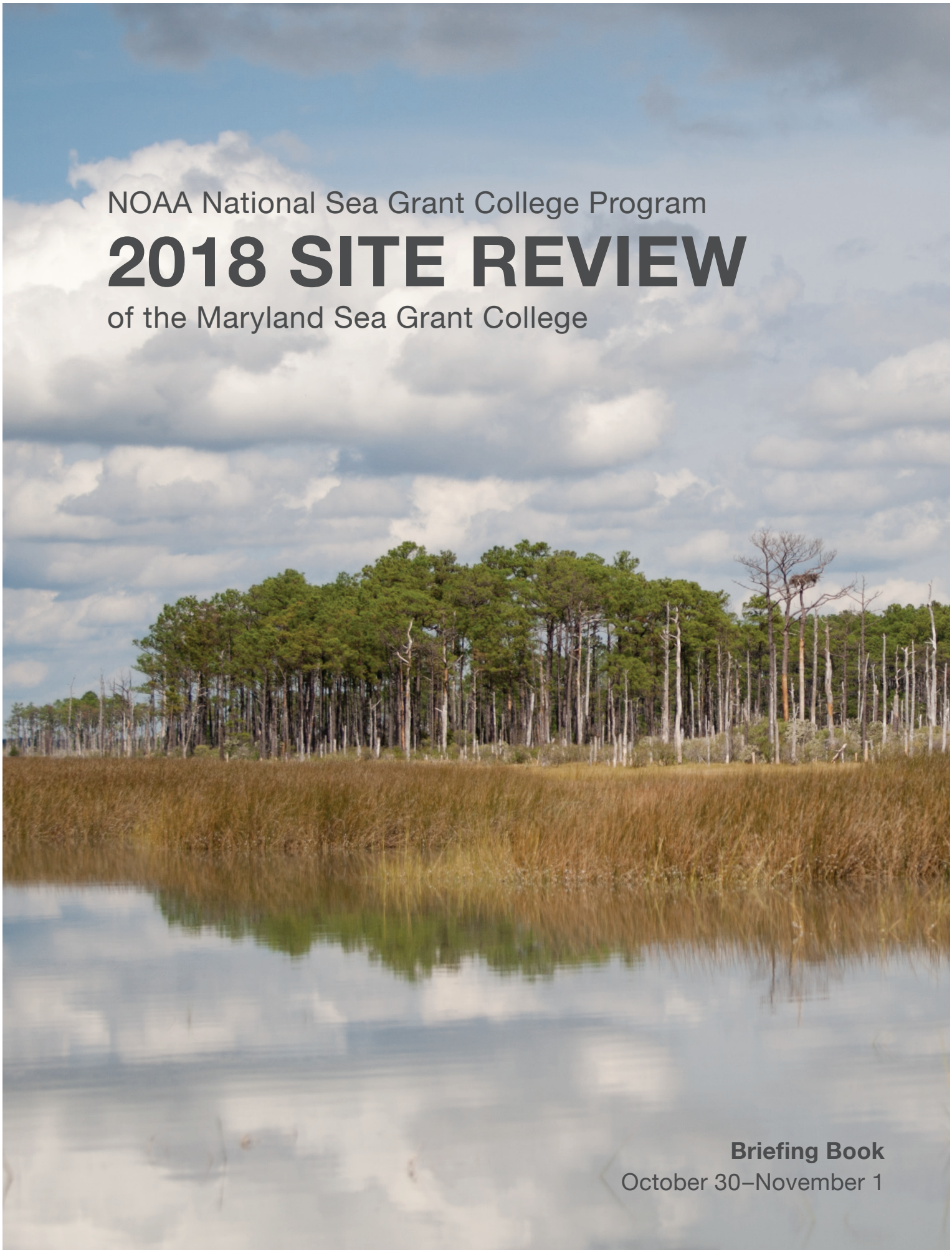


NOAA National Sea Grant College Program

2018 SITE REVIEW

of the Maryland Sea Grant College

Briefing Book

October 30–November 1

Cover photo by MDSG/Goldman

PROGRAM MANAGEMENT AND ORGANIZATION

THE MARYLAND SEA GRANT PROGRAM

Since its founding in 1977, Maryland Sea Grant (MDSG) has effectively and responsibly administered the public funds and programs entrusted to our care, and has worked collaboratively with a variety of partners to help meet stakeholder needs. MDSG has supported research, education, and outreach that has helped to provide Maryland's leaders and citizens with the science-based information and analyses they need to make decisions that can promote a more sustainable and resilient future for the state's coastal natural resources and economy. This approach, coupled with strong program management and organization, has allowed us to achieve recognition as an intellectual and practical leader in marine science, education, and advisory services in the state and region.

We focus on the continuing effort to restore and preserve the Chesapeake Bay, the largest estuary in the United States. The Bay's size, location, and diversity account for the number and variety of organizations dedicated to its restoration and preservation—a network in which Maryland Sea Grant plays an important part. The need for a reliable scientific basis for effective management of this environmentally and economically important natural resource remains as critical now as it was 40 years ago.

We have adapted to major policy shifts: shellfish leasing laws for aquaculture transformed the industry in Maryland (2009); regulators established the Chesapeake Bay Total Maximum Daily Load (TMDL), which set mandatory limits on nutrients and sediment inputs to the Bay to improve water quality (2010); and the Maryland legislature passed the Greenhouse Gas Reduction Act (2009), and then reauthorized it (2016), setting the state on a clear path of climate mitigation and adaptation. MDSG's university base and its determination to deliver credible, translational research findings, and to integrate them into action through our education and outreach portfolio, is an important contribution to regional and state efforts.

ORGANIZATION

Management Team: Composition & Responsibilities

The program's mission is to support research, education, and public outreach. We meet our mission under the guidance of a highly qualified leadership team, whose strong management structure is based on communication, transparency, and collaboration.

The senior staff meets at least once a month to discuss opportunities, plan activities, prioritize critical administrative and planning issues, and evaluate results. The entire staff meets monthly to discuss these and other issues. In addition, the director meets regularly with the University of Maryland Extension's administrative leadership to pursue collaborations. Maryland Sea Grant Extension Program (Extension) faculty interacts regularly with the director. Both the director and the Extension Program leader communicate frequently about strategies, work plans, and program evaluation between monthly meetings.

Our leadership team, and their respective responsibilities, is as follows:

FREDRIKA MOSER, PHD

Director

Provides overall leadership, staff management, coordination, and direction setting. Moser leads the program's interactions with the governing boards, the University of Maryland, College Park (UMCP), Extension, and our state, regional, and federal partners. She reports directly to the president of the University of Maryland Center for Environmental Science (UMCES), our administrative home.

MICHAEL ALLEN, PHD

Associate Director for Research and Administration

Oversees the program's research portfolio, budgets and grants management, and compliance with federal and state regulations and auditing. This work includes managing our requests for proposals and overseeing our extensive undergraduate and graduate fellowship programs. Allen coordinates with the University System of Maryland's administration, including Extension and the UMCES Administrative Council.

J. ADAM FREDERICK, MS

Assistant Director for Education

Manages our K–12 and free-choice learning programs and oversees the National Marine Educators Association (NMEA) office. He coordinates with education leaders in state and local government, schools, and free-choice learning venues.

ROBERT TJADEN, PHD
Interim Extension Program Leader and
Assistant Director, University of Maryland Extension
Oversees personnel and program priorities for 12 Extension faculty experts in such fields as restoration of Maryland watersheds and fisheries. He also supervises an administrative assistant and a business manager.

JEFFREY BRAINARD, MS
Former Assistant Director for Communications
Led our communications team until December 2017. That team consists of a graphic designer, a science writer, and a writer and documentary producer (retired August 2018). Together they produce our magazine, online articles, blogs, and videos. They also maintain a social media presence and a network of communicators around the state of Maryland.

Extension Program: Organization and Integration

The Extension Program is a unit within University of Maryland Extension (UME), part of the College of Agriculture and Natural Resources (AGNR), UMCP. The Extension Program leader reports directly to Dr. James Hanson, UME's associate dean. Guidance for and approval of programmatic decisions are coordinated jointly by the Sea Grant director, the UME associate director, and the dean of AGNR, Dr. Craig Beyrouty, who is also director of UME and the Maryland Agricultural Experiment Station. Maryland Sea Grant, UMCES, and UME operate under an agreement codified in our Memorandum of Understanding, signed July 2013.

The Extension Program leader attends regular MDSG staff and management team meetings and is a member of the UME administrative team. Extension faculty members prepare annual Individual Extension Plans for long-range planning in coordination with MDSG's program planning. MDSG leadership meet routinely with Extension personnel, and MDSG provides communications and reporting support to Extension. Our research staff work with Extension to prepare grant proposals and develop creative programs that integrate research and extension. Our Extension faculty also interact with members of our advisory boards.

MDSG's association with UME also allows Sea Grant to leverage UME's extensive network of specialists in the related program areas of agriculture and natural resources, family and consumer sciences, and 4-H, which strengthens Sea Grant and other Extension programs. This relationship was enhanced in 2013, when the position of Extension leader was changed to assistant director and program leader, Environmental/Natural Resources and Sea Grant Extension.

MDSG and UME have collaborated to secure funding from external sources that support new hires to expand

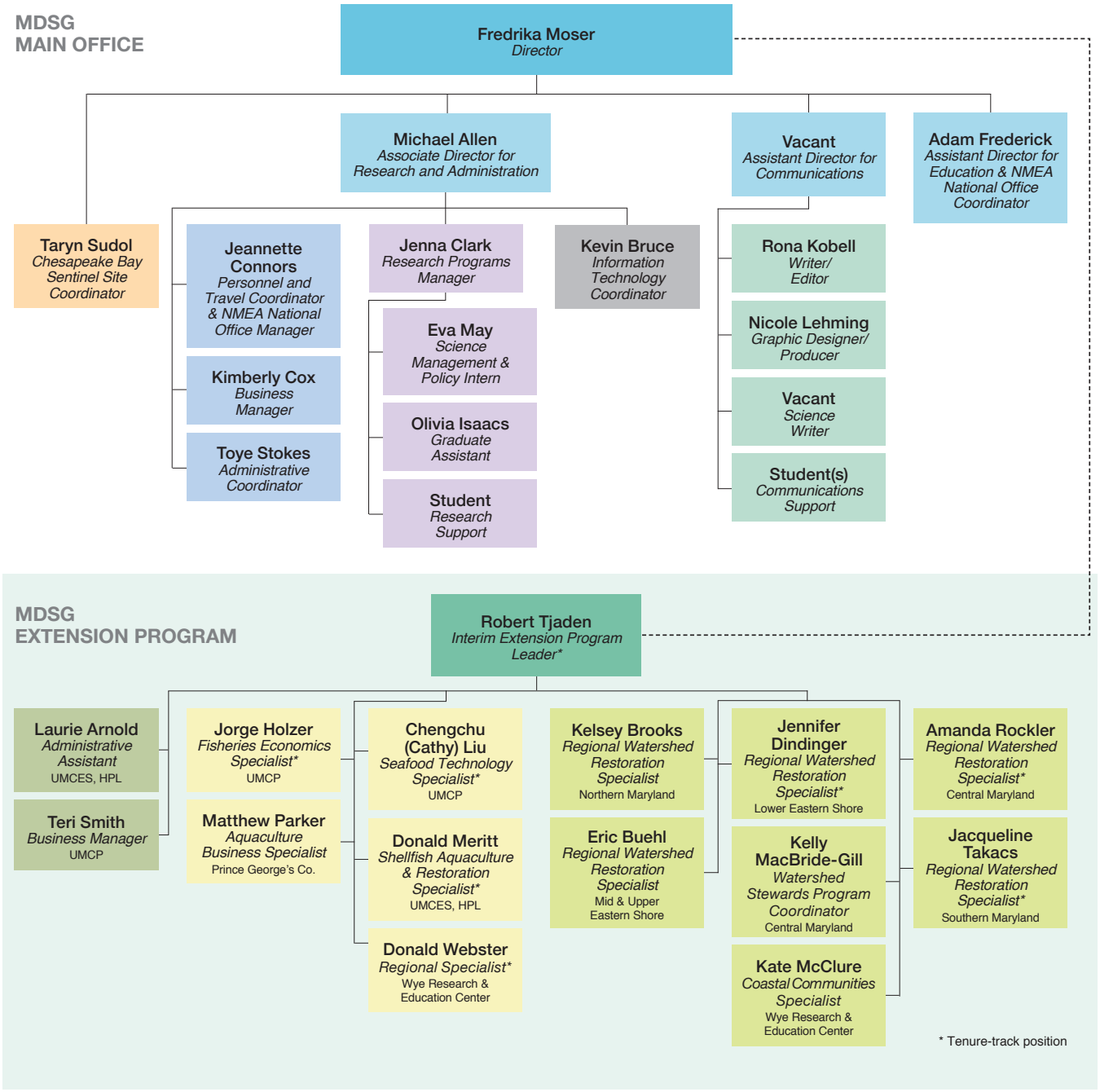

VAN FUNK
Extension faculty assists in stormwater management construction.

our work with stakeholders. First, in partnership with the Maryland Department of Natural Resources (DNR) in 2009, we created two regional watershed restoration specialist positions within UME. Currently, our watershed restoration team consists of five full-time faculty; they work with local organizations and governments to plan and carry out stormwater management projects that help communities improve water quality in the Chesapeake Bay and its tributaries. These five positions are supported through funds from UME, MDSG, DNR, and National Oceanic and Atmospheric Administration (NOAA).

