electronic versions and files of popular DESG authored ocean and coastal resources. EPE has won numerous state and national awards for its excellence in communications.

Sea Grant Delaware

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

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