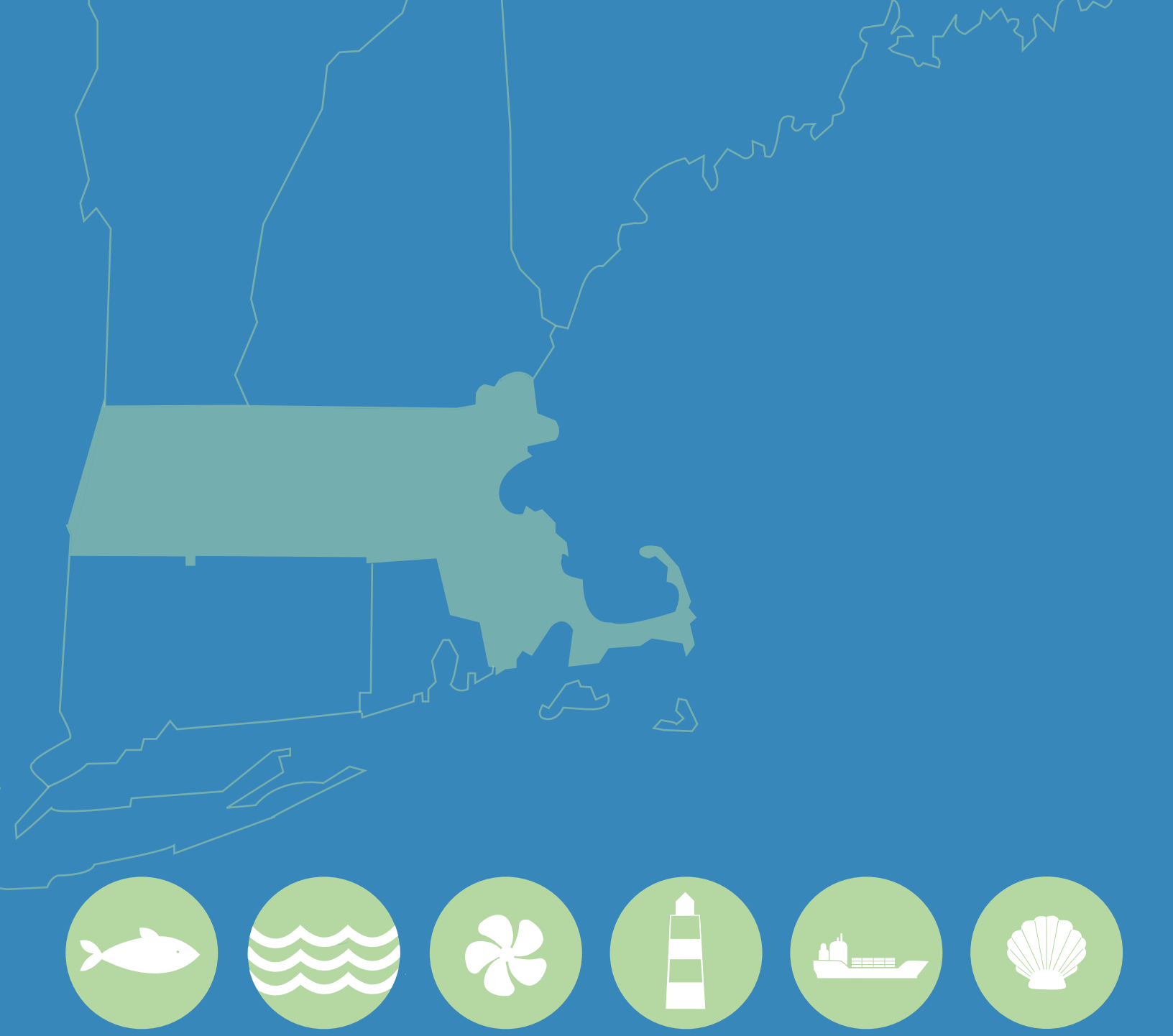


Navigating the Global Economy: A Comprehensive Analysis of the Massachusetts Maritime Economy

Public Policy Center
UMass Dartmouth

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Our Mission

The mission of the Public Policy Center (PPC) at UMass Dartmouth is to:

- Inform evidence-based policymaking.
- Improve public understanding of critical policy issues.
- Provide educational and research opportunities to our faculty and students.
- Connect the resources of the University of Massachusetts to the communities we serve.

The PPC's primary goal is to inform public policy discussions by providing policymakers with university quality research, technical assistance, and analytical services designed to help make our state, region, and communities better places to live, work, and do business. We do this by leveraging the substantial skills of our students and faculty partners, and enhancing the connections between the University and the communities it serves.

Seaport Economic Council

As part of the Baker-Polito Administration's commitment to promote prosperity in communities of all sizes as well as to cultivate job and economic growth in the maritime economic sector, the Seaport Advisory Council was revitalized under Executive Order 564 and is now known as the Seaport Economic Council. The Seaport Economic Council (SEC) works with Massachusetts' 78 coastal communities to provide statewide coordination of all coastal community planning and investment activities, with the aim to stimulate economic development and create jobs in the maritime economy sector as well as to protect coastal assets that are vital to achieving these aims.

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Trade Association Seat 2, Murray Scudder, Passenger Vessel Association, VP/ Operations Hyline Cruises

"We are tied to the ocean. And when we go back to the sea.. we are going back from whence we came."
- President John F. Kennedy

Acknowledgements

The Public Policy Center would like to thank the Seaport Economic Council and Lieutenant Governor Karyn Polito for funding and supporting this research. The PPC would also like to thank Dr. Charles Colgan, Director of Research at the Center for the Blue Economy at the Middlebury Institute of International Studies at Monterey Bay, Leslie Ann-McGee, Director of the Cape Cod Blue Economy Project, and the business and industry leaders who shared their insights with the project's authors.

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EXECUTIVE SUMMARY

The Massachusetts Maritime Economy is comprised of 5,555 establishments that employ 90,482 workers, pay $3.4 billion in total wages, and account for $6.4 billion in gross state product. These businesses are a significant economic driver in Massachusetts, representing 2.6 percent of the Commonwealth's direct employment and 1.3 percent of its direct gross state product.



Employment in the industry compares favorably with other major sectors of the state's economy, including the Information and Manufacturing sectors.

Employment in Major Sectors

Industry	Employment (2015)
Maritime	90,482
Computer & Electronics Mfg.	56,088
Finance & Insurance	168,192
Information	93,961
Legal Services	27,895
Real Estate	32,667
Wholesale Trade	123,917

Source: ENOW; NOEP; Authors' calculations.

Growth in the Massachusetts Maritime Economy Was More Robust Than the Statewide Industry Total

Growth in Massachusetts' Maritime Economy was generally more robust than the state as a whole from 2005 to 2015; employment grew by 18.2 percent from 2005 to 2015, compared to 8.4 percent for the statewide industry total. Gross State Product (48.0% vs. 32.1%) and Real Gross State Product (36.7% vs. 11.4%) also increased significantly more than the state total, although the number of establishments grew at a slower pace.[1]

Change In the Massachusetts Maritime Economy
Establishments, Employment, Wages, and GSP

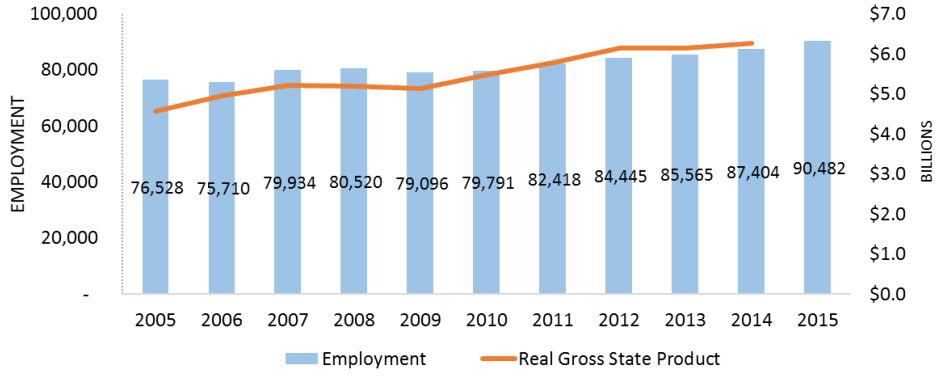
	2005	2014/15	Change	State Change[2]
Establishments	5,237	5,555	6.1%	16.5%
Employment	76,528	90,482	18.2%	8.4%
GSP ($M)	$4,342.7	$6,426.6	48.0%	32.1%
Real GSP ($M)	$4,570.9	$6,246.7	36.7%	11.4%

Source: ENOW; NOEP; Authors' calculations.

The Maritime Economy Grew Through the Great Recession

The Massachusetts Maritime Economy exhibited fairly consistent employment and real GSP growth throughout the economic cycle. While the Maritime Economy experienced a slight downturn in employment and real GSP in 2009, both indicators returned to an upward trajectory just a year later and this trend continued through 2014 and 2015 (see below).

Employment & Real GSP, 2005 - 2014/15



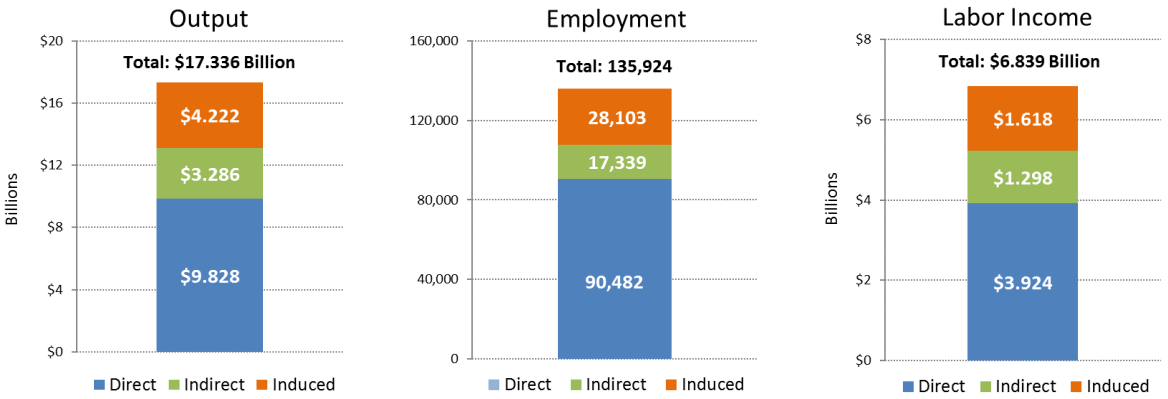
Source: ENOW; NOEP; Authors' calculations.

[1] Establishment, employment, and wage data are for 2015. The latest available GSP data are for 2014.
[2] Includes all of the state's industries.

The Massachusetts Maritime Economy Is a Significant Economic Driver

The Massachusetts Maritime Economy generated a total statewide economic impact of $17.336 billion in output (sales), 135,924 jobs, and $6.839 billion in labor income in 2015. Or put another way, with $9.828 billion in output, 90,482 workers, and $3.924 billion in labor income (direct impacts), maritime related businesses supported an additional $7.508 billion in output, 45,442 jobs, and $2.915 billion in labor income in the Massachusetts economy (indirect and induced impacts).

Economic Impact of the Massachusetts Maritime Economy



Source: Public Policy Center.

Tourism & Recreation is the Largest Maritime Economy Sector

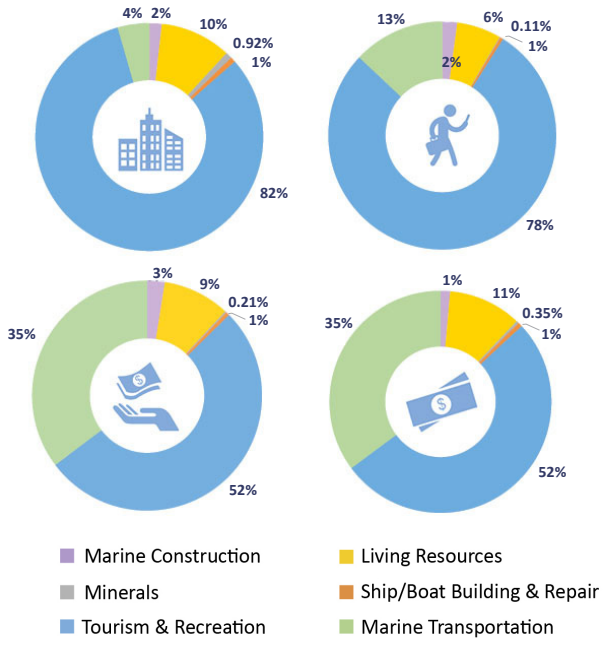
There are six major sectors in the Massachusetts Maritime Economy:

- Living Resources
- Marine Construction
- Offshore Minerals
- Ship & Boat Building & Repair
- Tourism & Recreation (Coastal)
- Transportation

Tourism & Recreation is by far the largest sector in terms of employment, although it accounts for a smaller share of total wages and gross state product. Conversely, the Marine Transportation sector, which includes Marine Technology, accounts for only 13 percent of employment, yet 35 percent of total wages and 35 percent of GSP, is primarily due to the high value of the products and services the sector provides.