Second, in partnership with the DNR, NOAA National Ocean Service, and NOAA Oceanic and Atmospheric Research, MDSG and UME established the Chesapeake Bay Sentinel Site Cooperative (CBSSC) coordinator position, which fully supports administration and management of the CBSSC's activities to understand and translate regional socioenvironmental responses to sea level rise. It is part of an expanding climate team, which includes our coastal climate specialist and one watershed specialist.

Third, with initial funding from a National Sea Grant College Program office (NSGCP) Aquaculture National Strategic Initiative grant, we established a permanent

FIGURE 1. Maryland Sea Grant Organizational Chart, October 2018



aquaculture business specialist position to assist Maryland's emerging shellfish aquaculture industry with developing business plans and applying for loans from the Maryland Agriculture and Resource Based-Industry Development Corporation (MARBIDCO).

MDSG and Extension Staff Structure

MDSG uses federal and state funding to employ 14 staff members *(Figure 1)* who provide programmatic and administrative support. Graduate and undergraduate students also assist the communications and research programs; special projects and grants may allow us to hire additional assistants.

UME provides partial or full funding for the program leader, 12 faculty positions, and two staff positions, with federal and state support. Extension personnel are housed statewide at research and education centers of AGNR.

ADVISORY BOARDS MEMBERSHIP AND FUNCTION

Advisory Boards

Two advisory bodies provide guidance and oversight at various levels: (1) the External Advisory Board (EAB), representing a diverse group of stakeholders, and (2) the Academic Advisory Committee (AAC), representing scientists from Maryland institutions. The EAB includes industry, government, and nongovernment institutions with marine-related interests; the board provides guidance in response to concerns of relevant stakeholders and realistic assessments of regional and state needs. We believe that managed turnover in the EAB is desirable, and we recognize the value of both new membership and long-term contributors *(Table 1)*. MDSG meets biannually with the EAB and communicates otherwise via email, phone, and in-person discussions.

The AAC provides essential input to the research program, advising on programmatic issues, the integration of research and extension, our request for proposal (RFP) process, and graduate student support and fellowships *(Table 2)*. AAC members help to evaluate the scientific merit and relevance of preproposals and fellowship proposals. Committee members are selected based on their scientific credentials, expertise, and knowledge. Although some members of the AAC are affiliated with research institutions, MDSG engages individuals from the state government and nongovernment organizations. We encourage turnover to foster new ideas, while maintaining essential institutional knowledge and continuity. MDSG meets with the AAC annually and also consults with the group virtually to address research and programmatic planning.

Maryland Sea Grant's External Advisory Board on a visit to Hart-Miller Island.

TABLE 1. External Advisory Board (2014–2017)

Mr. David Blazer
Maryland Department of Natural Resources

Mr. Mark Bryer
The Nature Conservancy

Mr. Scott Budden
Orchard Point Oyster Co. LLC

Dr. Jana Davis
Chesapeake Bay Trust

Mr. Martin Gary
Potomac River Fisheries Commission

Mr. William Matuszeski
U.S. EPA Chesapeake Bay Program (retired)

Dr. Beth McGee
Chesapeake Bay Foundation

Dr. Thomas Miller
UMCES, Chesapeake Biological Laboratory (AAC liaison)

Mr. Adam Ortiz
Prince George's County Department of the Environment

Mr. Eric Schwaab
National Fish and Wildlife Foundation

Ms. Ann Swanson
Chesapeake Bay Commission

Mr. Dave Wilson
Conservation Community Consulting LLC

TABLE 2. Academic Advisory Committee (2014–2017)

Dr. William Boicourt
UMCES, Horn Point Laboratory

Dr. Marie Bundy
NOAA Office for Coastal Management

Dr. Feng Chen
UMCES, Institute of Marine and Environmental Technology

Dr. Maurice Crawford
University of Maryland Eastern Shore

Dr. Patricia Delgado
Jug Bay Wetlands Sanctuary

Dr. Keith Eshleman
UMCES, Appalachian Laboratory

Dr. Tom Miller
UMCES, Chesapeake Biological Laboratory

Dr. Jay Nelson
Towson University

Dr. Ariana Sutton-Grier
The Nature Conservancy; UMCP

Dr. Peter Tango
U.S. Geological Survey, Chesapeake Bay Program Office

TABLE 3: Institutional Council Members (2014–2017)

Dr. Robert L. Caret
Chancellor, University System of Maryland

Dr. Peter Goodwin
President, UMCES

Dr. Mary Ann Rankin
Senior Vice President and Provost, UMCP

Dr. Craig Beyrouty
Dean, College of Agriculture and Natural Resources, UMCP

Dr. Moses Thairu Kairo
Dean, School of Agricultural and Natural Sciences, University of Maryland Eastern Shore

Dr. Scott Knoche
Director, Patuxent Environmental & Aquatic Research Laboratory, Morgan State University

Dr. Anson Hines
Director, Smithsonian Environmental Research Center

Dr. Grace Brush
Professor, Johns Hopkins University

Dr. Fredrika Moser
Director, Maryland Sea Grant College

TABLE 4. Funding success rate of proposals[1]

Indicators	2014–2016	2016–2018	2016–2018 Regional
Preproposals	29	30	4
Preproposals from home institution (UMCES)	13	14	0
Institutions (including departments)	30	33	19
Multi-institutional preproposals	16	27	4
Full Proposals	17	19	3
Proposals Funded	7	8	1
Proposals Funded (% success)	41%	42%	33%

[1] Summary of the preproposals, full proposals, and institutions represented for each competition in 2014–2018. In Maryland and Washington, DC, there are 73 institutions, often with multiple departments, that receive the Request for Proposals.

UNIVERSITY PROGRAM SETTING AND GOVERNANCE STRUCTURE

MDSG's institutional setting is consistent with its University System of Maryland program standing and its mission to serve all of Maryland. A governance board oversees our program. It consists of University System of Maryland chancellor Robert L. Caret, who represents the broad interests of the state; UMCES president Peter Goodwin, who represents the institution with legislative responsibility for environmental science; and Wallace Loh, president of UMCP, a land-grant institution that oversees Extension. Craig Beyrouty, AGNR dean, and James Hanson, associate dean for Extension, provide administrative links with the UMCP president and may act as president Loh's designee on the governance board. This organizational structure fully supports MDSG's partnerships within and across the university, the state, and NOAA's National Sea Grant Office.

Graduate student researcher installs equipment to study Chesapeake Bay ecosystem dynamics.

As the program's administrative home, UMCES is responsible for financial and personnel management and ongoing supervision of the MDSG director, a member of the UMCES leadership team who serves on the president's executive and administrative councils. The Institutional Council (IC) consists of eight members from the institutions that perform research, education, and outreach activities in marine and coastal science in Maryland *(Table 3)*. The IC meets at least every other year to address issues pertinent to accountability, mission development, and priorities from the perspective of Maryland's academic and research institutions.

PROGRAMMED TEAM APPROACH: STRATEGIC PLANNING

We strive to build our capacity to make sound decisions; address critical issues, such as water quality and climate change; and implement adaptive management across four focus areas. We support relevant, high-quality, integrated multidisciplinary research, education, and extension efforts to meet our goals and objectives. We use a detailed implementation plan to track our activities, measure our success, and inform future strategic planning. This approach allows us to find solutions to oceanic, coastal, and watershed issues within the Chesapeake and the coastal bays.

Strategic Plan 2014–2017

In 2011 and 2012, we developed our 2014–2017 strategic plan. We surveyed more than 50 stakeholders from federal, state, county, and local governments, nonprofit organizations, industry, academia, and educational institutions. Survey respondents *strongly agreed* or *agreed* on our proposed priorities. We held strategic planning meetings with our advisory boards and workshops with our staff and Extension faculty. In October 2012, we submitted to NOAA our 2014–2017 strategic plan, its alignment with NOAA priorities, and our national performance four-year targets.

RECRUITING TALENT

MDSG has developed several types of grant competitions to advance scientific knowledge of the Chesapeake Bay region and cultivate the next generation of marine and coastal scientists. During the 2014–2017 review period, we conducted our omnibus and regional research competitions (2014–2016, 2016–2018, and 2018–2020) and numerous graduate research fellowship competitions.

Our success in supporting relevant and innovative research projects and fellowships stems from two fundamental strengths of our program: 1) close adherence to the goals of our strategic plan to guide the RFP priorities and the selection of projects; and 2) a robust, web-based proposal and fellowship management system.

Our strategic plan is the foundation for the language and intent in our RFP and fellowship announcements. We draw our research priorities directly from our strategic plan and seek research proposals from each of our focus areas. We then review proposals based on a project's technical feasibility, its support of our goals, and its potential impact. We follow strict conflict-of-interest policies for panelists and reviewers, and we outline our specific review criteria in RFPs. In 2017, we transitioned from our MDSG-developed online system to eSeaGrant, which many other programs use. Our review process is followed in all of our RFPs, and we list all funded projects and students on our website. We document and submit the process to the national office in a letter of intent to fund proposed projects.

We widely distribute our RFP announcements through an extensive email list, webinars, social media, conversations, and our website. Our email list contains representatives from all Maryland research universities with programs that relate directly to our mission. Although most of our research funding supports science at academic institutions, we welcome applications from a range of institutions. Staff and interns update and maintain our mailing lists through web searches, national and local conference and meeting lists, communications with relevant research and educational institutions, and information provided by researchers and department staff. We strive to include new faculty hires at Maryland research institutions, which helps us reach early career investigators and newcomers to the state.

