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, our focus is on developing 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 Vehicle (AUV) Laboratory
- Funded research projects
- Education and advisory services

Autonomous Underwater Vehicle Laboratory

The MIT Sea Grant College Program is historically credited with creating and developing AUVs—small, inexpensive, artificially intelligent, robotic submarines for undersea exploration.

The lab's newest vehicles are Odyssey IV, a deep-water AUV with hovering capability, rated to 6,000 m and designed for high-speed dives and ascents, and Reef Explorer II, which is designed to maneuver in delicate underwater ecosystems without harming its environment.

Odyssey IV

The Chevron Corporation, Office of Naval Research, and Sea Grant together have funded development of the Odyssey IV, a vehicle capable of supporting both ultra-deepwater oil production and oceanographic research missions. The AUV Lab staff were busy this year developing, testing, and refining the vehicle's systems to comply with the mission demands of Chevron's deepwater project. The vehicle has been outfitted with a nonintrusive load monitor to track power usage and activity. A 1,200-bit/s acoustic modem has been integrated that will allow the vehicle to transmit status signals during a mission and receive supervisory control signals from operators onboard the surface ship without the use of a

Odyssey IV being deployed from a Gloucester dock.

tether. This system will receive extensive testing during the coming year when the vehicle runs survey missions at 50-m depths in Cape Cod Bay and then in deeper diving maneuvers beyond the continental shelf.

Odyssey IV has a number of characteristics that make it an excellent platform for underwater exploration. Its energy storage and power management system can support payloads requiring up to 1.5 kW (peak power). Live supervisory command and control and small amounts of science data upload are available via acoustic modem. It is stable in towed flight and can perform fast, drop-weight assisted dives. Reaching target depth triggers a weight release mechanism and transition to controlled flight. A hover-capable design, Odyssey IV is controllable from zero speed up to 1.5 m s^{-1} in sustained survey runs. Powerful vectored thrusters are used for hovering in place or precise four-degree-of-freedom maneuvers (control of surge, sway, heave, and yaw). Navigation suitable for exploratory missions is via Doppler velocimeter-aided dead reckoning, which eliminates the need for reference beacons on the sea floor and increases operational flexibility.

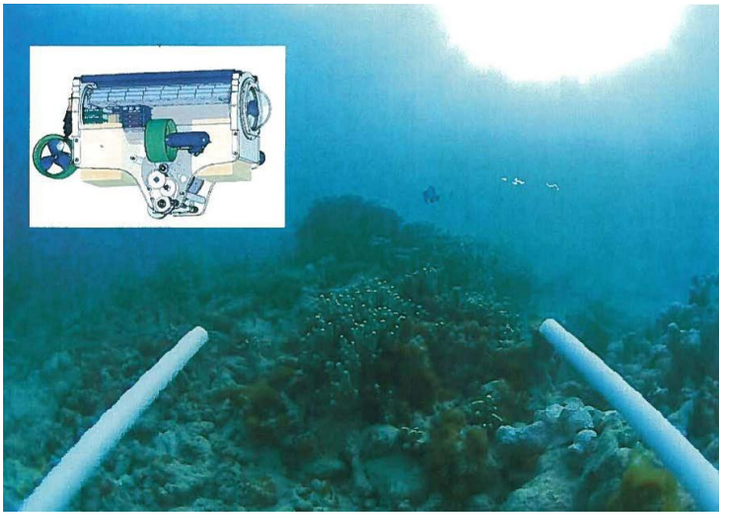
The *Didemnum* Cruise, July 2008

Odyssey IV has also been configured to support research in biological oceanography. In July 2008, we deployed the vehicle to the fishing grounds of Georges Bank from the deck of the National Oceanic and Atmospheric Administration (NOAA) *R/V Bigelow* to map the distribution of an invasive tunicate, *Didemnum vexillium*. For the duration of 10 highly successful runs, the vehicle maintained constant altitude, recorded geo-referenced data, and logged its location for each optical image recorded, while continuing to record additional environmental data (e.g., temperature, salinity, and pH).