The Living Resources sector accounts for six percent of Maritime Economy employment. Employment in the sector has been declining since 2009, particularly in the fishing industry. Ship & Boat Building & Repair accounts for only small portions of employment and GSP due to the almost total absence of major ship and boat builders in the Commonwealth.

Massachusetts Maritime Economy Establishments, Employment, Total Wages and GSP by Sector



Source: ENOW; NOEP; Author's calculations.

Marine Construction, which is connected to industries across many of the other maritime sectors, accounts for two percent of Maritime Economy employment and is highly dependent on overall economic conditions and larger government-supported projects such as dredging and infrastructure. The Offshore Minerals sector, which is comprised primarily of oil and gas production companies, is a very small sector in Massachusetts.

Massachusetts Has a Higher Concentration of Maritime Industries in Comparison to the Nation

The location quotient (LQ) measures the concentration of employment in Massachusetts' Maritime Economy sectors relative to employment in these sectors nationally. Overall, Massachusetts' Maritime Economy has an LQ of 1.14, which means that the state is 14 percent more dependent on maritime sectors as a source of employment than the nation.[3] Living Resources and Tourism & Recreation are among the most specialized industries, with LQs of 2.92 and 1.27, respectively. These are also the two largest sectors in the Massachusetts Maritime economy, collectively accounting for 85 percent of Massachusetts' maritime employment (see table to the right).

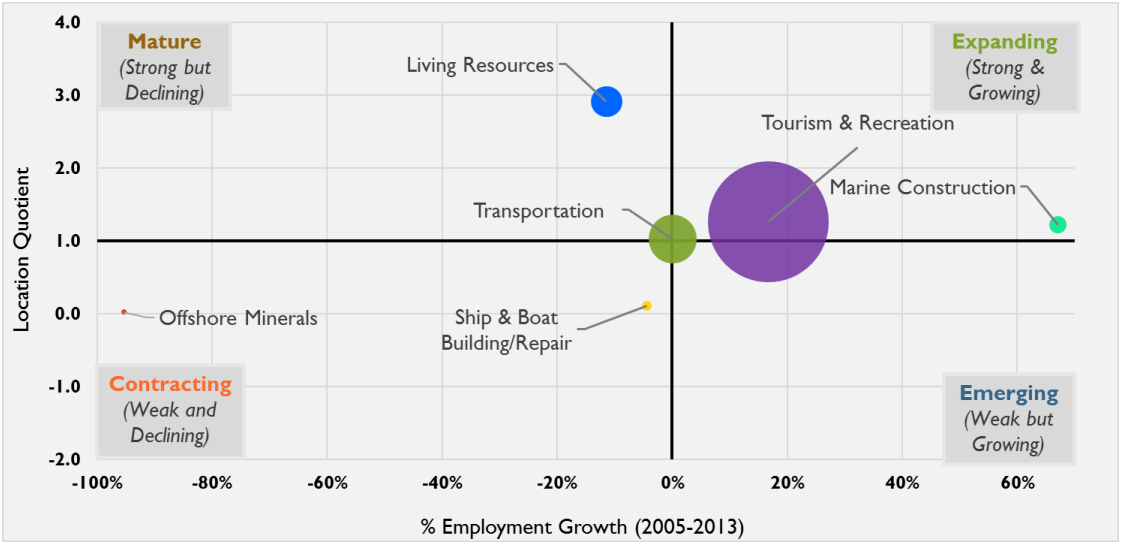
The figure below displays the LQ for each of the sectors in relation to their size and employment growth from 2005 to 2013, with the size of each circle representing total employment. Tourism & Recreation and Marine Construction are "Expanding" sectors, meaning they have above average employment concentrations and have experienced employment growth since 2005. Living Resources is a "Mature" sector, with high employment concentrations, indicating regional specialization, but with a shrinking labor force. Offshore Minerals and Ship & Boat Building & Repair are defined as "Contracting" industries, with lower concentrations of employment compared to the nation and negative employment growth from 2005 to 2013. The Marine Transportation sector straddles all four quadrants, indicating an average employment concentration and stable employment levels.

Location Quotient, 2013

Industry Category	LQ
Living Resources	2.92
Marine Construction	1.22
Minerals, Offshore	0.03
Ship & Boat Building/Repair	0.11
Tourism & Recreation	1.27
Transportation	1.03
Maritime Economy Total	1.14

Source: ENOW; NOEP; Authors' calculations.

Location Quotient, Growth, and Size of Massachusetts Major Maritime Economy Subsectors, 2013



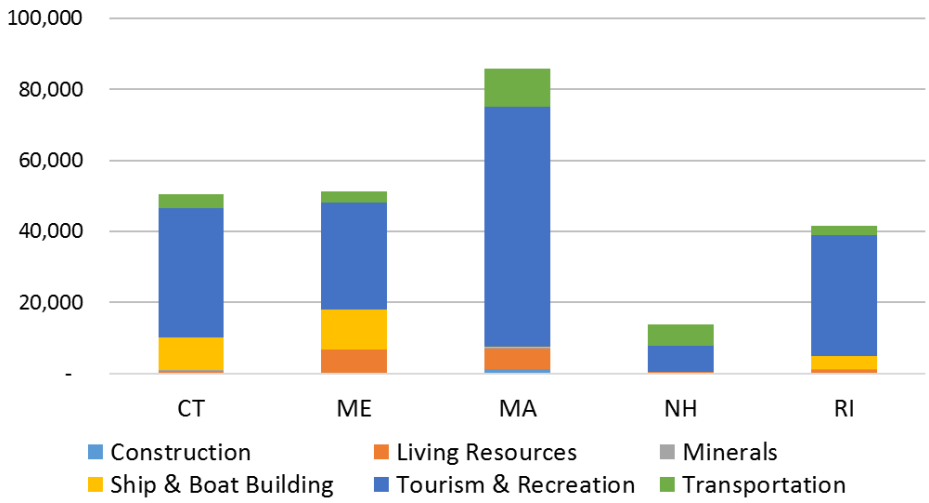
Source: ENOW; NOEP; Author's calculations.

[3] Retrieved February 2, 2017, from http://marinebio.org/oceans/ocean-resources/.

Massachusetts' Maritime Economy is the Largest Among New England's Coastal States

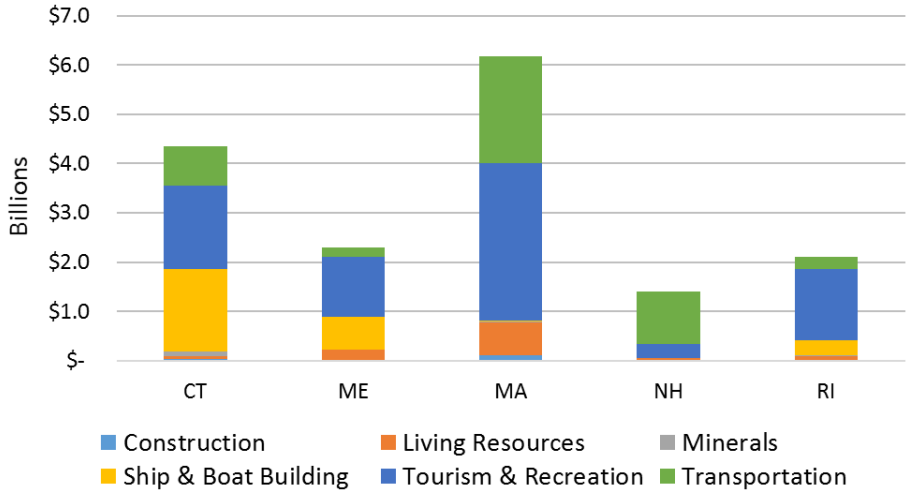
Massachusetts has the largest Maritime Economy in terms of employment and GSP among New England's coastal states. Tourism & Recreation is the largest maritime employment sector in each of the states, although the relative importance of the six maritime sectors clearly varies by state.

Sector Employment by State, 2015



Source: ENOW; NOEP; Authors' calculations.

Gross State Product by State, 2015

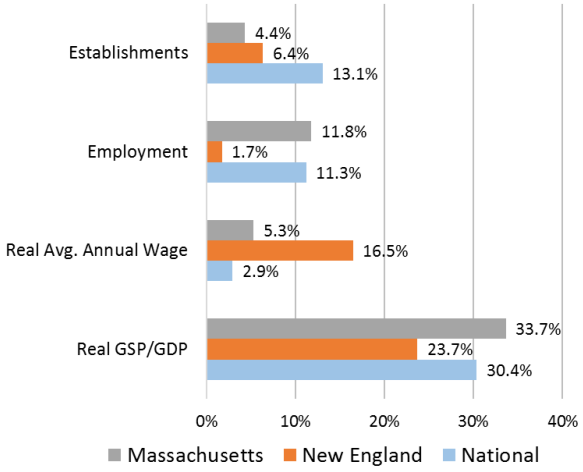


Source: ENOW; NOEP; Authors' calculations.

Employment and Real GSP Growth Outpaced New England and Northeast

The Massachusetts Maritime Economy performed well from 2005 to 2013 in comparison to the national and New England maritime economies.[4] For example, the state outpaced the national and New England maritime economies in terms of employment (+11.8% versus +1.7% and +11.3%) and real GSP growth (+33.7% versus +23.7% and +30.4% respectively),[5] while average annual wages grew faster than the nation but slower than the New England average (+5.3% versus +23.7% and +30.4% respectively). Conversely, the number of Massachusetts maritime establishments increased at a slower rate.

Change in the Maritime Economy, 2005 - 2013



Source: ENOW; NOEP; Authors' calculations.

Marine Technology is a Significant Contributor to the State's Innovation Economy

The Marine Technology cluster includes many fields, including robotics, oceanography, renewable and non-renewable energy, biotechnology, communications hardware, information technology, advanced materials, and civil engineering. The state is home to the Woods Hole Oceanographic Institute, the largest oceanographic research center in the country. Massachusetts is also widely acknowledged as a leading, if not the foremost, international Unmanned Underwater Vehicle (UUV) cluster. This sector primarily falls under the Search, Detection Navigation, & Instrument Manufacturing industry classification. Companies in this industry alone employed approximately 5,193 people in Massachusetts in 2015 and paid average annual wages of $145,285, more than twice the statewide average.

Federal funding is key to the state's Marine Technology cluster. Institutions of higher education in Massachusetts collectively spent $164.8 million on oceanographic research and development (R&D) in 2014, which places the state second in the nation (see table below). The majority of academic R&D activities are federally financed, accounting for 76 percent of Massachusetts' oceanographic R&D expenditures. Most of the funding is awarded by the National Science Foundation (NSF), the U.S. Navy, and the National Oceanic Atmospheric Administration (NOAA).

While federal defense spending has been one of the primary growth drivers for the Marine Technology cluster, marine renewable energy, adaptation to sea level rise, and other technical fields provide new growth opportunities for the cluster.

Top Ten States by Total Oceanographic R&D Expenditures, 2014

Port	Value ($Millions)	Pounds (Millions)
Alaska	$1,087.90	2,877.7
Massachusetts	$430.90	232.5
Louisiana	$295.30	909.3
Maine	$294.10	159.3
Washington	$238.10	150.7
Florida	$170.70	63.9
Texas	$155.60	70.1
New Jersey	$147.00	138.7
California	$118.20	183.5
Virginia	$108.20	372.5

Source: NSF Survey of R&D Expenditures at Universities and Colleges-Higher Education Research and Development Survey, 2010-2014.

