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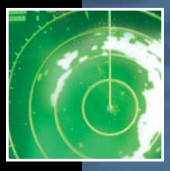
THE MARINE SCIENCE AND TECHNOLOGY INDUSTRY IN NEW ENGLAND



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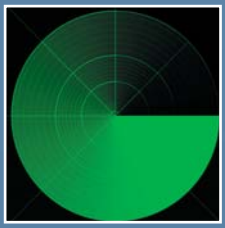

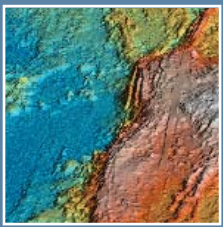

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Introduction

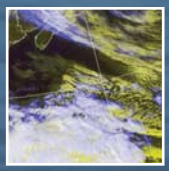
New England's marine science and technology industry today has grown through technology, sophistication and market outlook into a robust cluster that covers five states. In 2004, 481 firms in this marine science and technology cluster directly employed more than 38,906 people in New England and produced annual sales worth over $4.8 billion.

Massachusetts is home to almost two-thirds of the region's firms, representing one quarter of total employment and almost one-third of sales. Though Massachusetts has a lower rate of new company formation than the nation as a whole, the Bay State overall ranked consistently among the top ten states nationwide over the entire period in terms of number of businesses, employment and sales.

The concentration of marine science and technology businesses and research institutions positions Massachusetts as a global leader. And because most of the state's firms are concentrated in high value-added, high technology production, they are unlikely to be seriously affected by the decline in defense-related shipbuilding that will dramatically affect industry employment in neighboring states.

This report provides a picture of an industry that is comprised mainly of small firms, many of which are relatively new and less dependent on federal defense-related procurement. Many of these firms now serve international markets, and most expect to grow in terms of both employment and sales in the next few years. In terms of wages, payrolls generated by this industry are substantially above both the New England and Massachusetts averages for all industries.

Much of the industry interfaces with several high technology sectors as well as higher education establishments and independent think tanks in Massachusetts. However, there is substantial potential for greater linkages, particularly with higher education, to advance product development and applied research. In a survey conducted for this report, many firms expressed an interest in expanding such connections. The survey also found that many firms remain concerned about an adequate supply of highly skilled labor, especially marine engineers, which sends a strong signal to local higher educational institutions that they should seek to expand programs in this area. Most firms are interested in programs that could provide enhanced grant support for proof-of-concept research and the survey also found significant interest in establishing a technology center that could serve as a laboratory for product development and testing.



Part I

A Diverse High-Tech Industry with Economic Impact

CORE INDUSTRY SECTORS

The marine science and technology sector consists of a diverse range of industries and technologies, employing people across the region who produce items as basic but essential as communications antennas and chain and rope for commercial fishing and other clients and as advanced and critical as undersea robotics and stabilized sensor systems for military and other uses. This part of the report offers a description and analysis of the industry, based on a master list of 481 companies in the industry. (See Appendix 1 for detail about study methodology).[1]

For purposes of this report, the research team identified five primary subsectors of the marine science and technology cluster. (A complete list of the sectors and all subsectors appears in Appendix 2). This analysis was supplemented by a review of company SIC codes, CorpTech sectors, web site descriptions and interviews with company executives, marine technology specialists and other scholars and researchers in the field.

The following are the five primary sectors and some of their primary industries:

Marine Instrumentation and Equipment
This category contains firms producing cutting-edge marine equipment, such as transducers, various meters, remote sensing equipment, fiber optic and GPS systems, a variety of sensors and underwater power sources and generating equipment.

- Oceanographic and geophysical measuring instruments, such as magnetometers and current meters.
- Acoustics for underwater remote sensing, imaging and positioning.
- Electronics for marine instruments and platforms, which enable sensing, imaging, positioning and other instruments to function in extreme underwater conditions.

[1] Bryan Bender, "Navy to Cut Orders; Job Losses Seen," Boston Globe, February 7, 2005, p. A1; Bryan Bender, "Navy Eyes Cutting Submarine Force: Plan Would Hurt New England," Boston Globe, May 12, 2004, p. A1.

- Electronics for marine navigation and communications, which enable onboard, under and above water navigation and communication, including GPS systems and fiber optic systems to allow Internet-based communications relays.

Marine Services
This category contains a wide variety of marine engineering and consulting firms, marine monitoring systems, floating research facilities and marine security and/or defense firms.

- Commercial marine research and consulting, which covers marine-related technical services, including applied research; design and engineering; testing and evaluation; GIS and other mapping services.
- Software and systems design for marine monitoring and operations.

Marine Research and Education
This category consists mainly of higher education institutions and a variety of research institutes and consulting groups, working in areas such as:

- Marine and fisheries research and consulting, including applied ocean physics and engineering, marine chemistry and geochemistry and physical oceanography.
- Marine education.
- Industry and technology transfer groups.

Marine Materials and Supplies
This includes much of the material input for marine activities, such as paints, engines, riggings, machinery, composites and coatings, mooring systems and packing and crating.

Shipbuilding and Design
This category includes major defense-related shipbuilding operations.

Establishments represent a range of levels of involvement with the marine sector. Some manufacture products or offer services destined only for the marine sector, while others provide some services or parts for the marine sector while devoting most of their output to non-marine sectors of the economy. For example, a company might market electronic measurement systems for industrial use as well as for oceanographic monitoring efforts. Therefore, the research team classified firms into three different segments reflecting the relative intensity of their involvement with the marine technology sector: core firms (accounting for 210 of the 481 master list companies), in which more than half of the business was devoted to marine related products; partial core firms (233 companies), where 25 percent to 50 percent of the business was marine related; and second tier firms (38 companies), with less than 25 percent of their business focused in the marine area. These categorizations were used to determine more accurately the employment and sales activity generated in the marine technology sector.

Some manufacture products or offer services destined only for the marine sector, while others provide some services or parts for the marine sector while devoting most of their output to non-marine sectors of the economy.

Finally, a survey was sent to 481 identified companies, asking about their employment and revenue trends, characteristics of their product lines, business relationships, obstacles to commercialization of their products, workforce needs and challenges, the business environment and what types of business assistance, if any, would be most useful to them. Some key findings are discussed in the second part of this report, and the complete survey analysis appears in Appendix 3.