TABLE 5. External Technical Panelists (2014–2017)

2014–2016 Omnibus Research Technical Panel
East Carolina University, *Fisheries and Fish Ecology*
Texas A&M University at Galveston, *Coastal and Wetland Ecology*
University of Southern Mississippi, *Chemical Oceanography/ Biogeochemistry*
University of New Hampshire, *Environmental Sociology*
2016–2018 Omnibus Research Technical Panel
East Carolina University, *Wetland Ecology*
Northwestern University, *Coastal Ecosystems*
University of South Carolina, *Behavioral Ecology and Marine Biology*
University of Washington, *Fisheries and Population Genetics*
Villanova University, *Coastal Biogeochemistry*
2015 Coastal Resilience Fellowship Panel
American University, *Ecohydrology*
Johns Hopkins University, *Environmental Engineering*
National Oceanic and Atmospheric Administration, *Coastal Management*
University of Maryland Eastern Shore, *Fisheries Ecology*
2016 Coastal Resilience Fellowship Panel
Coastal and Estuarine Research Federation, *Oceanography*
Maryland Sea Grant, *Education and Outreach*
National Socio-Environmental Synthesis Center, *Environmental Sociology*
University of Maryland Center for Environmental Science, *Coastal Marine Ecology*
Washington College, *Biogeochemistry*
2017 Coastal Resilience Fellowship Panel
Chesapeake Bay Foundation, *Water Quality*
Conservation Community Consulting LLC, *Conservation*
Maryland Sea Grant Extension, *Aquaculture*
Maryland Sea Grant Extension, *Watershed Restoration*

Review Process

PREPROPOSALS. We send each preproposal to experts with relevant publications, who are active members of the research community outside Maryland, Virginia, and Washington, DC. Two independent panels review the proposal: one consisting of Extension faculty, who evaluate the project's outreach potential, and the other of AAC members, who assess for technical soundness and relevance to the RFP's strategic priorities. These reviews help to determine which preproposals receive encouragement

TABLE 6. Average proposal scores[a]

	2014–2016		2016–2018		2016–2018 Regional	
Indicators	**Funded**	**Unfunded**	**Funded**	**Unfunded**	**Funded**	**Unfunded**
External peer review average score	1.4	1.9	1.65	1.79	1.5	2.69
Technical panel average score	1.68	2.33	1.56	2.73	2	4

[a] Based on a standard scoring scale (1.0–excellent; 2.0–very good; 3.0–good; 4.0–fair; 5.0–poor)

TABLE 7. Recruiting new investigators

Indicators	2014–2016	2016–2018
New projects	7	9
Multi-investigator projects	5	9
Regional and multi-program projects (leveraged funding)	n/a[a]	1
New PIs (includes co-PIs)[b]	8	18
New institutions[c]	4	12

[a] No regional competition in 2014–2016.

[b] PI new to MDSG or not funded for two cycles.

[c] Institutions new to MDSG or not funded for two cycles.

TABLE 8. Institutions supported by Program Development funds (2014–2017)

Atlantic Estuarine Research Society

Friends of Jefferson Patterson Park and Museum

Friends of Jug Bay

Hampton University

Harbor Branch Oceanographic Institute, Florida Atlantic University

Institute for Broadening Participation

International Conference on Shellfish Restoration

Johns Hopkins University

Maryland Sea Grant Extension Program

Mid-Atlantic Marine Education Association

Society for the Advancement of Chicanos and Native Americans in Science

Smithsonian Environmental Research Center

Somerset County Library System

Stevenson University

University of Baltimore

University of Maryland, Baltimore County

University of Maryland Center for Environmental Science

University of Maryland Eastern Shore

University of Maryland, College Park

University of Maryland, Institute for Applied Environmental Health

for development. Additionally, we ask our EAB to review abstracts to identify which projects might have the highest stakeholder impact, if technical aspects are sound. The AAC considers the EAB input in their overall review.

FULL PROPOSALS. All full proposals receive external peer review by recognized experts. Proposals must include a complete, well-conceived outreach plan developed by the principal investigators (PIs); the plan is examined by the same Extension panel. A panel of scientists, including one social scientist, from outside the region convenes for the final technical review; these experts use protocols consistent with those set forth by the National Science Foundation (NSF) and NOAA. Panelists rank proposals within given topical areas, and they provide written and oral rationales for their decisions. Our NOAA program manager attends the full proposal panel review and is invited to participate in all panel meetings. The final decision is based on technical ranking, fund availability, and the need to develop a balanced portfolio of research projects to meet strategic plan goals. The director and associate director for research and administration develop the final portfolio of projects, which the NSGCP approves. PIs who submitted preproposals, full proposals, and fellowship applications receive blind external peer reviews, outreach panel comments, and technical panel comments.

Table 4 provides information on the funding success rate of proposals submitted to our 2014 and 2016 omnibus competitions; *Table 5* lists the expertise of the external technical review panels for those years; *Table 6* summarizes our ratings and scoring analyses for our grants competitions funded through our omnibus appropriations; and *Table 7* provides summary data on new omnibus research projects and new PIs and institutions.

FELLOWSHIPS. Applications follow the full proposal process. Expert technical peer reviewers evaluate the technical feasibility and potential impact. A panel of faculty, end-users, and the director review the applications and peer reviews to make funding recommendations.

Program Development Funds

MDSG uses program development (PD) funds to catalyze new research areas, complete projects, and support meetings and specific outreach efforts. While small, these

funds have proven extremely useful in engaging a diverse cross-section of the research, outreach, and education communities in Maryland and beyond. These funds also give us access to new stakeholders in academic, government, and nongovernment organizations. *Table 8* lists a sampling of institutions and programs supported by PD funds. We augment omnibus funding for program development activities with state appropriations and funds derived from recovery of indirect costs.

Evaluation of Funded Projects

Each research project must submit annual and final reports summarizing their progress relative to their proposal's objectives, as well as Sea Grant performance measures and metrics, data management, presentations, publications, and overall impact beyond academia. The director or associate director reviews the reports; they also maintain contact with funded PIs and students to ensure that projects stay on track. Projects are evaluated by their intellectual contributions, publications, outreach engagement, effect of the research on environmental action or policy, and contribution to building a more diverse marine science workforce. Reports are also submitted to the NSGCP.

PROGRAM SUPPORT

Table 9 summarizes Maryland Sea Grant's funding from the state of Maryland, the NSGCP, and other funding sources for 2014–2017. Though the budget climate for higher education is challenging, funding for MDSG through UMCES is generous. From 2014 to 2017, MDSG funding grew by 7.6 percent to $1.135 million. Extension support is also significant *(Table 9)*.

During this time we received consistent core program support from NOAA *(Table 10),* as well as from the National Strategic Initiative and special competitions *(Table 11)*. Omnibus support for our research program includes research grants to PIs (R/) and fellowships (R/E-1 and R/E-22). Support surpassed 50 percent of our total core annual funding, reflecting the priority we place on these programs. In 2016 and 2017, we diverted program development funds to support an extra research project.

We use diverse sources to meet our 50-percent matching fund requirement on NSGCP funds. UMCES and UME allow us to forego collecting indirect costs on the administrative, communications, extension, education, and program development portions of our omnibus award. Research projects are required to provide a 50-percent match on direct and indirect costs. During 2014 to 2017, UMCES and MDSG continued to waive subcontracting fees on MDSG awards to other institutions. We also compete, when appropriate, for external grants and contracts to support projects consistent with our mission and goals. Grantors have included the Department of the Interior, NSF, NOAA, Chesapeake Bay Trust, NMEA, and the European Union ERASMUS program. During 2014 to 2017, we received approximately $1.8 million in external grants and contracts beyond NSGCP. *Table 11* lists additional funding from the NSGCP and other NOAA programs that have been added to MDSG's funding portfolio for the period 2014–2017.

TABLE 9. Distribution of all funds supporting Maryland Sea Grant efforts (2014–2017)

	Annual period February 1–January 31				
	2014	2015	2016	2017	Total
MDSG Core NOAA Funding[a]	1,538,054	1,538,054	1,538,054	1,538,054	6,152,216
% of total year	33%	32%	30%	32%	
MDSG State Funding[b]	1,054,787	1,091,751	1,103,671	1,135,680	4,385,889
Extension State Funding	750,269	1,035,503	923,892	948,484	3,658,148
% of total year	39%	44%	39%	43%	
MDSG Other Funding[c]	796,938	876,133	1,418,871	1,032,317	4,124,259
Extension Other Funding	495,616	293,741	176,405	159,405	1,125,167
% of total year	28%	24%	31%	25%	
TOTAL MDSG & Extension	4,635,664	4,835,182	5,160,893	4,813,940	19,445,679

[a]Fiscal year February 1–January 31.
[b]Fiscal year July 1–June 30.
[c]Start and end dates vary.

TABLE 10. Maryland Sea Grant Core NOAA funding (2014–2017)

	Research R/	Research Fellowships R/E-1 R/E-22	Extension Core A/	Communi-cations C-1	Program Development P-1	Management M-1	% Research	TOTAL
2014	477,401	310,000	271,000	234,000	74,653	171,000	51%	1,538,054
2015	463,017	310,000	271,000	234,000	89,037	171,000	50%	1,538,054
2016	547,000	315,054	271,000	234,000	*	171,000	56%	1,538,054
2017	547,000	315,054	271,000	234,000	*	171,000	56%	1,538,054

*P-1 funds used to support research projects. Carryover funds from 2014 and 2015 used to support program development.

TABLE 11. Other funding, including National Strategic Initiatives (NSIs), pass-through, enhancement funds, and external awards, 2014–2017.

Funding Years	Source[a]	Amount	Project Title (PI)
2014	NOAA/NSGCP	$169,500	3 Knauss Fellowships (Moser)
2014	NOAA/NSGCP	$151,876	Sea Grant Aquaculture Extension 2013: Evaluation of Innovative Practices for Sustainable Aquaculture Development in Chesapeake Bay (Lazur)
2014–2015	NOAA/NSGCP	$80,000	Enhancing Coordination of the Chesapeake Bay Sentinel Site Cooperative (Lazur)
2014–2015	NOAA/NSGCP	$124,276	NSI: Social Science Supplement (Moser)
2014–2017	DOI/FWS	$160,000	Support for Activities of the Mid-Atlantic Panel of the Aquatic Nuisance Species Task Force (Moser)
2014–2017	NMEA	$95,033	Administrative Support for NMEA (Frederick)
2014–2017	NOAA/NSGCP	$120,000	Enhancing Sea Grant's Ability to Help Coastal Communities Adapt to Climate Change (Lazur)
2014–2017	NSF	$830,942	Research Experiences for Undergraduates in Estuarine Science (Moser)
2015	CBT	$39,914	Cultivating Student Leadership in STEM and E-Lit through the Schoolyard Chesnut Grove (Frederick)
2015	NOAA/NSGCP	$169,500	3 Knauss Fellowships (Moser)
2015	NSF	$19,580	Getting It Right: A Strategic Planning Workshop to Develop a Sustainable Pathway for Educating Underrepresented Puerto Rican Students in Geosciences (Moser)
2015–2016	NOAA/NMFS	$134,687	NOAA BWET: Aquaculture in Action: A Model for STEM and E-Lit Education (Frederick)
2015–2016	NOAA/NSGCP	$222,117	Sea Grant Aquaculture Extension 2015: Evaluation of Innovative Practices for Sustainable Aquaculture Development in Chesapeake Bay (Lazur/Parker)
2016	NOAA/NSGCP	$226,000	4 Knauss Fellowships (Moser)
2016	NOAA/NSGCP	$30,000	Rapid Response Sampling of Chesapeake Bay for 2015 Nor'easter and Hurricane Joaquin (Harris)
2016	NOAA/NSGCP	$20,000	Resilience NSI: Climate Integrator Specialist in the Mid-Atlantic (Moser/Kenney)
2016	NOAA/NSGCP	$20,000	Illustrated Guide to Diseases and Parasites of Oysters (Allen)
2016	NOAA/NSGCP	$19,995	Aquaculture Conferences: Oyster Futures Symposium (Moser/North)
2016–2017	NOAA/NSGCP	$299,827	Sea Grant Aquaculture Research: Developing a Technology to Induce Sterility in Sablefish (Wong)
2016–2017	NOAA/NSGCP	$112,500	Enhancing Coordination of the Chesapeake Bay Sentinel Site Cooperative (Moser)
2017	EU	$25,122	ERASMUS+: Virtual Interactive Resources and Tools in Universal Education of the Sea (Frederick)
2017	NOAA/NSGCP	$287,500	5 Knauss Fellowships (Moser)
2017	NOAA/NSGCP	$30,000	NSI: Network Visioning (Moser)
2017	NOAA/OAR	$26,131	Ecosystem Based Management: An Analysis of National Needs and Opportunities by the Cooperative Institute for the North Atlantic Region (Roman/Moser)
2017	NOAA/NOS	$12,048	NOAA COCA: Investigating the Contributions of Coastal Church Communities (Moser)
2017–2018	NOAA/NSGCP	$149,067	Sea Grant Aquaculture: Controlling Fouling and Pests Associated with Water Column Oyster Aquaculture (Tjaden/Parker)
2017–2019	NOAA/NSGCP	$114,785	FY 2017 NMFS/Sea Grant: Population and Ecosystem Dynamics Graduate Fellowship (Miller)
2017–2019	NSF	$433,859	IUSE-IMPACT: Pathways TO RENEW: Tropical Oceanography Research Experiences for the Next-Generation Workforce (Moser)
Total		$4,124,259	

[a] Funding sources include the following: NOAA (National Oceanic and Atmospheric Administration); NSGCP (National Sea Grant College Program); NMFS (National Marine Fisheries Service); OAR (Oceanic and Atmospheric Research); DOI/FWS (Department of Interior, Fish and Wildlife Service); NMEA (National Marine Educators Association); NSF (National Science Foundation); CBT (Chesapeake Bay Trust); EU (European Union)

STAKEHOLDER ENGAGEMENT

We generate value for the investment made in our program by continually working with our stakeholders to discern and meet their needs. We stay abreast of relevant and pressing issues throughout the Chesapeake and coastal bays so that we may better serve our stakeholders.