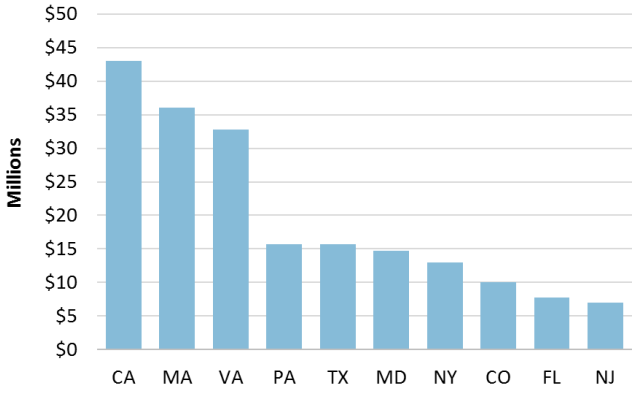
[4] Retrieved January 15, 2017, from http://oceanexplorer.noaa.gov/facts/climate.html.

[5] Note that 2014 and 2015 NOEP data is not available on the regional and national level.

Massachusetts Ranks Second Among U.S. States in Total Dollar Value of Small Business Innovation Research (SBIR) & Small Business Technology Transfer (STTR) Program Awards

The SBIR/STTR program is another important funding source for marine-related R&D. In 2015, Massachusetts companies were awarded 500 SBIR/STTR awards. Of these, 81 were maritime-related, bringing in $204 million of investment in new technologies. This represents 11 percent of all SBIR/STTR money coming into the state. The U.S. Navy awards the vast majority of maritime-related SBIR/STTR dollars, though some U.S. Navy SBIR/STTR awards are for technologies related to their flight program. With $36 million received in 2015, Massachusetts ranks second among U.S. states in the total dollar value of SBIR/STTR funds awarded by the Navy.

Value of U.S. Navy SBIR/STTR Awards
Top Ten States, 2015

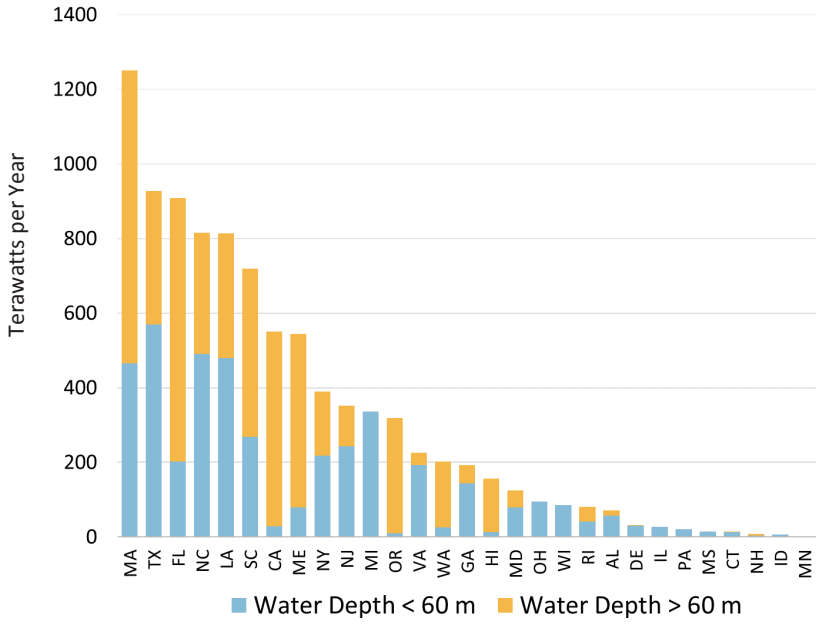


Source: U.S. Small Business Association.

Aquaculture and Marine Renewable Energy Offer Emerging Opportunities in Marine Technology

Aquaculture and marine renewable energy — particularly offshore wind — offer two opportunities to expand the Marine Economy in Massachusetts. In 2013, Massachusetts was home to an estimated 145 aquaculture operations, which generated $18 million in revenue and employed 769 workers. While over half of the seafood that the U.S. imports was farmed using aquaculture, only 7.8 percent of seafood produced in the U.S. comes from aquaculture, the remainder being wild caught. Therefore, an opportunity exists for domestic aquaculture to fill a significant portion of the U.S. seafood demand currently fulfilled by imports. Austrailis Aquaculture is a prime example Massachusetts' growing aquaculture industry. The Turners Falls based company operates one of the largest indoor re-use water aquaculture facilities in the world, growing 1,000 metric tons (2.2 million pounds) of barramundi annually.

Technical Offshore Wind Potential by State and Water Depth, (TWHr/yr)



Source: National Renewable Energy Laboratory, 2016.

Offshore wind deployment represents an opportunity to many industries in the Marine Economy, including boat building, marine construction, and marine transportation. Massachusetts has the largest offshore wind potential of any state in the contiguous U.S., which if harnessed, could produce over 1,000 TWh/yr. By comparison, in 2014, Massachusetts consumed 54.5 TWh of electricity. Therefore, if fully developed, offshore w ind energy could potentially generate over 18 tim es the state's existing electricity consumption, making it a potential export industry for the state. While there are not any wind farms currently operating off the coast of Massachusetts, development is expected to accelerate thanks to a 2016 bill passed by the Massachusetts state legislature and signed into law by the Governor requiring the state's major electrical utilities to enter into long-term contracts to procure 1,600 megawatts of locally generated offshore wind power.

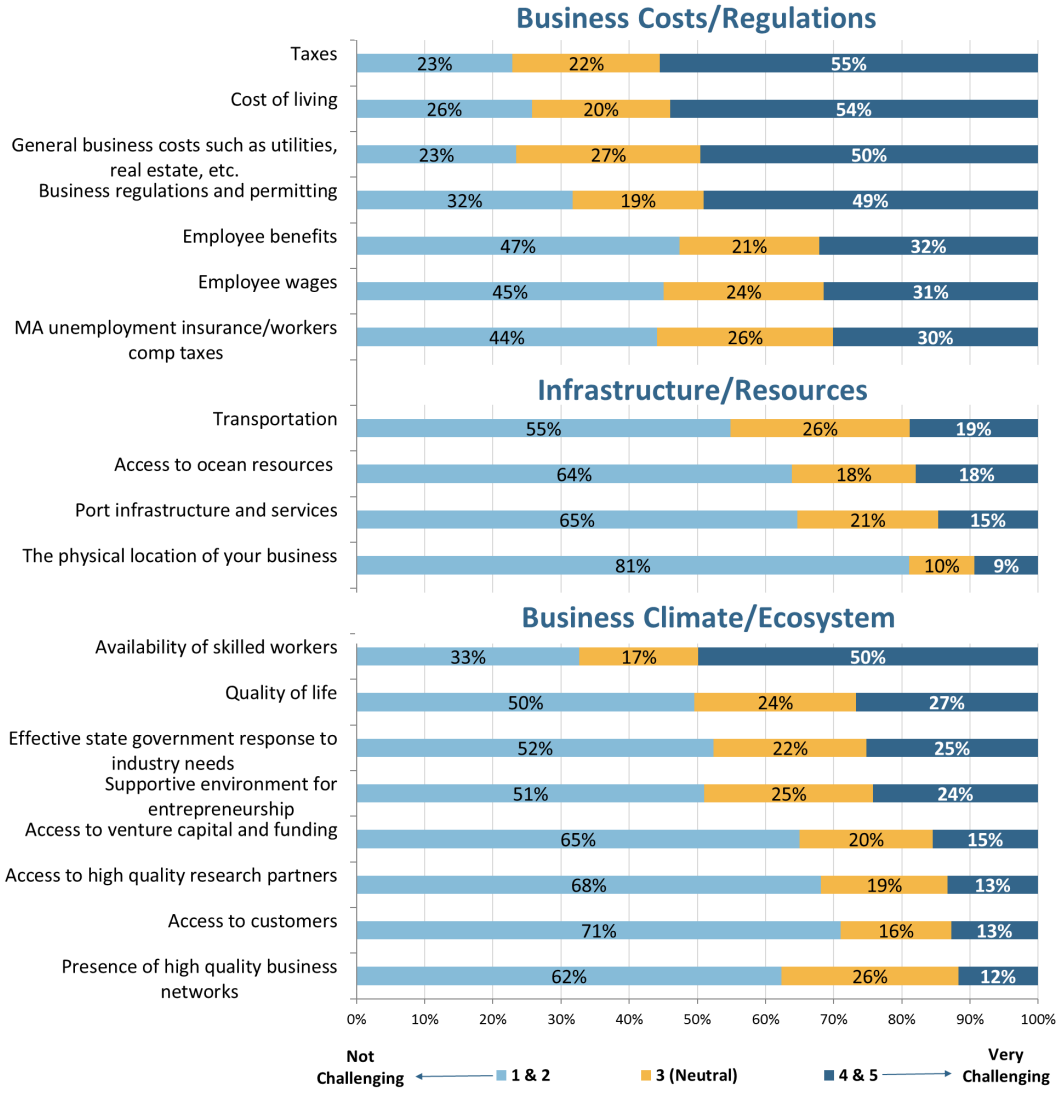
Maritime Businesses Identify Business Costs and Regulations as the Greatest Challenges to Operating in Massachusetts

The Public Policy Center surveyed 735 Maritime Economy businesses to identify challenges and opportunities in the Maritime Economy. Respondents were screened so that only individuals who considered their business to be part of the Massachusetts Maritime Economy were interviewed. Nearly all respondents hold a senior position in their company and 94 percent are head-quartered in Massachusetts. Two-thirds (66%) have less than ten employees and 75 percent have been in business for more than 10 years.

Business Challenges

In terms of challenges to the future success of their business in Massachusetts, respondents are most concerned with issues related to business costs and regulations, including taxes, cost of living, general business costs, and business regulations and permitting (see figure below). Respondents also cite the availability of skilled workers as a significant challenge to their business. These challenges are consistent across each of the Maritime Economy's six sectors, although business regulations and permitting were of greater concern for respondents representing the Living Resources and Tourism & Recreation sectors.

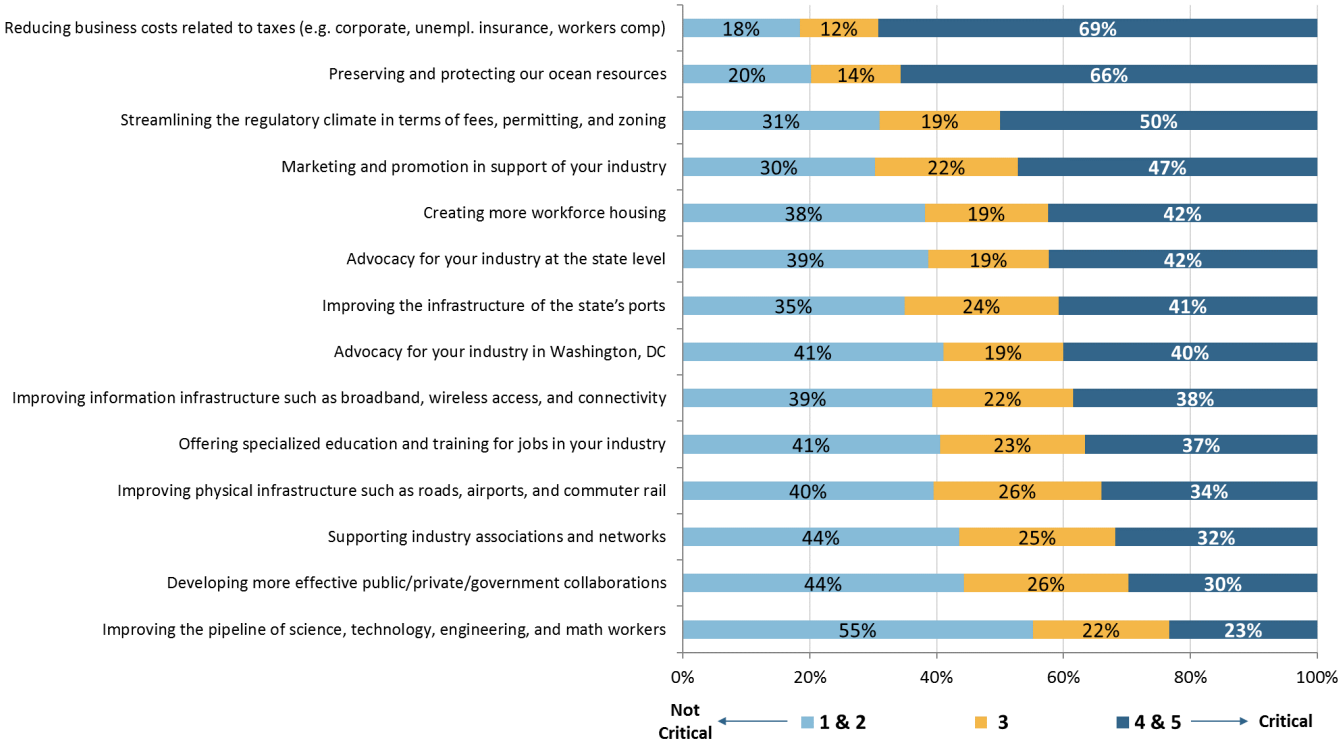
Please tell me how challenging you believe each of the issues is on a scale of 1 to 5, with 1 being not challenging and 5 being very challenging.



