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Sailing into a Strong Future: The Massachusetts Marine Science and Technology Industry

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WITH ITS FOCUS ON HIGH-TECHNOLOGY, VALUE-ADDED MARKETS, THE BAY STATE'S MARINE SCIENCE AND TECHNOLOGY CLUSTER AND ITS DIVERSE RANGE OF COMPANIES KEEPS EXPANDING INTO HIGH-END MARKETS.

When workers demolished the craneway and other remnants of the former Fore River shipyard in Quincy this summer, the event hardly made a news ripple in Massachusetts. But not that long ago, the future of that Quincy shipyard — or the lack thereof — was a major economic story. Until it was shut down by General Dynamics Corporation in 1986, the sprawling facility provided steady careers and good wages for thousands of skilled machinists and other workers, spinning off economic activity and revenues to a wide range of businesses. No wonder that through the 1980s and into the 1990s, political leaders and others kept scrambling for ways to revive shipbuilding work at Quincy. The loss of such an established Massachusetts industry was felt to indicate yet another body blow to the state's manufacturing economy. Now, if they think about it at all, Massachusetts political leaders, economists and others have generally come to accept the fact that where Navy battleships were once built and launched is now the site of an auto storage and shipping facility.

But while such largescale shipbuilding and repair work may have left the Bay State, a new study by the University of Massachusetts Donahue Institute — *The Marine Science and Technology Industry in New England* — reveals that a less visible, but fully robust, marine science and technology industry has emerged in its place. This marine science and technology sector (MST) consists of a diverse range of industries and technologies, employing people 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. While MST firms operate all across New England, the Commonwealth is home to almost two-thirds of these companies and accounts for one-quarter of their total employment and almost one-third of total MST sales in New England.

This concentration of marine science and technology businesses and research institutions positions Massachusetts as a global leader, according to the report. Because

Massachusetts MST firms are concentrated in high value-added, high-technology production, they and the Bay State economy are unlikely to be seriously affected by any decline in defense-related shipbuilding. The MST sector 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.

The first part of this article presents an overview of the MST sector in New England, with a particular focus on Massachusetts. It discusses various qualitative and other issues involving MST. The second part of this article presents a more quantitative economic impact analysis of MST in New England and Massachusetts.

Part I

Marine science and technology: what and where?

The research team identified five primary sub-sectors of the marine science and technology cluster.

- **Marine instrumentation and equipment (MIE)**
  This category includes firms that produce cutting-edge marine equipment, such as transducers, various meters, remote sensing equipment, fiberoptic and GPS systems, a variety of sensors and underwater power sources and generating equipment. Also included are oceanographic and geophysical measuring instruments, such as magnetometers and current meters, acoustics for underwater remote uses, electronics for marine instruments and platforms and for marine navigation and communications, which enable onboard, under- and above-water navigation and communication, including GPS systems and fiberoptic systems to allow Internet-based communications relays.

- **Marine services (MS)**
  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. Also within this sub-sector is 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, as well as software and systems design for marine monitoring and operations.

- **Marine research and education (MRE)**
  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 and industry and technology transfer groups.

- **Marine materials and supplies (MMS)**
  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 (SBD)**
  This category includes major defense-related shipbuilding operations including military installations, such as Portsmouth Naval Shipyard and the Naval Submarine Base in Groton, CT.

Some establishments 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.

MST 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 more accurately determine the employment and sales activity generated in the marine technology sector.

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 the UMass 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.

The 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 higher value-added nature of Massachusetts production, which is typical of most of the Commonwealth's manufacturing and service industries. Because of 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. Unlike Massachusetts, however, 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, the study 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 per cent and second-tier firms at 10 percent. The results of this weighting process, which appear in Table 2, present what the study authors believe to be the most accurate estimate of employment (38,906) and sales (more than

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

The character of the industry is quite different in Massachusetts which, rather than being dominated by a few large shipbuilding operations, is composed predominantly of smaller companies involved in a far more diverse set of sub sectors.

$4.8 billion) in the marine technology sector for the New England region in 2004.

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 which, rather than being dominated by a few large shipbuilding operations, is composed predominantly of smaller companies involved in a far more diverse set of sub-sectors. 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 Naval Shipyard, 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.