Massachusetts advantage

Table 1 presents employment and sales data by state for all 481 companies in the master list, regardless of their level of involvement in the industry. Overall, these industries employ nearly 56,000 people and generate sales of approximately $7.8 billion. Among the states, Massachusetts represents approximately one third of total employment in the sector and almost half of its sales (43 percent). The higher proportion of sales reflects the

Photo credit: Dr. Eugene A. Terray, Woods Hole Oceanographic Institution

higher value-added nature of Massachusetts production, which is typical of most of the Commonwealth's manufacturing and service industries. Because of the relatively higher energy, labor and housing expenses in Massachusetts compared to the rest of the nation, Massachusetts industries tend to succeed by exploiting niches that require a large amount of technical expertise as opposed to mass-produced, lower value-added production.

Maine and Connecticut rank next, with slightly more than 19 percent of total employment but with 11 and 15 percent of sales. Most of the Maine and Connecticut employment is in the lower value-added shipbuilding sector, largely in Bath and Kittery, ME and in Groton, CT. Rhode Island is next, accounting for 17 percent of New England employment (over half of which is generated by the Naval Undersea Warfare Center and its subcontractors) and a similar percentage of sales. New Hampshire accounts for around 12 percent of employment and has a significant presence in the higher technology segments of the industry, with 14 percent of sales in New England.

In order to achieve a more accurate picture of the marine sector itself, we weighted the employment and sales numbers to reflect whether the firm was in the core, partial core or second tier segment of the industry. Core firms were weighted at 100 percent, partial core at 40 percent and second tier firms at 10 percent. The results of this weighting process, which appear in Table 2, presents what we believe to be the most accurate estimate of employment (38,906) and sales (more than $4.8 billion) in the marine technology sector for the New England region in 2004.

Massachusetts is composed predominantly of smaller companies involved in a diverse set of subsectors.

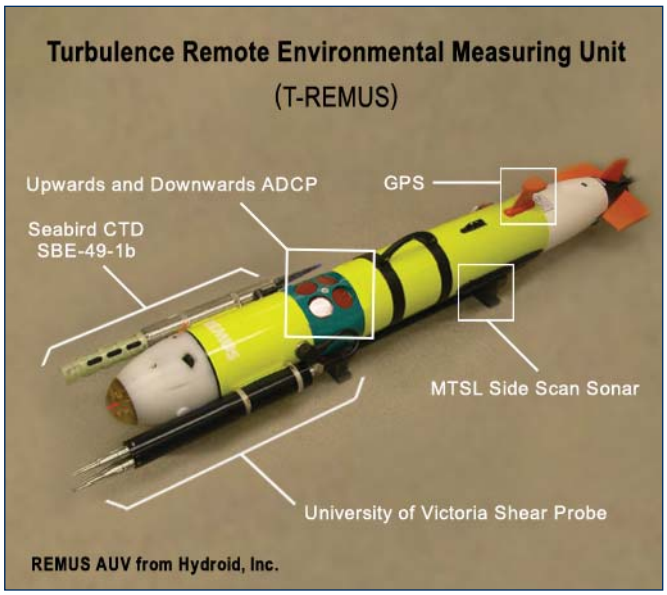


Photo credit: The Marine Turbulance Laboratory, School for Marine Science and Technology, University of Massachusetts Dartmouth

Table 1. Establishments Providing Marine Science and Technology Products and Services, 2004

	Establishments	Employment	Sales ($m)
Massachusetts	298	18,152	3,330.6
Maine	19	10,909	883.5
Connecticut	61	10,831	1,169.1
Rhode Island	74	9,301	1,335.3
New Hampshire	29	6,754	1,079.3
New England	481	55,947	7,797.8

*Data in this table represent employment and sales for all companies providing marine-related products and services, regardless of their level of involvement.
Source: D&B MarketPlace; author's survey

Table 2. Marine Science and Technology Employment and Sales, 2004

	Establishments	Employment	Sales ($m)
Maine	19	10,773	868.1
Connecticut	61	9,389	945.4
Massachusetts	298	8,863	1,540.8
Rhode Island	74	6,944	1,011.3
New Hampshire	29	2,938	503.3
New England	481	38,906	4,868.9

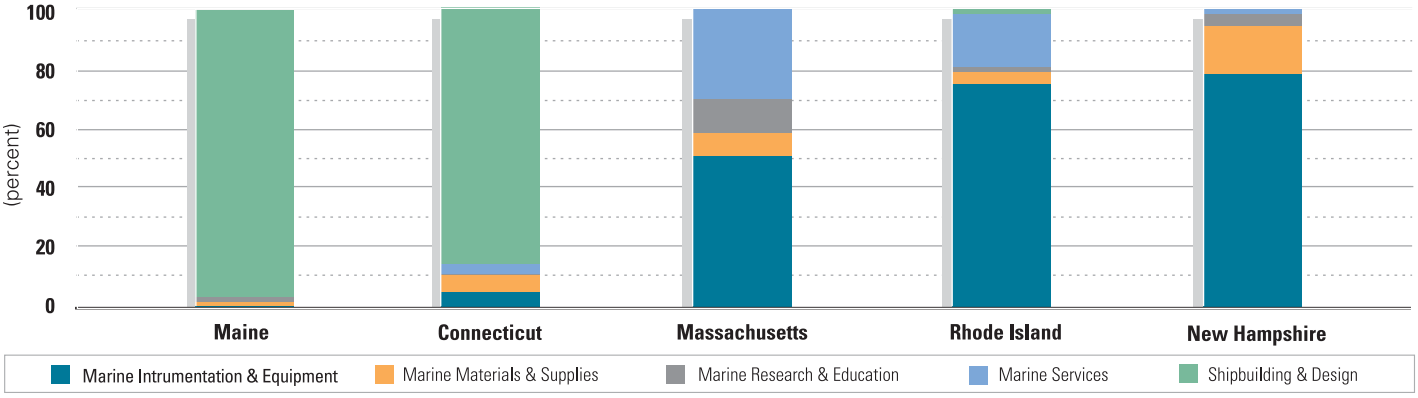
* Adjusted for the varying levels of involvement among core, partial and second tier companies. All following figures are adjusted as such unless stated otherwise.
Source: D&B MarketPlace; author's survey

Because they are home to large shipbuilding operations, Maine and Connecticut are the industry's largest employers in New England, followed closely by Massachusetts. The character of the industry is quite different in Massachusetts. Rather than being dominated by a few large shipbuilding operations, the industry in Massachusetts is composed predominantly of smaller companies involved in a far more diverse set of subsectors. Furthermore, the industry in Massachusetts is composed of a high proportion of firms that sell their technologies to a variety of markets, not just marine-related ones.