Most Critical Policy Areas

The most critical policy areas cited by respondents relate to reducing business costs, preserving and protecting ocean resources, streamlining the regulatory environment, and the need for more marketing and promotional support of their industry.

Please tell me how critical each of these policy areas is to your business on a scale of 1 to 5, with 1 being not critical and 5 being critical.



Greatest Strengths of Doing Business in Massachusetts

Respondents were asked what they believe is the greatest strength of doing business in Massachusetts. The number of responses was extensive and the word cloud below displays the major issues by font size. The most cited strengths are location, access to the ocean and coastal areas, and access to customers/tourists.

What do you perceive as the greatest strength of doing business in Massachusetts?



State Action To Help Business Succeed

Respondents were asked to report the one action the state could take to help their business succeed. As with much of the survey, business costs are the primary concern of respondents across all sectors, including issues related to taxes and permitting. Respondents also report that housing affordability and general business affordability are salient issues.

If there was only one action the state could take to help your business succeed, what would it be?



Policy Implications

The research presented in this report is designed to assist the Seaport Economic Council in understanding the current state of the Massachusetts Maritime Economy and to provide evidence to inform the development of a statewide growth strategy for the sector. Several broad policy implications that imply a series of strategic objectives emerged from our research.

1. Preservation and protection of ocean and coastal resources

   The sustainability of ocean and coastal resources is the cornerstone of a vibrant maritime economy. This fact was echoed by survey respondents, 66 percent who cited “preserving and protecting ocean resources” as a critical or very critical issue to the success of their business.

2. Maintenance of a stable and predictable business cost and regulatory environment

   Over half of survey respondents report that general business costs pose one of the greatest challenges to their Massachusetts business. In addition, 49 percent of respondents rate “business regulations and permitting” as challenging or very challenging to the success of their business. State policies that stabilize business costs can help support a positive business environment.

3. Advocacy for continued federal research funding, which is vital to the Marine Technology cluster

   Applied and basic research are the foundation of Massachusetts’ Marine Technology cluster. To conduct this research, both public organizations and private businesses are highly dependent on federal funding. For example, Massachusetts’ higher education institutions reported $165 million in R&D expenditures related to oceanography in 2014, of which 76 percent was federally-financed.

4. Support for infrastructure improvements, which affects port capacity and growth potential

Forty-one percent (41%) of survey respondents report that "improving the infrastructure of the state's ports" is a critical or very critical policy area. In addition, key informants at the state's ports consistently cited the need for dredging and other port improvements to expand their operations and to attract a greater number of ships and/or larger ships.

5. Capacity development of specialized, sector-specific training programs

Workforce issues were cited by many survey respondents and key informants as a major challenge to the success of their businesses. Thirty-six percent (36%) of survey respondents report that the jobs in their business require specific educational credentials or technical certifications, and a common refrain during key informant interviews was, "Where are my future workers going to come from?" Expanding the capacity of specialized training programs will help to meet the labor requirements of growing maritime economy businesses in Massachusetts.

6. Flexibility in harbor area zoning, particularly in Designated Port Areas

Massachusetts established ten Designated Port Areas (DPAs) to promote and protect water-dependent industrial uses. While many waterfront parcels within the state's DPAs continue to be used predominately for marine industrial activities, some port cities are looking to redevelop their ports to transition toward more innovation-oriented maritime industries, such as research and education, or to include mixed-use development and more public spaces. The ability to do so will require more flexibility than is currently permitted.

7. Strengthen connections within the Marine Technology cluster

As noted, the Marine Technology cluster is highly dependent on federal funding, both for private business and non-profit organizations. In addition, key informants note that access to capital is an impediment to commercialization, since venture capitalists and large banks do not generally fund small projects that do not have a clear path to scale. The cluster is also confronted with various workforce, compliance, and regulatory issues. However, key informants note that the Marine Technology cluster is somewhat fragmented, and that businesses and organizations are primarily focused on R&D rather than advocacy. Consequently, there is a role the state can play to strengthen connections within the cluster, with the goal of developing a cohesive industry strategy with clear messaging to stakeholders.

8. Capacity development for technology commercialization and transfer

Evidence from key informant interviews suggests the need for increased capacity with respect to commercialization and technology transfer in order to help companies grow to scale. This lack of capacity is partly due to the small size of many technology businesses, which must focus on product development rather than commercialization, and also the industry's traditional reliance on short-term defense contracts. State programs that foster commercial development of marine-related technologies will ensure that Massachusetts remains in the forefront of the Marine Technology field.

9. Capitalizing on the Ocean-to-Table Movement

People in Massachusetts are not eating most of the seafood that is landed in the state. While market forces dictate where locally-landed seafood is sold, addressing these problems through the creation of a locavore "foodie" movement has the potential to benefit both the Living Resources and Tourism & Recreation sectors through increased consumer interest and price premiums. While isolated efforts to promote locally-sourced and fresh seafood already exist, these efforts can be supported and expanded upon as a means of diversifying and strengthening the industry through the cultivation of a more sophisticated regional demand for local seafood.

1.0 INTRODUCTION

Nearly 70 percent of the Earth's surface is covered by ocean—one of the planet's most valuable resources—yet the oceans are often viewed simply as natural obstacles that segment the terrestrial world. In fact, the oceans are one of the most valuable forms of natural capital that hu-mans possess, delivering many different goods and services at no cost to us. In Massachusetts, the presence of the ocean shaped our early history and was the driving force behind our economy for many years, from international trade, to ship building, to fishing and whaling. Today, the ocean is very much a part of the state's identity; it is a major feature of our tourism economy and a central resource for our world class research driven innovation ecosystem.

The oceans play a significant role in the global economy by facilitating the exchange of goods, people, and ideas. Although ocean commerce of the past primarily focused on the movement of exotic goods such as spices and precious metals, today 90 percent of the Earth's cargo was on a ship at some point, and it is likely that most of the goods in your home or the clothes on your back came from another coun-try by ship.[6]



The ocean is also an important source of raw materials—the most obvious example being seafood. It is estimated that more than 3.5 billion people depend on the ocean as their primary source of food[7] and 16 percent of all animal protein consumed by humans comes from fish.[8] Fish harvesting, which includes both shellfish and finfish, supports tens of thousands of jobs worldwide to meet demand.

The ocean floor contains an abundance of minerals that we use in everyday life. Salt, potassium, sand, gravel, and other minerals are mined from the ocean's depths, and new technologies and higher commodity prices encourage deeper and deeper exploration for ocean minerals. The oil and natural gas that we use to fuel our cars and heat our homes also frequently comes from beneath the ocean floor.

One of the most important ways the ocean influences our daily life is its role in regulating the planet's climate. Chances are that the weather you feel today is highly influenced by ocean currents and temperature, as the ocean absorbs and redistributes the majority of the sun's warmth.[9] Furthermore, ocean currents act as global conveyor belts for weather patterns, such as the Gulf Stream, which is part of a system that transports warm, tropical water and air from the Gulf of Mexico to the British Isles, creating milder weather there than across the Atlantic in northeastern Canada.[10]

While we understand the ocean's complex role in Earth's climate, there is still a great deal we have yet to learn. The vast majority of the ocean is defined as the Deep Sea, an area that represents 95 percent of the earth's living space and where light barely penetrates. Yet, only five percent of the world's seafloor has been mapped in some detail. This is part of the reason that wreckage is so diffcult to find when airplanes crash into the ocean. In addition to expanding our understanding of the world we inhabit, the drive to explore these depths stimulates the development of new technologies.

The ocean also provides abundant recreational opportunities, from swimming and fishing to paddle boarding and walks on the beach. In Massachusetts, the coastal areas attract tourists, creating thousands of jobs for residents who work directly in traditional maritime trades and for those in the hospitality, restaurant, and entertainment industries in seaside communities.

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[6] George, Rose. 2014. *Ninety percent of everything; Inside shipping, the invisible industry that puts clothes on your back, gas in your car, and food on your plate.* London. Picador.

[7] Retrieved February 13, 2017, from http://savethesea.org/STS%20ocean_facts.htm.

[8] Retrieved January 28, 2017, from http://marinebio.org/oceans/ocean-resources/.

[9] Retrieved February 13, 2017, from http:/oceanexplorer.noaa.gov/facts/climate.html.

[10] Gyory, J., Mariano, A.J., & Ryan, E. H. (2013). The gulf stream. *Ocean Surface Currents. University of Miami.*

All the activities related to the oceans—harvesting, constructing, building, extracting, transporting, studying, and playing—create significant economic impacts that ripple through local, state, national, and world economies, whether directly from ocean-related industries, or indirectly from supplier relationships and the wages spent by Maritime Economy workers. In 2013, the ocean economy, which includes six economic sectors dependent on the ocean and Great Lakes, contributed more than $359 billion to the U.S. Gross Domestic Product and provided more than 3.0 million jobs, which is greater than many other natural resource industries, including farming, food products, oil and gas extraction, and forest products.[11]

Importantly, the ocean provides environmental and recreational value that is not measured by the market. For example, what is the value to society of clean water, a healthy shellfish population, and an undeveloped beach? While these non-market values are often difficult to estimate, they are as important as market values. While they are not the focus of this study, the reader should keep in mind that the value of non-market resources are important in developing a full assessment of the true values these public resources provide.[12]



[11] Kildow, J. T., Colgan, C. S., Johnston, P., Scorse, J., & Gardiner-Farnum, M. (2016). *State of the U.S. and ocean economies 2016 update.* Monterey, CA: National Ocean Economics Program.

[12] Kildow, J. T., Colgan, C. S., & Scorse, J. (2009). *State of the U.S. ocean and coastal economies*. Monterey, CA: National Ocean Economics Program.

2.0 PROJECT BACKGROUND

2.1 PROJECT GOAL

The Seaport Economic Council (SEC) works with Massachusetts' 78 coastal communities to provide statewide coordination of all coastal community planning and investment activities, with the aim to stimulate economic development and create jobs in the maritime economy sector and to protect coastal assets that are vital to achieving these aims. The SEC authorized the funding for this study in order to understand the current state of the Massachusetts Maritime Economy, and to provide a framework for the design and implementation of a statewide growth strategy for the Maritime Economy sector.

The scope of the study is guided by the charge of the SEC as set forth in Executive Order No. 564, which states that the Council has the following duties and responsibilities, among others: researching and monitoring economic activity in the local, national, and global maritime economy so as to make informed, up-to-date policy and funding recommendations to the Governor; and designing and implementing a statewide growth strategy for the maritime economic sectors, including trade, science and technology, recreation and tourism, clean energy, and the seafood industry.[13]

2.2 PROJECT SCOPE

Toward these ends, the Public Policy Center (PPC) at UMass Dartmouth conducted a comprehensive analysis of the Massachusetts Maritime Economy. The analysis includes the following broad tasks:

1. Affirming and Refining the Definition of the Maritime Economy in Massachusetts

   The definitions of industries that comprise the maritime economy were designed to capture, to the extent that is possible with available industry classifications, existing and emerging maritime economic opportunities for Massachusetts. This report includes a systematic assessment of key industry sectors and relevant types of businesses operating in each sector.

2. Describing the Major Features of the Maritime Economy

   This task required a rigorous data collection process to provide the most up to date information about the maritime economy in Massachusetts and New England, including data on employment, establishments, wages, and contributions to Gross State Product (GSP). Other data sources were also drawn on to paint a more complete picture of each of the maritime economy sectors, including data on fishery landings and port utilization. In addition to describing the state and regional maritime economy, the analysis explores important trends in the Massachusetts Maritime Economy and how it fits within the larger national and global maritime context.

3. Analyzing the Economic Contributions of the Maritime Economy to the State Economy

   This section provides detail on the economy-wide effects of the Commonwealth's maritime industries. The analysis quantifies the economic contributions of the Massachusetts Maritime Economy to the state economy, including the estimation of the direct, indirect, and induced economic impacts of the state's Maritime Economy using input-output modeling.