A DIDSON (dual-frequency identification sonar) and an optical camera system were mounted on the vessel to collect images to be used in identifying seafloor-dwelling species and their relative abundance. The optical camera provided a valuable collection of visual images of the *Didemnum* infestation with which to judge the extent and density of the mats it forms. There was less success with the DIDSON, which did not provide sufficient detail to distinguish *Didemnum* from the surrounding gravel habitat. We will therefore continue this work by researching other potential sensors for which the Odyssey IV is a suitable platform.

Reef Explorer

Reef Explorer (or REX II as the current version is titled) is a lightweight, hybrid AUV remotely operated underwater vehicle (ROV), particularly well suited to shallow-water missions. It has a substantial payload volume in spite of its light construction and is exceptionally easy to deploy and maneuver. Because of



REX II camera view as it hovers over a Hawaiian reef. Inset is a schematic drawing of the vehicle.

these qualities, it is in constant demand among our own staff and our collaborators both as an environmental scout and as a test bed for sensors, manipulators, and communications experiments.

This year, REX II has been heavily used by our education and outreach staff. It made an appearance at the Fourth Annual Maker Faire in San Francisco in late May 2009. The vehicle also spent considerable time on loan in Hawaii, collaborating on a classroom project for remote viewing of coral reefs via the web. The AUV Lab is looking forward to REX being back in the lab full time during the coming year for testing the sensors and other equipment being developed for Odyssey IV for the Chevron project.

Research

Underwater Communication

Networking AUVs with other subsea devices calls for a dramatic improvement in underwater signal processing capability, both to enable navigation and to collect and transmit data. Our underwater communications group is led by Dr. Milica Stojanovic, who is a key participant in major research projects funded by the National Science Foundation, NOAA, the Office of Naval Research, and industry. She is a frequent participant in international conferences and teaches at Northeastern University in addition to her part-time appointment with MIT Sea Grant. Her publications for this reporting year are:

- M. Stojanovic, Design and Capacity Analysis of Cellular Type Underwater Acoustic Networks, *IEEE Journal of Oceanic Engineering*, Vol. 33, No. 2, April 2008, pp. 171–181.
- D. Lucani, M. Medard, and M. Stojanovic, Underwater Acoustic Networks: Channel Models and Network Coding based Lower Bound on Transmission Power for Multicast, *IEEE Journal on Selected Areas in Communications*, Special Issue on Underwater Wireless Communications and Networks, December 2008, pp. 1708–1719.
- A. Harris, M. Zorzi, and M. Stojanovic, Idle-Time Energy Savings Through Wake-up Modes in Underwater Acoustic Networks, *Elsevier Ad Hoc Networks Journal*, Vol. 7, No. 4, June 2009, pp. 770–777.
- M. Stojanovic and J. Presig, Underwater Acoustic Communication Channels: Propagation Models and Statistical Characterization, *IEEE Communications Magazine*, January 2009, pp. 84–89.
- P. Ceballos and M. Stojanovic, Adaptive Channel Estimation and Data Detection for Underwater Acoustic MIMO OFDM Systems, submitted to *IEEE Journal of Oceanic Engineering*, June 2008.
- W. Zhang, M. Stojanovic, and U. Mitra, Analysis of a Linear Underwater Acoustic Network, submitted to *IEEE Journal of Oceanic Engineering*, January 2009.

Recently Dr. Stojanovic's group has focused on demonstrating the feasibility of wireless underwater video transmission, a new field of endeavor. The group proposes to combine the latest video compression technology (e.g., MPEG-4) with recent advances

in high-speed underwater acoustic signal transmission. Real-time, underwater video transmission would constitute an important breakthrough in the field of oceanography.

The group is currently working on a specific application of this technique to monitor deep-sea oil fields. Initial tests were conducted to assess the ambient-specific noise in this environment. These results will be used to design communications signals that are best suited to the problem at hand.

