

# Strategic Alliances

Homeland Security

Drug Development Pipeline

## Technology Road Map

Ocean Science & Technology

Nanotechnology

### The Massachusetts Technology Road Map and Strategic Alliances Study

Work Group Report on:

## OCEAN SCIENCE & TECHNOLOGY

A Science & Technology Initiative Report  
March 2005

 Science & Technology  
INITIATIVE

 **Mi** Mass Insight  
CORPORATION

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#### *Keeping Massachusetts Competitive*

Mass Insight Corporation is a public policy research and consulting firm that seeks to keep Massachusetts and its businesses and institutions globally competitive. Through client and leadership networks, the firm shapes public-private dialogues and delivers policy results on issues where state actions and investments affect profitability, growth and new jobs.

Our corporate clients and sponsors represent a range of sectors, including universities, financial institutions, telecommunications, health care, utilities, professional services, trade organizations, and state agencies.



*A Mass Insight Corporation project supporting science and technology education, research and R&D strategic alliances in Massachusetts*

The Science & Technology Initiative brings together a broad-based consortium of leading businesses, public and private universities, and economic development organizations to develop a Technology Road Map for Massachusetts. Its mission is to facilitate and support major science and technology education and research initiatives and R&D strategic alliances that maintain and expand the state's research, development, commercial and economic leadership in emerging technologies. The Implementation Phase of the Science & Technology Initiative focuses on promoting R&D Strategic Alliances among the public and private universities, teaching hospitals, government and industry in Massachusetts and New England to identify and build support for flagship R&D projects.

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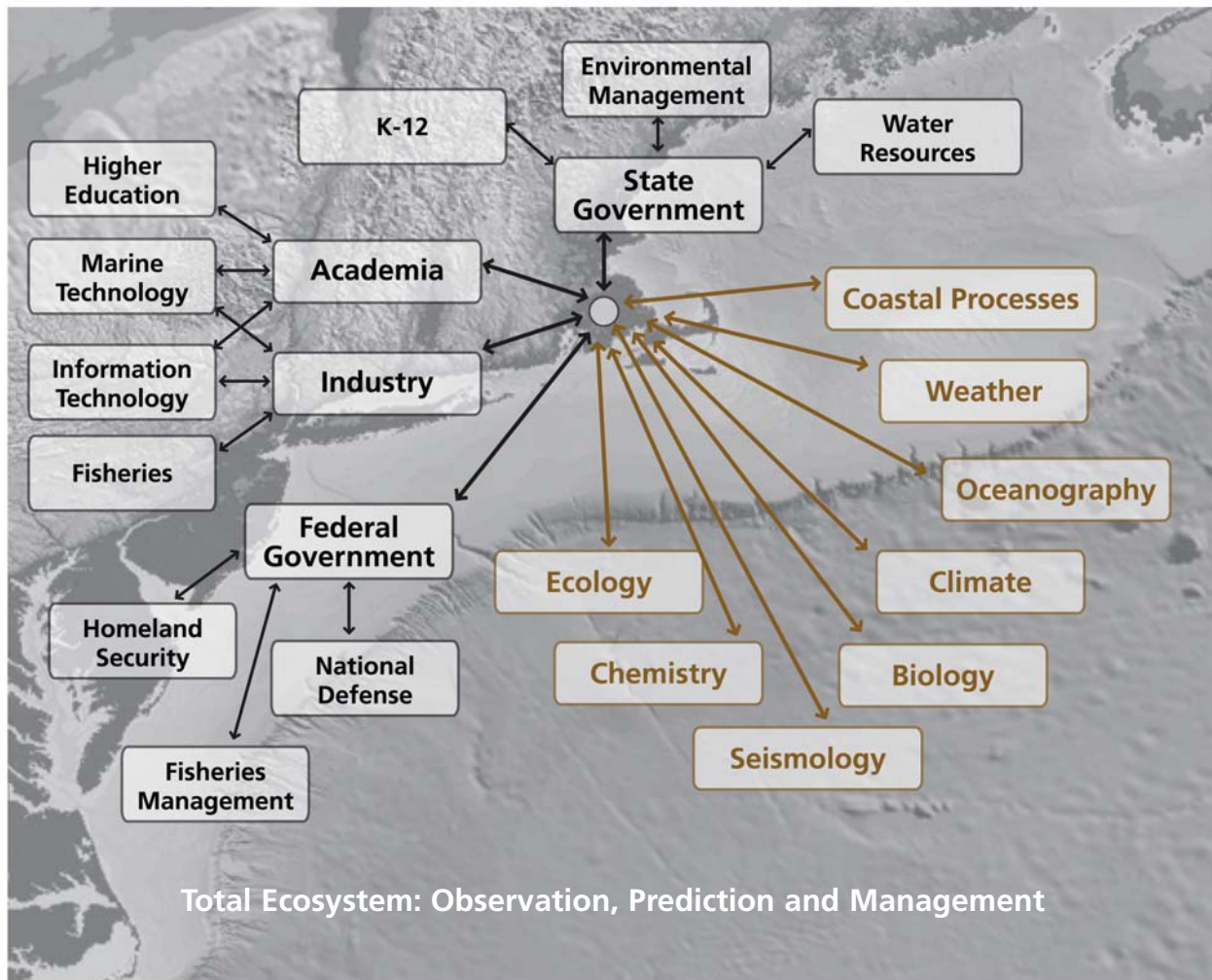
## **OCEAN SCIENCE & TECHNOLOGY**