4. Analyzing Marine Technology and Its Contribution to the Massachusetts Innovation Economy

   The variety of fields that are involved in the development of Marine Technology, from engineering to biology to oceanography, make it difficult to characterize. Similarly, Marine Technology firms are classified into a variety of industry codes. In spite of these challenges, this report includes an analysis of key indicators of the Massachusetts Marine Technology cluster, including employment in the Search & Navigation industry, funding for technology development and academic research, and patenting activity. Opportunities in renewable energy are also explored. Industry spotlights highlight important collaborations and research outcomes.

5. Understanding the Challenges and Opportunities Facing the Massachusetts Maritime Economy

   A variety of approaches were used to solicit input from Maritime Economy businesses and to identify challenges and opportunities. These include:

   - The establishment of an Industry Advisory Group for the study,
   - A scientifically valid survey of Maritime Economy businesses,
   - Selected in-depth interviews with key industry and government stakeholders, and
   - Focus groups with leaders in the maritime economy.

[13] See http://www.mass.gov/governor/legislationexecorder/execorders/executive-order-no-564.html.

Both the qualitative and quantitative data collected as part of this final task were used to inform an analysis of the strengths, weaknesses, opportunities, and threats (SWOT) of the Maritime Economy including, but not limited to, obstacles to growth, access to capital, workforce development, and other issues that emerged from the research.

6. Developing Policy Implications

Informed by the findings that emerged from the tasks above, this report includes a discussion of the policy implications and associated strategic objectives that emerged from the research.



2.3 NON-MARKET IMPACTS

As noted earlier, there are many important environmental and recreational values that are not fully captured by an economic analysis. However, the primary purpose of this study is to identify policy implications as they relate to market impacts and thus non-market impacts are not systematically considered by this study.[14]

[14] A detailed description of non-market impacts can be found on the NOEP website: http://www.oceaneconomics.org/ nonmarket/.

3.0 PRIMARY DATA SOURCES AND METHODOLOGY

The Massachusetts Maritime Economy is defined as those industries for which the inputs are derived, in whole or in part, from the ocean. This includes:

a) an industry whose definition explicitly ties the activity to the ocean as defined in part by the definition of an industry in the North American Industrial Classification System (NAICS) (for example, fishing), or

b) an industry that is partially related to the ocean and is located in a shore-adjacent zip code (for example, a near shore restaurant).

Accordingly, this report's focus is limited to economic activity that is related, directly or indirectly, to the ocean rather than the broad array of economic activities that are located in coastal areas of Massachusetts.

3.1 SECONDARY DATA

The report's findings draw from a number of secondary sources. Much of the economic data in this report was obtained from the Economics - National Ocean Watch (ENOW) data series, which is produced by NOAA's Office for Coastal Management.[15] Using algorithms originally developed by the National Ocean Economics Program (NOEP) at the Middlebury Institute of International Studies at Monterey, the Office for Coastal Management of NOAA compiles the ocean economy data in cooperation with NOEP and publishes the data as the ENOW data series.

There are six sectors comprising twenty-three industries in the ENOW database as defined by their NAICS code (see Table 1). ENOW provides data on four specific indicators:

1. Business establishments: ENOW counts individual places of business and a single firm may have multiple places of business.
2. Employment: Includes part-time and seasonal workers. Employment does not include self-employed workers, government employment, independent contractors, and undocumented workers.
3. Annual wages: Wages paid to employees.
4. Gross Domestic State Product (GSP): the industry's share of the value of goods and services produced in Massachusetts.

ENOW's employment, establishment, and wage data are derived from Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW), which is collected by the Massachusetts Executive Office of Labor and Workforce Development. The QCEW data for shore-adjacent zip codes in Massachusetts is estimated using the U.S. Census Bureau Zip Code Business Pattern data due to a lack of access to the establishment level data. GSP is derived from the Bureau of Economic Analysis' GSP by state data. Data for fourteen of the maritime industries are tabulated for shore-adjacent counties in each state.[16] However, each of the industries in the Tourism & Recreation sector are defined as ocean-related if the establishments are located in near-shore zip codes, as defined by NOEP.[17]

The principal strength of the ENOW data is that it allows easy comparisons across states and across years, which is an important project goal of the SEC in terms of understanding the context of regional, national, and global trends in the Maritime Economy. Another advantage of this approach is that the data permits consistent measurement of the ocean economy across time and consequently will allow researchers and policymakers to annually update much of the data contained in this report.

[15] For more on the ENOW data, see https://coast.noaa.gov/digital-coast/tools/enow.html.

[16] While most of the Maritime Economy is located in coastal regions, some of the Maritime Economy (for example, some boat building and seafood retailers) is located in non-coastal regions. Data for these establishments is not included in the ENOW dataset.

[17] A detailed table of the six sectors and industries within each can be found in *Volume II: Technical Appendices* on the Public Policy Center website.

Table 1
Maritime Economy Sectors and Industries

Sector	Industry
Living Resources	Fish Hatcheries & Aquaculture
	Fishing
	Seafood Markets
	Seafood Processing
Marine Construction	Marine Related Construction
Offshore Minerals	Oil & Gas Exploration & Production
	Sand and Gravel Mining
Ship & Boat Building	Boat Building & Repair
	Ship Building & Repair
Tourism & Recreation (Coastal)	Amusement & Recreation Services
	Boat Dealers
	Eating & Drinking Places
	Hotels & Lodging Places
	Marinas
	RV Parks & Campgrounds
	Scenic Water Tours
	Sporting Goods
	Zoos, Aquaria
Transportation	Deep Sea Freight
	Marine Passenger Transportation
	Marine Transportation Services
	Search & Navigation Equipment
	Warehousing

Massachusetts Estimates

The PPC partnered with Dr. Charles Colgan, a leading marine economy expert who is Director of Research for the Center for the Blue Economy (CBE) at the Middlebury Institute of International Studies at Monterey, an organization which houses the National Ocean Economic Program (NOEP). The current composition of the ENOW sectors is largely the result of NOAA-funded work conducted by NOEP. Publicly available ENOW data is currently available only through 2013, however Dr. Colgan estimated 2014 and 2015 Massachusetts data for employment, establishments, and wages specifically for this report as well as 2014 GSP estimates.[18] Thus, all 2014 and 2015 data should be viewed as preliminary NOEP estimates.

3.2 DATA LIMITATIONS

Several inherent limitations in measuring maritime economic activity include, but are not limited to data availability, geography, and industry aggregation.

[18] At the time of this report, the latest gross state product data from the Bureau of Economic Analysis was 2014.

QCEW and Self-Employment

ENOW data is derived from employer-reported data (QCEW) that is covered by federal and state unemployment insurance laws, which covers about 90 percent of employment in the U.S. It excludes farm employment, the military, railroads, and self-employment. The exclusion of self-employment means that some industries are underrepresented in the data. To account for self-employment, the PPC estimated the proportion of self-employment for each industry using Census Non-Employer Statistics and Emsi economic modeling software. From this analysis, adjustments were made to account for a high percentage of self-employment in the Fishing industry. Other industries had much smaller percentages of self-employment and no adjustments were made in these cases to avoid over-counting and to maintain a more conservative estimate of Maritime Economy employment.

Confidentiality

Employment and wage data are a cooperative state-federal program, and the states have some discretion over how the data are used. All data derived from the QCEW data series are subject to confidentiality screening. Federal law prohibits the release of data at any level of aggregation that could reveal the employment or wages of a single firm. Massachusetts is one of a handful of states whose legislature prohibits outside researchers from accessing its confidential establishment data.[19] Consequently, Massachusetts data in the ENOW data series are estimated using an approach that is similar in concept to the estimates in other states, but uses only publicly available data.[20,21]

[19] New Hampshire, New York, and Michigan also prohibit release of the confidential data to researchers, though by administrative decision. Technically, the Massachusetts exclusion is an administrative interpretation of the statute that prohibits researchers seeing the establishment data except "for purposes of administering the unemployment system."

[20] National Ocean Economic Program. 2016. *State of the U.S. and Ocean Economies 2016 Update.* Middlebury Institute of International Studies at Monterey. Center for the Blue Economy. See http://midatlanticocean.org/wp-content/uploads/2016/03/NOEP_National_Report_2016.pdf.

[21] Where zip code level data were required for the Tourism & Recreation industries, data from the U.S. Census Bureau Zip Code Business Patterns (ZCBP), which shows aggregate employment and wages by zip code, were used to estimate shares of employment and wages. They do not show annual average data for employment, as do the QCEW. The proportion of employment reported in shore-adjacent zip codes, as reported in ZCBP relative to all employment for a given county, is used to estimate the Tourism & Recreation employment that is shore-adjacent in the QCEW data. All of the Tourism & Recreation employment reported by BLS as defined above is included for Dukes, Nantucket, and Barnstable counties.

Military and Government Employment

ENOW data does not include military employment or the Coast Guard (Homeland Security). There are approximately 1,977 active and reserve Coast Guard personnel within the state of Massachusetts, while the U.S. Navy employs approximately 781 active and reserve personnel in the state.[22] Because data on wages is not available for these personnel and the military and Homeland Security are not included in the ENOW Maritime Economy definition, the PPC was conservative in its approach and did not include this data in the primary data sets used in this report.

The ENOW dataset also does not include other government personnel related to the Maritime Economy that are outside the ENOW sectors, since these ocean-related activities are embedded within larger organizations and the specific ocean-related components cannot easily be separated from those organizations. This problem is greatly magnified at the state and local government levels. For example, NOAA, the Environmental Protection Agency, and the Army Corps of Engineers have programs that are ocean and coastal related, yet the standard budget reporting does not permit these to be easily identified.

In addition, much of the ocean-related scientific research takes place within universities, which do not necessarily separate ocean from non-ocean research in their reporting. Development of specific employment and related data for this sector would require a significant investment in research on individual programs.

Geography

The shore-adjacent zip code is an imperfect geographic unit for the purpose of defining location. For example, a restaurant may be located in a shore-adjacent zip code, yet be miles from the ocean. This is not necessarily an issue in a major tourist location such as Cape Cod, where it can be argued that all restaurants are at least tangentially connected to the Maritime Economy, yet may slightly overstate establishment and employment data in less tourist-oriented areas.

Estimating Contribution to Gross State Product [23]

GSP data are published only at the state-level and for industry aggregations greater than used in the Ocean Economy definition.[24] In order to estimate a share of GSP in an Ocean or Coastal Economy industry, the proportion of the GSP for a given sector is calculated based on the proportion of total wages paid in that sector by a given establishment. The proportion of GSP for a given establishment or industry equals that establishment's or industry's share of totalwages. Since wages often account for as much as 60% of GSP, this method is a reasonable approximation of individual establishments' contribution to GSP given data limitations.

Industry Aggregation and Overlap

Many industry definitions are too aggregated for true maritime economy measurement. That is, the data is not sufficiently available at more detailed industry levels and there is no easy method by which employment in ocean-related activities can be separated from other activities. For example, there is no systematic data available for Boat Dealers, which resides under the larger category of Motor Vehicles & Parts. One solution is to build the dataset from the establishment level by categorizing each business into a NAICS code, a strategy that is fraught with its own methodological issues.

In addition, industries sometimes do not fit neatly into NAICS sectors, and consequently industry overlap occurs. For example, marinas include many activities that cross both recreational and commercial sectors, such as commercial fishing, boat building and repair, sail making, retail, fuel, food and beverage, and bait. However, the vast majority of boats in marinas are recreational boats and so this sector is assigned to the Tourism & Recreation sector. Another example is Search & Navigation Equipment, where products such as sonar, radar and GPS may be used in marine transportation, recreational boating, and aviation systems. ENOW assigns Search & Navigation to the Marine Transportation sector, since the largest dollar volume of marine-related products is in the commercial transportation side of the business.

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[22] Defense Manpower Data Center (DMDC). *Military and civilian personnel by Service/Agency by State/Country. R*etrieved December 21, 2016 from, https://www.dmdc.osd.mil/appj/dwp/stats_reports.jsp.

[23] The Bureau of Economic Analysis' technical term for Gross State Product is Gross Domestic Product-State (GDP-S). However, the traditional term for Gross State Product (GSP) is used in this report.

[24] GSP is now available at the MSA level, but not at the County level. The methodology for GSP estimates was developed before MSA data became available and this approach has been kept.

3.3 PRIMARY DATA

A variety of approaches were utilized to solicit input from Maritime Economy businesses and leaders to identify challenges and opportunities.

Industry Advisory Group

An Industry Advisory Group was established to help guide the research. There were seven members on the Industry Advisory Group, each representing a different maritime sector (see Table 2).