The acoustics group's work is supported by a number of visiting students from the Polytechnic University of Barcelona, who spend between 9 and 12 months working with us on a specific topic in underwater wireless communications. Their work at MIT, under Dr. Stojanovic's supervision, both supplements our research and contributes toward completion of their graduate theses (equivalent to our SM degree). The students are self-funded and selected by competition. Some of the SM theses that have resulted from this international collaboration are:

- J. M. Montana, Energy Efficient Underwater Acoustic Networks
- J. Miguel, Adaptive MIMO Detection of OFDM Signals in an Underwater Acoustic Channel
- P. Ceballos, Implementation of a Wireless Underwater Video Link Using a Software-Defined Acoustic Modem
- A. P. Dolc, Power Saving Techniques for Underwater Networks
- A. Porto, Channel Sharing Methods for Underwater Acoustic Networks

Electric Ship Research and Development Consortium

MIT Sea Grant director Chryssostomos Chryssostomidis is active in the nationwide Electric Ship Research and Development Consortium (ESRDC) whose mission is to design an all-electric vessel for the US Navy. The group is managed by the federal Office of Naval Research, with participation from leading electric power research institutions and senior naval officers. The MIT ESRDC team is led by Professor Chryssostomidis and includes Professors George Karniadakis of Brown University and MIT, Richard Kimball of Maine Maritime and MIT, Michael Triantafyllou of MIT Mechanical Engineering, Steve Leeb of MIT Electrical Engineering and Computer Science, James Kirtley of MIT Electrical Engineering and Computer Science, and Franz Hover of MIT Mechanical Engineering. The professors are assisted by research scientist Julie Chalfant and postdoctoral appointee Mirjana Milosevic.

The overall goals of the ESRDC program are as follows:

- Design all systems for an all-electric warship: propulsion, pulsed power weapons, sensors, and all other functions
- Substantially reduce vessel volume and weight through the all-electric design
- Establish naval facilities for the vessels and assemble trained staff to evaluate and monitor emerging technologies and costs
- Work with university partners to assess longer-term options and train students in electric ship technology

The MIT team is responsible for the stochastic modeling of the electromechanical components and for providing the vessel with a supervisory "brain" that can quantify the sensitivity of the system and adjust its performance according to operating conditions, varying material properties, and diverse mission scenarios.

This year we created the basic design tool to evaluate the merits of changes one might make to the propeller and propulsion motors. We analyzed two propeller–motor combinations that have the potential to produce substantial weight savings. Next we will expand the scope of this tool to test overall architecture, including a fully integrated simulation of electrical, hydrodynamic, thermal, and structural components of the ship operating in a seaway.

In a parallel effort, we developed a suite of open-source computer codes for designing and testing propellers and turbines called OpenProp. The program's numerical model is based on the vortex lattice lifting line methods used by the US Navy and commercial designers. The code is written in MATLAB M-code, widely used in academia and industry. We are now focused on code integration, graphical user interface development, and streamlining the propeller prototype manufacturing process. Our intention is to release OpenProp Version 2.0 by November 2009.

For the electric ship's power system, we are using a random network theory approach, in which the network generation parameters, rather than realizations, are optimized for robustness to failures. Two general approaches are proposed, one in which an entire network can be optimized from the ground up and another in which a smaller set of edges, added to a preexisting network, is optimized.

Mathematic developments were carried out on two fronts: (1) completion of a detailed simulator, and (2) advancing polynomial chaos to high dimensions. We are creating an end-to-end simulation system for the all-electric ship, including both the integrated power system and hydrodynamics. In the chaos work, we have addressed the so-called curse-of-dimensionality that we encounter in global sensitivity analysis when the number of uncertain parameters increases to more than 10. We have developed a new extension of polynomial chaos that employs new mathematical concepts and analysis-of-variance ideas.

Investigation of the propulsion induction motors over the past year focused on detailed electromagnetic design and analysis of the tens of megawatt drive motors. Baseline motor designs were created and then adjusted to examine the impact of various design changes to the motor power rating, dimensions, maximum speed, and frequency. A number of modifications to the motor design and analysis software were implemented to better account for the differences between the megawatt scale propulsion machines and smaller, more traditional induction motors. We also implemented an approximate method of comparing direct water cooling with closed-circuit air cooling for the motors. A more general motor evaluation program was also developed that is able to interface with the propeller design software.