### *Summary*

*A growing national and international consensus has emerged on the economic importance of the world's oceans. December 2004's catastrophic tsunamis in South Asia briefly focused the world's attention on just one terrible aspect of the oceans' impact on the world's population. Governments worldwide are committing to fund ocean observing systems to generate the information needed to manage this vast and vital resource.*

*Massachusetts has the capability to lead a coalition that will establish this region as the world leader in creating economic benefit through the generation, integration and management of information gathered from the coastal and ocean ecosystem by these observing systems. The combination of world-class research, an emerging marine technology industry and a leading information technology and telecommunications industry cluster can generate a sustainable advantage if the region seizes the opportunity now.*

## North Atlantic Ocean Observation Applications Center



*A proposed national research center focused on the development of new scientific, defense and commercial applications for ocean observation systems could be an umbrella for institutes focusing on port & harbor security, marine bio-technology, environmental applications, underwater vehicle development, energy research, ocean modeling, and other issues.*

### *The National Challenge*

The direct impact of ocean-related activities in 2000 contributed over two million jobs and \$117 billion to the United States economy. Yearly, \$25–\$40 billion of oil and gas is extracted from US coastal waters, commercial fisheries generate \$28 billion and a vital part of the nation's food supply, while recreational fishing and boating together add another \$50 billion. Tourism is a fast-growing segment of the economy and, at the same time, \$700 billion in merchandise flows through US ports. The indirect impact of the coastal zone is staggering — the coastal watershed counties of the United States represent 60 million jobs and over \$4.5 trillion in GDP representing half the US economy.

With this huge economic engine as background, the U.S. Commission on Ocean Policy this past year issued its report and recommendations for the creation and implementation of a new national ocean policy framework. The recommendations are wide-ranging and comprehensive and, as with most such reports, are expected to guide policy makers and funders in the years to come. Several are directly relevant to regional strategic alliance opportunities.

The Commission report highlights several areas of resource management in which its recommendations on governance, coordination, data management and research will have a direct economic impact. The regional effect is clear as well:

- More effective marine commerce management affects the 7% of GDP which comes from global commerce. Although the Port of Boston is only the 38th largest US port, 90% of the region's petroleum passes through it, and the cargo at the three largest New England ports (Portland, Boston, New Haven) combined would rank #11 nationally.
- The economic cost of water quality has been painfully apparent to Boston-area consumers through the cost of the Boston Harbor cleanup and the loss of commercial shellfish beds.
- The effect on tourism and recreation of beach closures from pollutants or harmful algal blooms.
- The importance of vessel safety becomes apparent with incidents like the Buzzard's Bay oil spill, and vessel and harbor security are growing homeland security concerns.
- Sustainable fisheries are a vital concern for the economic health of the southeast and northeast coastal regions.
- The proposed 130-turbine Cape Wind alternative energy project in Nantucket Sound has been highly controversial because of a mix of competing claims about the economic and environmental benefits, costs and tradeoffs.

- A 2004 Massachusetts Ocean Management Task Force called for new laws to oversee the use and management of coastal waters. In March 2005, Governor Romney announced his intention to file an Ocean Resources Conservation Act to regulate siting of projects in state waters. Senator O’Leary filed a similar bill in early 2005 with additional focus on conservation.
- Aquaculture is a small but growing industry in the region.
- The creation of regional ocean councils as a coordination and conflict-resolution mechanism encourages a parallel regional effort in the R&D community.
- Regional ocean information programs are recommended to identify priorities for research, data and science-based information. These programs would be significant users for projects that aim to collect, manage and use information gathered from ocean and coastal observatories.