RELEVANCE

We understand our stakeholders' needs for participation in working groups, community and government roundtables, one-on-one meetings, and collaborative endeavors. In Maryland, as well as regionally and nationally, leaders and communities are paying more attention to the alteration of the region's ecosystems by climate change; therefore, our future efforts are likely to more tightly couple human responses to climate change with the restoration and sustainability of our waterways. Our stakeholders include decision makers at all levels of local, state, and federal government; nonprofit organizations; students and teachers; landscapers; watermen (the Maryland term for commercial fishermen); aquaculturists; and seafood processors.

We are a bridge builder and an honest broker between the knowledge base of our academic partners and this user community. We work to provide an unbiased forum to facilitate public discussion, understanding, and consensus building about Chesapeake Bay issues, and we have synthesized scientific findings to inform such discussions. Our stakeholders see us as a trusted and immediate source of information relating to the Chesapeake and coastal bays. We measure our relevance by our involvement in multiple working groups, committees, and distribution of resources. Because of the extremely high demand for the Sea Grant team to participate in activities across the state, region, and nation, we use our strategic plan to guide the investment of our resources and staff time.

EXTENSION SERVICES AND TRAINING

Extension programming covers the continuum of research to user needs to translate scientific understanding into practical efforts that help us to achieve restored and sustainable bays and watersheds. Several examples are listed below and in the Performance section:

AQUACULTURE INDUSTRY EXPANSION. Extension specialists were integral to developing new state policies, regulatory changes, critical support programs, and funding opportunities that have helped the aquaculture industry grow. Their efforts provide watermen and other entrepreneurs with business advice, access to financing, and training on critical skills needed for profitable aquaculture production. These helped spur the growth of Maryland shellfish aquaculture in recent years. Engagement with industry, scientists, and government agencies continues through MDSG-supported meetings and seminars.

SEAFOOD SAFETY AND PROCESSING. Our Extension seafood specialist helped Maryland's seafood industry improve production techniques and safety and reliability of products through Hazard Analysis and Critical Control Point (HACCP) training programs. These programs educate seafood industry personnel about safe handling and processing of blue crabs and oysters to prevent food-borne illnesses. MDSG's innovative quality assurance training for Maryland crab processors is run successfully in partnership with supportive industry and academic collaborators in and outside the state.

WATERSHED RESTORATION SPECIALISTS. Extension faculty collaborate with multiple stakeholders to help coastal communities manage stormwater runoff and reduce the input of nutrients and sediment into the Chesapeake and coastal bays. These efforts improve bay health and help communities meet EPA-mandated TMDL requirements. Extension provides guidance and training to local governments, NGOs, faith-based communities, and many others to help them secure resources and implement stormwater best management practices.

CHESAPEAKE BAY LANDSCAPE CERTIFICATION PROGRAM. Through their work with researchers and communities, Extension specialists provide industries with information about installing and maintaining green infrastructure that can improve stormwater management and water quality. Together with multiple partners, a regional certification program was created to train landscape professionals in techniques specific to meeting the TMDLs requirements in the Chesapeake Bay watershed.

COASTAL CLIMATE CHANGE. A full-time Extension faculty member works closely and collaboratively with researchers, UME faculty, and MDSG to design, coordinate, and implement climate activities for MDSG. We network with partners on local to national levels. Activities focus on identifying local needs and establishing partnerships between academics and these communities to help residents understand and adapt to climate change.

MDSG STAFF AND EXTENSION FACULTY PROFESSIONAL SERVICE (2014–2017)

Michael Allen
Associate Director for Research and Administration

Chair, MDSG Search Committees

Vice Chair and Fiscal Officer, Mid-Atlantic Panel on Aquatic Invasive Species (MAPAIS)

Member:
- Association for the Sciences of Limnology and Oceanography (ASLO) Public Policy Committee
- GEO-REU Workshop Planning Committee
- Sea Grant Association (SGA) Diversity, Equity and Inclusion Visioning Team
- SGA Research Coordinators Network
- SGA Fiscal Officers Network

Jeffrey Brainard
Former Assistant Director for Communications

Chair, MDSG Search Committees

Member:
- Chesapeake Bay Program Office (CBPO) Communications Work Group
- SGA Communicators Network

Kelsey Brooks
Northern Maryland Watershed Restoration Specialist

Member:
- Baltimore County Agriculture Agent Search Committee
- Watershed Assistance Collaborative (WAC)

Eric Buehl
Mid- and Upper Eastern Shore Watershed Restoration Specialist

Chair, Northern Cluster Search Committee

Member:
- Cecil County Watershed Implementation Plan Advisory Committee
- Envision the Choptank Steering Committee
- Talbot County Hazard Mitigation and Community Resilience Plan Stakeholder Committee
- Town of St. Michaels Stormwater Task Force
- UME Faculty Advisory Executive Committee
- UME Plan of Organization Committee
- WAC

Jennifer Dindinger
Lower Eastern Shore Watershed Restoration Specialist

Northeast Regional Representative, Association of Natural Resources Extension Professionals Finance Committee

Chair, UME Faculty and Staff Search Committees

Co-chair, UME Strategic Planning Committee

Member:
- CBPO Citizen Stewardship Work Group
- Climate Resiliency Work Group
- Chesapeake Watershed Forum Planning Committee
- Environmental Leadership Program Selection Committee
- NSF-funded "People Land Water" Project Steering Committee
- SGA Community Response to Flooding Visioning Team
- UMCP Senate–Diversity, Equity, and Inclusion Subcommittee

J. Adam Frederick
Assistant Director for Education

National Office Coordinator, National Marine Educators Association (NMEA)

Chair, SGA Educators Network Website Committee

Member:
- *Science Activities* Journal Editorial Board
- Mid-Atlantic Marine Educators Planning Committee for NMEA Conference
- NMEA Executive Committee
- Ad Hoc NMEA Governance Committee
- SGA Environmental Literacy Visioning Team
- Stevenson University Department of Biology Advisory Board

Jorge Holzer
Fisheries Economics Specialist

Vice Chair and Maryland Representative, Atlantic States Marine Fisheries Commission (ASMFC) Committee on Economics and Social Sciences

Chair, International Council for the Exploration of the Sea Working Group on Economics

Member:
- ASMFC Striped Bass Plan Review Team
- CBPO Sustainable Fisheries Goal Implementation Team
- Maryland Department of Natural Resources (DNR) Chesapeake and Coastal Service's (CCS) Working Waterfronts Advisory Committee
- Maryland DNR Fisheries Service Striped Bass Fisheries Management Plan's Allocation Policy Task Force
- Mid-Atlantic Fishery Management Council
  - Expert Panel Review of the Scup Allocations Study
  - Expert Panel Review of the Summer Flounder Allocation Study
- NOAA Office of Science and Technology's Economics and Human Dimensions Program Review
- Recreational Fisheries Panel

Andrew Lazur
Former Maryland Sea Grant Extension Director

Member:
- NOAA Fisheries Habitat Work Group

Chengchu (Cathy) Liu
Seafood Technology Specialist

Chair, Institute of Food Technologists Aquatic Food Product Division, Student Poster Competition

Member:
- National Seafood HACCP Alliance Steering Committee
- UNESCO/IOC/WESTPAC Project on Toxic Marine Animals and their Toxins Steering Committee

Fredrika Moser
Director

President-elect, Executive Board, SGA

Mentor, ASLO Multicultural Program

Member:
- Chesapeake Bay Sentinel Site Cooperative (CBSSC) Management Committee
- CBPO Climate Resilience Work Group
- Maryland Commission on Climate Change, Adaptation and Response Working Group
- MAPAIS Executive Committee
- Mid-Atlantic Regional Association for Coastal Observing Systems Board of Directors
- SGA
  - External Relations Committee
  - Network Advisory Committee
  - Program Mission Committee
- UMCES Self-Study Design, Middle States Commission on Higher Education Steering Committee
- USDA Northeastern Regional Aquaculture Center (NRAC) Board of Directors

Matthew Parker
Aquaculture Business Specialist

Marketing Chair, eXtension Marine Aquaculture Community of Practice

NSGCP Representative, National Aquaculture Extension Steering Committee

Secretary and Treasurer, US Aquaculture Association

Member:
- CBPO Partnership Water Quality and Habitat Goal Implementation Team
- EPA Nutrient Best Management Practice Expert Panel
- National Sea Grant Law Center Advisory Committee
- US Aquaculture Association Finance Committee

Amanda Rockler
Central Maryland Watershed Restoration Specialist

Member:
- Chesapeake Conservation Corps
- Chesapeake Conservation Landscaping Council Advisory Board
- UMCP University Senate and Senate Undergraduate Courses Committee

Taryn Sudol
Chesapeake Bay Sentinel Site Coordinator

Member:
- CBSSC Management Team
- CBSSC Surface Elevation Table Working Group
- CBPO Climate Resiliency Work Group

Jacqueline Takacs
Southern Maryland Watershed Restoration Specialist

Treasurer, Mid-Atlantic Marine Education Association

Treasurer, NMEA

Commissioner, Patuxent River Commission

Chair, Statewide Tenure Faculty Hiring Committee

Chair, UME Appointment, Promotion, and Tenure Committee; College of Agriculture and Natural Resources, UMCP

Sarah Wilkins
Former Chesapeake Bay Sentinel Site Coordinator

Member:
- CBSSC Management Team
- CBSSC SET Working Group
- CBPO Climate Resiliency Work Group
- DNR CCS Climate Coordination Group

Donald Webster
Regional Specialist

Chair, Maryland Aquaculture Coordinating Council

Maryland Representative, NRAC Technical Advisory Council

Co-chair, UME Statewide Faculty Search Committee

Chair-elect, UMCP Senate (included Chair, Committee on Committees, Facilities Council, Library Council, Senate Executive Committee)

Chair, UMCP Senate (included Chair, Senate Executive Committee Ex officio, Council of University System Faculty)

Past-chair, UMCP Senate

Member:
- Maryland Agriculture Council
- Maryland Oyster Advisory Commission
- Middle States Accreditation Steering Committee

EDUCATION AND TRAINING

MDSG takes a multilevel approach to education by supporting workforce development in environmental and marine sciences and providing Marylanders with access to different learning opportunities.

Pre-College

We have ensured that our programming is innovative and comprehensive—and that it reaches students across the geographic and social spectrum, from rural to urban, in schools from Baltimore to Charleston, South Carolina. We have developed a teacher professional development model for science-based education; it is informed by a university setting that has seen successes in the classroom and includes partners from state and federal agencies, academia, nonprofits, and school administrations.

