Coastal Technologies Portfolio
FROM INNOVATION TO APPLICATION: TECHNOLOGY FOR ENVIRONMENTAL PROBLEM SOLVING

Meeting the Technology Challenge

Coastal ecosystems, as well as the businesses that depend on products and resources from the marine environment, face challenges that call for the creative use of cutting-edge technology. From tracking nutrients dynamics in the open environment to developing new seafood products and other marine-related commodities, Maryland Sea Grant has fostered new approaches to solve tough problems and to take advantage of exciting new opportunities.

For the past 15 years, we have worked with scientists and engineers to foster scientific innovation that meets the needs of a changing watershed. Technology for commercial applications, especially those that have employed the tools of modern biology (molecular genetics and endocrinology) for aquaculture and natural product or process development have formed an important part of our "R&D" approach. In addition, we have fostered the application of onsite (in situ) and remote sensing methods to help us understand basic ecosystem processes and to provide key data for management of the Chesapeake Bay.

Maryland Sea Grant has worked to support important technological innovation both for immediate practical solutions and for creative explorations of new ideas. During the 1980s, for example, the state of Maryland was struggling to understand how to aid a diminished oyster fishery through aquaculture. Sea Grant Extension experts Donald Meritt and Donald Webster traveled to the Pacific Northwest and came back with improved techniques for remote setting of oyster spat — techniques not then used on the East Coast. They passed their knowledge on to others, and in this way they provided an important link in technology transfer and in the free flow of ideas, literally from coast to coast.

In other cases, researchers work to develop inroads into biological systems, to unlock potential uses of novel compounds or novel processes — of marine bacteria, for example. This portfolio describes recent advances achieved as a result of Maryland Sea Grant's commitment to supporting both technology transfer and the exploration of novel technological applications.

Consistent with goals articulated in our 2000-2005 Strategic Plan, the context for our investments in coastal technologies has evolved over the past five years to reflect several key elements. We have worked to:

- Catalyze interest and involvement by new investigators
- Expand our strong technology education and outreach effort
- Support Maryland's "underserved" seafood industry
- Foster greater industry linkages
- Balance "risk-taking" with potential payoff

Funding Opportunities as Catalysts

In a concentrated effort to nurture and support technological innovation, Maryland Sea Grant's 2004-2005 special Omnibus Request for Proposals focused exclusively on Coastal Technologies. This unique opportunity enabled us to address critical needs in a very directed manner. When combined with research projects supported through core funding and judicious use of program development awards, this endeavor represents a very extensive and far-reaching investment in technology-driven research, outreach and application.

Throughout the last five years, program development funds have also played an important role for research efforts in this portfolio — both as a catalyst to initiate efforts or extend ongoing efforts as well as a means to bring closure to ongoing work. Several of the

projects that will be highlighted in detail below, such as endocrinologist Yonathan Zohar's work on sterility in larval fish and microbiologist Ronald Weiner's work on marine bacteria, relied on program development funds for some initial "proof-of-concept" research. These awards have also helped to build an effective outreach component into our research endeavors. One such example is an ongoing education partnership with MIT Sea Grant, the National Aquarium in Baltimore, and the NOAA Alliance for Coastal Technologies that will bring cutting-edge sensor technology mounted on a remotely operated robotic fish called SeaPerch to K-12 science activities.

Program development funds also help leverage existing funds. For example, Maryland Sea Grant enhanced an investment made through a National Strategic Initiative on marine biotechnology to support researcher Daniel Fisher's research on the impact of endocrine disruptive chemicals originating in poultry manure. Subsequently, Edward Orlando received program development funds to examine a separate aspect of the problem and collaborated with Fisher in the process. Similarly, the ability to make small investments in new projects allows a rapid response capability to emerging problems. For example, after the putative harmful algae *Pfiesteria piscicida* became a national issue in the late 1990s, Maryland Sea Grant funded research through program development funds that used molecular tools to show that *Pfisesteria* had actually made its first appearance in Chesapeake Bay 50 years earlier (David Oldach and Grace Brush).

From Discovery to Applications: —A Common Thread

In each of the studies highlighted in this section on molecular approaches, Maryland Sea Grant's investment in basic science has led to important scientific discoveries ***and*** *applications with commercial value.*

Modern Tools for Commercial and Environmental Applications

Maryland Sea Grant has made a substantive commitment toward the use of molecular technologies for economic opportunities and novel environmental applications. With research and program development investments totaling over $430,000 since 2000, we have funded a diverse mix of short- and long-term projects that emphasize these integrated efforts.