The clear goals laid out by the Commission on Ocean Policy, coupled with priorities and programs already in place, offers an opportunity for this region to take a leadership position in addressing these challenges. In late December, 2004 the White House indicated its clear support for the Ocean Initiatives and directed the formation of management structures as outlined in the report. The administration also said it was committed to funding the observing projects. This will be helpful in getting funding underway, although the predicted cuts in domestic spending over the next several years makes a quick ramp-up unlikely.

The report recommends an improved governance structure for ocean-related policy and programs:

- At the national level, strengthening NOAA and consolidating federal programs could provide both a more stable source of funding as well as one that could support larger-scale projects.

Recognizing the relative decline in funding for ocean science from 7% of the federal research budget twenty-five years ago to 3.5% today, the commission strongly urges the doubling of the ocean and coastal research budget over five years, and urges an active ocean exploration program.

With regional strength in exploration and research, our institutions should come together to both define national and regional priorities and compete for increased investments.

Through a series of studies and reports, the scientific community has already articulated large-scale ocean observing systems as a critical requirement for advancing knowledge and exploration. As in many scientific domains, there tends to be a divide between research and operational information needs. On one hand are research interests seeking to understand underlying causes and mechanisms – more fundamental science questions, where experimentation and flexibility are important.

On the other hand are more operational interests such as forecasting weather or counting fish populations where 24 by 7 operation and stability are critical. In truth, both systems need each other to build a complete and useable picture.

The National Science Foundation has made the construction of a research-based system, the Ocean Observatories Initiative (OOI), a top priority. The NSF created ORION, the Ocean Research Interactive Observatory Networks program, to coordinate the development of observatory networks and to manage existing and new sites. In addition to a large-scale investment in sea-floor tectonic observation off the northwest coast of North America, ORION is expected to support infrastructure for two regional coastal observatories.

At the same time, a high priority is placed by the Commission report on the construction of an operational network of observing systems in support of agency missions, the Integrated Ocean Observing System (IOOS). This system is intended to provide a coordinated network of observatories, along with the facilities for data gathering, management, communication, analysis and simulation, to provide information, historical and predictive, on the coasts and oceans in and around the US. Effective integration and communication of this information to decision makers fosters more effective management and conservation of ocean and coastal resources.

The information is gathered and applied in support of seven societal goals:

- improve predictions of climate change and weather, and their impact
- facilitate safe, efficient marine operations
- improve homeland security
- mitigate the impact of natural hazards
- improve public health
- maintain healthy coastal & marine ecosystems (through ecosystem based management)
- ensure sustainability of natural resources

The IOOS system is itself seen as a component of an international earth observing system that has similar goals on a global scale. GEOSS (Global Earth Observing System of



*Data buoy*

*Photo: NOAA, National Ocean Service*

Systems) will interconnect regional and national systems. A global system significantly improves the capability of each of the national systems by extending their reach and thus their ability to understand and forecast accurately. A one degree improvement in the accuracy of weather forecasting is estimated to save the US \$1 billion annually in electricity costs, while increased preparedness could mitigate the \$7 billion in annual losses from coastal storms.

The critical elements these systems have in common are

- science-based understanding of the information needed
- marine technology to construct and manage the facilities
- a complex cyber infrastructure for turning data into useable information
- the ability to transfer and apply the complex scientific information into relevant reports and recommendations for management decisions.

All four of these are strengths of Massachusetts and the New England region.

A key concern raised in all the major reports and plans is coordination between the research-oriented Ocean Observatories Initiative and the operationally-focused Integrated Ocean Observing System. The national monitoring network recommended in support of ecosystem-based management

would also require coordination with IOOS and OOI efforts as it traces the effect of human activity on inland, coastal and deep ocean waters. There is a clear opportunity for leadership in bringing together research and operational needs and providing solutions that can either support both sets of users or can be reused in both environments.

### *New England Coastal Observation System Project Concept*

Recognizing some of the elements of these national challenges, along with the breadth of capabilities in the region, the initial concept for a large-scale Massachusetts or regional project considered an integrated coastal zone observation and management system in the New England region to address homeland security, environmental, planning and research needs.