Other successful stakeholder programming relationships include working with the Maryland Science Center and the National Aquarium, both located in Baltimore, to develop exhibits that support free-choice opportunities for lifelong learners. We also partner with the Institute of Marine and Environmental Technology, the Maryland DNR, and teachers and administrators in public schools through the Aquaculture in Action program, which uses aquaculture as a tool for project-based learning and integrating science content across disciplines. In addition, the American Chestnut Education Project in western Maryland schools developed a new science curriculum to teach biology and restoration science. Internationally, our Biofilms and Biodiversity program is part of a European Union effort, in partnership with the University of Gothenburg in Sweden, to train students and teachers to analyze results of biofilm and harbor water quality studies in Sweden, Germany, Spain, and Baltimore. All of our programs address instructional strategies, state environmental literacy standards, ocean literacy principles, and the cross-cutting themes represented in the Next Generation Science Standards.

High school students study biodiversity in harbor waters.

Since 2014, MDSG has served as the headquarters for the NMEA. Our staff oversees the organization's membership services and provides a central office for its executive committee. The collaboration contributes to national level education for pre-college and free-choice learners. This important partnership strengthens our educational role at the national level and provides opportunities to engage with NMEA members. We helped boost NMEA membership, improve conference management, and assist regional NMEA chapters.

Graduate Fellows: Partnerships and Outreach

Since 1977, MDSG has supported hundreds of undergraduate and graduate students, at institutions across Maryland, in scientific fields relevant to our mission. Our core graduate fellowship program, Maryland Sea Grant Research Fellows, gives qualified graduate students the opportunity to work with established marine scientists in the design and conduct of university-based research, as well as in outreach in academic and nonacademic venues. Selected through a competitive process, students work on projects associated with our omnibus-funded research grants.

Other fellowships we manage are Coastal Resilience and Sustainability Fellows, Knauss Policy Fellows, Coastal Management Fellows, Population and Ecosystem Dynamics and Fisheries Economics Fellows, and regional fellowships (e.g., Mid-Atlantic Coastal Storms and Ocean Acidification). All fellowships offer opportunities for professional development, including communication training and editing support for posts to our student blog, *Fellowship Experiences.*

In 2015, we started our Coastal Resilience and Sustainability Fellowship to provide support for graduate students' resilience-related research projects. We provide stipend, tuition, supplies, and travel. The fellowship trains young scientists how to effectively translate their research for a wider audience. It originated through a collaboration between our research program and outreach partners (e.g., resource managers, educators, Extension faculty). Each fellow had to identify an "end-user mentor," who would meet regularly with the student and advise him or her on outreach mechanisms for disseminating and applying research findings.

REUs sort oysters during research cruise on the Chesapeake Bay.

Undergraduate Students

MDSG is committed to providing undergraduate students with opportunities for marine science research and preparation for a possible career in science. We participate in four undergraduate research programs, each having a slightly different focus: 1) NSF-funded MDSG Research Experiences for Undergraduates (REU) in Maryland; 2) NSF-funded Centro TORTUGA in Puerto Rico; 3) University of Maryland Gemstone Honors Program; and 4) MDSG student interns.

The NSF REU program is a collaborative venture with scientists at the UMCES Chesapeake Biological Laboratory and the UMCES Horn Point Laboratory on the Chesapeake Bay. It brings 16 or 17 upper-division science, technology, engineering, and mathematics (STEM) majors from colleges and universities across the United States for an immersive, 12-week coastal and marine science research experience, during which students are paired with a scientist mentor. Centro TORTUGA (**T**ropical **O**ceanography **R**esearch **T**raining for **U**nder**G**raduate **A**cademics) is a year-round geosciences education and research effort to engage and retain underrepresented and underserved Puerto Rican undergraduates in marine science. The UMCP Gemstone Honors Program is a multidisciplinary four-year research program for honors undergraduate students. MDSG provides support for Gemstone research teams investigating research topics relevant to MDSG's mission (e.g., water quality, fisheries). MDSG also supports one or two undergraduates in our offices to assist our communications and research staff.

Communicating to Multiple Audiences

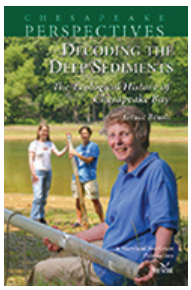
MDSG's communication team is highly effective at integrating research and outreach for stakeholders interested in understanding the science and policies driving restoration and sustainability of the Chesapeake and coastal bays. Our team employs a variety of methods to communicate information for use by our stakeholder communities.

One distinctive aspect of our communications work is our focus on long-form, narrative-driven articles and videos to describe scientifically accurate information that engage the interest of nonscientists. This approach is showcased in MDSG's magazine, *Chesapeake Quarterly,* and film documentaries, such as *Who Killed* Crassostrea virginica? *The Fall and Rise of Chesapeake Bay Oysters,* which was rebroadcast on public television stations nationwide in 2014. We are currently completing a new documentary on the blue crab fishery, *Chesapeake Casino: Betting Big on Blue Crabs*. Our magazine, which is free, has attracted more than 4,300 subscribers from varied backgrounds, including local and state officials, scientists, K–12 educators, and other citizens interested in the Chesapeake and coastal bays. It also has a well-established web presence and virtual distribution.

We reach out to stakeholder audiences through print and digital content. In collaboration with MDSG's leadership, the communications team produces an annual report highlighting the program's accomplishments during the previous year. We produce workshop reports, fact sheets, annual reports to NOAA, and correspondence with Congress. Our growing social media presence includes frequent postings on Facebook, Twitter, YouTube, and Instagram. We support two blogs, *Fellowship Experiences* and *On the Bay,* written by MDSG staff, students, and interns.

Our diversity of content helps us reach a broad range of audiences. Tracking user traffic on our different web-based platforms and a *Chesapeake Quarterly* reader survey suggest that our audience includes educators, aquaculture and fisheries enthusiasts, legislators, academics, and government workers.

HIGHLIGHTED PUBLICATIONS



COLLABORATIVE NETWORK ACTIVITIES

RELATIONSHIPS

Maryland Sea Grant values relationships in all aspects of the program, through our funded research efforts, our outreach programs, and collaborations. Many of our relationships have been sustained over several years—and in some cases for decades—helping to build trust and capacity. To keep our program relevant, our talent pool deep, and our stakeholder reach broad, we seek new collaborations with other Sea Grant programs and with NOAA entities on the local, regional, and national levels. We benefit from the insight, talent, and expertise that our federal, state, local, industry, and educational collaborative network activities bring to our program. As *Figure 2* shows, local and state stakeholders, the academic community, and nongovernment organizations account for the majority of our partners over the past four years. These collaborations catalyze new programming across our focus areas and improve our capacity to best serve a broad spectrum of stakeholders.

Building and sustaining relationships with our state-level partners helps us meet stakeholder needs. Many of our partnerships cross federal, state, or academic boundaries, including climate working groups, research and communications work with the EPA Chesapeake Bay Program, the NOAA-funded Oyster Futures and Remote Sensing Harmful Algal Blooms workshops, and our Aquaculture Roundtable workshops. Regional partnerships—especially with Sea Grant and NOAA programs in the Mid-Atlantic—also are critical for reaching wider audiences. We have more than 380 partners *(Figure 2)*.

Our collaborations extend regionally (e.g., Mid-Atlantic), nationally (primarily eastern and Gulf Coast states), and internationally (e.g., European Union, Myanmar, Afghanistan, and China). Through these connections, we lead and assist others in developing research, training, and management competence.

The Sea Grant network fundamentally strengthens all Sea Grant programs. It is a source of information, collaboration, and capacity building. Our staff are active in several network activities and partners on projects with Mid-Atlantic Sea Grant programs. We maintain close contact with the NSGCP office and our program manager (up until 2016, Mr. Dorn Carlson; since then, Dr. Rebecca Briggs), ensuring that we are knowledgeable of both internal and external network activities. Director Moser is the Sea Grant Association's president-elect and will become president in 2019. This leadership has deepened considerably our engagement with the network, NOAA, and Congress.

Several important collaborations are highlighted below:

Sea Grant Collaborations

VIRGINIA SEA GRANT. Our neighboring state has been a principal and highly valued collaborator for decades as we address Chesapeake Bay issues in a regional fashion.

MATHIAS MEDAL. With Virginia Sea Grant (VASG) and the Chesapeake Research Consortium, we jointly administer and award the Mathias Medal, a prestigious accolade given to senior scientists whose work has made major contributions to Chesapeake Bay policy. We hosted the event in 2016 to honor the newest recipient of the award, Dr. Walter Boynton.

REGIONAL RESEARCH PROJECT. With the Virginia, Delaware, and New Jersey Sea Grant programs, we support research for managing biodiversity and blue carbon in the face of sea level rise and barrier island migration.

SGA NETWORK ACTIVITIES. Staff participate in SGA networks that include the National Sea Grant Law Center Advisory Committee (Parker), research coordinators and fiscal officers networks (Allen), SGA board (Moser), educators (Frederick, Takacs), communicators (Brainard, Kobell) and Extension Assembly (Dindinger, Rockler). Staff and faculty participate on network visioning initiatives (Allen–diversity and inclusion; Frederick, Lehming, Takacs, Dindinger–environmental literacy; Kobell–aquaculture; Liu–integrated seafood; Sudol–weather and climate; Dindinger–community response to flooding). Extension and Communications groups participate in the Mid-Atlantic Sea Grant regional meetings, as do directors. MDSG and Extension are also involved in Communities of Practice (e.g., climate, diversity and inclusion) and collaborate directly with counterparts in other programs (e.g., education, seafood safety, aquaculture, communications).

NOAA Program Collaborations

CHESAPEAKE BAY SENTINEL SITE COOPERATIVE (CBSSC). Funded through a partnership with NOAA, our CBSSC coordinator has engaged state and federal governments, academia, and non-governmental organizations and decision makers to share data and synthesize findings to improve spatial and temporal understanding of ecological change and rates of sea level rise.

REGIONAL FELLOWSHIPS. With NOAA and our Mid-Atlantic Sea Grant partners, we have participated in two regional fellowship competitions: Mid-Atlantic Coastal Storms; and Ocean Acidification. Using shared revenue streams, fellows from across the region receive support to conduct issue-specific research and create a cohort of young scientist specialists in these fields.

WATERSHED RESTORATION. MDSG has worked with NOAA, Extension programs, and others in an innovative interagency effort to assist local governments with coordination and resources for advancing watershed implementation projects**.** Key is the collaboration between Extension, MDSG, the Chesapeake Bay Trust, and the Chesapeake and Coastal Service (CCS) under DNR, which is funded through NOAA's Office for Coastal Management. This sharing of capacity is a model with national implications.

CLIMATE CHANGE PROGRAMMING. Extension is collaborating with the NOAA Coastal Training Program offered by the Chesapeake Bay National Estuarine Research Reserve and DNR's CCS Program to deliver coordinated programming around climate change and adaptation. The efforts of all three programs leverage staff and funding in innovative ways critical for supporting Maryland counties at risk from nuisance flooding and erosion.

COASTAL OBSERVING NETWORKS. MDSG has been an active participant and a board of directors member in the Mid-Atlantic Regional Association Coastal Ocean Observing System, a partnership of universities, private companies, nongovernment institutions, and state and federal government agencies that coordinates and facilitates observations of the ocean and estuaries between Cape Hatteras and Cape Cod. Key to success is NOAA's participation, through the Integrated Ocean Observing System and the National Weather Service.

