Sea Grant College Program

The MIT Sea Grant College Program's fundamental purpose is to lead in the development of technologies that contribute to the field of ocean science and ensure the wise use of marine resources. In pursuit of this goal, the program supports research, education, and outreach in areas essential to developing the science and technological advances that address critical problems in human use of the sea. Of particular importance is the development of systems that provide ever-increasing accuracy and range in exploration, data gathering, analysis, and understanding of marine processes.

Essential to this purpose is the transfer of knowledge to and within the program's broad constituency—industry, government agencies, public and private educational institutions, and the general public.

The program can be loosely organized into three areas of endeavor:

- The Autonomous Underwater Vehicles Laboratory
- Funded research projects
- Education and advisory services

There is some crossover of function between these areas. For example, all three groups have an active educational component, ranging from funding graduate students to designing K-12 classroom projects.

We also encourage a useful cross-fertilization of ideas, issues, and solutions between the three areas that is highly productive in addressing our strategic goals, which are to:

- Create the technology—the tools—that the oceanographic community needs
- Engineer solutions to the problems facing ocean and coastal fisheries
- Expand the realm of basic scientific knowledge of the oceans

We meet these goals with a combination of projects and initiatives by the program's research and outreach staff, the larger MIT research community, and the broader ocean science community in the Commonwealth of Massachusetts.

Autonomous Underwater Vehicle Laboratory

The MIT Sea Grant College Program is generally credited with developing the current generation of autonomous underwater vehicles (AUVs)—small, inexpensive, artificially intelligent, robotic submarines for undersea exploration (Figure 1). Today, an increased focus on oceanographic data needs, advances in enabling technologies, regional collaborations for more synoptic research programs, and the challenges of remote, extended missions continue to drive the development of the AUV as a viable and essential ocean research tool. In the past five years, we have pulled together a very strong field team of four engineers capable of conceiving, designing, implementing, and executing complex field experiments addressing key scientific questions.

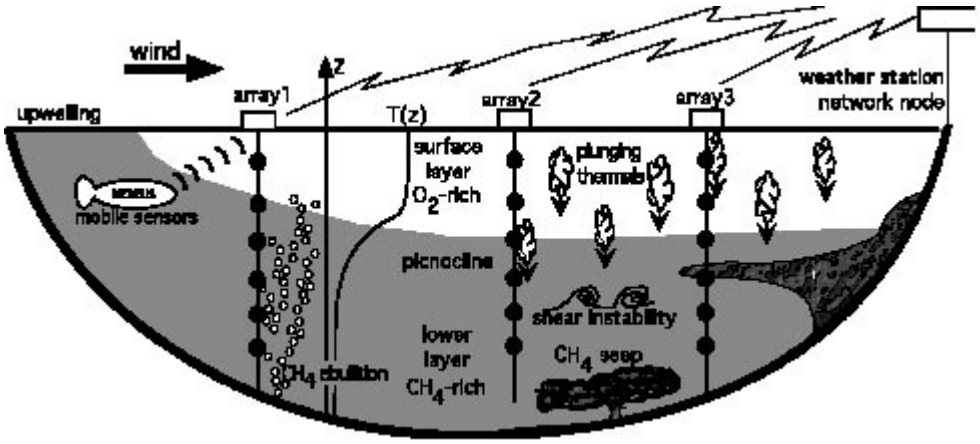

Figure 1. An autonomous underwater vehicle harvests data as the mobile component of a network of aquatic sensors. From "Sensor Networks for the Study of Heterogeneous Fluxes in Lakes," by H. Hemond, C. Chryssostomidis, and H. Nepf. Funded by the National Science Foundation.

In the area of vehicle design, MIT Sea Grant engineers are working with the next-generation AUV, a hovering craft capable of maintaining its position even in the presence of strong external excitation. Various sizes are being investigated. Working with Bluefin Robotics Corporation, the lab built a prototype for a suitcase-sized hovering vehicle with homeland security applications, which has been transferred to Bluefin for commercial development. The conceptual design of a larger hovering vehicle is being developed to serve in ultradeep offshore oil fields. They will make it possible to extract hydrocarbons from these recently discovered ultradeep fields at a reasonable cost.

A more recent focus for our program is underwater communications, where we are positioning ourselves as leaders. Our staff includes Dr. Milica Stojanovic, a recognized authority in signal processing, and Dr. Ethem Sozer, who first joined us as a postdoc and is now a research engineer specializing in the field. We have strengthened our collaboration with Woods Hole Oceanographic Institution to provide additional capability in hardware design. In April 2003, we held a symposium to identify critical research in the area of underwater communications. The proceedings of that symposium have provided a research blueprint for the communications community at large. Our near-term goal is to develop near-real-time communication between any two nodes in our network; our long-term goal is to develop multiple-agent communication and control.