The integrated focus was driven by the appreciation of the breadth of capability in the region. In addition to the marine research and educational cluster of institutions including Woods Hole Oceanographic Institution, UMass Dartmouth and Boston, MIT and others, Massachusetts has a leading position in software, communications, sensors, information technology and systems integration research



*Turbulence Remote Environmental Monitoring Unit (T-REMUS)*  
Photo: SMAST, UMass Dartmouth

along with life sciences, all vital components of any integrated approach to ocean observation. Massachusetts also boasts leading industry clusters in these related areas as well as a vibrant marine technology-based industry. Regional universities in Rhode Island, New Hampshire, Connecticut and Maine boast strength in marine, oceanographic and environmental sciences and those states also have a significant cluster of marine-related businesses.

By virtue of its size, the range of needs it could address, and its potential scalability, such a regional system would demand the volume of devices and scale of technology that would help drive down the costs of production of the sensing and information technologies used. Some of the tools and applications developed could be applied to other data-intensive environments. This could in turn make additional deployments cost-effective, creating a virtuous cycle leading to new applications and a larger market, facilitating the growth of new firms and attracting larger companies in sensing, information technology and systems integration.

Advances in R&D and technology development offer the opportunity to deploy an integrated system to gather, integrate and manage information and deploy a suite of decision support tools to address multiple applications. If the needs of multiple research and operational constituencies could be met with an integrated system, the cost of development and deployment could be spread over a wider

pool of funders. The result would be a much more powerful model for nationwide, even worldwide, deployment.

The existence of IOOS and Orion as separate observing systems for operational and research uses confirms the difficulty of building an integrated system. But the practical impact of considering an integrated system is to focus users on both sides on the common elements of their respective systems. Development and deployment of shared infrastructure components will still reduce costs for each system and could lead to greater integration in the future.

An important first step toward advancing the creation of a large-scale national-model ocean observing system is for research leaders to define its scope and objectives. That definition must:

- incorporate the research and science strengths of the region to establish its credibility and gain support from those who will implement it.
- articulate how its implementation will advance the national and international goals for observing systems to gain the support of existing programs and build a case for new funding
- establish clearly the importance of the northwest Atlantic ecosystem as a must-have location for an observing system

Equally importantly, the region must come

together to articulate its capabilities and its needs with one voice. Multi-institutional collaboration is increasingly the norm for large-scale federal funding in all domains, but the structures on which both research and operational observing systems are being built have been designed to assemble as regional building blocks for a national, and ultimately international system. Having only a subset of institutions coming forward or, worse, having multiple groups come forward from this region is a prescription for marginalization and failure. IOOS regional organizing conferences and the upcoming Orion RFA are near-term opportunities to begin establishing a regional focus and identity.

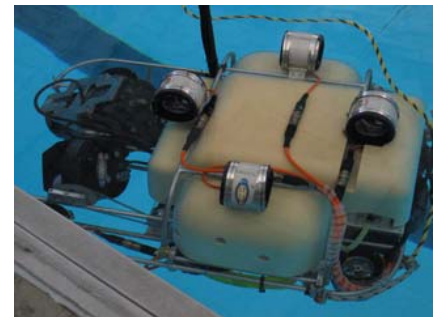
### *Link to Defense*

Defense needs drive direct large scale collaborative products as well as opportunities for linking defense-based R&D and technology needs with both civilian research and homeland security needs. A successful MIT-led national team, including two other Massachusetts institutions (WHOI and Harvard) and a Massachusetts company (Bluefin Robotics) have won \$32 million over three years to develop an autonomous coastal surveillance system. Their work is developing new sensing and communications concepts to manage coordination among autonomous underwater vehicles.

The project envisions connecting sensing, control and simulation to build adaptive systems that can react to their environment,

along with developing communications technologies and protocols for dealing with the unique challenges of undersea communication – uncertainty and latency. Successful development of such adaptive systems allows a finite number of deployed vehicles to cover a much larger geographic range. These concepts and technologies are readily generalizable to observe and monitor a range of phenomena and could thus be part of a coastal and ocean observing system.

These technologies, and the focus on coastal observation and analysis, support the US Navy's move toward a greater emphasis on littoral (coastal) combat. In fiscal 2004, the Navy made an initial request to Congress for \$4.1 billion for the design and construction of Littoral Combat Ships (LCS) These smaller implementations of the next generation DD(X) destroyer, would be focused on operations in coastal waters, including anti-submarine and anti-mine warfare and intelligence and surveillance. These ships would be equipped with a range of autonomous underwater vehicles (AUVs) customized for specific operations, another regional strength.



