

Education Portfolio

BUILDING SCIENCE LITERACY AT ALL LEVELS

Confronting Challenges at National and Regional Scales

Concern continues to rise over the status of science education in the United States. The U.S. now ranks 17th among developed nations in the proportion of college students majoring in science, according to a recent study by the National Science Board. Thirty years ago, the U.S. graduated more Ph.D.'s than all of Europe and more than three times as many as all of Asia, based on a paper by Harvard University Economist Richard Freeman cited in an August 5, 2005 article in the *Washington Post*. Now the European Union graduates 50 percent more Ph.D.'s and Asia slightly more, on track to surpass the U.S. by 2010.

Placed within Maryland's universities, Maryland Sea Grant is well positioned to address the status of science education within the state. The Chesapeake Bay and other natural resources provide a rich laboratory for educational opportunities from K-12 all the way through graduate and adult education. In the mid-1980s environmental education became a formal priority in Maryland, incorporated into the state curriculum as the result of bylaws mandating that each local school system provide a "comprehensive, multi-disciplinary program of environmental education" at least once in the early, middle and high school learning years. The *Chesapeake 2000* agreement ratcheted up the charge to the public school system, specifying that each student graduating in 2005 and after should participate in a "meaningful Bay experience." These experiences should be integrally linked to the classroom curriculum and sustained over time — more than a simple field trip or museum visit.

Despite a strong substrate for environmental education in Maryland, our state faces a host of challenges that reflect many of the issues seen nationwide. Many teachers lack the expertise to incorporate content and applications from environmental science into their classrooms, and teacher shortages have increased more than two fold in the last decade, according to the Maryland State Department of Education. Many secondary schools do not connect with the wealth of cutting-edge university-based research that this state has to offer. This is where Maryland Sea Grant has a singular role to play, connecting scientists and engineers to teachers and students. Our programs work to develop close long-term associations between scientific research and education across age, stage and grade levels.

Carving a Niche: Maryland Sea Grant's Innovative Approach

Maryland Sea Grant has a diverse approach to education. We engage elementary, middle and high school students, teachers, undergraduates, graduate students, and adult learners, bringing expertise and technology from the university community to bear in each of our programs. We widen the scope of our impact by building partnerships with the public school system and other universities and by leveraging our resources strategically through collaborative grants with organizations such as the National Science Foundation, the National Oceanic and Atmospheric Administration, and the Chesapeake Bay Trust. Our intent is to empower users with knowledge that extends beyond specific aspects of coastal science grounded in the Chesapeake watershed to a full understanding of the scientific method and how it influences decision-making at local, regional and national levels.

Reaching Students and Teachers at the K-12 Level. "One way [we] can help foster a world-class system of education is by linking K-12 education with our already world-class science and engineering enterprise," said former National Science Foundation administrator Rita Colwell in 1999. The goal to connect students and educators with current research and methods for scientific inquiry is what shapes the focus of Maryland Sea Grant Extension's efforts at the K-12

level. Our programs emphasize education geared both directly towards students and those aimed at teacher professional development, which link educators with the research community.

The *Science and Technology Education Program* (SciTech) provides another example of a successful program that directly engages students in grades 6-12 level and their teachers with the world of scientific research. Maryland Sea Grant Extension works in partnership with the University of Maryland Biotechnology Institute (UMBI) at the Columbus Center in Baltimore to make science more accessible and exciting through hands-on programming based on current research in a real laboratory setting — a one-of-a-kind opportunity in Maryland. Students can participate in laboratory experiences that include: biofilms and biodiversity, DNA extraction from marine animals, zebrafish development, oyster biology, biosurfactants in treating pollution, and plankton dynamics in the Bay. The current structure at UMBI's Columbus Center facility allows SciTech to accommodate approximately five thousand students and their teachers each year.

Increasingly, the Internet has created new frontiers for education. Students can share lessons and data in real time with students across the state or in other countries. One such collaboration, through a five-year grant from the National Science Foundation, brought students from Norway and Sweden together with students from Maryland to share an interactive data-centered lesson over the Web. The interactions were so popular that they spread to Italy and Estonia via university partnerships. Maryland Sea Grant's interactive web-based lessons have now been downloaded in all 50 states and in 58 countries.