The marine technology sector in Maine and Connecticut is likely to be negatively impacted over the coming decade as the U.S. Navy scales back its purchases of new warships and submarines. Bath Iron Works employs about 6,400 workers in Maine, while Electric Boat employs 8,750 people in Groton, CT, and 2,100 in Quonset Point, RI. All three facilities are owned by General Dynamics. In addition, the Portsmouth

Figure 1. Marine Employment by Major Subsector

The industry in MA and RI is more diversified then in ME and CT



Naval Shipyard in Kittery, ME, which overhauls and refuels nuclear-powered submarines, has a workforce of 4,404. These yards could lose up to 10,000 employees over the next decade.[1]

However, because shipbuilding is a lower value-added, less high technology-oriented sector, most of the firms in Massachusetts and much of Rhode Island — which are concentrated in high value-added, high technology production — are unlikely to be affected much by a decline in this sector. Nor are their sales likely to be significantly impacted since the shipbuilding sector in New England is not a significant purchaser of their products (most of these firms sell to global markets).

Subregional analysis: Massachusetts and Rhode Island

We estimate total marine technology sector activity in Massachusetts to encompass around 300 firms, with marine-related employment of nearly 9,000 and marine-related sales of over $1.5 billion. This compares to the much larger telecommunications industry in the state, which the Massachusetts Telecommunications Council estimated to include nearly 6,000 establishments in 2004, employing over 100,000 people, the biotech industry, which had almost 1,000 establishments employing 42,000 people (Mullin and Lacey, 2003), or the environmental industry, which includes almost 2,400 firms, employing over 30,000 people with sales of almost $5 billion (Diener, Terkla, and Cooke, 2000). The medical devices industry has fewer firms (221) but employs more than twice as many people (20,370) than the marine science

Figure 2. Distribution of Marine Science and Technology Establishments, Eastern Massachusetts and Rhode Island

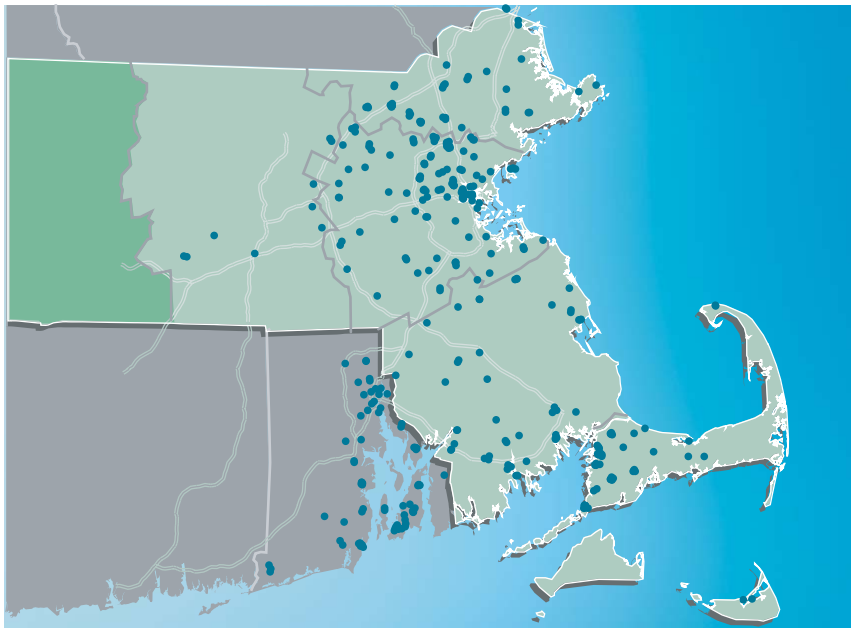


Table 3. Marine Science and Technology Industry, Massachusetts, 2004

Benchmarks Region	Establishments	Employment	Sales ($m)
Berkshire	3	1,022	62.1
Cape and Islands	56	1,075	64.0
Central	8	59	5.0
Greater Boston	128	3,217	660.5
Northeast	45	2,121	570.9
Pioneer Valley	10	384	29.7
Southeast	48	985	148.6
Massachusetts	298	8,863	1,540.8

Source: D&B MarketPlace; author's survey

Given that Greater Boston accounts for a little over one half of the state's total employment, it is a bit underrepresented in this industry, while the coastal areas and the Northeast have relatively larger shares than their overall percentage of total state employment.

and technology cluster and has shipments valued at $5 billion (Clayton-Matthews and Loveland, 2004). The marine science and technology industry is more comparable to the clean energy industry, which is estimated to include 300 to 400 firms, employing nearly 11,000 people (Levy and Terkla, 2004).

To get some sense of the regional distribution of the ocean science and technology industry, we divided the master list of Massachusetts firms into different regions as defined by the *Massachusetts Benchmarks Project*. Figure 1 (above) shows several clusters of firms in eastern Massachusetts and Rhode Island, including the South Coast, particularly Cape Cod, Boston and its west and northwest suburbs, and the northeast region just north of the Greater Boston region. As seen in Table 3, 43 percent of the firms are located in the Greater Boston region, followed by Cape Cod (19 percent), the Southeast (16 percent), and the Northeast (15 percent). Marine science and technology industry employment is biggest in the Greater Boston region (36 percent), followed by the Northeast Region (24 percent), Cape Cod (12 percent), and the Southeast (11 percent). Given that Greater Boston accounts for a little over one half of the state's total employment, it is a bit underrepresented in this industry, while the coastal areas and the Northeast have relatively larger shares than their overall percentage of total state employment. However, Greater Boston accounts for almost 43 percent of sales and the Northeast region for 37 percent, indicating that firms in these two sub-regions tend to produce higher value added products.