*Hovering AUV prototype  
Photo: MIT Sea Grant Program*

At the time, the Navy projected an eventual total of 30–60 such ships, representing between 10% and 20% of the overall fleet. Two reports delivered to Congress in early

2005, one by the Center for Naval Analysis and the other by the Office of Force Transformation, strongly endorsed the move to increase the number of littoral combat vessels and projected a needed total of 36 – 56 ships. There has also been some interest in the Littoral Combat Ships as a platform for Homeland Security operations.

Two related programs envision a Littoral Surveillance System (LSS) and a Littoral Support Craft (LSC-X). The LSS is a component of a joint Navy, Army and Marine program focused on tactical intelligence. The LSC is a prototype for a small, stealthy ship for specialized operations in coastal regions.

The Maritime Information Technology Initiative at the University of Massachusetts Boston and Dartmouth campuses aims to leverage and transition information and off-the-shelf technology developed over decades by the U.S. Navy to address port security problems in homeland defense.

The Harbor Shield program being developed at the Naval Undersea Warfare Center (NUWC) to improve the safety of maritime trade without causing significant delays in shipping is another example of a direct opportunity that shares common elements and challenges with generalized observing systems. Combining above-surface optical imaging (LIDAR) with sub-surface arrays and sensors and a networked knowledge base of merchant ship profiles, the system aims to track vessels and detect changes in the vessel's

configuration that may indicate problems or hostile intent.

An automated inspection system reduces costs over manual inspection, can conceivably cover all vessels and may be the only way to implement inspections without slowing commerce. A manual system could never work at a busy harbor like Singapore where the average separation between vessels is less than four minutes.

Combining multiple types of sensors; working in a sub-surface environment; and building and exploiting a cyber-infrastructure to turn data into information are all challenges that apply to generalized observing systems. These projects are examples of how a large-scale regional observing project might combine with defense-based projects to the benefit of both.

The Ocean Commission Report points to the need to fuse data from research, monitoring and observing systems in a coordinated fashion among the many users, and to coordinate this information among the governmental agencies for effective decision making based on sound science. Regional-scale data integration would be critical for any large-scale regional initiative. Battelle Memorial Institute's Marine Science Laboratory in Duxbury is currently providing IOOS communities with basic research and technology applications. Battelle is also supporting regional coordinated monitoring frameworks and indicators development as well as provid-

ing decision support and analysis tools in the Northwest Atlantic, Gulf Coast and California regions. Battelle has a significant local presence with a national reach, through its extensive experience in the development and management of complex regional measurement programs in Boston Harbor, the Everglades and New York Harbor.

### *Regional Infrastructure and Economic Development*

Seed funding from the University of Massachusetts President's Office supported the creation of the Ocean Technology Innovation Collaborative, a partnership among UMass Boston and Dartmouth and MOTN. This team is leading efforts to develop the regional marine technology infrastructure. Noting that the conversion rate for SBIR (Small Business Innovation and Research) grants from Phase I (proof of concept) to Phase II (commercialization) was lower for marine science companies in Massachusetts than that in other states, the team first aims to provide facility support with technical and commercialization expertise and the potential to allow secure access to classified technologies for development.

This new infrastructure will be created as the Business Incubator of New Bedford through a partnership between the City of New Bedford and the UMass Dartmouth. The successful launch of the Technology Venture Center at UMass Dartmouth's Advanced Technology and Manufacturing Center in Fall River pro-

vides both encouragement and experience to draw on, having nearly filled its currently allocated space.

The second leg of this development strategy is a series of pilot projects. These R&D-driven projects aim to leverage the enhanced infrastructure to generate near-term economic development while simultaneously connecting to and supporting the larger-scale observatory concept. Similarly, the observatory project provides a longer-term context for the investments made to generate the more immediate impact.

The initial pilot project envisions a rapid response team that could rapidly respond to a marine accident or disaster – whether caused by natural forces (severe weather) or human activity (oil or chemical spills, bioterrorism). This team would draw on capabilities from universities, industry and government to provide real-time assessment, analysis and recommendations for remediation. It would maintain an information management system to monitor and detect incidents, deploy mobile observation platforms with needed sensors to the accident scene and leverage computational models and simulations to recommend remedial actions. This unique capability can test technologies for use in a wider-scale observing system as well as provide targeted fill-in capability to a deployed observing system to generate finer-grained information.

Combined, the infrastructure support and the pilot projects will demonstrate the feasibility

*Successful development of these projects also positions the region to seek and provide the leverage for major national funding*

and viability of developing and deploying new commercial applications for ocean observation systems in emerging markets such as homeland security, environmental monitoring, fisheries management, marine bio-technology, shipping and energy exploration.

