Sea Grant College Program

The National Sea Grant Program supports research, education, and outreach activities that address critical problems in human use of the sea. At the MIT Sea Grant College Program, we focus on developing the scientific and technological systems that can 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 (AUV) Laboratory
- Funded research projects
- Education and advisory services

Autonomous Underwater Vehicle Laboratory

The MIT Sea Grant College Program is historically credited with the creation and development of AUVs—small, inexpensive, artificially intelligent, robotic submarines for undersea exploration. In keeping with this tradition of innovation, the laboratory's current strategic plan revolves around these key elements:

- Building a strong field team capable of conducting critical ocean experiments
- Developing the next generations of AUVs
- Designing and implementing near-real-time, multiuser, underwater communications systems.

Hovering AUVs—the Next Generation

Odyssey IV

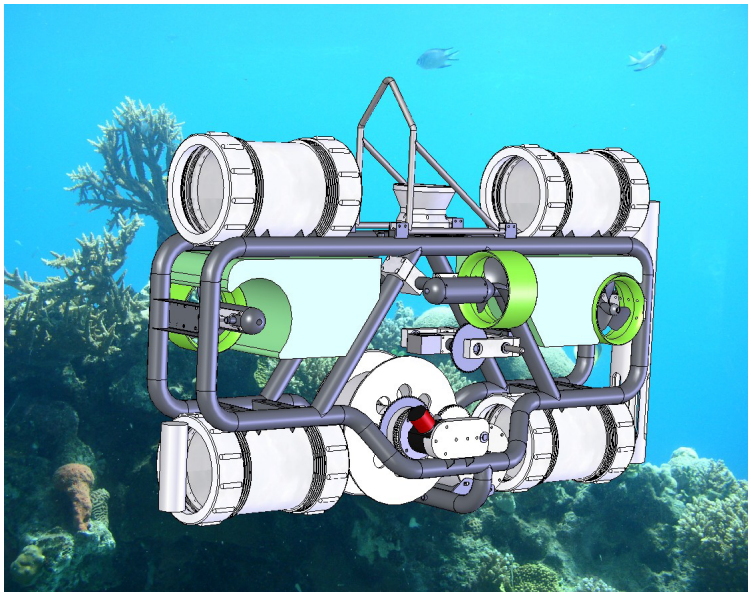
The lab has completed construction of its third hovering vehicle, a deep water AUV rated to 6000 m and designed for high-speed dives and ascents. The vehicle was tank-tested this May with good results.

Odyssey IV is currently outfitted with sonar instruments provided by Edgetech, Inc. (formerly EG&G, founded by Doc Edgerton). It is currently being prepared for use, in collaboration with the National Oceanic and Atmospheric Administration (NOAA) and the National Marine Fisheries Service, in tracking the extent and spread of a recent infestation of *Didemnum sp.*, an invasive tunicate, on the seafloor at the important offshore fishing grounds of George's Bank.

This coming year, Odyssey IV will also be included in the Chevron MIT University Partnership Program, which seeks to develop technology for ultra deep-water oil and gas exploration, development, and production.

Reef Explorer

The lab has added another hovering vehicle to its fleet this year: Reef Explorer, currently being prepared for an expedition to Hawaii where it will play a key role in an educational mission, exploring coral reefs far offshore and beaming live video back to classrooms on the island and to the web. Transmission is via a buoy deployed to the surface as the vehicle hovers over the reef deep below.



Conception of Reef Explorer's Hawaii mission.

Autonomous Surface Craft

Katrina

Katrina is a diesel electric vertical-profiling autonomous surface craft designed to take water quality measurements in lakes, rivers, and calm ocean environments. The boat can run either autonomously, executing mission scripts, or remotely controlled by a human operator.

On an ordinary mission the boat will go to a series of way points and take a vertical profile of water quality measurements using a sensor array on a winched cable. The navigation sensors currently outfitted on the boat are a GPS, compass, six-axis inertial measurement system, depth sounder, and a paddle wheel speed sensor. A radar and video camera are available for obstacle avoidance.