International Collaborations

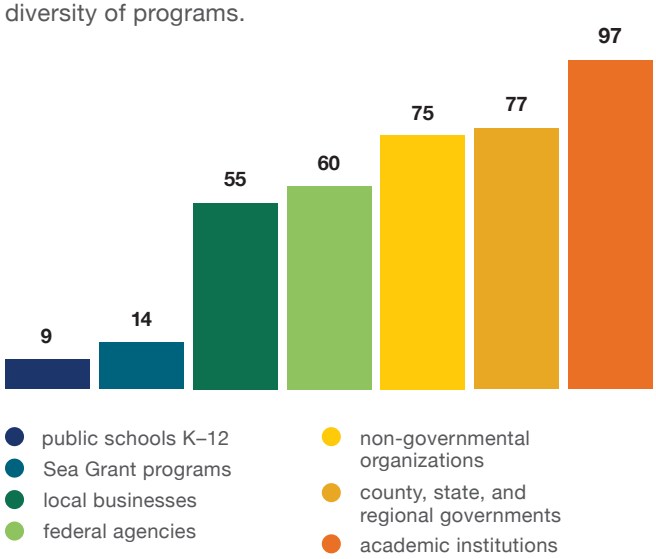
Extension specialists worked with international communities on a variety of projects: leading Aquafarming as a Business workshops for USAID in Myanmar, which reached more than 120 participants; working with women in Afghanistan; and raising awareness of risks from seafood poisoning via a Western Pacific UNESCO Steering Committee panel.

Other Collaborations

CLIMATE WORKING GROUPS. MDSG sponsors a collaborative, interdisciplinary discussion group on climate resiliency. These discussions have led to collaborations on research projects, identification of priorities and gaps in climate resilience needs, and plans for a University System of Maryland climate forum. In addition, MDSG participates on the Chesapeake Bay Program's Climate Resiliency Work Group and the state of Maryland's Adaptation and Response Working Group of the Maryland Commission on Climate Change.

FIGURE 2. Partners

Maryland Sea Grant worked with 387 partners from a diversity of programs.



INVASIVE SPECIES. MDSG staff are active with the Mid-Atlantic Panel on Aquatic Invasive Species (MAPAIS). MDSG partners with MAPAIS and the U.S. Fish and Wildlife Service to administer the panel's funding and awarding of small grants. The panel consists of state and federal decision makers with whom MDSG works closely on issues concerning communication and integration of science and outreach on invasive species issues. Pennsylvania Sea Grant is an active partner with us on MAPAIS activities.

EAST COAST COMMERCIAL FISHERMAN'S AND AQUACULTURE TRADE EXPOSITION. MDSG coordinates with the VASG Extension Program to organize and conduct training sessions and seminars at this longstanding trade event held annually in Ocean City, Maryland. The event expands our reach to the Mid-Atlantic regional aquaculture industry and highlights aquaculture training opportunities via Extension.

PROFESSIONAL CONFERENCE SPECIAL SESSIONS. Staff are involved in professional societies related to Sea Grant interests. Our associate director for research and administration is on the Association for the Sciences of Limnology and Oceanography (ASLO) Public Policy Committee. He has co-chaired sessions at the Ocean Sciences and ASLO Aquatic Sciences meetings.

PERFORMANCE

Since 1977, MDSG has played a vital role in supporting science that develops new understanding to inform policies to conserve and restore Chesapeake Bay and our state's coastal resources. Our programming is helping to solve our state's marine, coastal, and watershed environmental challenges and improve the health and prosperity of our state's residents. Though much of our work cuts across multiple topical and programmatic areas, we address them here through our focus areas.

The success of our program and its impacts are a reflection of our management and organization, stakeholder engagement, collaborative working style, strong leadership, and high productivity. The excellence of our team, and their passion to work closely with our partners and stakeholders, allows our program to meet our strategic plan mission to "conduct a locally responsive and nationally eminent program that advances the sustainable use and conservation of coastal, marine, and watershed resources in Maryland, in the Mid-Atlantic region, and in the nation."

RESEARCH PUBLICATIONS

MDSG supported research that led to 106 scholarly publications in 65 journals; 24 articles are open access. In all, these publications have received more than 850 citations. Our PIs are publishing with high frequency and relevance; our highest h-factor PI is 76 (median is 14). High-impact journals in which these publications appeared included:

Environmental Science & Technology
Estuaries and Coasts
Frontiers in Ecology and the Environment
Limnology and Oceanography
Marine Ecology Progress Series
Nature Communications
PLoS One
Transactions of the American Fisheries Society

RESILIENT ECOSYSTEM PROCESSES AND RESPONSES

Healthy Coastal Ecosystems

From 2014–2017, MDSG investigated key coastal and ecosystem processes in marine, estuarine, and freshwater reaches of our watersheds through a series of groundbreaking applied research projects and robust educational and outreach efforts. Bay grasses, stream health, the resiliency of native species, and the long-term survival of our forage fish species tell us a lot about the overall health and sustainability of the Chesapeake and coastal bays and their watersheds.

Susquehanna River, the Conowingo Dam, and Chesapeake Bay Water Quality

New insights into options for managing sediment and nutrients flowing into the Chesapeake Bay from the Susquehanna River and over the Conowingo Dam resulted from MDSG-supported research. Scientists used computer modeling tools in novel ways to refine estimates of long-term trends in the accumulation and loss of sediment and nutrients in the reservoir behind the dam and in the Chesapeake's other tributaries.

SAVs are a key restoration metric for the Chesapeake Bay. MDSG-supported researchers investigated the influential role of the Susquehanna Flats—a bed of underwater grasses in the upper Chesapeake Bay downstream of the Conowingo Dam—in capturing some of the sediments flowing from the river. They found that submerged aquatic vegetation (SAV) effectively engineered its environment by reducing current and wave energy, which improved water clarity by trapping nutrients and sediments. This created a feedback loop that increased growth and expansion of SAV beds.

Understanding sediment resuspension is critical to the investigation of benthic-pelagic coupling in estuaries. MDSG-supported underrepresented students in marine science and their mentor from University of Baltimore worked together at Morgan State University's Patuxent Environmental & Aquatic Research Laboratory (PEARL) to build mesocosms to study shear turbulence resuspension. These mesocosms will help investigate how currents disturbing bottom sediments may affect resident benthic organisms.

Reducing nutrient pollution from septic systems is an important component of the Bay cleanup for many rural Maryland counties. MDSG-supported researchers

are developing tools to trace the chemical compounds associated with septic pollution in local watersheds. These tracers will allow managers to identify watersheds with septic contamination.

OUTCOMES: The findings informed a midpoint review of the Chesapeake Bay Program's water quality model, providing new understanding to resource managers as they work to meet the Bay's water quality goals. SAV research confirmed that increased sediment trapping occurred when seagrasses were present. The findings informed the third Chesapeake Bay Program SAV technical synthesis report. Scientists' research on septic contamination was featured on National Public Radio and shared with environmental health officials, as part of a Maryland legislative hearing on septic systems.

Marshes and Sea Level Rise

As sea level rates in the region rise at about twice the national average, policy makers see new urgency in understanding marsh ecosystems and their potential to sequester carbon, affect nutrient cycling, and mitigate effects of storm surge and flooding. This includes considerable research into the invasive reed, *Phragmites australis,* and how marshes dominated by this plant respond to changes in carbon and nutrient cycling under increasing atmospheric CO_2 concentrations, important in Maryland marshes and regionally. In another regional study, Sea Grant-funded scientists are investigating marsh response to sea level rise and how storms and inundation affect plant biodiversity and carbon sequestration.

OUTCOMES: Scientists found reducing nitrogen availability could decrease invasive *Phragmites* expansion in marshes. MDSG researchers are developing new maps of carbon distribution in marshes, and they have briefed Congress on how sea level rise changes landscapes and seascapes. The CBSSC coordinator assisted multiple state and federal entities to select sites for new water level gauges, reached consensus with partners on how to share their marsh measurements of sea level rise, and co-led with NOAA a pilot for 13 participants from five agencies and organizations in water level training. The course proved highly successful and is now being offered in multiple locations in the United States.

Invasive Species

MDSG has led research, education, and outreach on the most effective ways to prevent the introduction of nonnative species into our waterways. MDSG has been a key participant and executive committee member on the MAPAIS from its inception in 2003. Since 2012, our staff has managed the panel's annual competitive grant program. In 2014, we participated in a regional public education campaign—part of a large, NOAA-funded project—to warn anglers that live bait-worm packaging contains invasive species. The campaign was carried out through development of educational materials for anglers and bait shop owners that encouraged the proper disposal of packaging.

OUTCOMES: MDSG has managed 12 grants for MAPAIS over the past four years. A regional effort to encourage proper disposal of live-bait algal packing material saw the distribution of educational materials—brochures (2,450), stickers (8,620), and magnets (600)—to anglers; an educational website was also created and made available to anglers.

Stream Health

MDSG has supported significant research and publications on oxygen and nutrient dynamics in the Chesapeake Bay. In the last decade, we expanded to include investigation of the watershed and the role that Maryland's upstream reaches play in the Bay water quality. As communities strive to meet new nutrient and sediment water quality requirements, as part of a massive TMDL effort to reduce inputs to the Bay, we supported research to improve understanding of stream dynamics.

Riparian buffers are important for stream health, but their ecological function, especially in light of climate change, is less well understood. Researchers whom we funded developed a model to identify tree species best suited to survive on flood plains, where flooding frequency is increasing. Since classification of stream health is based on expensive water quality and invertebrate community

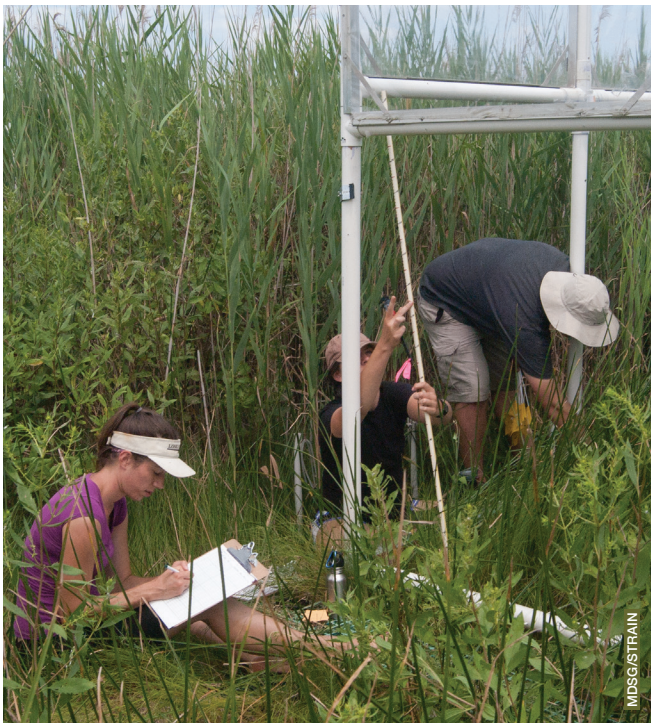
KEY IMPACTS
2014–2017

- Chesapeake Bay Sentinel Site Cooperative coordinator completed a data and infrastructure inventory and summary to begin a regional synthesis of marsh responses to sea level rise.
- Ecosystem research above and below a major hydropower dam informed Chesapeake Bay TMDL management decisions.
- Genetics and plant growth research provided new insights into seagrass restoration decisions.
- Sophisticated models and DNA analyses identified new techniques to improve stream monitoring.

monitoring, researchers explored how genetic analysis of microbial communities could be used as a diagnostic screening tool to rapidly assess stream health, thus potentially lowering costs.

MDSG-funded scientists also created an Integrated Ecosystem Assessment model for the Potomac River. The model, based on multiple and highly varied data sets (e.g., socioeconomic, climate, fisheries, water quality), is an example of how managers could improve the use of data in modeling and analysis to inform adaptive management and meet restoration goals. In a study of Rock Creek, scientists are investigating the effects of dissolved oxygen—created in the stream by a huge aeration system—on nutrient cycling as the aerators turn on and off and oxygen levels go from oxic to anoxic.