For Rhode Island, the vast majority of business activity is in the Newport area. While the number of firms is fairly evenly divided among Providence (26 percent), Washington County (27 percent), and Newport (32 percent), almost 88 percent of

Figure 3. Distribution of Marine Science and Technology Establishments, Greater Boston and Northeast MA, 2004

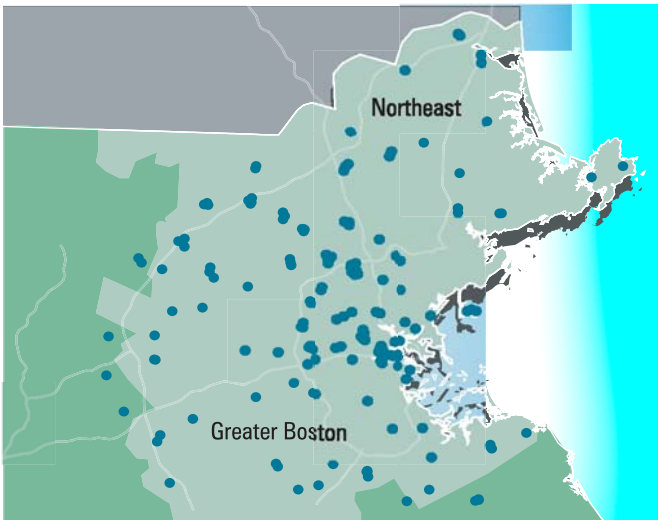


Figure 4. Distribution of Marine Science and Technology Establishments, Southeastern MA and Rhode Island, 2004

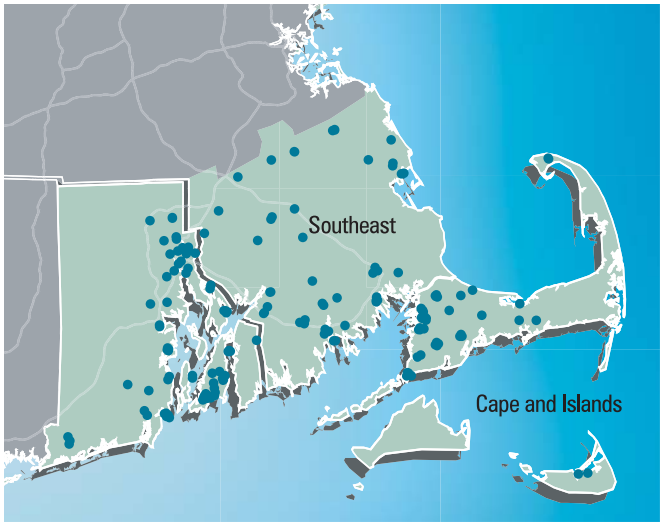


Table 4. Marine Science and Technology Industry, Rhode Island, 2004

Counties	Establishments	Employment	Sales ($m)
Bristol	7	16	3.9
Kent	4	22	1.7
Newport	24	6,080	776.3
Providence	19	423	192.3
Washington	20	402	37.2
Rhode Island	74	6,944	1,011.3

Source: D&B MarketPlace; author's survey

Table 5. Marine Sector Employment by State and New England Region, 2004

	Marine Instrumentation & Equipment	Marine Materials & Supples	Marine Research & Education	Marine Services	Shipbuilding & Design	Total
Maine	28	150	184	7	10,404	10,773
Connecticut	524	524	2	339	8,000	9,389
Massachusetts	4,470	679	1,027	2,687	0	8,863
Rhode Island	5,179	278	119	1,223	145	6,944
New Hampshire	2,295	464	126	53	0	2,938
New England	12,496	2,095	1,457	4,309	18,549	38,906

Source: D&B MarketPlace; authors' survey.

Table 6. Marine Sector Sales ($m) by State and New England Region, 2004

	Marine Instrumentation & Equipment	Marine Materials & Supples	Marine Research & Education	Marine Services	Shipbuilding & Design	Total
Massachusetts	668.6	112.2	6.6	753.5	N/A	1,540.8
Rhode Island	786.5	182.3	0.1	35.1	7.2	1,011.3
Connecticut	72.0	86.2	0.1	42.6	744.5	945.4
Maine	2.8	19.8	N/A	0.7	844.8	868.1
New Hampshire	436.4	56.8	N/A	10.1	N/A	503.3
New England	1,966.3	457.3	6.8	842.1	1,596.5	4,868.9

Source: D&B MarketPlace. * Note - Although sales for marine research and education are reported here for three states, these commercial data do not capture grant and contract activity, thus actual revenues in this sector are significantly underreported.

all employment is located in and around Newport. However, Newport accounts for a smaller percentage of sales (77 percent) and Providence a higher percentage (19 percent) than their relative employment shares, reflecting the higher value added component of Providence firms compared to those near Newport.

Analysis of marine industry sectors

Tables 5 and 6 show the breakdown by state of employment and sales in the different sectors. Not surprisingly, most of Massachusetts' industry activity is in the Marine Instrumentation and Equipment (MIE) sector, which accounts for a little over half of all Massachusetts marine technology employment. The largest New England subsector in terms of employment is Shipbuilding and Design (48 percent) in Connecticut and Maine, though this represents just over 33 percent of sales revenue, compared to MIE, which accounts for almost 40 percent of total marine technology sales revenue in New England.

MIE accounts for the largest number of New England firms (175), with Marine Services (MS) a close second (174). Most MS activity is in Massachusetts and Rhode Island, with Massachusetts firms heavily dominating the sales generated by this subsector. Given its large number of higher education institutions, Massachusetts also tends to dominate MRE sector employment. Unlike other subsectors, Marine Materials and Supplies (MMS) activity tends to be more spread out among the five states.

Not surprisingly, most of Massachusetts' industry activity is in the Marine Instrumentation and Equipment sector, which accounts for a little over half of all Massachusetts marine technology employment.

Because the MIE, MS and MMS subsectors contain so many different products, it is important to indicate which segments account for most of the economic activity. Table 7 shows that MIE is dominated by firms producing electrical

Table 7. Marine Instrumentation and Equipment, 2004

Subsectors	Employment	Sales ($m)	Establishments
Electronics for marine instruments and platforms	7,621	1,143.5	68
Electronics for marine navigation and communications	3,058	524.8	31
Oceanographic and geophysical measuring instruments	962	151.6	28
Acoustics	442	31.0	23
Floatation equipment	152	19.8	6
Underwater construction equipment	130	70.9	9
Underwater vehicles	118	22.2	5
Diving and underwater work equipment	11	2.2	2
Underwater telecommunications systems	N/A	0.1	2
Remediation equipment	N/A	N/A	1
Total	12,496	1,996.3	175

Source: D&B MarketPlace; authors' survey.