This year the lab tested Katrina in the Charles River where it handled well at speeds up to 10 knots, in rough water, and with winds gusting up to 30 knots.

Katrina on a test run in the Charles River, March 2007

An unexpected benefit of the Katrina boat is that it can also be used in data assimilation, a technique used to improve the predictive accuracy of major oceanographic computer codes. A joint project with Rutgers has allowed us to determine the optimum location of ocean measurements for use with data assimilation for ocean circulation prediction. Such a capability has opened up a completely new line of investigation, which will allow the laboratory to participate in cutting-edge research in physical oceanography. This capability has direct applications in defense, oil exploration and production, and global warming.

Underwater Acoustic Communication

Deploying AUVs in a network with other subsea devices requires a dramatic improvement in underwater signal processing capability, both to enable vehicle navigation and for data collection and transmission. Our underwater communications group is led by Dr. Milica Stojanovic, who is one of the key participants in a number of major research projects funded by the National Science Foundation, NOAA, the Office of Naval Research, and industry. Her research continues to focus on signal processing with a major thrust in underwater communications, from assessing the fundamental acoustic channel capacity to new modulation and detection methods that promise high-rate, low-complexity implementations.

Additionally, this year we have started developing research in the area of underwater network protocols. The objective here is to allow communication among distributed sensor nodes, including mobile assets. The acoustics group has also hosted a number of international students and visiting scholars who have assisted significantly in the work.

Funded Research

MIT Sea Grant conducts a yearly funding competition as mandated by NOAA through its National Sea Grant Office. Grants are available to researchers throughout Massachusetts. Proposals selected support the goals outlined in our strategic plan and we are required to match every two dollars from our federal grant money with one from nonfederal sources. This year we are supporting the following major research projects with grants that average $75,000 per year for two years, and one larger, six-year project focused on solving an issue of national importance:

New projects, begun February 2007

- Wendell Brown, University of Massachusetts-Dartmouth
  An Investigation of Transient Tidal Eddies in the Western Gulf of Maine
- Matthew Charette, Woods Hole Oceanographic Institution
  Development of a Radon/Nitrate Mapping System for a Large Scale Assessment of Submarine Groundwater Discharge and Non-Point Source Pollution to Coastal Waters
- Douglas Hart, MIT Department of Mechanical Engineering
  Versatile, High-Resolution, Low-Cost AUV 3D Sensor
- John J. Leonard, MIT Department of Mechanical Engineering
  Adaptive Mapping of Complex 3-D Marine Environments
- Milica Stojanovic, MIT Sea Grant College Program
  Acoustic Communication Networks for Distributed Autonomous Underwater Platforms (Six-Year Focused Research Project)
- Tim Verslycke, Woods Hole Oceanographic Institution
  Development and Validation of in vitro Bioassays for Pesticides in Coastal Waters

Continuing projects, begun February 2006

- Cliff Goudey, MIT Sea Grant
  Acoustic Height Control for Trawl Doors
- GeorgeKarniadakis, MIT/Brown
  Design of New Hybrid Actuators for Drag Reduction and Underwater Acoustic Communications
- Jeffrey Lang, MIT Department of Electrical Engineering and Computer Science
  Touch-at-a-Distance: Pressure Microsensor Arrays for AUV Navigation (Six-Year Focused Research Project)
- Changsheng Chen, University of Massachusetts-Dartmouth
  Development of a Management Model System for the New England Shelf
- Nicholas Makris, MIT Department of Mechanical Engineering
  Classifying Hurricanes with Natural Underwater Sound
- Janina Benoit, Wheaton College Chemistry Department
  Fate of Sedimentary Monomethyl Mercury in Boston Harbor
- Richard Limeburner, Woods Hole Oceanographic Institution
  Nantucket Sound Circulation—Observations, Analysis, and Model Development

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.