Table 2
Industry Advisory Group

Member	Industry
Harlan M. Doliner, Esq. Verrill Dana LLP	Marine Science and Technology
Frank Ragusa, Director of Fresh Seafood Gloucester Seafood Processing	Seafood – Consumer
Peter Anthony, Treasurer Eastern Fisheries	Seafood – Processing
Jamy Buchanan Madeja, Esq. Buchanan & Associates	Marine Trades
Sheree Zizik, Principal Beauport Hospitality Group	Recreation and Tourism – Hospitality
Paul Vigeant, Vice President Bristol County Community College	Ocean Energy
Lisa Wieland, Port Director Massachusetts Port Authority	Shipping and Trade

Survey of Maritime Economy Businesses

The PPC conducted a scientifically valid survey of Maritime Economy businesses. The survey questionnaire was developed by the Public Policy Center in consultation with the staff of the Seaport Economic Council. A list of firms that made up the sampling frame for the survey was compiled by the Public Policy Center using various resources, including InfoUSA, ESRI Business Analyst, web searches of professional and trade associations, and institutional knowledge. Note that businesses were only included if they were directly linked to the maritime economy. The final list included 3,710 businesses and a total of 735 surveys were completed among the six sectors.

Key Informant Interviews

The PPC also conducted in depth interviews with key industry and government stakeholders to further understand the challenges and opportunities facing the Massachusetts Maritime Economy. Interviews represented a cross-section of the Maritime Economy sectors.

Focus Groups and Listening Sessions

The PPC worked with the Blue Economy Project, an initiative funded by the Seaport Economic Council that aims to promote and sustain a maritime focused economy in the Cape Cod region. Blue Economy Project staff conducted nine Listening Sessions throughout the Cape and Islands. The PPC staff attended several of these sessions and the final qualitative analysis collected by the Blue Economy Project was shared with the PPC.[25]



[25] More about the Blue Economy Project can be found at http://www.bluecapecod.org/.

4.0 HISTORY OF THE MASSACHUSETTS MARITIME ECONOMY

Early explorers and colonists arriving in Massachusetts in the early seventeenth century did not anticipate that the colony would be distinguished for its maritime industries. In fact, while exploring islands off the coast of southern Massachusetts in search of Asian sassafras in 1602, William Gosnold dubbed the main land to his north "Cape Cod" after the fish that had "pestered" his boat over the course of the voyage.[26] After permanent European settlements had been established in Plymouth and Boston, it became clear that successive waves of colonists could not be supported by farming the nutrient-poor New England soil.[27] Thus, following the example of coastal Native American tribes, the colonists supplemented their farming with shellfish and fish harvested from the shoreline or using small fishing dories.

While there was global demand for the salt cod New England traders were exporting, this industry alone accounted for a small fraction of the overall colonial economy. The drive to build and maintain ships within Massachusetts constituted much of the maritime economic activity in the pre-revolutionary colony, and by the late seventeenth century, shipbuilding had become a leading industry.[28] The unique geographic and environmental features of Massachusetts drove the expansion of shipbuilding. With hundreds of miles of coastline, including sheltered bays and naturally deep harbors, and pristine old-growth forests, enterprising merchants had all the materials required for ship construction.

As the colony expanded, shipbuilding rapidly became the most successful and profitable industry. Prominent families cemented their status at the head of shipping empires by controlling the production of the ships that imported and exported goods from seaside communities like Boston, Essex, Gloucester, New Bedford, Plymouth, and Salem. The shipbuilding industry helped support ancillary industries like rope and sail making. These colonial entrepreneurs supported the construction of warehouses and wharfs, expanded the Massachusetts economy, and spurred innovation by supporting the development of new maritime technology.[29]

At the time of the Revolution, the Massachusetts marine industries would play an important role in the war effort. By the late eighteenth century, fish represented the single most lucrative export in New England, and Massachusetts dominated this trade due to the success of the cod fishermen in Gloucester. By converting their trade ships and schooners to weapons of war, the merchants and fishermen of Massachusetts were essential in the formation of the American navy and in securing supply lines for the Revolutionary Army.[30] After independence was won, while ports elsewhere in the state returned to constructing ships and boats mostly for fishing, whaling, and trade, the shipyards around Boston became essential in the procurement and maintenance of naval vessels – a status they maintained until the closure of the Boston Naval Yard nearly two centuries later.[31]

Throughout the nineteenth and early twentieth century, the majority of Massachusetts' maritime economy was dominated by the whaling and fishing industries, as the majority of international shipping was conducted by foreign vessels following the trade restrictions imposed by European powers after the American Revolution. The success of the Yankee whaling fleet in Massachusetts is evident in the commercial shops, mansions, and public buildings constructed during the peak of the whaling in the 1800s, which still stand today in places like Nantucket, New Bedford, Edgartown, and Wellfleet. Similarly, the success of the groundfish industry brought prominence and fortune to the communities of Beverly, Gloucester, Salem, and Duxbury. Indeed, the importance of the codfish can be seen throughout Massachusetts, as its visage is carved into the architecture of bank buildings in New Bedford and Gloucester, and the third incarnation of a wooden "sacred cod" hangs above the chamber in the Massachusetts House of Representatives.[32]

[26] Kurlansky, M. (1997). Cod: *A biography of the fish that changed the world.* New York: Walker.

[27] Perunko, J., Bisher, K., & Davis, S. (2007). *Maritime history of Massachusetts.* Washington, DC: Nation Park Service.

[28] Ibid.

[29] Ibid.

[30] Magra, C. P. (2006). *The New England cod fishing industry and maritime dimensions of the American Revolution.* Pittsburgh, PA. University of Pittsburgh.

[31] Perunko, J., Bisher, K., & Davis, S. (2007). *Maritime history of Massachusetts.* Washington, DC: Nation Park Service.

[32] Roberts, E. W., Gallivan, J. A., & Irwin, R. W. (1895). A *history of the emblem of the codfish in the Hall of the House of Representatives.* Boston, MA: Massachusetts General Court. House of Representatives. Committee on History of the Emblem of the Codfish.

While the fishing and whaling industries supported the shipbuilders, cod exporters, candlemakers, mechanics and other tradesman of their communities, they relied on finite marine resources to support themselves. As cod stocks were depleted in the Gulf of Maine and whale pods could no longer be sighted in the North Atlantic, ships from the harbors of Massachusetts pushed outside of New England waters in search of their quarry. This expansion drove innovations not only in ship design, but eventually in commercial freezing and processing techniques, such as George Birdseye's experiments in flash freezing fish fillets in Gloucester. While the fishing industry remained, whaling eventually, and fortunately, fell out of favor when petroleum was discovered to be a viable alternative to whale oil.

Massachusetts lost its status as a major ship producer with the advent of the industrial age, which abandoned traditional Massachusetts wood and sail shipbuilding in favor of steel and steam shipbuilding. However, the advent of World Wars I and II created a shipbuilding boom in Massachusetts. The Second World War also spurred the investment in the research and development of new marine technology, which was conducted at the newly founded Woods Hole Oceanographic Institution and other academic research facilities in the Commonwealth.[33] Although the wartime research cemented a relationship between the federal government and marine researchers in the state, following the end of World War II, shipbuilding in the Commonwealth continued to decline as producers relocated to regions with greater demand, with the exception of small firms serving niche markets.

The post-war era benefitted the fishing industry, with new technology applied to the construction of fishing vessels. The mechanization of the fishing industry allowed fishermen in Gloucester and New Bedford to improve the efficiency of their catches. This industrialization also provided foreign fishing fleets the means to exploit the stocks off the coast of the United States throughout the middle of the twentieth century. New England fishing trawlers competed with Russian, Polish, and Spanish factory ships, which drastically decreased landings.

The passing of the Magnuson-Stevens Fishery Conservation and Management Act in 1976 gave the U.S. explicit control of the fish stocks in its coastal waters. The passing of the Magnuson Act and the elimination of foreign boats from Georges Bank and other profitable fisheries spurred a major investment in fishing vessels and industrial facilities for processing the catch. However, the struggling stocks had not yet rebounded, and the industry began to decline again. In ports like New Bedford, where groundfish had been replaced by scallops, there remained viable means for fishermen to earn a living. Yet, as the Fisheries Management Council and stakeholders continue to search for a balance between catch limits, gear restrictions, and maintaining a way of life, most seafood processing facilities on the waterfront in Massachusetts handle fish caught elsewhere in the world.

While the long decline of fishing and shipbuilding means that these traditional industries no longer support the bulk of the Massachusetts economy, they are engrained in the identity of the Commonwealth. This history is evident in the historic districts found in many seaside communities, which preserve the buildings and cobblestone streets financed by the shipping magnates and whaling tycoons, which now support local tourism. Likewise, the state has not turned its back to the sea. With the development of offshore wind farms on the horizon, continued research in Marine Technology, and an expanding tourism industry, Massachusetts is poised to enter a new era of maritime-related prosperity.



[33] Woods Hole Oceanographic Institute. (2016). *History and legacy: Over 80 years of ocean research, education, and exploration.* Retrieved November 19, 2016, from http://www.whoi.edu/main/history-legacy.

5.0 THE MASSACHUSETTS MARITIME ECONOMY

5.1 OVERVIEW

The Massachusetts Maritime Economy is comprised of 5,555 establishments that employ 90,482 workers, pay $3.4 billion in total wages, and account for $6.4 billion in GSP (see Figure 1).

Figure 1
Massachusetts Maritime Economy, 2015



Source: ENOW; NOEP; Authors' calculations.

The Maritime Economy is a significant economic driver in the state, representing 2.6 percent of the Commonwealth's direct employment and 1.3 percent of its gross state product. Employment in the industry compares favorably with other major sectors of the state's economy, including the Information and Computer & Electronic Manufacturing sectors (see Table 3).

Table 3
Employment Comparison of Select Industries

Industry	Employment (2015)
Maritime	90,482
Computer & Electronics Mfg.	56,088
Finance & Insurance	168,192
Information	93,961
Legal Services	27,895
Real Estate	32,667
Wholesale Trade	123,917

Source: ENOW; NOEP; QCEW; Authors' calculations.

[34] Establishment, employment, and wage data are 2015. The latest available GSP data are 2014.

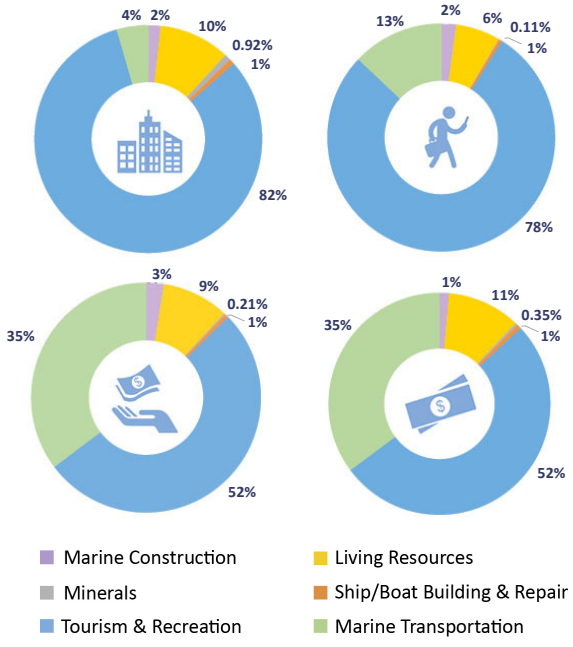
5.2 MARITIME ECONOMY SECTORS

The Massachusetts Maritime Economy includes six major sectors:

- Living Resources
- Marine Construction
- Offshore Minerals
- Ship & Boat Building & Repair
- Tourism & Recreation
- Marine Transportation

Each of the Maritime Economy's six sectors contribute varying levels of employment, wages, and GSP to the state economy (see Figure 2). While Tourism & Recreation is by far the largest sector in terms of employment, it accounts for a smaller share – albeit still a majority – of total wages and GSP. Conversely, the Marine Transportation sector accounts for only 13 percent of employment, yet 35 percent of total wages and 35 percent of GSP.[34]

Figure 2
Massachusetts Maritime Economy Establishments, Employment, Total Wages, and GSP by Sector



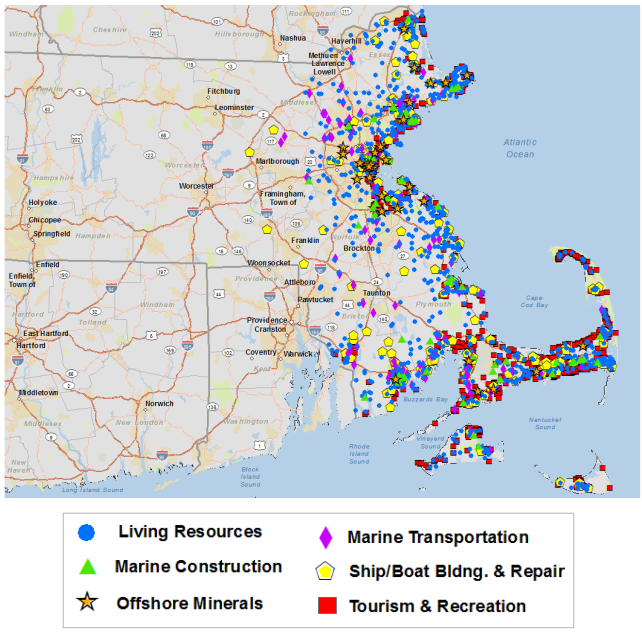
Source: ENOW; NOEP; Authors' calculations.