To get some sense of the regional distribution of the ocean science and technology industry, the master list of Massachusetts firms was divided into different regions as defined by the Massachusetts Benchmarks Project. Figure 1 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 region (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

Figure 1. Distribution of Marine Science and Technology Establishments, Eastern Massachusetts and Rhode Island

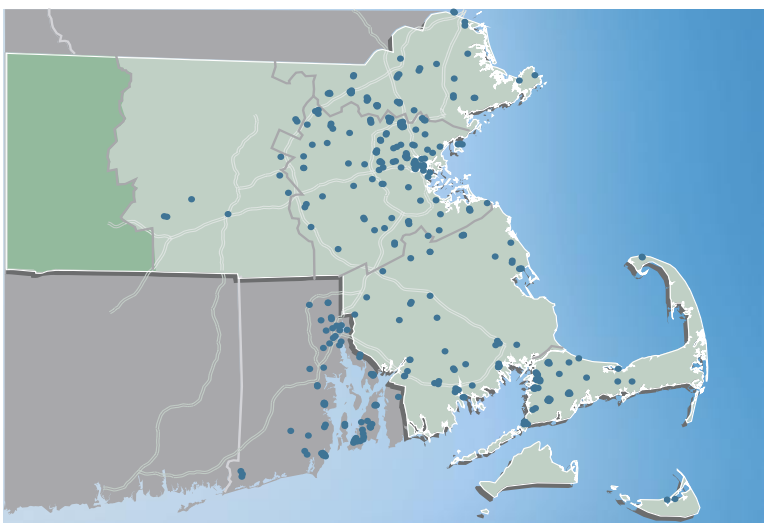

Table 3. Marine Science and Technology Industry, Massachusetts, 2004

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

Table 4. Top Ten 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

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.

Not surprisingly, a little over half of all Massachusetts marine technology employment is in the marine instrumentation and equipment sector, which also accounts for the largest number of firms (175) across the New England region. Marine services is a close second with 174 firms, with Massachusetts firms heavily dominating the sales generated by this sub sector. Given its large number of higher education institutions, Massachusetts also tends to dominate MRE sector employment.

Massachusetts and U.S. MST industries: A comparison

In order to compare the Massachusetts and national MST industries, the study focused on a subset of Bay State firms within a core sector that was covered by SIC codes. Though the resulting data set includes only 80 Massachusetts firms employing 910 people with total sales of $163 million, it represents 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.

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.

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 4).

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 benefits. 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.

Another analysis conducted for the study also showed the state's strength in the MST industry. This analysis found that marine science-related ventures represent an important proportion of overall SBIR awards coming into Massachusetts. About 12 percent of the state's total SBIR funding comes through product development projects mapped to the marine science and technology sector under the U.S. Navy SBIR program. 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 these national SBIR awards from the Navy and converts about 55 percent of them into Phase II Awards. 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.

Part II

Economic analysis of MST sector in Massachusetts

The total annual economic impact of the marine science and technology cluster in New England, including direct, indirect and induced impacts, is $12 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 into 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.

Total marine technology sector activity in Massachusetts was estimated to encompass about 300 firms, with marine-related employment of nearly 9,000 and marine-related sales of over $1.5 billion. By comparison, the much larger telecommunications industry in the state included nearly 6,000 establishments in 2004, employing over 100,000 people, according to the Massachusetts Telecommunications Council. The biotech industry had almost 1,000 establishments employing 42,000 people (Mullin and Lacey, 2003), and the environmental industry, which includes almost 2,400 firms, employed 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 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).

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. 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.

Conclusion: A future in new and emerging markets

The diversity of the industry in Massachusetts helps strategically position it to expand into new and emerging markets 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, a change that benefits manufacturers of marine instruments, electronics and underwater vehicles.

- Federal initiatives for oceanographic and atmospheric monitoring, including oil spill monitoring, will also benefit these same sectors as well as the scientific research community and providers of commercial marine services. The National Science Foundation'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 10 to 15 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. General Electric is creating a test windmill for this purpose in collaboration with MIT, UMass and Woods Hole Oceanographic Institution.

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.

In short, a wide range of trends, technology and other factors are coming together to create major opportunities for the state's marine science and technology cluster, especially if it forms major alliances with the rich pool of research institutions, agencies and firms in Massachusetts and across New England. 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. These trends and realities create opportunities for firms and research institutions in the marine, science and technology cluster.

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