Table 8. Marine Services, 2004

Subsectors	Employment	Sales ($m)	Establishments
Commercial marine research and consulting	2,200	248.0	90
Software and systems design for marine applications	1,611	422.8	42
Marine engineering	355	149.2	32
Marine surveying and exploration	137	22.0	5
Boat facilities	6	N/A	5
Total	4,309	842.1	174

Source: D&B MarketPlace; authors' survey.

components for marine instruments, such as smart sensors, onboard computer chips, data acquisition and processing systems, electronics designed for underwater use and power generation equipment for underwater use. Table 8 shows that the largest amounts of economic activity in the MS subsector are in applied marine research, design and engineering, testing and evaluation, defense-related consulting, GIS and other mapping services and software and systems design for marine monitoring and operations. Finally, cables, engines and related marine equipment and materials dominate the MMS subsector.

U.S. and Massachusetts industries compared

Because we wanted to have some form of national comparison with Massachusetts firms, we focused on a subset of Massachusetts firms within a core sector that was covered by SIC codes, resulting in a data set that included only a few non-marine firms. Though this subsample includes only 80 Massachusetts firms employing 910 people with total sales of $163 million, it covers a broad range of companies. About half of these firms are on the less technical side of the marine technology industry, including marine construction and marine supplies; the other half are more technical firms in areas such as marine surveying, nautical equipment, marine communications and marine engineering. However, marine instruments is severely underrepresented since most firms in this industry are classified in the partial core segment.

We compared employment in this subsample of SIC codes with the rest of the nation for the 1997-2004 period. During this period, overall employment in the nation fell by 20 percent but by 61 percent in Massachusetts. However, this figure is misleading because we are identifying such a small number of Massachusetts firms. Upon closer examination it is apparent that most of this decline is due to one large firm being bought by another and having operations absorbed under a different industry code. In fact, despite this employment decline, sales remained constant in Massachusetts, while increasing nationally by 185 percent. Within the limited sectors we were able to compare nationally, the

number of firms in the nation increased by 14 percent and declined 2 percent in Massachusetts.

Overall, Massachusetts ranked consistently among the top ten states nationwide over the entire period in terms of number of businesses (ninth in 2004), employment (eighth in 2004) and sales (eighth in 2004). Not surprisingly, Massachusetts performed better if the half of the sub-sample that represents the more highly technical segments is separated out, ranking sixth in employment and number of firms and fifth in sales.

So while this comparison involves a weaker segment of the Massachusetts marine technology industry (low-tech marine construction and marine supply) and leaves out much of the marine instrument sector, this comparison shows that the Commonwealth still performs quite well on a national basis. (See table 9).

Innovation performance

Another way to approximate the innovativeness of the state's marine science and technology industry is by assessing its effectiveness in securing Small Business Innovation Research (SBIR) awards. SBIR is a set-aside program for domestic small business concerns to engage in research and development that has potential for commercialization and public benefit. Federal agencies with research and development budgets over $100 million are required to administer SBIR programs with an annual allocation of 2.5 percent for small companies to conduct innovative research or research and development.

An analysis conducted for this study indicated that marine science-related ventures represent an important proportion of overall SBIR awards coming into Massachusetts. According to our research, about 12 percent of the state's total SBIR funding comes through product development projects that we have mapped to the marine science and technology sector under the U.S. Navy SBIR program.

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Massachusetts captures 15 percent of the Navy's national SBIR awards and converts about 48 percent of them into Phase II Awards. By comparison, California captures 20 percent of

Table 9. Top Ten US States by Employment, 2004

Selected marine - related SIC codes

	Establishments	% Total	Total Employment	Total Sales ($m)	Average Employment	Average Sales
1. Connecticut	43	1.9	8,664	790.4	222	20.8
2. Florida	485	21.4	3,711	399.1	8	0.9
3. Texas	161	7.1	3,469	729.9	22	5.3
4. California	203	9.0	3,111	365.3	16	2.1
5. Virginia	115	5.1	2,296	16,883.7	22	179.6
6. Maryland	79	3.5	1,141	39.2	15	0.6
7. Louisiana	108	4.8	1,066	5,333.0	10	61.3
8. Massachusetts	80	3.5	910	162.8	11	2.2
9. Washington	141	6.2	798	109.1	6	0.9
10. New Jersey	85	3.8	727	383.9	9	5.1

Source: D&B Marketplace

these national SBIR awards from the Navy and converts about 55 percent of them into Phase II Awards (See Appendix 4). For Massachusetts, the combined new Phase I Navy SBIR awards and carried forward Phase II awards represent estimated economic investments in private sector marine technology R&D of $28 million per year under the assumptions established in our study.

New and emerging markets

The diversity of the industry in Massachusetts helps position it strategically to expand, despite cutbacks in the shipbuilding sector. New and emerging markets are developing for marine instrumentation, research and services.

- Homeland security priorities have been shifting from deep water submarine- and destroyer-based defense operations to shallow water coastal defense operations. This shift in emphasis benefits manufacturers of marine instruments, electronics and underwater vehicles.

- Federal initiatives for oceanographic and atmospheric monitoring, including oil spill monitoring, will benefit these same sectors as well as the scientific research community and providers of commercial marine services. NSF's Ocean Observatories Initiative, for example, which involves the construction of an integrated observatory network, will bring hundreds of millions of dollars to the region over ten to fifteen years, especially in the areas of marine instrumentation and hardware.

- Government and private corporations interested in far-offshore wind power generation are funding a Massachusetts-based research effort to develop a capability to develop wind farms 20 miles off shore. GE is creating a test windmill for this purpose in collaboration with MIT, UMass and WHOI, which are providing science, engineering and related policy research.

Global markets also offer expanding opportunities for Massachusetts firms. A variety of new foreign navies continue to be added to the list of authorized purchasers for U.S. defense-related products. A large number of developing countries in Asia and Latin America are reaching a point where they view marine/ocean resources as assets to be managed rather than exploited. These countries can now afford to pursue environmentally conscious policies requiring a wide range of marine science and technology products and services. Recent efforts to improve international oceanographic and atmospheric monitoring systems (for example, tsunami and typhoon warning systems) also benefit Massachusetts firms. Entrance into these international markets, of course, puts us in competition with Japan, Australia and the UK.