The Living Resources sector accounts for six percent of Maritime Economy employment. Employment in the sector has been declining since 2009. The decline is primarily driven by federal regulations that make it increasingly difficult for smaller fishing operations to operate profitably. Consequently, the industry is consolidating around larger fishing operations that have economies of scale. Despite these challenges, this most traditional of Massachusetts industries is reinventing itself to address these new realities, such as employing technologies that assist with resource management.

The Offshore Minerals sector, which is comprised primarily of oil and gas production companies, is a very small sector in Massachusetts and New England in general, although it accounts for high levels of economic activity in other states, particularly those along the Gulf of Mexico. Ship & Boat Building & Repair, once a titan of the Massachusetts economy in the 18th and 19th centuries, accounts for only small portions of employment and GSP due to the almost total absence of major ship and boat builders in the Commonwealth.[35] Marine Construction, which is connected to industries across many of the other maritime sectors, accounts for two percent of Maritime Economy employment and is highly dependent on overall economic conditions and larger government-supported projects such as dredging and infrastructure.

Figure 3 maps the distribution of Massachusetts Maritime Economy businesses by sector, which are concentrated along all of the state's coastal areas (see Figure 3). [36]

Figure 3
Distribution of Maritime Economy Businesses



Source: Public Policy Center

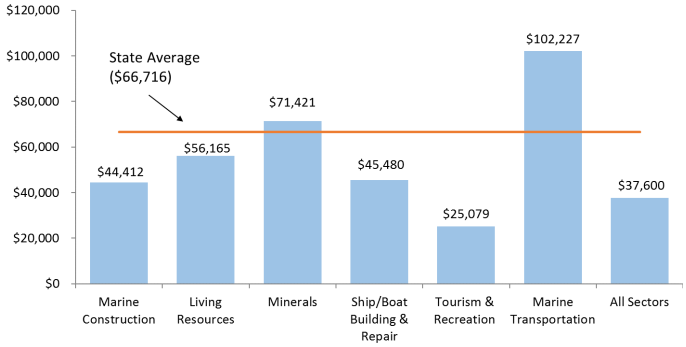
[35] As opposed to Connecticut and Maine, which have large shipbuilding facilities.

[36] The map only includes maritime businesses located in coastal counties, although maritime businesses are also located in other areas of the state.

5.3 AVERAGE ANNUAL WAGE

The average annual wage in the Maritime Economy is $37,600, which compares to a statewide wage of $66,716. Annual wages range from a low of $25,079 in the Tourism & Recreation sector to a high of $102,227 in the Marine Transportation sector (see Figure 4).

Figure 4
Average Annual Wage by Sector, Massachusetts, 2015



Source: ENOW; NOEP; Authors' calculations.

There are twenty-three industries within the six Maritime Economy sectors. Table 4 lists the average annual wage for each of these industries, which range from a high of $145,289 in Search & Navigation Equipment to a low of $21,678 in Eating & Drinking Places.[37]

Table 4
Average Annual Wage by Industry, Massachusetts, 2015

Sector	Industry	Wage
All	All Maritime Industries	$37,600
Transportation	Search/Navigation Equipment	$145,289
Transportation	Deep Sea Freight Transportation	$130,723
Minerals	Oil/Gas Exploration/Production	$76,240
Minerals	Limestone, Sand & Gravel	$68,536
Transportation	Warehousing	$67,839
Tourism/Recreation	Fishing	$66,932
Living Resources	Seafood Processing	$58,103
Transportation	Marine Transportation Svcs.	$56,226
Tourism/Recreation	Zoos & Aquaria	$53,235
Tourism/Recreation	Boat Dealers	$51,593
Ship/Boat Building	Boat Building & Repair	$47,548
Marine Construction	Marine Construction	$44,412
Ship/Boat Building	Ship Building & Repair	$43,856
Living Resources	Fish Hatcheries/Aquaculture	$42,810
Tourism/Recreation	Marinas	$41,803
Tourism/Recreation	Hotels & Lodging Places	$38,606
Transportation	Marine Passenger Trans.	$35,673
Tourism/Recreation	Scenic Water Tours	$29,877
Tourism/Recreation	RV Parks & Campgrounds	$28,208
Living Resources	Seafood Markets	$27,409
Tourism/Recreation	Amusement/Rec Services	$24,428
Tourism/Recreation	Eating & Drinking Places	$21,678

Source: ENOW; NOEP; Authors' calculations.

5.4 MASSACHUSETTS MARITIME ECONOMY GROWTH

Maritime Economy growth was generally more robust in comparison to the state as a whole from 2005 to 2015. For example, maritime employment grew by 18.2 percent from 2005 to 2015, compared to 8.4 percent for all industries statewide. Maritime growth was also more robust in comparison to the state in terms of GSP (48.0% vs. 32.1%), and real GSP (36.7% vs. 11.4%), although the number of establishments grew at a slower pace (see Table 5).[38]

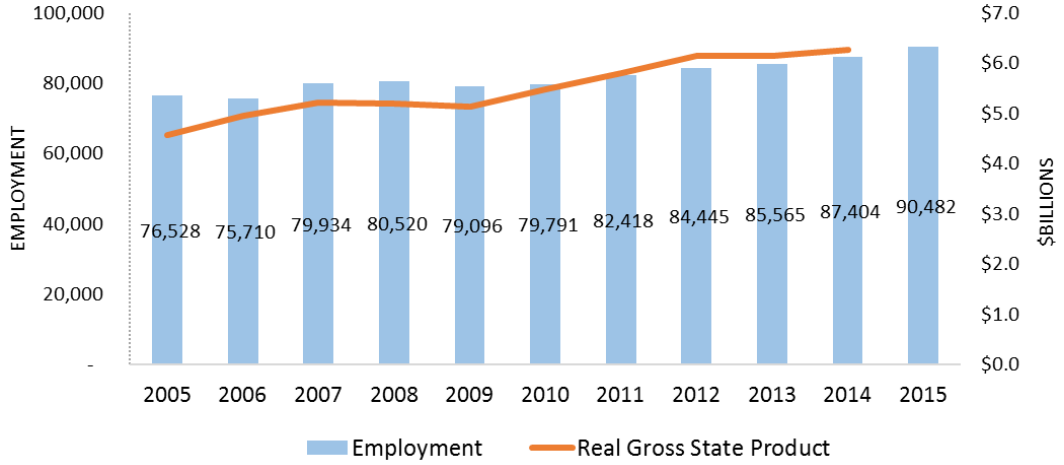
Table 5
Change In Massachusetts Maritime Economy
Establishments, Employment, Wages, and GSP

	2005	2014/15	Change	State Change[39]
Establishments	5,237	5,555	6.1%	16.5%
Employment	76,528	90,482	18.2%	8.4%
GSP ($M)	$4,342.7	$6,426.6	48.0%	32.1%
Real GSP ($M)	$4,570.9	$6,246.7	36.7%	11.4%

Source: ENOW; NOEP; Authors' calculations.

Maritime Economy employment and GSP growth were fairly consistent throughout the most recent economic cycle. Both metrics dipped slightly at the outset of the Great Recession but recovered by 2010 and have been on an upward trend since (Figure 5).

Figure 5
Employment & Real GSP, 2005 - 2014/2015



Source: ENOW; NOEP; Authors' calculations.

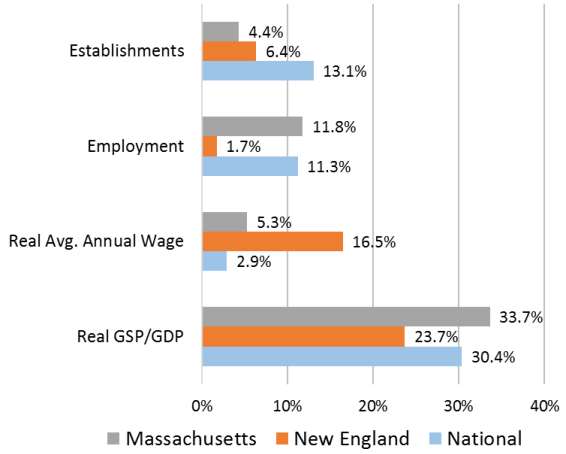
[37] Data is suppressed for the Sporting Goods and Oil & Natural Gas Pipelines industries.
[38] Real GSP applies the BEA chain-weighted index methodology based to 2009.
[39] Includes all the state's industries.

5.5 REGIONAL AND NATIONAL CONTEXT

Comparison to the Northeast and National Maritime Economies

The Massachusetts Maritime Economy performed well from 2005 to 2013 in comparison to the national and New England maritime economies. For example, the state outpaced the national and New England maritime economies in terms of employment and real GSP growth, while average annual wages grew faster than the nation but slower than the New England average.[40] The increase in real GSP is particularly salient since nearly half the national GDP is driven by the Offshore Minerals sector, which is an extremely small sector in Massachusetts. Conversely, the number of Massachusetts maritime establishments increased at a slower rate than the Nation and New England, which is primarily due to consolidation in the Fishing industry (see Figure 6).

Figure 6
Change in Maritime Economy, 2005 - 2013



Source: ENOW; NOEP; Authors' calculations.

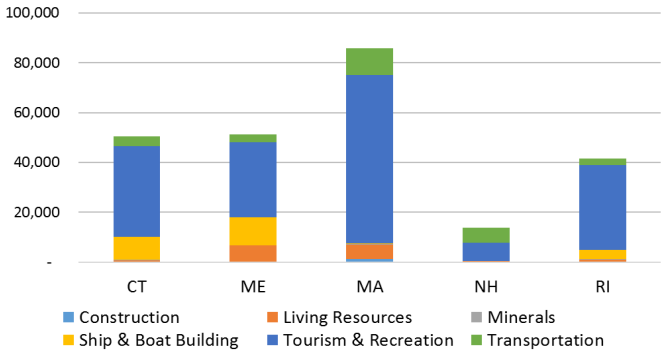
Comparison to New England's Coastal States

Massachusetts employs the greatest number of maritime employees among the five New England coastal states, followed by Maine, Connecticut, Rhode Island, and New Hampshire (see Figure 7). Tourism & Recreation is the largest maritime employment sector in each of the states, although the relative importance of the six maritime sectors clearly varies by state.

For example, the Ship & Boat Building & Repair sectors in Connecticut, Maine, and Rhode Island have a greater number of employees in comparison to Massachusetts, New Hampshire, and the nation. And while Transportation accounts for more than 43 percent of New Hampshire's maritime employment (which is primarily due to the presence of large firms in the Search & Navigation Equipment industry there), Massachusetts employs a greater number of workers in that sector. And while Massachusetts and Maine have the largest share of Living Resources employment, the sector accounts for a relatively small share of overall maritime employment in each state.

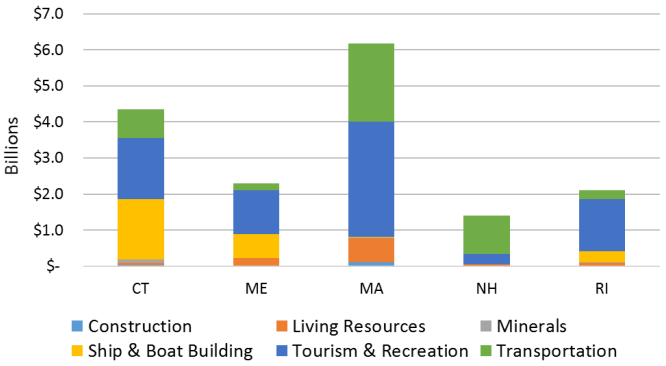
Similar patterns are evident in terms of GSP, with Transportation accounting for 75.3 percent of total GSP in New Hampshire and 35.1 percent of total GSP in Massachusetts. Otherwise, GSP is driven by the Tourism & Recreation sector, which accounts for 51.7 percent of total maritime GSP in Massachusetts, 38.8 percent in Connecticut, 52.8 percent in Maine, 20.2 percent in New Hampshire, and 67.5 percent in Rhode Island (see Figure 8).