Our new focus in the area of marine sensors is also beginning to bear fruit. We have entered into funded collaborations with the University of Massachusetts, and MIT's Civil and Environmental Engineering and Chemistry departments to design and produce chemical sensors to be deployed on board our AUVs. We are particularly excited about the collaboration with the Chemistry Department, as this allows us to enter a new field of marine sensors based on biotechnology principles. This also lays the foundation for our research in perception and life sciences that includes agent management, data acquisition, fusion, and interpretation.

In parallel with our work on AUV's, we maintain our excellence in our long-established research areas, addressing significant problems in living-resource management, coastal processes, and ocean engineering. One example would be our research in Lorenz force actuation, where the basic idea is to use electromagnetic force to control the surface/fluid interface of marine structures. We have started experimenting with this technology in underwater communications, specifically with creating modems capable of transmitting over a very wide range of frequencies, and of modulating and focusing signals almost at will.

We continue to collaborate with colleagues from around the Institute and other universities nationwide, and with our industrial partners, to raise additional funds for leading-edge ocean engineering research in those areas identified in our strategic plan (http://web.mit.edu/seagrant/aboutus/strategicplan/index.html). Currently we have funds from such sources as the National Science Foundation, the Office of Naval Research, private industry, and the Northeast Sea Grant Consortium.

Funded Research

Each year MIT Sea Grant conducts a competitive grant-funding process as mandated by the National Oceanic and Atmospheric Administration through its National Sea Grant Office. Grants are available to researchers throughout the Commonwealth of Massachusetts. The proposals selected support the goals outlined in our strategic plan, developed with input from our advisory committees.

Like the other 29 Sea Grant programs, we are required to match every two dollars of our federal grant with one from nonfederal sources. This year we are supporting the several major research projects with grants that average awards of $75,000 per year for two years.

New Projects (Begun March 2005)

- Development of a Bioindicator Species for Environmental Exposure to Spermatotoxicants: A Parameter of Fisheries Stock Management (Gloria Callard, Boston University)
- A General Methodology for Evaluating Bed Sediments for Narcosis Toxicity (Philip Gschwend, MIT)
- Software and Control Development for the Small Hovering Autonomous Vehicle (Franz Hover, MIT)
- Use of Passive Acoustics to Determine Spawning Time and Fecundity of Haddock (Francis Juanes, University of Massachusetts)
- Stable Isotopic Measurements in Shellfish as Sentinels of Multiyear Changes in Coastal Environments (Ivan Valiela, Boston University)
- In Situ Detection of Zooplankton Grazing (Juanita Urban-Rich, University of Massachusetts)
- Hydrodynamic Optimization of Staggered Schooling in Fish Swimming and Flapping Foils (Alexandra Techet, MIT)
- Classifying Hurricanes with Natural Underwater Sound (Nicholas Makris, MIT)

- Developing a Classroom Eelgrass Cultivation Program for Massachusetts (Brandy Moran, MIT)
- Assessing Risk of Marine Introductions by Vessels in Small New England Ports: A Community Development Program (Judith Pederson, MIT)

Continuing Projects (Begun March 2004)

- Development of a Rapid, In Situ Sensor System for Monitoring Bacteria in Coastal Waters (Julie Carruthers, University of Massachusetts)
- Retrofocusing Techniques for High-rate Acoustic Communications (Milica Stojanovic, MIT)
- Biomimetic Rigid Hull Vehicles with Flapping Foils for Enhanced Agility in the Surf Zone and Cluttered Environments (Michael Triantafyllou, MIT)
- Autonomous Multiscale Digital Imaging of Ocean Species (Cabell S. Davis, Woods Hole Oceanographic Institute)
- Data Fusion for Large-scale Cooperative Autonomous Ocean Mapping (John J. Leonard, MIT)
- Basic Scaling Law in Fast-starting and Rapidly Maneuvering Fish (Michael Triantafyllou, MIT)
- An Experimental Investigation of Lorentz Force Actuators for Control of Separated Flows and Associated Noise Around Marine Vehicles (Hamid Johari, Worcester Polytechnic Institute)

Advisory Services, Outreach, and Education

Part of Sea Grant's national and local mandate is to provide practical assistance to local communities, industries, educational institutions, coastal managers, fishermen, and the general public. The following is a sample of our advisory staff's current activities.