ECONOMIC IMPACTS

Economic analysis for New England

The total annual economic impact of the marine science and technology cluster in New England, including direct, indirect, and induced impacts, is $12.0 billion in output and 108,154 jobs with an annual payroll of $5.6 billion. This cluster is a high wage industry in New England and Massachusetts that is highly integrated with other high wage sectors such as professional services, semiconductor and electronic components manufacturing, and scientific research and development. The employee payrolls generated by the marine science and technology cluster are substantially above both the New England and Massachusetts averages for all industries. The cluster's total economic impact represents approximately 2 percent of the region's combined gross state products and 1.65 percent of its total ES-202 employment.

A variety of new foreign navies continue to be added to the list of authorized purchasers for U.S. defense-related products.

The complete economic analysis for both New England and Massachusetts, including details about methodology and definitions, appears in Appendix 5.

The following are key findings of the regional analysis:

- **Annual output**
  The annual direct output (2004 sales) of the marine science and technology cluster in New England is approximately $4.8 billion, which represents 0.80 percent of New England's combined gross state products. More than half (51.4 percent) of the cluster's annual output is concentrated in Massachusetts ($1.5 billion) and Rhode Island ($1 billion). Nearly three-quarters of the annual output is concentrated in marine instruments and equipment ($1.97 billion) and shipbuilding and design ($1.60 billion).

- **Employment**
  The marine science and technology cluster directly employs 38,906 persons (ES-202 basis) in New England, with more than half of the cluster's total employment in the region concentrated in Maine (10,773) and Connecticut (9,389) and another 23 percent in Massachusetts. Nearly one half (47.7 percent) of the cluster's total employment in New England is in shipbuilding and design (18,549) followed by marine instruments and equipment (12,496), then by marine services (4,309), marine materials and supplies (2,095) and marine education (1,457). Massachusetts employment is strong in the latter sectors and is widely diversified among those sectors.

- **Payroll**
  The marine science and technology cluster in New England generates an annual payroll of approximately $2.7 billion in wages and benefits, with an estimated average annual wage of $51,363, which is more than 17 percent higher than New England's average wage for all industries.

- **Indirect and induced economic impacts**
  The cluster made nearly $1.4 billion in local purchases in New England that indirectly generated an additional 9,679 jobs with $511.5 million in payroll and annual average wages of $39,635. These local purchases were distributed across 343 sectors of the regional economy, with the largest impacts occurring in the high technology, professional services, distribution and business travel setors.

  The cluster's indirect impacts are particularly notable in areas such as semiconductor and electronic components manufacturing, scientific research and development, wireless communications manufacturing, management consulting, computer system design services, architectural and engineering services, facilities support services and legal and accounting services.

  Consumer expenditures by employees of the marine science and technology cluster induced another 59,569 jobs in New England, with a total payroll of $2.4 billion and an annual average wage of $30,421. These consumer expenditures were distributed across 420 sectors of the region's economy with the largest impacts occurring in sectors providing consumer goods and services. The cluster's induced impacts are particularly notable in areas such as residential real estate and construction, retail distribution, automotive sales and services, eating and drinking places, child care, health care, financial services, educational services, and state and local government.

- **Multiplier effects**
  The cluster's employment multiplier effect on New England is 2.78, which means that for every 100 persons directly employed in marine science and technology, an additional 178 jobs is created by other business establisments in the region as a result of the cluster's local purchases and its employees' consumer expenditures.

  The cluster's payroll multiplier effect on New England is 2.10, which means that for every $100 of salaries and benefits paid to employees in marine science and technology, an additional $110 in wages, salaries and benefits is created by other business establishments in the region as a result of the cluster's local purchases and its employees' consumer expenditures.

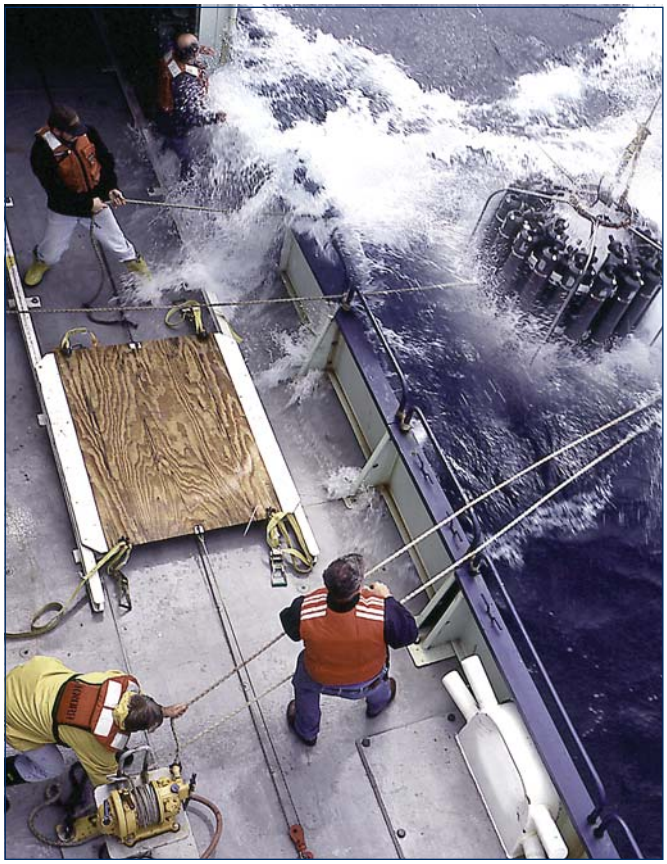

Photo credit: Craig Dickson © Woods Hole Oceanographic Institution

Economic analysis for Massachusetts

The total annual economic impact of the marine science and technology cluster in Massachusetts, including direct, indirect, and induced impacts, is $2.9 billion in annual output and 22,396 jobs with an annual payroll of $1.3 billion. This total economic impact is approximately one percent of the state's gross state product and 0.70 percent of its total ES-202 employment.

- **Annual output**
  Annual output (2004 sales) of the marine science and technology cluster in Massachusetts is approximately $1.5 billion, which is 34.1 percent of the New England industry regional total and 0.52 percent of the state's gross state product.

- **Employment**
  The cluster directly employs 8,863 persons (ES-202 basis) in Massachusetts, which is nearly 26 percent of the New England industry total and 0.28 percent of the state's total employment.

- **Payroll**
  The cluster in Massachusetts generates an annual payroll of approximately $661 million in wages and benefits, with an estimated average annual wage of $55,948, which is 20.8 percent higher than the state's average wage of $46,332 for all industries.