Analytical development, hardware construction, and field experiments to develop and demonstrate a "combat power monitor" (CPM) was carried out this year. The CPM uses power system monitoring based on the nonintrusive load monitor developed at MIT. Ultimately, the CPM is intended to serve as a demonstration platform for bringing advanced protection and diagnostic techniques to new naval power system architectures.

In accordance with our plan, we developed robust models for ship hydrodynamics, including forward propulsion and maneuvering as well as propeller and linear and nonlinear loads in a random sea state and models for the gas turbine, generator, electric system, and motor. Controllers for the gas turbine, generator, and motor were developed and tested. Simulations that involve random loads from the sea, random events such as propeller emergence, and maneuvering motions in a storm are possible with the models developed.

Papers resulting from the electric ship project include the following:

> "The Advanced Induction Motor," by Clive Lewis. The 2002 IEEE Power Engineering Society Summer Meeting
>
> "Electric Power Generation and Propulsion Motor Development for US Navy Surface Ships," by Benatmane, McCoy, and Dalton. September 1998 Institute of Marine Engineers All-Electric Ship Conference

T-Craft, the US Navy's Transformable Craft

Professor Chrys Chryssostomidis, MIT Sea Grant's director, has received funding from the Office of Naval Research, along with Professor George Karniadakis of Brown University and MIT to design and model a propulsion system for a multihull vessel capable of ferrying heavy tanks from ships at sea through the surf and onto beachheads. Requirements for T-craft are that it does 40 knots, carries at least six tanks, and is able to survive 57-knot winds and 60-ft waves. It must also mitigate wave motion to allow the transfer of vehicles from one ship to the other while rocking on the high sea.

MIT Sea Grant's role is to develop predictive simulation tools of the propulsion characteristics of the T-craft by using highly accurate computational fluid dynamics algorithms. In particular, we have focused on waterjet propulsion in both calm and rough seas, taking into account the full six-degree-of-freedom motion of the T-craft. We have developed a new method, the smoothed profile method (SPM), which is based on a structured Cartesian grid, making simulation of complex geometry flows on moving domains very efficient. The SPM can simulate waterjet-like systems. Using the SPM the seakeeping motion of the T-craft can then be predicted, based on the MIT5D code extended to multihull geometries.

Funded Projects

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 $2 from our federal grant money with $1 from nonfederal sources. This year we have selected four core research projects to support with grants that average $75,000 to $80,000 per year for two years. We are also supporting several larger, six-year focused research projects intended to address an issue of national importance.

New Projects, Begun February 2009

- Milica Stojanovic, Northeastern University: Wireless underwater video transmission
- Harold Hemond, MIT Department of Civil and Environmental Engineering: Enabling high- and low-molecular weight AUV-based chemical analysis, complementing mass spectrometry with multichannel time-resolved fluorometry aboard the NEREUS/Odyssey vehicle
- Cabell Davis, Woods Hole Oceanographic Institution: Incorporation of a compact digital holographic plankton camera into gliders and drifters
- Geoffrey Cowles, University of Massachusetts–Dartmouth: An assessment of the tidal kinetic energy resource off the Massachusetts coast and potential impacts of extraction

Continuing Projects, Begun February 2008

- Richard Limeburner, Woods Hole Oceanographic Institution: Data assimilation and optimal observing system design experiments in Massachusetts waters, moored and drifter measurements
- Changsheng Chen, University of Massachusetts–Dartmouth: Data assimilation and optimal observing system design experiments in Massachusetts waters, modeling
- George Karniadakis, MIT and Brown University: Data assimilation and optimal observing system design experiments in Massachusetts waters, adaptive sampling
- Jonathan King, MIT Department of Biology: Enzymes from marine viruses for the biotechnology industry
- Philip M. Gschwend, MIT Department of Civil and Environmental Engineering: Assessing the narcosis hazard of marine sediments, application of GCxGC analysis
- Elmer Caruso, University of Massachusetts–Amherst: Role of plant pathogens in sudden wetland dieback in Connecticut and Massachusetts (regional)
- Judith Pederson, MIT Sea Grant College Program: Assessing risk of marine introductions by vessels in small New England ports, a community development program
- Michael Triantafyllou, MIT Department of Mechanical Engineering: Biomimetic optimal force generation for underwater manipulators
- Steven Leeb, MIT Department of Electrical Engineering and Computer Science: Low-cost diagnostic system for shipboard environments