- *Stretch-mesh catch controls.* Design and testing in Gloucester, MA, of a trawl with a section of elastic netting as a way to reduce catches of undersized groundfish.
- *Whale-free buoy efficacy tests.* Testing of a buoy designed to resist entanglement by marine mammals. This buoy has received a US patent.
- *Selective gillnets for winter flounder.* Evaluation of a new design of gill net that targets winter flounder.
- *Low-impact scallop dredge.* Development of a habitat-sparing scallop dredge that does not scrape up the sea floor.
- *Sand lance sampling gear development.* Gear to aid in collection of sand lances, to evaluate their function in the food web of Stellwagen Bank, at the mouth of Massachusetts Bay.
- *Passive acoustic detection of cod and haddock.* Autonomous underwater listening stations are being designed to monitor vocalizations from spawning cod and haddock for better decisions on protective closures of fisheries.
- *Assessing Risk of Marine Introductions by Vessels in Small New England Ports: A Community Development Program.* Researchers are working with small ports and harbors in Massachusetts to prevent or reduce invasions by aggressive introduced species such as the sea squirt.

- *Marine finfish hatchery.* MIT Sea Grant's hatchery is located at the Maritime Heritage Center in Gloucester and is an experiment in hatching marine finfish (fingerlings) to see if these species can be successfully aquacultured.

K-12 Education

MIT Sea Grant has always been active in K-12 education and we continue to create unique marine education programs that range in scope from very local to national.

The Sea Perch Program

Using the expertise of our AUV Lab, we are developing a groundbreaking educational initiative in underwater robotics. Last year we began training high school teachers in the construction of a small, remotely operated vehicle called a Sea Perch. This little vehicle can be put together by teachers and students in a day-and-a-half (Figure 2), and then deployed in any nearby body of water for a hands-on experience in basic engineering and underwater exploration. The project has been extremely successful and our goal is to move it to a national stage. So far we have engaged Sea Grant partners in four neighboring states, and established a working alliance with the Museum of Science and with two professional societies. Our future plan is to team with the remaining Sea Grant Programs and the National Organization of the Museums of Science, and then recruit contacts within national aquaria. Our ultimate goal is to develop a national model for a self sustaining K-12 Sea Perch program.

Figure 2. Students building Sea Perches. Project jointly funded by MIT Sea Grant and Office of Naval Research.

Adopt-a-Boat

Through this program, commercial fishermen from Maine to Massachusetts, from seasonal lobstermen to captains of offshore trawlers, are partnered with classrooms. Each boat is linked with a classroom that may be in the same geographic region as the vessel's homeport or may be hundreds of miles away. Activities include visits, field trips, and information exchanges directly from the boat to the class. Through Adopt-a-Boat, fishermen help educate students about marine ecology, the complexities of marine resource utilization, and the daily life of fishermen.

Aquaculture in the Classroom

This activity is an extension of our Gloucester Marine Finfish Hatchery. We partner with science teachers, outfitting several Commonwealth schools with recirculating aquaculture systems for student participation and study.

Developing a Classroom Eelgrass Cultivation Program for Massachusetts

Eelgrass is both the most abundant sea grass in Massachusetts and one of the most ecologically valuable marine and estuarine habitats in North American coastal waters. In this project, students learn to cultivate eelgrass as part of a polyculture recirculating aquaculture system.

Faculty, Staff, and Oversight Committees

MIT Sea Grant College Program's management team consists of a director, Professor Chryssostomos Chryssostomidis; an associate director, Dr. Milica Stojanovic; and an associate director for research utilization, Dr. E. Eric Adams. Dr. Adams's research portfolio is in coastal processes, and Dr. Stojanovic's is in underwater communications. Professor Chryssostomidis is responsible for overall program management, including planning for the future.

MIT Sea Grant is overseen by a presidential committee consisting of 12 faculty members from six departments of the schools of Science, Engineering, and Management. One of the principal tasks of the committee is to advise the MIT Sea Grant management team as to research directions and opportunities. Four members can rotate out of the committee each year. The MIT Sea Grant Committee is supported and complemented by the State-Industry Committee. This external committee includes leaders of local industry, faculty members from neighboring universities, and representatives of state government and key nongovernmental organizations. The breadth, flexibility, and dedication of these two committees are key ingredients in the success of the MIT Sea Grant College Program.

The director is assisted by Mr. Richard Morris, executive officer; Mr. Timothy Downes, administrative officer; Mr. Clifford Goudey, marine advisory leader; Ms. Kathy de Zengotita, assistant to the director; and three administrative staff (two full-time equivalents [FTEs]). In addition, MIT Sea Grant employs nine (8.5 FTE) research engineers to support our research activities, which include research in AUVs and our other externally funded research. Our Advisory, Education, and Communications Program is executed by our advisory staff (5.7 FTE), whose activities include anthropological research in fisheries, control of nonindigenous species, public education, and communications.

Chryssostomos Chryssostomidis
Director
Henry L. and Grace Doherty Professor in Ocean Science and Engineering

More information on the Sea Grant College Program can be found online at http://web.mit.edu/seagrant/.