### *Connecting the Dots*

The Ocean Observing system, the links between defense and research/commercial applications and the infrastructure development support each other. Successful development of these projects also positions the region to seek and provide the leverage for major national funding (on the order of \$100M–\$200M) to establish a national research center focused on the development of new scientific, defense and commercial applications for ocean observation systems. This proposed national center could include or be an umbrella for institutes focusing on port & harbor security, marine bio-technology, environmental applications, underwater vehicle development, energy research, ocean modeling, and other issues. .

The center would support both virtual collaborations and a shared facility. It could:

- Serve as the communications hub for the information flowing from the observation system.
- Provide data integration, management and mining, as well as extensive modeling and simulation capability, it would be an enabled for the growth of the

Southeastern Massachusetts information technology work force.

- Support shared research projects among scientists from multiple institutions either based at or rotating through the facility
- Provide technology development, testing and deployment capability for commercialization
- House an interactive “war room” for real-time event monitoring and management
- Convene industry to help set the regional research agenda

IRIS, the Incorporated Research Institutions for Seismology, presents a working implementation of the type of project under consideration. IRIS is focused on exploring the earth’s interior through the collection and distribution of seismic data. Its largest project is operating the U.S. Global Seismographic Network (GSN), 137 seismic monitoring stations distributed around the world. It also manages a pool of 1,000 portable seismic monitoring devices, a data network to distribute and manage the information and an education and outreach program. IRIS is a not-for-profit corporation set up and managed by consortium of over 100 universities. It is supported by the NSF, the US Geological Survey, member fees and other contributions, totaling \$15 million in 2003. The largest portion of this support is a five-year, \$60 million NSF cooperative agreement.

*Funding for the OOI program is projected to total \$200–225 million over five years.*

### *The Funding Environment*

The **National Oceanographic Partnership Program** (NOPP) is a collaborative of 15 federal agencies that pools funds from those agencies to support programs that increase knowledge about the ocean. Ocean observing systems and related areas are a major focus of NOPP. The program supports collaboration and funds academic, government and industry work. NOPP supported over \$30 million in projects in FY 2004, with funding coming primarily from NOAA, the Navy, NSF and NASA (in descending order).

The National Science Foundation's **Ocean Observatories Initiative** (OOI) is one of the largest projects in support of ocean research. It responds to several reports strongly recommending the establishment of an infrastructure for research comprising a network of ocean observatories.

An NSF committee, the Dynamics of Earth and Ocean Systems Committee, recommended a National Academies study to validate the need for an ocean observation infrastructure that would address research needs. This committee strongly recommended proceeding with an initiative focused on research needs. They concluded that any exploration program should be science-driven (instead of agency-mission driven), larger, longer-term and more interdisciplinary than individual investigator projects. They saw the NOPP as potentially the most appropriate coordinator, but recognized the strengths of agencies like NSF and NOAA. They also cited the positive experi-

ence of programs like the Offshore Drilling Program in having benefited from operation by independent contractors.

Construction of the OOI would be funded through the Major Research Equipment and Facilities Construction program within NSF. Approval has been secured from the National Science Board for funding through the MREFC for the OOI, with a proposed start date in FY 2006. Funding for the OOI program is projected to total \$200– \$225 million over 5 years.

The largest portion of the funding, about \$150 million, will go to a large-scale network of cabled seafloor observatories, likely built on the work underway in the Pacific Northwest region through Project Neptune. The Project's 3,000-km network of fiber-optic/power cables will encircle and cross the Juan de Fuca tectonic plate in the northeast Pacific Ocean. Canada has already committed over \$50 million for the northern portion of this project.

The other large component of this project will likely provide about \$60 million of funding for an expanded network of coastal observatories. This funding is expected to support two regional observatories. Given competition from regions including, Florida, the Gulf Coast states and California, the New England region must be aggressive in securing a major coastal observatory as part of the overall Ocean Observatories Initiative. The Martha's Vineyard Coastal Observatory, constructed by

Woods Hole in 2001, is one such observatory funded by NSF.

It is important to note that the funding currently anticipated for the OOI is for enabling infrastructure. It will not cover all the funding needed for sensors, cyber infrastructure or the scientific experiments to be conducted in the observatories.

The Ocean.US initiative was set up by the National Oceanographic Partnership Program (NOPP) to coordinate the development of the IOOS. The initial priorities for the construction of the IOOS call for funding regional associations to develop the regional observatories (\$500,000/year per region), the initial development of the regional cyber infrastructures (\$100,000 in 2005, \$200,000 in 2006 per region) and regional pilot projects (\$500,000/year per region). Although the member agencies of the NOPP have accepted these priorities, funding will depend on actual FY 05 and FY 06 appropriations to the agencies.