The discovery of an estuarine bacterium with the ability to degrade compounds that normally resist breakdown (so-called recalcitrant) has led to a remarkable series of discoveries by Ronald Weiner and his research team (R/BT-7, R/BT-10). These researchers have shown that *Microbulbifer degradans* (2-40), isolated from decaying marsh grass (*Spartina*), contains a suite of enzymes capable of degrading chitin,

Seafood Science and Technology: A Unique Asset for Maryland

Maryland Sea Grant Extension maintains a central role in Maryland's seafood industry and provides unique support, such as introducing state-of-the art techniques for the development of new products. Sea Grant Extension Specialist Tom Rippen is working on new ways to use normally discarded crabmeat byproducts. Instead of using binding additives, his research focuses on the use of raw crab muscle as binder. Cooked, flaked crabmeat is mixed with raw crabmeat produced with a meat-bone separator, then stuffed into casings and cooked. After cooling, the casings are diagonally cut to produce pieces. This approach, if successful, will provide a clean label of 100 percent crabmeat, which should compete well with imitation product on the market. Further efforts are underway to develop innovative packaging systems that can withstand pasteurization. This partnership with industry (Cryovac Corporation, Ross Industries and commercial packing houses) represents the application of new technology from plant to market and ultimately to the consumer. Studies are also underway to optimize commercial handling and transport systems to improve crab survival on boats, in transport and in storage.

cellulose, pectin and other compounds typically found in plant cell walls. In addition, the extracelluar structures (degradosomes) housing many of these enzymes are quite exceptional. Funding from Sea Grant, with substantial input from the Joint Genome Institute of the U.S. Department of Energy, helped researchers sequence the complete genome of this bacterium (2-40), revealing tantalizing clues to the genetic basis for these novel functions. The project has led to one approved patent, six pending patents and one additional disclosure, as well as scientific publications and very strong mentorship of graduate and undergraduate students.

Maryland Sea Grant has made a significant investment in understanding and manipulating the core endocrine functions of fish species, information important both to the aquaculture industry and more recently to those interested in re-stocking depleted natural populations (*e.g.*, of shad). The detailed understanding of the growth hormone system (GnRH) developed by Yonathan Zohar's laboratory focused first on new technologies to enhance reproductive success. More recently research has explored how the same system can be manipulated to curtail reproductive development. Since sterile fish place much more energy into growth than do their fecund counterparts, the development of a non-invasive means to inhibit reproduction or simply eliminate it as early as the larval stage promises a significant payoff — bigger fish (R/AQ-1, R/A-3, R/BT-8).

While this long-term investment in studies of endocrine function heads towards its logical conclusion, we have continued to explore new territory in the field of fish growth regulation. A new investigator, molecular biologist James Du, is pioneering work to develop an original model system to examine fish muscle growth. The objective of his study is to detail both expression and function of a muscle growth inhibitor in zebrafish called myostatin, and he will determine if inhibition of myostatin leads to enhancement of fish muscle growth (R/CT-1). The research team has now developed a new quantitative assay (RT-PCR) and has used transgenic technologies to produce a new line of zebrafish that contain a muscle-specific green fluorescence protein (GFP), a tool that will be useful for studying gene expression. Du is also working closely with Maryland Sea Grant Extension Education Specialist Adam Frederick to develop an innovative programs based upon Du's emerging zebrafish studies.

Using Technology to Take the Bay's Pulse

Stakeholders have emphasized the need for coastal technologies that will aid efforts to understand, conserve and restore Maryland's coasts. This emphasis has grown over the past five years, and Maryland Sea Grant has responded with over $530,000 in funding for a variety of programs statewide.

Our long-term investment in the use of aircraft remote sensing to define seasonal productivity in the Bay has moved from initial support of operations to synthesis and outreach. Oceanographer Lawrence Harding's work has given us the first synoptic view of the Chesapeake Bay's biological processes — one that can help both managers and the public understand the large-scale spatial and temporal responses of plankton to changes in river flow and nutrient input (R/P-42, R/P-44).

Rip Currents: Developing Technology to Enhance Public Safety

The National Sea Grant Program, in partnership with NOAA's National Weather Service and the U.S. Lifesaving Association, operates a highly successful outreach campaign, *Break the Grip of the Rip!,* to educate beachgoers on rip currents, a potentially deadly coastal hazard. Maryland Sea Grant, reflecting the high profile of this issue nationwide, is currently funding a project that explores a novel use of technology to model and potentially predict rip currents along the Atlantic coast that could threaten lives and harm Maryland's busy beach economy. Civil engineer Robert Dalrymple is working to deploy a sophisticated camera system and to use new models for Ocean City, Maryland. This regional effort brings together scientists and outreach staff in Maryland and Delaware and has direct links to lifeguard associations along the coast (R/EH-3).

Linking this large-scale information on plankton dynamics to fish production through dynamic models is the logical next step, and a recently funded effort by fisheries biologist Edward Houde and Harding will focus on linking primary productivity to population distributions of a critical forage fish — bay anchovy (R/WQ-2). The NOAA Chesapeake Bay Office is funding a companion project that examines similar relationships in menhaden.