OUTCOMES: USGS scientists are benefitting from our riparian buffer modeling research to rethink the ecological consequences of flooding. Researchers shared the results of a large genetic survey with Maryland DNR and other stakeholders; the survey was completed with the help of citizen scientists on almost 100 streams to create a new low-cost stream evaluation tool. Chesapeake Bay Program managers and scientists are using our approach to improve predictions of hypoxia severity in the Potomac River. Research in Rock Creek is helping local managers seek restoration funding to improve water quality.



Maryland Sea Grant researchers.

Ecosystem Dynamics and Fishery Implications

Understanding food webs and species movements are basic building blocks for understanding fish ecology. Atlantic menhaden *(Brevoortia tyrannus)* are significant in Chesapeake Bay and coastal ocean food webs, serving as prey for many species; menhaden is also an important commercial fishery on the Eastern seaboard.

Using data from a historic, large-scale fish tagging study, researchers quantified estimates of species migration patterns, finding a 17 percent annual difference in mortality than what was previously assumed; an ecosystem-based fisheries management model was developed that estimates productivity. Other researchers investigated winter blooms of dinoflagellate species in Chesapeake Bay and found that these species play an important role in the food web. They are closely coupled with the preferred prey of the estuary's population of striped bass, a commercially important fishery. The research indicated that improved monitoring of the winter blooms could help improve understanding of annual variation in the striped bass population and refine management of this fishery.

OUTCOMES: This research has informed the Atlantic menhaden stock assessment prepared by a technical committee for the Atlantic States Marine Fisheries Commission, which manages the fishery. The commission will consider ecosystem-based reference points, which will be brought to peer review in 2019 as part of the benchmark stock assessment process.

SUSTAINABLE FISHERIES AND AQUACULTURE

We continue our longstanding focus on achieving sustainable harvests for the Chesapeake's traditional fisheries and supporting the rapidly expanding aquaculture industry. Those occupations produce healthy seafood for the state's citizens, are key forces in the culture of tidewater Maryland, and create thousands of jobs in related seafood businesses. We directed major research and extension efforts, including understanding the menhaden fishery and informing ecosystem-based fisheries management, expanding oyster aquaculture, exploring polyculture, and ensuring safe seafood production. Importantly, as reported by Maryland DNR, the seafood industry adds nearly $600 million to the state's economy.

Aquaculture Advancements

Shellfish aquaculture offers new employment opportunities and an alternate income source for traditional wild oyster harvesters and entrepreneurs. With oyster aquaculture, Maryland may be able to improve estuarine water quality, promote biodiversity, produce sustainable food, and provide jobs. Since 2011, our aquaculture business specialist has helped commercial watermen and other applicants learn how to prepare business plans to apply for financing, which is important as traditional loans are often not available. Our Extension specialists help lead a university demonstration oyster farm that highlights multiple methods of innovative water column production and is used for hands-on training of growers.

Our Extension business specialist and a NOAA scientist are working to determine how much nitrogen and phosphorus oysters can remove; classification of oyster farms as a best management practice would qualify them to receive credit if the state implements a nutrient trading program. Both individuals are members of an expert panel to develop best management practices (BMP) for nutrient and sediment removal to meet TMDLs. The panel will consider if oysters can be considered as a BMP.


MDSG/PENDICK

222

participants trained in HACCP

2014–2017

KEY IMPACTS
2014–2017

- Extension economic specialist advised the Atlantic States Marine Fisheries Commission on the socioeconomics of the menhaden fishery, while fishery scientists' new models inform stock assessments.
- Extension aquaculture business specialist helped 15 oyster growers obtain $817,120 in loans; assistance to MARBIDCO helped secure a total of $1.6 million in loans for oyster farmers.
- MDSG-funded scientists worked with industry to secure approximately $150,000 in state industrial partnership and other grants to advance polyculture in the region.
- MDSG assembled approximately 80 scientists and aquaculture industry experts to identify joint projects for funding to advance the industry.
- Extension seafood specialist provided guidance to crab industry representatives on seafood safety and analysis of plant microbiological status. In 2015, the economic impact was about $728,000.
- Extension trained 222 individuals in seafood safety Hazard Analysis and Critical Control Points (HACCP); 94 percent of industry participants surveyed in 2017 would recommend this program to colleagues.

Polyculture production is another promising area for aquaculture industry expansion. MDSG-supported scientists worked to commercialize their research findings, showing how growing seaweed *(Gracilaria)* and oysters together in Chesapeake Bay can provide economically valuable crops while improving water quality.

OUTCOMES: Between 2014 and 2017, Extension's aquaculture business specialist worked with MARBIDCO, a state-chartered quasi-public economic development organization, to secure about $1.6 million in loan commitments for oyster farmers. He helped oyster growers complete loan applications for oyster aquaculture development assistance. Two demonstration farm workshops and 12 one-on-one sessions allowed oyster farmers to experiment with different types of cage gear.

Researchers secured a $150,000 industrial partnership grant to commercialize a macroalgae-oyster farming operation. When fully operational, researchers estimate that each acre cultivated could produce net revenue of $3,300 or more per year and remove 13,500 pounds of CO_2, 300

13 out of 18

Maryland crabmeat businesses participated in the Crabmeat Quality Assurance Program[a]

2014–2017

[a] average

pounds of nitrogen, and 20 pounds of phosphorus annually, which would help to improve water quality.

Aquaculture collaborations

We organized two workshops that brought together aquaculture entrepreneurs, scientists, Extension specialists, and state and federal partners. The focus of the workshops was to determine ways to remove obstacles that have hampered the Maryland aquaculture industry's growth and to collaborate on projects to advance the industry.

In collaboration with researchers leading the NSF-funded "Oyster Futures" project, MDSG helped host a symposium to benefit stakeholders on Maryland's Eastern Shore, including local communities within the NOAA Choptank River Habitat Focus Area. Speakers from outside Maryland presented innovative ideas about production techniques and management strategies that could help the industry grow.

OUTCOMES: More than 80 aquaculture experts attended two workshops. Collaborations focused on ways to expand oyster aquaculture and other potential areas for aquaculture expansion. Survey results indicated that attendees found the meetings to be highly valuable. The Oyster Futures event received high scores on the question of whether they learned new and useful information.

Seafood Safety and the Blue Crab Industry

To help Maryland's blue crab industry compete with cheaper imported crabmeat, our seafood technology specialist worked with local businesses in the Maryland Crabmeat Quality Assurance Program. Participating businesses agree to undergo food safety inspections beyond state and federal requirements, which earns them use of a special logo marketed by the State's Office of Seafood Marketing. This program ensures that Maryland crabmeat has low bacterial counts and no presence of *Listeria*. Our specialist conducts routine trainings in Hazard Analysis and Critical Control Points (HACCP) to keep the industry compliant with food safety procedures.

OUTCOMES: Our Extension agent generated 168 reports for companies detailing the microbiological testing at their plants. Up to 13 of Maryland's 18 seafood processing plants participated in the program from 2014–2017. A survey conducted in 2015 estimated the program's annual economic impact at $728,000.

Science-based Fisheries Management

Our work and research findings play important roles in finfish harvest management. Work from 2008–2011 helped to fundamentally shift the fisheries management conversation away from single species and toward ecosystem-based fisheries management (EBFM). MDSG remains committed to funding science in support of EBFM.

We supported researchers in a large tagging study to evaluate where adult crabs migrate and determine the percentage of crabs harvested by the state's recreational and commercial sectors. They found that the recreational harvest was about 6.5 percent the size of the commercial harvest, consistent with earlier findings. Researchers recommended that fishery managers adjust their stock assessments ratios of recreational harvest to total commercial male and female crab harvest allowed.

High-quality science is crucial for the effective management of Maryland's commercial fisheries. At the request of NOAA Fisheries, Extension's fisheries resource economist reviewed the scientific basis of a proposed NOAA management action for recovery of Atlantic sturgeon populations. He also advised the Atlantic States Marine Fisheries Commission on an ongoing socioeconomic assessment of the menhaden fishery, and he provided scientific review for a study on the allocation of summer flounder catches to the Mid-Atlantic Fisheries Management Council. He is a valued member of the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team.

OUTCOMES: We remain committed to supporting science to inform fishery decisions. Important commercial shell and finfish management decisions in multiple state and federal fisheries regulatory bodies benefit from our research and expert advice. MDSG researchers presented their findings to industry and key managers with the Bi-State Chesapeake Bay Stock Assessment Committee and the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team.

RESILIENT COMMUNITIES AND ECONOMIES

Maryland's coastal communities are central to the state's culture, history, and economy. As traditional drivers, such as commercial fishing and agricultural patterns, change, recent policy decisions and management actions are creating different economic opportunities. The emerging need to adapt to climate change and meet new requirements to limit nutrient and sediment pollution will present new challenges for communities and local governments. Those challenges open the door to solutions that we are in an excellent position to provide. Working with government and nonprofit partners and scientific researchers, we can help Maryland's aquaculture seafood businesses grow sustainably, train new leaders to help reduce stormwater pollution, and understand and mitigate risks from climate change.

Supporting Coastal Communities

A decade ago, Maryland shellfish aquaculture was a small industry with many restrictive laws, so few farms could exist. But with guidance from the Maryland Aquaculture Coordinating Council, and with leadership by MDSG Extension specialists, the state legislature changed the lease laws in 2009, creating a modern program to attract investors to this economically and environmentally beneficial industry. When that happened, Maryland Sea Grant and Extension offered assistance to help grow shellfish farms. Today, more than 170 oyster farmers lease more than 6,500 acres of Maryland's Chesapeake and coastal bays and tributaries.

Remote setting to produce seed oysters was introduced by Extension specialists in the 1980s; the technique had a renaissance after passage of the new lease program requiring "active use" of leases. The NOAA-funded Oyster Aquaculture Education and Training Program expanded its assistance to watermen and entrepreneurs who were entering the oyster farming business; 44 training events were held from 2016 to 2017, attended by over 700 people; many of those counted attended more than one event. By 2017, Extension and partners assisted watermen by providing seed oysters, access to remote setting tanks, and training and support for on-bottom and water-column oyster aquaculture production.

To understand why some watermen resisted participating in aquaculture while others adopted it, MDSG supported a graduate student who applied her anthropology methodology to explore this question. Her findings, gathered through interviews and network analysis, suggest that startup costs and differing harvest practices were significant obstacles to participation.

KEY IMPACTS
2014–2017

- Extension supported 45 oyster growers, who produced 269 million seed oysters, using 38 remote setting systems, with an estimated market value of more than $4 million.
- Extension and partners expanded aquaculture to 409 leases on 6,600 acres, creating more than 170 jobs; they produced approximately 224,000 bushels worth about $11.2 million (about $50 per bushel).
- Watershed Stewards Academies expanded to six counties; graduated 114 stewards; built 31,007 square feet of BMPs, treating 135,562 feet of impervious surfaces; planted 18,001 native plants; educated 5,080 individuals; and engaged 918 volunteers from 2016–2017.
- Extension specialists helped secure $7.1 million in watershed restoration grants.
- The Landscape Certification Program certified 233 professionals, whose efforts reduced nitrogen, phosphorus, and sediment inputs to the Chesapeake Bay.
- Using climate models, researchers found that shoreline hardening in the Chesapeake Bay would increase a Category 2 storm's surge by 50–80 cm.
- Extension and partners assisted rural communities in securing $1 million for climate adaptation.

EXTENSION ASSISTED ECONOMIC IMPACTS FROM 2014–2017

$11,232,000	$817,120	$7,132,943
Oyster aquaculture harvest	MARBIDCO loans	Stormwater adaptation/ mitigation planning grants

Watermen fishing crabs in the Chesapeake Bay.

OUTCOMES: In 2017, 45 on-bottom oyster growers produced 269 million seed oysters, using 38 remote setting systems across the state. Estimated market value of seed oysters produced was more than $4 million. Much of the larvae for seed was provided by Sea Grant in collaboration with multiple partners. From these seed oysters, farmers produced nearly 78,000 bushels of market-ready oysters, worth approximately $3.9 million (about $50 per bushel).