Fisheries Engineering

Our advisory group has a long history of providing innovative engineering solutions to problems with traditional gear used in local fisheries. Currently a variety of devices and systems are being designed, built, and tested, among them:

- a new kind of buoy that prevents entanglement by marine mammals
- control systems for trawlers that allow bottom-following by trawl doors to keep them from gouging the seabed
- a low-impact scallop dredge, also to prevent scraping up the sea floor
- Autonomous Underwater Listening Stations (AULSs) that monitor vocalizations from spawning cod and haddock, to help with decisions on fisheries closures
- an offshore aquaculture cage that is self-propelled and remotely controlled.

Coastal Resources Management

Advisory Services also provides information, assessments, and recommendations to government and industry decision makers so that policies and practices that affect our coastal waters will be based on good science. Activities this year included:

- an ongoing, five-year project to create a Regional Ocean Research plan to provide a valid scientific basis for managing the Gulf of Maine ecosystem
- convening the 5th International Conference on Marine Bioinvasions (http://web.mit.edu/seagrant/bioinvasion2007/), May 21–24, 2007, here at MIT
- conducting a Rapid Assessment Survey (http://massbay.mit.edu/exoticspecies/ras/RASfactsheet.html) of nonnative marine species with taxonomic experts from Massachusetts to Maine.

Education

Educating students at all levels, and the general public, about the sea and its resources is also a mandate of the advisory group.

To support this goal, we maintain the Marine Finfish Hatchery and Education Center (http://web.mit.edu/seagrant/edu/hatchery/index.html) at the Maritime Heritage Center in Gloucester, MA. This facility conducts research on the egg, larvae, and juvenile stages of marine finfish to determine if they are viable candidates for aquaculture. The hatchery has a display on aquaculture and is open to the public for tours and field trips. From the hatchery several valuable programs have evolved:

- Aquaculture in the Classroom, which outfits several Commonwealth schools with recirculating aquaculture systems for student participation and study.
- The Classroom Eelgrass Cultivation Program for Massachusetts, where students learn to cultivate eelgrass as part of a polyculture recirculating aquaculture system. The goal is to develop a program in which Massachusetts schools will grow eelgrass from seed and then replant their seedlings in local waters in a statewide eelgrass restoration initiative.

Sea Perch

Perhaps our most groundbreaking educational initiative has been in underwater robotics, in the many versions of the Sea Perch program.

Currently the program involves training high school teachers in the construction of a small, remotely operated vehicle called a Sea Perch, which is then deployed on some "mission" in a local body of water.

Sea Perch program participants in Hawaii. The AUV Lab's Coral Reef Explorer mission developed out of this event.

Teachers from dozens of schools around the country have participated in Sea Perch training. This year, among other trainings, the MITSG staff traveled to Savannah, GA to present the lead program in the Ocean Sciences Education Leadership Institute's "Underwater Research and Technology" seven-day residential workshop for middle and high school teachers from the Southeast region.

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. The three are jointly responsible for planning the future research direction of the program.

MIT Sea Grant is under the oversight of a presidential committee consisting of faculty members from Sloan School and seven departments from the Schools of Science and Engineering. 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 nongovernment 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, who will retire on June 30, 2007. Our plan is to appoint Ms. Kathy de Zengotita to that position in an acting capacity. Administration staff includes Mr. Timothy Downes (administrative officer), Mr. Clifford

Goudey (marine advisory leader), Ms. Kathy de Zengotita (currently assistant to the director), and three administrative support staff (two FTEs). MIT Sea Grant also employs eight (7.5 FTE) research engineers in our AUV section and in support of our other externally funded research. Our Advisory, Education, and Communications Program is executed by our advisory staff (4.5 FTE), whose activities include anthropological research in fisheries, control of nonindigenous species, public education, and communications.

Sea Grant funds research in various MIT departments. In addition it is home base for four undergraduates doing in-house research, three visiting students, and two graduate students. We also support young MIT faculty by awarding the Doherty Career Development Chair for Ocean Utilization. This year's recipient is Roman Stocker, assistant professor in the Department of Civil and Environmental Engineering, for work in microfluidics that gives biologists the ability to study the movements of microorganisms in the marine environment.

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

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