Continuing Six-Year Focused Research Projects

- Jeffrey Lang, MIT Department of Electrical Engineering and Computer Science (started 2006): TOUCH-AT-A-DISTANCE, pressure microsensor arrays for AUV navigation
- Milica Stojanovic, Northeastern University (started 2007): Acoustic communication networks for distributed autonomous underwater platform
- Franz Hover, MIT Department of Mechanical Engineering (started 2008): Autonomous Vehicle Exploration and Sampling of Deep-Water Corals

The National Aquatic Invasive Species Research Competition: In 2008, we were instrumental in awarding National Sea Grant funds to a project that addresses the spread of aquatic invasive species *Didemnum vexillium*. Titled "BioBullets for the Control of Fouling Sea Squirts" by David Aldridge, the project is progressing well. Two potential products for eliminating *Didemnum*—one a 50 percent citric acid solution, and the other sodium diacetate—have been produced and are considered to be worth testing against *Didemnum* sea squirts. Testing will begin mid-summer 2009 in collaboration with Robert Whitlach of the University of Connecticut.

Advisory and Outreach

The MIT Sea Grant has a large and active advisory, education, and outreach program designed to address issues that are important to local, state, and regional government agencies, businesses, and citizen's organizations. Our staff members have forged strong links to the community and serve as conduits for the transfer of marine-related information and technological developments between scientists and our constituent groups.

Out of the rich and extensive program of initiatives carried on by our advisory services group, we are choosing this year to highlight the activities of our education team.

Education

The Sea Perch Program

Much progress was made over the past year in this, our most successful education and outreach effort. The Sea Perch is a simple, remotely operated underwater vehicle, or ROV, made from polyvinyl chloride pipe and other inexpensive, easily available materials. Since 2003, we have been training educators across the United States and around the world to build the Sea Perch and integrate the project with their curricula. Teachers return to the classroom and work with students to build their own Sea Perches and deploy them on research missions in nearby bodies of water. The hands-on Sea Perch experience is a gateway to further study and careers in robotics, engineering, marine sciences, and more.

During this reporting year, the team's goals were to expand the teacher trainings, begin sending "Sea Perch ambassadors" to high schools, and develop the next generation of our reef explorer vehicle to be used for remote exploration in the classroom.

Sea Perch Trainings

Our training offerings have gone beyond our original scheduled programs to include several workshops by request. We met with a professor and representative from the Université Pierre et Marie Curie in France to design an undergraduate curriculum for use at their college built around the Sea Perch and to conduct a training workshop for their educators. At the college level, we also introduced two professors from the Technical University of Catalonia, Barcelona, including Elisa Sayrol, dean of the School of Electrical Engineering there, to Sea Perch during a visit to MIT Sea Grant. In a third overseas initiative, 15 teachers and 100 students were taught to build Sea Perches on the Mediterranean island of Cyprus as a follow-up to last year's Cyprus outreach.

Closer to home and working in collaboration with local partners, we trained 178 students and teachers from seven high schools in basic Sea Perch construction and in more sophisticated use of sensors and data collection. Our Sea Perch activities extended from Gloucester, MA, to the US Virgin Islands, to Los Angeles during this reporting year.

Sea Perch Ambassador

Heather Brundage, a graduate student in mechanical engineering, traveled back to her local high school to present the details of her research and career in ocean engineering to her younger schoolmates. We hope to continue this practice to help inspire an early interest in ocean engineering at the high school level.