Maryland Sea Grant places a strong emphasis on teacher training through workshop, fellowships and graduate courses. Teacher training to bring unique experiences back to the classroom is a goal of *Aquaculture-in-Action*, a highly successful endeavor to create a network of aquaculture educators throughout the state. *Aquaculture-in-Action* provides educators with a "hands-on" workshop experience to understand recirculating aquaculture and how to use it in their classroom to enhance their science curriculum. Each year, ten teachers from Maryland counties learned how to design, build and set up a successful aquaculture system for their classrooms. In addition, they gain experience using the appropriate tools and techniques for monitoring an aquaculture system, including lab-based activities for students. Today 41 schools in Maryland, Pennsylvania and West Virginia have aquaculture programs based on the *Aquaculture-in-Action* approach.

In addition, two new partnerships with the National Aquarium in Baltimore (NAIB) and Department of Juvenile Services are expanding the reach of the *Aquaculture-in-Action* model. The NAIB partnership features the development of an aquaponics ecosystem that can be used to raise native fish and smooth cordgrass (*S. alterniflora*) being promoted by the NAIB for restoration purposes in wetlands. The partnership with the Department of Juvenile Services started in 1998 with the first *Aquaculture-in-Action* workshop and has continued with three of their schools in western Maryland. The schools have seen the value of using aquaculture as a learning tool, and interest in this effort has resulted in the formation of a panel to develop a

One by one, the stripers head out. Kathleen McClellan, a senior at South Carroll High School in Sykesville, Maryland, stands in the water guiding them over the lip of the cooler. Kevin Weeks and Mike Steel, two juniors, carry the rest of the coolers down from the car. Guys are too cool to wade in the water so they work on the dock, pouring buckets of warm Bay water into the coolers, getting the rest of the fish ready.

The fish have somewhere to go and so, perhaps, do the students. Science teacher Bob Foor-Hogue and Maryland Sea Grant Extension Specialist Adam Frederick have helped steer students into aquaculture, biology, oceanography, aeronautical engineering and environmental science and policy. Kathleen McClellan, the girl in the water guiding the stripers, is headed to the Air Force Academy.

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certificate in aquaculture that will help students make the transition into the workplace with a set of employable skills.

Maryland Sea Grant also engages teachers directly with researchers through the *Environmental Science Education Partnership* (ESEP), a collaborative effort with the University of Maryland Center for Environmental Science. The *ESEP Summer Research Fellowship Program* immerses 6th-12th grade teachers in Chesapeake research to advance their scientific inquiry skills and understanding of regional ecological and environmental topics and issues. Teacher fellows spend seven weeks of the summer working with scientists on a research project at one of four laboratories: Horn Point Laboratory in Cambridge, Chesapeake Biological Laboratory in Solomons, Appalachian Laboratory in Frostburg, or UMBI in Baltimore. With support from the ESEP team, teachers also develop associated classroom applications that support state science standards and meaningful Bay and stream outdoor experiences. Since its inception in 2002, 48 teachers have participated in the ESEP Fellowship.

As part of a large NSF-funded project, Maryland Sea Grant is partnering with multiple universities and the Montgomery County Public Schools to help overhaul the way that science is taught throughout the state. "*Vertically Integrated Partnerships K-16*" (VIP K-16) aims to enrich science teacher knowledge in order to improve high school science instruction and to improve the teaching skills of college science faculty in order to improve the quality of undergraduate general education science courses. The program provides summer institutes and school-year collaborative sessions aimed at developing best instructional practices and instructional materials linked to high school assessments. Phasing in biology, earth/space science and physics/chemistry over a three-year period, VIP K-16 engages 350 science teachers serving approximately 37,000 high school students, and substantively involving 36 university faculty. Maryland Sea Grant has developed an innovative web-based community (*ScienceInquiry.org*) that fosters interaction, exchange and collaborative learning.

Short courses and multi-day workshops for teachers are also a key element of Maryland Sea Grant programming. Workshops are often organized as multi-institutional or multi-state partnerships. Course and workshop topics include among others: cleaning-up turbidity, aquatic invasive species and integrating the *Chesapeake 2000* agreement into the classroom.

IMPACTS: REACHING STUDENTS AND TEACHERS

Over the past five years, Maryland Sea Grant programs have enabled:

- Over 26,000 students and 1300 teachers to participate in the SciTech Education program.
- 41 elementary, middle, and high schools in Maryland, Pennsylvania, and West Virginia to rear fish and teach science using the *Aquaculture-in-Action* approach.
- 48 teachers to participate in the ESEP Teacher Fellows Program, gaining a greater understanding of the process of science and how to deliver these concepts in the classroom.
- More than 2,200 interactive web lessons to be downloaded in 49 states 56 countries.
- 252 teachers (representing 20 counties) to participate in 283 hours of workshops and courses.