- **Indirect and induced economic impacts**
  The marine science and technology cluster in Massachusetts made approximately $328 million in local purchases that indirectly generated an additional 2,434 jobs with $131 million in payroll and annual average wages of $40,483, which is substantially higher than the cluster's indirect wage impacts for New England as a whole. These local purchases were distributed across 253 sectors of the Massachusetts economy, with the largest impacts occurring in the high technology, professional services, distribution and real estate sectors.

  The cluster's indirect impacts are particularly notable in areas such as semiconductor and electronic components manufacturing, scientific research and development, wireless communications manufacturing, architectural and engineering services, facilities support services, legal and accounting services, and advertising.

  Consumer expenditures by employees of the marine science and technology cluster induced another 11,099 jobs in Massachusetts with a total payroll of $472 million and an annual average wage of $31,910. These consumer expenditures were spread across 353 sectors of the state economy, with the largest impacts in sectors providing consumer goods and services. The cluster's induced impacts are particularly notable in areas such as residential real estate and construction, retail distribution, automotive sales and services, eating and drinking places, health care, educational services, and state and local government.

- **Multiplier effects**
  The cluster's employment multiplier effect on Massachusetts is 2.53, which means that for every 100 persons directly employed in marine science and technology, an additional 153 jobs is created by other business establishments in the state as a result of the cluster's local purchases and its employees' consumer expenditures.

  The cluster's payroll multiplier effect on Massachusetts is 2.23, which means that for every $100 in wages, salaries and benefits paid to employees in marine science and technology, an additional $123 in wages, salaries and benefits is created by other business establishments in the state as a result of the cluster's local purchases and its employees' consumer expenditures.

Part II

Industry View of Cluster Development Potential

Significant as they are, the quantitative data tell only part of the story of the marine science and technology cluster. To learn more about the industry, including its trends, needs and other issues, the study team sent surveys to a wide range of firms across the region. This survey was designed in part on the basis of interviews conducted with industry executives, scholars and others knowledgeable about the industry. Nearly 60 companies from five of the six New England states (60 percent of them from Massachusetts) answered the survey. The typical respondent was a small to medium-sized firm, with median current revenue of about $1.2 million. Three-fourths of the respondents have focused on the marine market for 25 years or less.

Appendix 3 presents all findings of the survey, including tables summarizing the results in each of the following categories. This part of the report presents the main results. Section I summarizes business profile information, including employment, revenues and product areas and market conditions. Section II reports more subjective responses to survey questions about the advantages and disadvantages of being located in New England, recruiting problems and other issues. In this section, parenthetical quotations are drawn directly from answers to the survey.

I. BUSINESS AND ECONOMIC PROFILE

Employment and revenue

- 53 percent of companies reported employment growth over the previous two years and 74 percent expect jobs to increase from the current mean of 24 employees to 30 over the next two years.

- Typical of smaller firms in technology-driven industries, workforce data reflect an emphasis on knowledge creation, product development and production. The largest segments of the responding companies' workforces are engineers (38 percent average across the sample), production workers (24 percent) and scientists (24 percent).

- 63 percent of respondents reported revenue growth over the previous two years and 85 percent expect revenue growth in the next two years, which would result in median annual revenue of $1.5 million.

Products and services

- Responding companies are involved in a wide array of products and services, with 55 percent saying they provide more than one marine-related product or service. Defense-related marine equipment manufacturing, ocean/environmental surveying and monitoring and marine science equipment manufacturing were the most frequently cited business products or services.

- Respondents were also asked to identify which of 10 niche markets they currently serve. Defense (66 percent), oceanographic (64 percent), atmospheric/environmental and offshore oil and gas (each at 33 percent) were the most frequently identified. Wind/tidal energy (10 percent), offshore communications (14 percent) and fisheries (24 percent) were less frequently named.

- The majority of respondents believed that the defense (55 percent) and homeland security (53 percent) sectors offer potential for growth, while 88 percent of companies serving the wind/tidal energy and offshore communications markets indicated that those markets are not poised for growth.

II. INDUSTRY TRENDS AND ISSUES

Obstacles to commercialization

Respondents were given a range of factors that could pose obstacles to commercialization of their products and services. They were asked to say which factors were of greatest concern and which were of least concern.

Most frequently cited obstacles to commercialization:

- Lack of labor with required skills/expertise (74 percent said this was a great or moderate concern).
- Product cost (73 percent great or moderate concern).
- Access to capital (59 percent).

Least frequently cited obstacles to commercialization:

- Lack of test sites to demonstrate product (66 percent little or no concern).
- State regulations and permitting (52 percent little or no concern).
- Federal regulations and permitting (51 little or no concern).

Workforce recruitment

The survey confirmed earlier interviews with industry executives who cited worker recruitment as a critical concern to the industry. The most difficult positions to fill are engineers (53 percent of respondents reported difficulty) and technicians (45 percent). The least difficult positions to fill included scientists (25 percent) and managers (33 percent).

Comments from the survey

"Marine/ocean engineering is an inherently multi-disiciplinary industry. This makes finding well-rounded people difficult."

"Not many U.S. students are in underwater acoustics. "

"Finding people with backgrounds in the ocean industry is such a plus – these folks are in short supply."

Asked what factors make employee recruitment difficult, several firms responded that the nature of the industry itself makes recruitment difficult. Other respondents listed more specific difficulties they face in recruiting employees, including rural locations and high housing and other costs of living.

Business environment

Respondents were asked to rate the various advantages and disadvantages of being located in New England. They were asked to rate factors in three broad areas — business and industry factors, infrastructure factors and quality of life factors — as being a significant advantage, modest advantage, neutral, modest disadvantage or significant disadvantage.

- **Business and industry factors**
  Respondents said their New England location presented several advantages to their companies. Access to research institutions was rated as an advantage by 77 percent of respondents, 60 percent cited "proximity to others in the industry" and 57 percent cited "proximity to testing facilities" as a regional advantage. On the disadvantage side, 70 percent of respondents identified the cost of doing business in New England as a modest or significant disadvantage.

- **Infrastructure factors**
  "High speed data transmission (broadband)" was identified as a significant or a moderate advantage by more than half of respondents (54 percent) in the overall sample.

"Physical infrastructure" was cited as a slight advantage (48 percent). As for "state regulatory policy," 65 percent of companies identified that factor as neutral or said they did not know. Of those with an opinion on this factor, one third viewed it as a disadvantage and only 8 percent viewed it as an advantage.