Reef Explorer—REX II, the Next Generation

This vehicle is used by education staff in collaboration with our AUV Laboratory. For a full-size, working vehicle, it is particularly inexpensive and easy to deploy. REX II can adapt to a variety of payloads and is simple to operate. During this reporting year, REX II went to the Hawaii Institute for Marine Biology to be tested in a previously planned education project. About 50 students from three different classes were able to drive the vehicle remotely via the web, conducting underwater research experiments from their classrooms. Our Hawaii colleagues are anxious to continue this collaboration and are seeking funding for the next phase.

Maker Faire—San Francisco, CA, May 29–31, 2009

MIT Sea Grant educators were invited to take a booth at this massive annual event for do-it-yourselfers (estimated attendance 80,000). We accepted because it allowed us to advertise Sea Perch to a broad audience of interested teachers, students, and members of the public. In addition to our Sea Perch booth, we had a REX vehicle on display and held live demos in a pool, along with Sea Perch building stations.

Future Sea Perch Projects and Activities

Sea Perch Institute (SPI): We will offer a SPI workshop to teachers from up to four high schools, focusing on new technology, current research, and field sessions to provide more in-depth knowledge on using and working with Sea Perch in the classroom.

Blue Lobster Bowl Internship: In partnership with our regional National Ocean Science Bowl, the Blue Lobster Bowl, we created a four-week, paid internship with Sea Perch as its basic foundation. Two students have been selected to work with MIT Sea Grant and Ocean Engineering and MIT staff for four weeks this summer.

Ocean Engineering Experience Summer Camp July 2010: We are developing a residential camp at MIT for 30 tenth and eleventh graders to provide them with in-depth experience in ocean engineering.

Cyprus training for students and teachers. A Sea Perch test run.

Around the Americas: In collaboration with a group that sponsors a circumnavigation-by-sail of North and South America, we have trained an America staffer to use the Sea Perch at each port of call to collect water-quality data, explore local waters, and promote awareness of ocean health. The expedition set out in May 2009.

Sensor Development: We are developing a sensor pack for the Sea Perch, a do-it-yourself project that is affordable and customizable. Fabrication and programming are simple and can be completed in just a few hours with a soldering iron, a personal computer, and some wire cutters.

Students Supported by MIT Sea Grant

MIT Sea Grant promotes and administers a number of programs and awards that directly support young people who are pursuing studies and careers in marine research, such as:

Dean A. Horn Award: The 2009 winner of the Dean Horn Award was Corinna Hui, SB mechanical engineering, for her project, "Laser Range Finder Mapping of Floating Vehicle."

The Dean John A. Knauss Marine Policy Fellowship: This program places graduate students with host organizations in the legislative or executive branches or appropriate institutions in Washington, DC, for a one-year, paid fellowship. Our successful candidate, Abigail Franklin, a PhD candidate with the University of Massachusetts, Amherst, Department of Natural Resources Conservation, will complete her placement year at the NOAA National Marine Fisheries Service Office of Sustainable Fisheries, Domestic Fisheries Division, at the end of this year.

Judge Paul J. Garrity Scholarship: Acting on behalf of the Massachusetts Office of Coastal Zone Management, we awarded this $500 scholarship to our Undergraduate Research Opportunities Program (UROP) student Clifton Dassuncao for his two papers, *Geographical Analysis of Ballast Water Data* and *Potential Threats of Invasive Species for the North Eastern United States and Temperature and Salinity Tolerances Predict Range Expansion for Two Invasive Marine Invertebrates*, which address timely issues in biopollution.