Helping Communities Protect Watersheds

The fastest growing source of pollution in the Chesapeake Bay watershed is stormwater runoff. Extension is teaming up with multiple partners to address this challenge and help communities meet their mandated TMDLs in a number of significant ways.

Watershed Stewards Academies (WSA) is a train-the-trainer program that teaches volunteers to lead efforts to restore streams; install stormwater best-management practices (BMPs), such as rain gardens and plant buffers; and secure grant funding for additional projects. Extension has partnered with local groups in five counties, as well as in the DC metropolitan area, to build six academies, where hundreds of volunteers have been educated about pollution issues and management practices related to stormwater.

Extension created the Chesapeake Bay Landscape Certification Program (CBLP) with regional partners to train individuals and companies in effective conservation landscaping design and installation and maintenance of stormwater management systems. With MDSG assistance, the collaborators produced a manual and designed a two-tiered certification program. The certification training is currently being piloted as a course offering at Baltimore County Community College.

An MDSG-supported graduate student studied mosquito infestation in household stormwater systems for a possible explanation as to why residents may hesitate to install rain barrels and gardens; the student discovered that these systems harbored fewer human-biting mosquitos than other garden features.

OUTCOMES: Since 2016, WSAs graduated 114 stewards; built 31,007 square feet of BMPs, treating 135,562 feet of impervious surfaces; planted 18,001 native plants; educated 5,080 citizens; and engaged 918 volunteers.

100+

commercial watermen trained in aquaculture harvesting

2014–2015

Climate Research Informs Management Decisions in Maryland

MDSG supports both natural and social science research to facilitate science-based planning and action in response to climate change. Physical oceanographers supported by

114

Master Watershed Stewards graduated from WSA

2016–2017

MDSG used computer models to investigate how future sea level rise and storm surge events might affect coastal areas in Maryland. They found shoreline features in the Chesapeake Bay that could affect storm surge inundation. A fully hardened shoreline could increase storm surge by 50 to 80 centimeters; natural shorelines would allow low-lying areas to flood and thereby reduce overall inundation.

A MDSG-supported study examined sedimentation patterns associated with different types of shoreline stabilization techniques. Researchers found that riprap shorelines can increase transport of coarse sediments, which could contribute to increased growth of SAV because of its affinity for sandy sediments.

OUTCOMES: Scientists created digital images to illustrate the effects of sea level rise and extreme storm events to help city and town managers improve flood risk management. Findings regarding the relationships between SAV and shoreline stabilization techniques were shared with various work groups tasked with shoreline management, SAV restoration, and land use.

Building Community Resilience to Climate Change

In Maryland's Kent County, Extension specialists and partners guided managers and planners through a Vulnerability, Consequences, Adaptation, and Planning process to improve community resilience. On Deal Island, MDSG-supported researchers, Extension specialists, and state policy makers used a collaborative learning model to bring together community members, faith leaders, county officials, and ecologists to devise a more resilient approach for these communities.

OUTCOMES: Communities vulnerable to climate change on Maryland's lower Eastern Shore were assisted in securing grants to build a protective living shoreline, and county officials improved ditch maintenance to reduce impacts from nuisance flooding. Extension facilitated the EPA's Coastal Bays Program's Climate Change Vulnerability Assessment.

EFFECTIVE ENVIRONMENTAL SCIENCE EDUCATION

Environmental Literacy and Workforce Development

Since 1995, Maryland Sea Grant's assistant director for education and Extension faculty have run highly successful, pre-college educational programming. These programs focus on science-based, experiential learning. Key to success is the close coupling of scientists to classroom cirriculum development. These programs support project-based learning that integrates chemistry, physics, biology, and mathematics to investigate problems, such as rearing fish from larvae to adults, or urban harbor water quality.

Expanding Access to Project-based Science in K–12 Schools

The highly successful and long-running Aquaculture in Action education program added new instructional strategies to its curriculum including a microcomputing guide for water quality monitoring in aquaculture tanks, and a digital imaging system to measure fish dimensions without removing fish from tanks. MDSG created workshops for teachers to master these technologies and use them in the classroom. This innovative programming reaches students from rural Carroll County to inner-city Baltimore and has expanded to Florida and Hawaii.

For more than two decades, our assistant director for education worked with local schools and collaborators in Sweden and Norway to develop the Biofilms and Biodiversity project. Racks of small disks have been placed in Baltimore's Inner Harbor and other bodies of water at various locations around the world; the disks attract organisms that students identify in the classroom. The project advances the idea that life abounds even in waters known for their poor quality. Thanks to a recent European Union grant, students now have access to an interactive web

KEY IMPACTS

2014–2017

- Undergraduate research programs supported 89 underrepresented students in marine science.
- Maryland schools teach 900 students in science skills through aquaculture curricula.
- *Chesapeake Quarterly* transforms complex Bay science into accessible stories for 4,300 print and 830 email subscribers.
- Our science-based videos attain a global reach through YouTube with over 365,000 views of our top-five videos.

interface that allows them to compare biofilm biodiversity across continents.

OUTCOMES: Twenty-two Maryland schools have Aquaculture in Action programs—with 14 microcomputing systems—educating 900 students, who raised and released over 2,500 native fish. More than 200 students analyzed biofilms; hundreds more participated throughout Europe. Our interactive lessons and other curricula supporting these projects, viewed worldwide, are the most popular parts of our website.

Research Opportunities for Undergraduates

Our initial REU program began in 1989 with 10 students. Over the last four years, our core commitments (REU, Centro TORTUGA, Gemstone Scholars, MDSG internships, conference funding) have broadened to include partnerships with deaf and hard of hearing students from Gallaudet University (DC) and underrepresented and underserved students at Universidad del Turabo and Universidad Metropolitana (PR). We provide students with strong mentorship and professional development in communications skills, ethics, science careers, and writing. We have also mentored dozens of students through the ASLO Multicultural Program and SACNAS.

OUTCOMES: We have brought more than 230 undergraduates into research-focused marine science training, including 19 underrepresented minority students through the REU and 70 Hispanic students through the Puerto Rico partnership in the review period. REU students have given 47 presentations at national and international meetings and published 11 journal articles.

Supporting Graduate Research and Education

Research training focuses on environmental and social science issues relevant to Maryland. In addition to research and policy experience, students receive mentorship in science writing, professional development training (e.g., MDSG-led proposal writing workshop), and outreach opportunities on Sea Grant projects.

PERFORMANCE MEASURE

17,543

people engaged in Sea Grant supported informal education programs.

PERFORMANCE MEASURE

68

Sea Grant facilitated activities that are implemented by formal and informal educators and professional development workshops.

OUTCOMES: Maryland Sea Grant supported 23 research fellows, 15 Knauss Policy fellows, and a Population and Ecosystem Dynamics fellow. Many more students have worked on Sea Grant-funded research projects. Fellows published more than 50 blog entries related to their research and graduate experiences; editorial mentorship from our staff helped them develop and enhance their writing skills.

Educating the Public through Communications Products

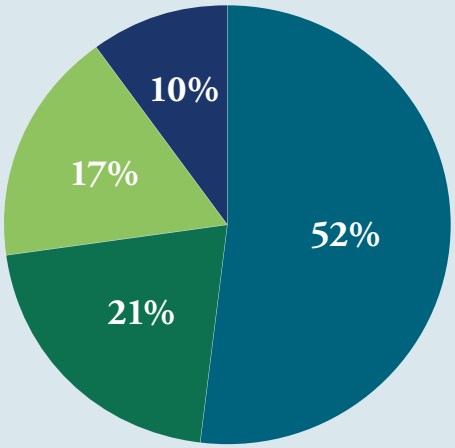
Our award-winning magazine, *Chesapeake Quarterly,* and blogs have covered issues pertinent to Chesapeake science and policy, including the Chesapeake Bay water quality model, forage fish and ecosystem-based fisheries management, the booming oyster aquaculture industry, and stormwater management.

Other recent publications include a book, *Decoding the Deep Sediments: The Ecological History of Chesapeake Bay* by Grace Brush of Johns Hopkins University; a report on sea level rise, *Come High Water;* a manual on green landscaping practices; and annual report brochures.

MDSG is a trusted source for science-based information relevant to Chesapeake Bay and watershed legislation. Our Extension specialists produce a newsletter, *Headwaters,* to inform their constituents about stormwater management issues.

OUTCOMES: *Chesapeake Quarterly* has more than 4,300 print subscribers. With our partners at the *Chesapeake Bay Journal,* we wrote, edited, designed, and published *Come High Water,* an in-depth report on sea level rise, which was distributed to the Maryland General Assembly. Sea level rise is being taken into account more—in part because of these and other efforts—as communities plan for their futures.

Our assistant director for education was featured in an Aquakids television special, which won a Telly Award. He coauthored *Salamander Season,* which was a commended book in the AAAS/Subaru SB&F Prize for Excellence in Science Books.



253 students

funded by MDSG have been employed in their field within two years of graduating. Of these:

52% are seeking an advanced degree or working in academia

21% are working in industry positions

17% are working in government positions (federal, state, or county)

10% are working in other fields (e.g., non-governmental organizations, K–12 education, medical, Sea Grant)

343 new undergraduate and graduate students supported

72 graduate degrees awarded

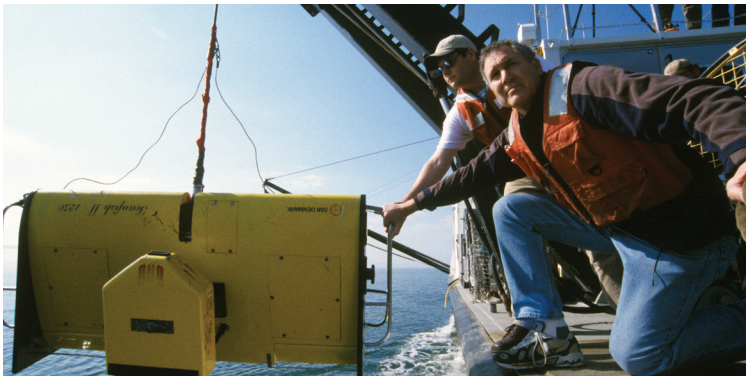
103 undergraduate degrees awarded

PROGRAM CHANGES FROM THE PREVIOUS SITE REVIEW

Maryland Sea Grant received no recommendations and five suggestions from the 2010–2013 Site Review Team. Below are their suggestions and our responses:

SUGGESTION	Continue to support social science.
RESPONSE	We supported anthropologic study of community response to and understanding of adaptation to climate change in the following ways: We collaborated with George Mason University on research to understand underserved communities' attitudes on environment, health, climate change, and resilience. We supported two graduate Coastal Resilience and Sustainability Fellowships, one to investigate homeowners' socioeconomic status, knowledge, and attitudes regarding stormwater, and the other to explore watermen's participation, or lack thereof, in oyster farming.
SUGGESTION	Continue to explore leveraging, partnerships, and joint granting opportunities in climate resilience.
RESPONSE	We submitted collaborative grant proposals: a Regional Integrated Science Assessment proposal to NOAA (not funded); a Coastal and Ocean Climate Applications (COCA) HABs grant (not funded), a NOAA COCA Coastal Resiliency grant (funded), and a NSF IUSE-IMPACT grant (funded). We expanded Extension's reach to communities and local governments concerning coastal resilience and planning for the effects of climate change. We also participate in local and state working groups focused on climate and with regional partners on sea level rise effects through the CBSSC.
SUGGESTION	Interact with the University of Maryland Extension communication staff.
RESPONSE	We have an established relationship with the recently formed UME communications office.
SUGGESTION	Continue to seek ways to involve the private sector in our EAB membership.
RESPONSE	We have added an oyster industry expert to our board.
SUGGESTION	Consider hosting a webinar or workshop with the National Marine Educators Association (NMEA) on integrating education and research.
RESPONSE	The NMEA board determined this was not an effective strategy.


Sustainability
Open Water Aquaculture




Social Marketing
Influencing Behaviors for Public