If we are to make progress in restoring the Chesapeake, we must understand the temporal and spatial distribution of different forms of nitrogen, a primary driver of eutrophication in the Bay and one of the most vexing challenges facing resource managers and decision makers. Urea, one form of nitrogen, is of particular interest because it is thought to be an important nutrient source for harmful algae. The ability to measure urea in real-time with an on the spot (in situ) sensor could be useful in understanding or even predicting harmful algal blooms (HABS). Through a valuable partnership with a commercial firm (EnviroTech), biologist Patricia Glibert and oceanographer Louis Codispoti have developed a prototype organic-nitrogen sensor that can measure urea, and they have deployed it in the Choptank River (R/CT-3). Direct telemetry data from the sensor is accessible in their laboratory and records fine-scale differences in urea concentrations over time. Building on this initial award, the team is now developing a small-scale near real-time autoanalyzer/sensor system to place on small boats. The instrument will be used to study the Maryland coastal bays (R/WQ-3) — a focus suggested in our 2000 program assessment.

Ultimately, understanding nutrient dynamics in the Bay will require learning more about how they move through different parts of the watershed. Maryland Sea Grant has invested in a novel new technology that promises to help document nutrient uptake in marsh habitat. A research team led by a new investigator, ecological engineer David Tilley, has developed a boat-borne hyperspectral scanner that links leaf reflectance in marsh vegetation to nutrient concentrations in the underlying sediments (R/CT-2). This technology should facilitate our understanding of nitrogen flux — a critical component in wetland function and restoration. The sensor generates a vast amount of data; and with much still being evaluated, the project is continuing with new funding from the Maryland/DC chapter of The Nature Conservancy. In addition, the University of Maryland Agricultural Experiment Station has provided additional funds to examine whether the technique can be used to detect stress in wetlands caused by heavy metals.

Technological Tools for the Future

Maryland Sea Grant's investment in coastal technologies has yielded high returns and will continue to be a focal area in future endeavors. Strong initial results from many of the pilot projects funded through program development funds successfully leveraged additional grants and jump-started new areas of investigation. Commercial applications are currently under development and Sea Grant-funded research has to date resulted in 10 patents, in various stages, with several new ones on the horizon. Improved capabilities under development for understanding the role that nutrients play in Bay ecosystem function have attracted interest from the management community.

Maryland Sea Grant's technology portfolio also reflects many of the emerging priorities on the national scene. Based on recommendations from the U.S. Commission on Ocean Policy, we are moving nationally towards an Integrated Ocean Observing System (IOOS), an effort that will integrate data deployed on buoys, gliders, ships and satellites to provide critical information on issues ranging from ocean health to homeland security. Our efforts in coastal technologies have already made important steps in the direction of many IOOS priority areas including: protecting human lives and livelihoods from marine hazards; understanding human-induced and naturally caused environmental changes and the interactions between them; and providing a scientific basis for implementation and refinement of ecosystem-based management. While many technologies will play a role in the restoration of Chesapeake Bay, ocean observing systems have the potential to make very important contributions. Building on

the foundation of support given to aircraft remote sensing, Maryland Sea Grant currently participates in the development of a new coastal observing system in the Mid-Atlantic. Assistant Director for Research, Fredrika Moser is an active participant in the nascent Mid-Atlantic Coastal Ocean Observing Regional Association. Participation in the early stages of this endeavor will ensure that Maryland Sea Grant makes a strong contribution towards bringing new data and tools to stakeholders. Our program has also partnered with the Alliance for Coastal Technologies (ACT) to develop several joint educational programs. ACT, a national consortium sponsored by NOAA and headquartered at the Chesapeake Biological Laboratory, is dedicated to the development, testing and validation of the ocean sensors that ultimately will be the heart the new observing systems. On a regional and sub-regional scale, Maryland Sea Grant will continue to play a key role, fostering creativity and innovation for projects in the Chesapeake watershed that define and calibrate linkages between physical factors and biotic responses.

IMPACTS: DEVELOPING TECHNOLOGY FOR ENVIRONMENTAL PROBLEM SOLVING

Maryland Sea Grant and the researchers it supports have:

- Developed a new molecular technology to study muscle development in fish.
- Discovered a novel marine bacterium that can degrade many hard-to-break down compounds, providing insight into organic carbon use in the environment. This research has produced 1 approved patent, 6 pending, and 1 additional discovery disclosure.
- Developed a novel boat borne sensor to improve marsh monitoring and assessment that will help restoration efforts in Maryland and beyond. The Maryland Department of Natural Resources and the U.S. EPA have expressed interest in this work.
- Developed a new sensor to measure urea concentration in real time that will help scientists and managers understand the links between plankton blooms and the nitrogen sources that fuel them.