- **Quality of Life**
  Two factors — with two differing responses — were included in the quality of life component of the survey. When asked about the overall, quality of life in New England, 75 percent of respondents indicated that the quality of life is a significant or moderate advantage of their business location. The cost of housing, however, was viewed as a disadvantage by 67 percent of respondents.

Potential business assistance

Survey respondents were asked to rate ten possible business assistance initiatives that interviewees and other industry stakeholders suggested could boost the marine science industry. Respondents were asked to rate each option as "highly beneficial," "somewhat beneficial" or "not beneficial." They were also asked to rank the three assistance options that they believe would be most beneficial to their company.

The option most frequently identified as most beneficial was the provision of grants to support proof of concept research. The second highest ranked category was the creation of a forum for strategic alliances to secure funds for large-scale research, development and demonstration projects and the third most highly ranked form of potential business assistance was a center for product development, testing and demonstration.

Comments from the survey

"We supply equipment world wide. If our building was not owned by us, given the cost of energy, living and taxes, we would have few reasons to stay in New England."

"Western Massachusetts is a very appealing place to live from a quality of life perspective. The negative is the lack of a technically-based industrial segment."

"This area is known for marine-related activity. The dynamic of a concentrated marine tech community in close proximity is an advantage, along with quality of life."

"The region has zero commitment to traditional/mature industry. All capital is going to more sexy but more risky industries. We can't modernize because of lack of capital. We are more and more outsourcing our services to Brazil where competent scientists/engineers are very cheap and skillful."

"New England is a great place to live but is very expensive relative to other locations."

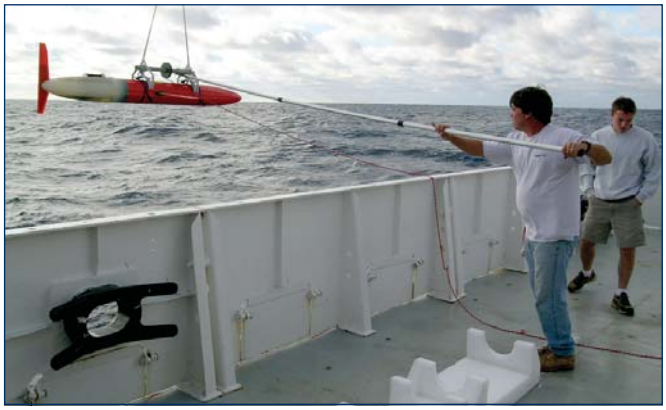

Photo credit: Jane Dunworth-Baker © Woods Hole Oceanographic Institution

Collaboration

Survey respondents were asked about their collaboration with oceanographic research institutions, colleges/universities, government agencies, marine technology and other firms. All respondents reported that they collaborated with at least one of the listed types of institutions. The data suggest a healthy level of collaboration exists within the industry and that these firms routinely engage academic, research, government organizations and/or other marine technology firms. Firms more frequently report that they collaborate on research and development than on testing and demonstration or other activities. Appendix 7 discusses the range of educational programs across New England that are linked to and collaborate with the marine science and technology industry.

Supplier relationships

The survey also inquired about companies' supplier relationships for various products and services. Generally, respondent companies rely more on New England suppliers than on suppliers from outside the region. The exception is in the area of electronics and sensors, where slightly more respondents rely on companies outside of New England than on local supplies. The three products and services most frequently supplied within New England include:

- Machining equipment (71 percent in New England)
- Marine components (62 percent)
- Raw materials (59 percent)

Software development is evenly split, with 37 percent obtaining software supplies from within New England and the same percentage sourcing this business to other suppliers.

NOTE
[1] A collection of appendices offering greater detail on certain aspects of this report is available on-line at http://www.massbenchmarks.org.

Strategic Opportunity

A wide range of trends, technology and other factors are coming together today to create major opportunities for the region's marine science and technology cluster, especially if it forms major alliances with New England's rich pool of research institutions, agencies and firms.

Technologies are converging that will provide unprecedented capability for monitoring and exploring the coastal zone and deeper ocean. Rapid progress continues in the development of traditional tools of ocean research, such as tethered and autonomous vehicles and acoustic, atmospheric and optical sensing devices. Cutting-edge biological and chemical sensors are becoming available to provide information in different domains. At the same time, advances in information technology, electronics and communications offer the possibility of deploying large networks of devices to gather and transmit data that can be examined in real time or stored for later analysis or use in simulation and modeling scenarios.

As technology creates opportunities, other factors are also affecting prospects for the region's marine science and technology firms. Security for our ports, coastal areas and shipping is already a large and growing concern nationwide. Environmental risks, whether due to long-term climate trends, weather events, accidents such as oil spills or potential terrorist acts are growing even as the population along the coasts continues to increase. The survival and long-term prosperity of our nation's fisheries is an equally daunting challenge. Recent initiatives illustrate a growing interest in deep water and far offshore wind energy generation systems. The ocean is also increasingly viewed as a source for novel materials and biopharmaceuticals.

These trends and realities create opportunities for firms and research institutions in the marine cluster, particularly those that are strong in major instrumentation, defense contracts and systems integration, software and systems focused on information technology, and communications relying on fiber optics and wireless technologies. There is also a potential tie-in with materials companies and biotech/pharmaceutical companies as research into diverse life forms and compounds develops and as chemical and biological sensors are increasingly deployed in the ocean.

The Department of Homeland Security (DHS) offers a new funding source for research and development. Not only could DHS research money go to challenging applications of new technologies, but a visible ocean research alliance would help position companies in the region for more substantial DHS funding to develop new technologies and systems.

The U.S. Navy has been an important funder of ocean research and ocean-related technologies. The U.S. Coast Guard has most of the explicitly defined homeland security mission for the coastal zone. NOAA has historically provided key funding in ocean exploration. Another opportunity is the National Science Foundation's major funding for its Ocean Observatories Initiative.

One of the keys to seeing these and other opportunities succeed lies in large-scale alliances between the industry and the region's research institutions, agencies and firms. Significant regions of the country, including California, North Carolina and Florida, are already competitors. In New England, we see evidence of collaboration among multiple institutions and firms on large-scale projects, such as NSF's Ocean Observatories Initiative and the Massachusetts Technology Collaborative's Offshore Wind Energy Collaborative. Recent reports by the U.S. National Research Council and the U.S. Commission on Ocean Policy, have called for national efforts to ignite a new era in ocean exploration. If the federal government accepts that call, new funding could become available. This region must be poised to compete.

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