Recruiting and Building Talent at the Undergraduate and Graduate Level. Across the board, scientific panels and organizations such as the U.S. Commission on Ocean Policy and the American Association for the Advancement of Science stress the need for scientists with multiple skills and intellectual nimbleness who can negotiate the complexities of science and

research in the 21st century. Maryland Sea Grant is deeply committed to supporting graduate and undergraduate student training programs responsive to the rapidly changing demands of the marine science job market.

As students move on to college and graduate school, Maryland Sea Grant provides opportunities and support to encourage them to develop a deep and lasting connection to environmental science, whether in research, policy or management. Since 1989, the National Science Foundation has funded Maryland Sea Grant to administer a “Research Experience for Undergraduates” (REU) summer program, one of only two Sea Grant programs in the country to do so. This program supports a competitively selected group of undergraduates from across the country to spend 12 weeks working on a research project with a scientist/mentor from either the Chesapeake Biological Laboratory or the Horn Point Laboratory. This experience gives most students their first serious exposure to scientific research and for many serves as a springboard toward careers in the sciences.

Maryland Sea Grant adds an important dimension to its REU program that many other REU programs housed at universities cannot. In recognition of students’ research accomplishments, we provide support for select REU fellows to present at scientific meetings, such as the Estuarine Research Federation and Benthic Ecology conferences. In concert with the two labs, we also support a two-day program that brings minority students from Hampton University’s Multicultural Students at Sea Together (MAST) program with REU students for a series of talks, lab visits and a Chesapeake Bay science policy workshop. In cooperation with the Smithsonian Environmental Research Center (SERC), Maryland Sea Grant hosts a “Career Panel” program for REU students and SERC REUs and interns at the Smithsonian facility on the Chesapeake Bay. Further, Maryland Sea Grant works with the National Estuarine Research Reserve’s Jug Bay Sanctuary to run a half-day canoe trip for REUs to investigate the unique tidal freshwater wetlands of the Patuxent River in Maryland.

In 2000, Maryland Sea Grant launched its new “Maryland Sea Grant Research Fellows Program” to expand opportunities for graduate student funding and to enrich their educational experiences. This program has roots in our earlier “trainee” program, but has developed new dimensions. Principal Investigators compete for funding for a Fellow through an application and panel review system. Maryland Sea Grant currently supports 5 to 6 fellows each year for a two-year period and has supported a total of 20 fellows since 2000. Once selected, Maryland Sea Grant designs a two-year program to help fellows pursue exciting research while developing new skills. Every other summer, we hold a summer symposium for Fellows and publish their abstracts in a proceedings volume, thus giving the students an opportunity to learn about each other’s research, to practice giving a scientific presentation, and to produce a publication. The alternate summer, we conduct a one-day workshop on science communication. This effort emphasizes the importance of scientists connecting beyond academia. The workshop includes a panel of academics and “users” of the scientists’ information who discuss their interactions with scientists and how science can help them do their job.

Maryland Sea Grant enriches both the REU program and Fellows program by bringing these undergraduates and graduate students together. Fellows often participate in the day-to-day management of REU students during the summer, providing them invaluable teaching, communication and leadership skills. REU students in turn, benefit from close interactions with Fellows, learning “up close and personal” the daily highs and lows of graduate student life and the demands of research.

Maryland Sea Grant also supports student interest to explore the science-to-policy connection first hand by serving as a pass-through for the Knauss policy fellowship administered by the National Sea Grant Office. Our program has successfully placed an average of 3 students each year in the fellowship program, a total of 17 since 2000.

IMPACTS: FOLLOWING FELLOWS INTO THE FUTURE

Many Maryland Sea Grant Fellows and REU students from 2000-2005 have completed or are currently completing advanced degrees.

- 54% of the REU students contacted (70 out of 206) from 1989 to 2004 are currently enrolled or have completed Ph.D.'s or master's degrees. By gender, 77% of the men and 95% of the women entered graduate school.
- 13 Maryland Sea Grant Fellows are currently enrolled or have completed Ph.D.'s and 7 Fellows have completed or are completing master's degrees.
- Fellows who have completed degrees have gone on to post-doctoral fellowships, positions in state or federal agencies, or resource management.

Bolstering Free-Choice and Lifelong Learning. Opportunities for learning extend beyond traditional venues and conventional school ages. In recognition of the variety of opportunities for learning, Maryland Sea Grant has engaged in several education projects aimed at a wide range of publics.