The United States, European nations and Japan were among 60 national to approve the 10-year strategic plan for the **Global Earth Observation System of Systems** (GEOSS) at 3rd Earth Observation Summit on February 16, 2005 in Brussels. The previous month, the Bush administration announced its readiness to spend \$37.5 million for improved U.S. tsunami detection and warning capabilities in the Pacific and Atlantic Oceans. These commitments should be a further spur to funding

of both the IOOS and research to prepare for integration of multiple systems, a strength in this region.

The Navy has been an important funder of ocean research and ocean-related technologies. By one estimate, 85% of the research funding into marine technology comes from the Navy. The Coast Guard has most of the explicitly defined homeland security mission for the coastal zone.

The **Sea Grant** program provides another source of project and seed funding. Sea Grant is a national network of university programs focused on coastal resource use and conservation. This NOAA-administered program supports research, education and training aimed at improving stewardship and use of coastal and aquatic resources. Proposals for marine research are peer-reviewed at the state level by a committee with industry and academic representative before being forwarded to the national program. Initial grants of up to \$300,000, with continuation grants on the same scale are available. Seed money for large proposals for marine centers is also available. These programs require a five-times match from other sources, but can provide up to \$1 million over a several year period.

Massachusetts is unique in having two Sea Grant programs, one housed at MIT and the other at Woods Hole. Neighboring states all have programs, housed respective at the Universities of Connecticut, Rhode Island,

New Hampshire and Maine. The Sea Grant program also has an advisory role for fisheries and biotechnology at the state level.

Although government has historically accounted for the overwhelming preponderance of funding for marine research, private funding is playing an increasingly important role. The impact of the largely unexplored diversity of marine life on the environment and global food chains and the potential impact on human health through the discovery of new sources of biopharmaceuticals has generated interest and resources.

#### **The Gordon and Betty Moore Foundation**

this past year announced a 10-year, \$145 million Marine Microbiology initiative to generate new knowledge on the composition, function, and ecological role of microbial communities in the ocean. Two MIT researchers, Sallie Chisholm and Ed DeLong, were each awarded \$5 million over 5 years from this program. The Craig Venter Institute is sponsoring the Sorcerer II Expedition, a sailing expedition to survey marine and terrestrial microbial populations around the globe, aiming to uncover new microbial species and elucidate new gene sequences and products. Venter's project has also received Moore Foundation funding.

Another potential source of ongoing funding could be generated through fees paid by entities engaging in commercial activities in federal waters. Based on precedents such as those established for federal land use or the

auctions of electromagnetic spectrum space, the Commission report proposes the creation of an Ocean Policy Trust Fund. While oil and gas extraction is a natural source for the proposed trust, the current controversy over alternative energy through wind power may point the way to additional resources. The possible construction of the first large-scale offshore wind farm in Massachusetts coastal waters provides the opportunity for our regional congressional delegation to take a leadership role in exploring such a trust fund.

A majority of [marine technology] companies expect job and revenue growth over the next two years.

### *Downstream Economic Impact*

There is a vibrant and growing marine technology industry which developed to meet the needs of ocean and coastal exploration and management and national defense. A number of firms have been created from technologies developed at research facilities such as Woods Hole. The two largest sub-sectors of the industry in Massachusetts are in marine equipment and technology and in marine services. The industry is particularly strong in sensors and marine instrumentation as well as in underwater vehicles. It comprises many small companies focused exclusively on marine science and technology as well as larger companies for whom marine technology is only a part of their business.

A Marine Science and Technology Industry survey completed by the UMass Donahue Institute provides a detailed look at this industry. Preliminary results from a statistical analysis indicates that the industry generates about \$1.5 billion in sales annually. Early survey data show that the a majority of companies have seen both revenue increases and job growth over the last two years, and an even greater proportion expect job and revenue growth over the next two years (74% and 85% respectively). The companies most frequently cite oceanographic and defense as target markets, and a majority expect defense and homeland security to grow over the next several years.

The Marine and Oceanographic Technology Network (MOTN) is the key industry associa-

tion, and includes major industry players in the related technology markets, including Sippican and Raytheon, along with major research institutions. Fisheries remain a vital industry in Southeast Massachusetts, and one which has already significantly benefited from ocean research and management technologies.