UROPs

During this reporting period, the following UROP students and their projects were active at Sea Grant:

- Clifton Dassuncao, sophomore, Mechanical Engineering Department, design in ocean engineering. Did mathematical modeling for a project to collect and analyze data on marine invasive species.
- Lina Garcia, sophomore, Mechanical Engineering Department, design in ocean engineering. The student assisted in designing a waterproof cable junction for a hydrophone to be used in an ultra-deepwater underwater acoustic study.
- Danielle Magrogan, junior, Civil and Environmental Engineering Department, automated identification of invasive tunicates. Developed a computer program to estimate the percent coverage of select benthic species on the sea floor from optical footage recovered by our AUVs—specifically, the tunicate species *Didemnum* sp.
- John Preis, sophomore, Mechanical Engineering Department, automated underwater vehicles research. John helped out in the AUV Lab, cleaning and organizing tools and lab space and training on the operations and sampling equipment. He fabricated some of the mechanical parts used on the vehicles and prebuilt modules for the Sea Perch kits.
- Grace Kane, junior, Mechanical Engineering Department, acoustic communications project. As part of a larger acoustic communications project aimed at developing a flexible underwater transceiver, Grace worked on the software behind the project—GNURadio—an open-source, software-based radio.

Internships

Frederick Moore, high school student, summer intern in the AUV Lab. Frederick was an intern in the AUV between his junior and senior year. He helped redesign the propulsion and drive system of a small ROV, built a working model of the ROV, taught himself SolidWorks, and redesigned the Sea Perch, making it more stable, powerful, and easy to control.

Administrative Initiatives

This year we created a web-based process for proposal submission, from the initial request for proposal, through preproposals, full proposals, several rounds of peer and committee review, and creation of the final omnibus document, which is sent to the National Sea Grant Office each fall. We are further developing this system to include online reporting for funded projects. Reactions of principal investigators and peer reviewers to the new system have been favorable.

In September 2008, our advisory services section moved their offices from E25 to E34. We have also implemented other administrative changes and trainings in response to MIT-wide initiatives, such as the switch to the new voice over Internet protocol phone system. We are now introducing the new vacation tracking system for our sponsored research staff.

Staffing and Oversight

The MIT Sea Grant College Program's management team consists of a director (Professor Chryssostomos Chryssostomidis) and an associate director for research utilization (Dr. E. Eric Adams). Dr. Adams's research portfolio is in coastal processes and Professor Chryssostomidis is responsible for overall program management. Our former associate director, Milica Stojanovic, has taken a faculty appointment at Northeastern University but retains a part-time position with MIT Sea Grant working on underwater communications. The research management team is jointly responsible for planning the research direction of the program.

Marine advisory leader Clifford Goudey stepped down from that position in the second half of 2008. Dr. Judy Pederson was appointed leader of the advisory group in 2009 to reflect the program's greater focus on the importance of a regional approach to research on the northeast ecosystem, identifying and combating invasive species and more sophisticated methods of data collection.

MIT Sea Grant's administrative staff consists of Timothy Downes, assistant director, and Kathy de Zengotita, program coordinator. The Advisory, Education, and Communications Program has five professional staff members whose activities include control of nonindigenous species, public education, anthropological research in fisheries, and communications. In addition MIT Sea Grant employed six research engineers in the AUV Laboratory and in support of our other externally funded research.

MIT Sea Grant is under the oversight of a Joint Advisory Committee consisting of MIT faculty members and leaders in Massachusetts marine-related industry, colleges and universities, state government, and key nongovernmental organizations. The breadth, flexibility, and dedication of the Advisory Committee are key to the success of the MIT Sea Grant College Program.

Sea Grant funds research in various MIT departments and is home base for undergraduates doing in-house research as UROPs and as visiting students from abroad and our own graduate students. We also support young MIT faculty by awarding the Doherty Career Development Chair for Ocean Utilization. It is a two-year appointment at $25,000 per year for a young MIT professor working on marine research. The 2009 winner is Pierre Lermusiaux of the Department of Mechanical Engineering for his ongoing project on adaptive sampling using swarms of smart autonomous underwater vehicles.

This year, MIT Sea Grant received funding from Eric Schmidt of the Google Corporation through the Schwab Fund for Charitable giving for an $80,000 fellowship. This money is supporting Mechanical Engineering graduate student Brenden Epps' work on open source code for the design and modeling of propellers. Brenden will present the open prop project at the American Physical Society fluid dynamics conference in November 2009.

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

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