Free-Choice Learning. At present there are nearly 6.1 million residents in Maryland and the District of Columbia who in some manner impact the Chesapeake Bay watershed and our coastal resources. Reaching this vast public presents a daunting task for a program of our scale and requires that we form innovative partnerships to leverage our expertise.

Our region is fortunate to have a wide variety of free choice learning venues (aquaria, museums and visitor centers), many of which have exhibits dedicated to coastal issues. Given that millions of coastal residents visit these facilities, Maryland Sea Grant sees this as an important opportunity to bring university-based science to new audiences. In 2004 we initiated a series of partnerships directed at this goal. First, we began collaborating with the Oregon Sea Grant (ORSG) program in the development of a conceptual framework for building a free choice learning capacity here in Maryland. Next we added two new members to our Advisory Board: Glenn Page, Director for Conservation at the National Aquarium in Baltimore (NAIB), and Dr. Lynn Dierking, Associate Director at the Institute for Learning Innovation (ILI) in Annapolis MD. Together these individuals provide experience and deep insights into free choice learning and the evaluation of programs targeted at this audience.

Together with Oregon Sea Grant, the National Aquarium, the Institute for Learning Innovation and Earth Echo International, Maryland Sea Grant has submitted a pre-proposal to NSF's Informal Science Education program for a multi-year effort to study and develop innovative programs in Maryland and Oregon. Building on the strengths of two aquaria (NAIB and the Hatfield Marine Science Center), the program will link university-based expertise to explore issues of watershed and coastal resource conservation on both coasts. Key in this effort will be a strong evaluative component that focuses on how effective we are in enfranchising the public and leading to substantive behavior change over time. By comparing venues of different sizes we hope to unravel how we might extend effective programs to new audiences in a wider variety of locations over time.

During the past year Maryland Sea Grant cooperated with the NOAA Coastal Zone Management Program and the Maryland Department of Natural Resources to design and produce four educational panel displays on Hurricane Isabel, a massive category-2 storm that slammed into the East Coast on September 18th, 2003. The panels display the science behind surging water levels produced by hurricane winds and provide eyewitness accounts of the storms, highlighted by dramatic pictures. These panels will be located near museums, visitors

centers, and other publicly-trafficked areas in Maryland that were deeply affected by the hurricane, including Annapolis, Fells Point in Baltimore, St. Michaels, and Solomons Island.

As part of a public outreach effort focused on non-indigenous species, Maryland Sea Grant also produced a poster that highlighted the risks of releasing non-native species to the environment. Produced in conjunction with the Maryland Association of Pet Industries, this poster became part of a coordinated outreach campaign, reaching more than a dozen pet stores throughout the state.

Another unique education program, and one that literally caters to adults, is *Savor the Bay*. *Savor the Bay* is a dinner seminar series offered three times a year in cooperation with local restaurants, offering the opportunity for participants to engage in lively discussions with researchers from the University of Maryland Center for Environmental Science about different environmental topics and with local chefs while delighting in a four-course meal prepared as part of the presentation.

IMPACTS: REACHING A DIVERSE PUBLIC IN NON-TRADITIONAL WAYS

From 2000-2005, Maryland Sea Grant has:

- Hosted 12 dinner seminars for 430 participants as part of the *Savor the Bay* series.
- Produced four educational display panels on Hurricane Isabel for display in Maryland coastal communities.
- Enlisted the support of more than a dozen pet stores to display a poster designed by the program on the risks of non-native species.
- Mounted a large-scale collaborative effort to bring the expertise of universities to bear on free-choice learning venues.

Future Focus: Deepening Connections and Engaging New Audiences. Maryland Sea Grant will continue to expand its educational programs, connecting at new levels and using its solid foundation to explore new opportunities. We will develop expertise with new technologies and creatively expand our use of the Web. Two examples highlight our scope for growth: 1) The Maryland Department of Juvenile Services partnership with *Aquaculture-in-Action* suggests how we can link with other organizations to increase a student's job skills and employment potential. 2) Sea Perch, an electronic "fish" with remote sensing and sampling capabilities developed by MIT Sea Grant, will become an education tool for students to study the Bay, introducing them to the growing role of marine and coastal observing systems nationwide.

As we begin to implement the recommendations of the U.S. Commission on Ocean Policy regarding marine education, Maryland Sea Grant will continue to engage in a wide range of activities — from educational programs aimed at adult learners to public school initiatives that bring marine-related science experiences into the classroom. In all these activities we will link adults, students and teachers with university-based science and the researchers who make it possible.