The major challenge will be to attract larger-scale technology companies to engage in this market. This would include major instrumentation vendors, defense contractors and systems integrators, software and systems focused information technology vendors and communications vendors working in fiber optics or next generation wireless technologies. There is also a potential tie-in with materials companies and biotech/pharmaceutical companies as research into diverse life forms and compounds develop and as chemical and biological sensors are increasingly deployed in the ocean.

A number of the larger scale national initiatives planned for funding assume a role for industry investment and involvement. Integration, management and operation of large-scale observing systems and coordination of exploratory systems could be attractive opportunities for private firms.

## *Competition*

The most significant broad-scale competitor is the University of California's Scripps Oceanographic Institution in La Jolla. The La Jolla campus is home to a joint institute between Scripps and NOAA. Its overall goal is to create a center of excellence in which state of the art observation capabilities in platforms (surface, sub sea, and air/space borne), sensors, and systems architecture are utilized to fill pressing research needs. Another major player to consider in California is the Monterey Bay Aquarium Research Institute (MBARI). This organization could be a powerful ally in a California-based bid in the area of ocean observation technologies.

Regional leadership on the Pacific Coast extends northward to Washington. The University of Washington is a strong institution, and its leadership in establishing Project Neptune along the Juan de Fuca plate likely ensures a long-term flow of funds and activity to the region through the OOI program.

The Pacific Coast institutions are also developing regional collaborations. A recent success has come in cyber infrastructure, an area where Massachusetts would aim to compete. A consortium including the University of Washington, UC San Diego and partners won \$3.9 million from the NSF to build a "Laboratory for the Ocean Observatory Knowledge Integration Grid (LOOKING)". This was the largest award from the NSF's IT Research program this year.

The University of North Carolina through its Institute of Marine Sciences has a long history of fisheries research. Moreover, the Beaufort-Morehead City area has one of the higher concentrations of marine scientists in the country. North Carolina State University and Duke University also maintain labs in the area.

Florida, meanwhile, has a leading center with the Harbor Branch Oceanographic Institute (HBOI) in Fort Pierce, Florida. The HBOI maintains a substantial fleet of research vessels. It also maintains strong engineering and production capabilities. The toll from this year's four hurricanes is further motivation for ocean-based systems that support weather prediction.

Rutgers University manages a coastal observing system in the NY/NJ area. The Ports of New York and Newark are among the most important in the nation. Their presence within and adjacent to the City of New York, the primary target of the 9/11 terrorists and the most visible symbol of US economic power, provides this region with a significant natural advantage for any major investments in port security.

### *Branding the Marine Research and Technology Corridor*

The strength of the regional research cluster, the vibrant marine technology industry and the legacy of nearly four hundred years of maritime commerce combine to provide an opportunity to re-establish this region's reputation as the nation's pre-eminent marine research and technology region as well as a world-wide leader.

A combined branding and communications campaign should be launched in parallel with these large-scale projects. Our marine science research and technology cluster should be much more visible in national and international media. Over the last sixty years, our R&D leadership made this region a required destination for companies in defense electronics, minicomputers, communications and now pharmaceuticals and biotechnology. Our marine science research cluster should be generating a similar draw. A branding campaign will be a mutually supportive effort – articulating our capabilities for large-scale projects demonstrates leadership at the same time that a clearly-defined brand image validates and reinforces decisions to invest here.

The results from the UMass Donahue Institute study of the Marine Technology industry should provide both validation and support for the brand concept along with identifying a pool of potential supporters for a branding campaign. The Marine and Oceanographic Technology Network (MOTN), economic development organizations such as the South Coast Development Partnership and local Chambers of Commerce, the institutions themselves, along with the Regional Competitiveness Councils could provide a broad base to support the cost of an initial campaign.

## *Next Steps*

- Formalize agreement for the collaborative regional strategy to advance the projects outlined
  - New England Coastal Observatory
  - Infrastructure Projects & Pilots
  - Branding and Communications Campaign
  - North Atlantic Ocean Applications Center
- Ensure a competitive regional response to OOI and IOOS solicitations, beginning with the NSF Orion Infrastructure RFA.
- Define the New England Coastal Observatory and develop an executable implementation plan
- Build a steering committee around the work group to guide the implementation of the projects and the overall strategy
- Fund and execute the infrastructure projects
- Plan and execute the branding and communications campaign
- Leverage all the above to build congressional delegation, state government and regional business support for full implementation of the projects
- Begin development of a plan to secure funding for the Ocean Applications Center





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