Figure 7
Sector Employment by State, 2013



Source: ENOW; NOEP; Authors' calculations.

Figure 8
Sector GSP by State, 2013



Source: ENOW; NOEP; Authors' calculations.

[40] Note that 2014 and 2015 NOEP data is not available on the regional and national level.

5.6 LOCATION QUOTIENT

The location quotient (LQ) measures the concentration of employment in the Massachusetts Maritime Economy sectors relative to employment in these sectors nationally. An LQ above 1.00 means that Massachusetts has an above average concentration of employment in that sector compared to the nation.

Overall, Massachusetts' Maritime Economy has an LQ of 1.14, which means that the state is 14 percent more dependent on maritime sectors as a source of employment than the nation (see Table 6).[41] Living Resources and Tourism & Recreation are among the most specialized industries, with LQs of 2.92 and 1.27, respectively. These are also the two largest sectors in the Massachusetts Maritime economy, collectively accounting for 85 percent of Massachusetts' maritime employment. On the other hand, the Offshore Minerals and Ship & Boat Building & Repair sectors are underrepresented in Massachusetts, with LQs of 0.03 and 0.11 respectively.

Table 6
Location Quotient, 2013

Industry Category	LQ
Living Resources	2.92
Marine Construction	1.22
Minerals, Offshore	0.03
Ship & Boat Building/Repair	0.11
Tourism & Recreation	1.27
Transportation	1.03
Maritime Economy Total	1.14

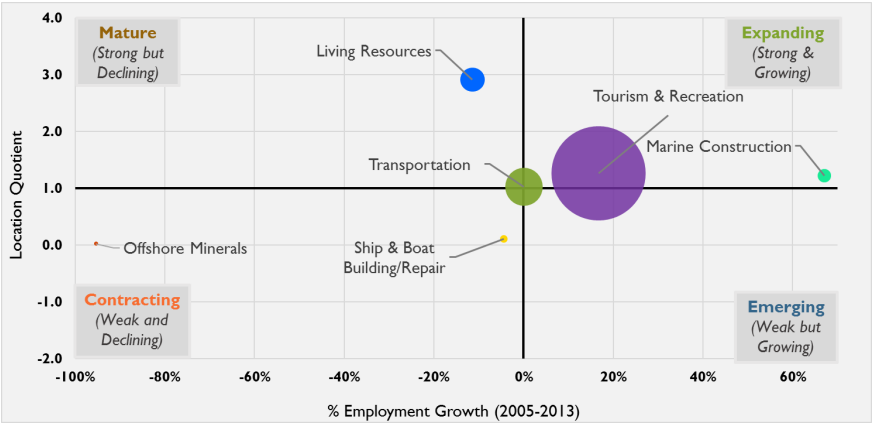
Source: ENOW; NOEP; Authors' calculations.

Importantly, an industry may have a high LQ but low levels of employment or declining employment, and therefore may not be as vital to a region's economy in comparison to industries with lower LQs. Figure 9 displays the LQ for each of the sectors in relation to their size and employment growth from 2005 to 2013, which presents a more holistic view of the strength of each industry. The LQ for each industry is presented on the vertical axis, while the horizontal axis displays employment growth. The size of the bubble corresponds to current employment.

There are four quadrants in the figure, with industries in the top left quadrant representing Mature industries, sectors in the bottom left representing Contracting industries, industries in the top right representing Expanding industries, and industries in the bottom right representing Emerging industries.

Offshore Minerals and Ship & Boat Building & Repair are defined as Contracting industries, with lower concentrations of employment compared to the nation and negative employment growth from 2005 to 2013. Living Resources lies in the Mature quadrant, with a higher concentration of employment compared to coastal states nationally, but declining employment levels since 2005. Tourism & Recreation lies primarily in the Expanding quadrant due to an LQ above 1.0 and growing employment. Marine Construction also lies in the Expanding quadrant, while the Transportation sector straddles all four quadrants.

Figure 9
Location Quotient, Growth, and Size of
Major Maritime Economy Sectors, 2013



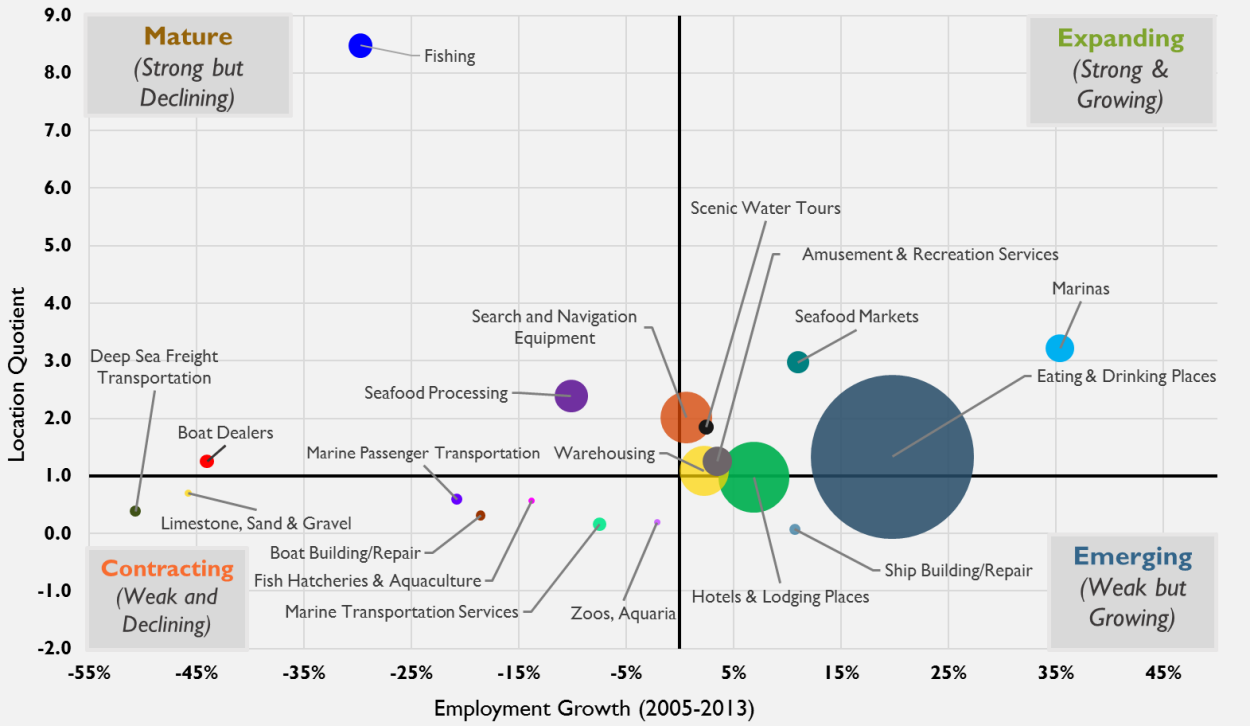
Source: ENOW; NOEP; Authors' calculations.

[41] The latest available national data is 2013.

Figure 10 displays similar data for the maritime industries within each of the six major sectors. Most of the larger industries in Massachusetts' Maritime Economy are situated in the Expanding or Emerging quadrants, while those in the Contracting quadrant are primarily the Maritime Economy's smaller industries.[42]



Figure 10
Location Quotient, Growth, and Size of Maritime Economy Subsectors, 2013



Source: ENOW; NOEP; Authors' calculations.

[42] Data not available for the Sporting Goods industry due to suppression.

6.0 SECTOR ANALYSIS

The following analysis examines the six major Maritime Economy sectors in more detail, including each of their component subsectors:

1. Living Resources
2. Marine Construction
3. Offshore Minerals
4. Ship & Boat Building & Repair
5. Tourism & Recreation
6. Transportation

6.1 LIVING RESOURCES

Industry Overview

Massachusetts is more specialized in Living Resources than in any other broad ocean economy sector. The sector is comprised of 561 establishments that employ 5,717 full- and part-time workers, pay $321.1 million in total wages, and generate $687.9 million in GSP (see Figure 11).

Figure 11
Establishments, Employment, Total Wages, and GSP



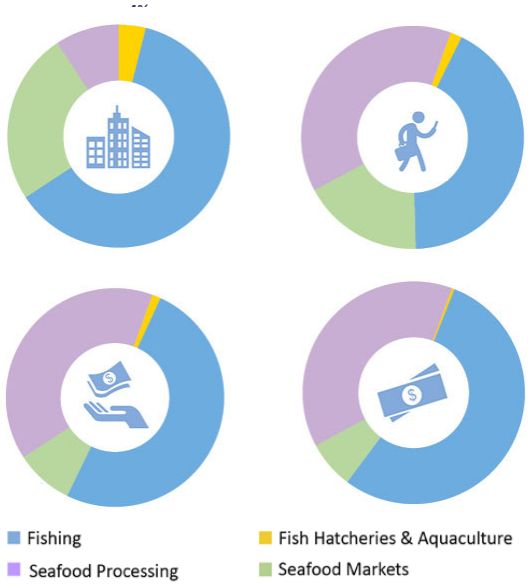
Source: ENOW; NOEP; Authors' calculations.

The Living Resources sector is composed of four key industries:

- Fish Hatcheries & Aquaculture
- Fishing
- Seafood Markets
- Seafood Processing

Within this sector, the Fishing subsector accounts for the majority of establishments (62%) and GSP (54%), and is the single largest industry in terms of employment, with 42 percent of the sector's workers (see Figure 12). Although the Seafood Processing industry accounts for only 9 percent of establishments, these businesses employ 38 percent of all Living Resources workers.

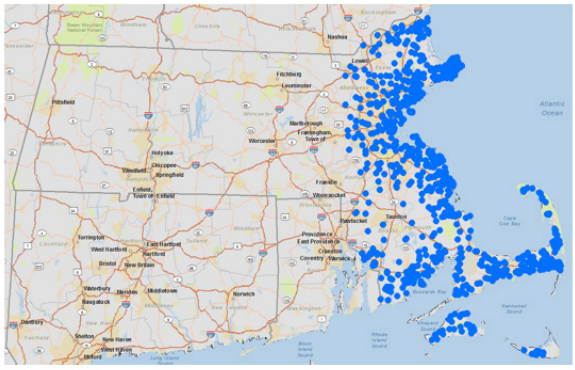
Figure 12
Establishments, Employment,
Total Wages, and GSP by Industry



Source: ENOW; NOEP; Authors' calculations.

As with other maritime industries, businesses in the Living Resources sector are concentrated along the Massachusetts coast, and particularly, they are clustered in areas with long histories in the Fishing industry (see Figure 13).

Figure 13
Massachusetts' Living Resources Businesses [43]

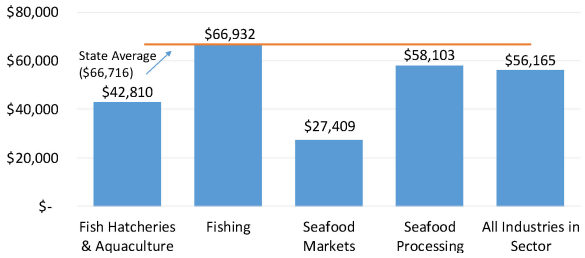


Source: Public Policy Center.

[43] Only includes Living Resources businesses in coastal counties.

The average annual wage for workers in the sector is $56,165. Across the industries, wages range from $27,409 for workers in Seafood Markets to $66,932 for workers in Fishing (see Figure 14).

Figure 14
Average Annual Wage by Industry, 2015



Source: ENOW; NOEP; Authors' calculations.

Historical Trend

The number of establishments and employment in the Living Resources sector declined since 2005 (–10.9% and -13.4% respectively) (see Table 7). These trends were primarily driven by the reduction of establishments and employment in the Fishing industry, which saw a 26.0 percent decline in the size of its workforce and a 17.8 percent decline in the number of establishments from 2005 to 2015. In part, this decline can be attributed to consolidation as a result of industry regulations, such as catch limits and by-catch monitoring, which disproportionately affected smaller operations.

However, GSP in the Living Resources sector increased by 34.3 percent in the decade since 2005, which translates to a 2.6 percent increase when adjusted for inflation (see Table 7). The increase in GSP was driven by the expansion of seafood processing and the increasing value of scallops. New Bedford is the top port in the nation in terms of the value of its catch, which is primarily due to its scallop fishery.

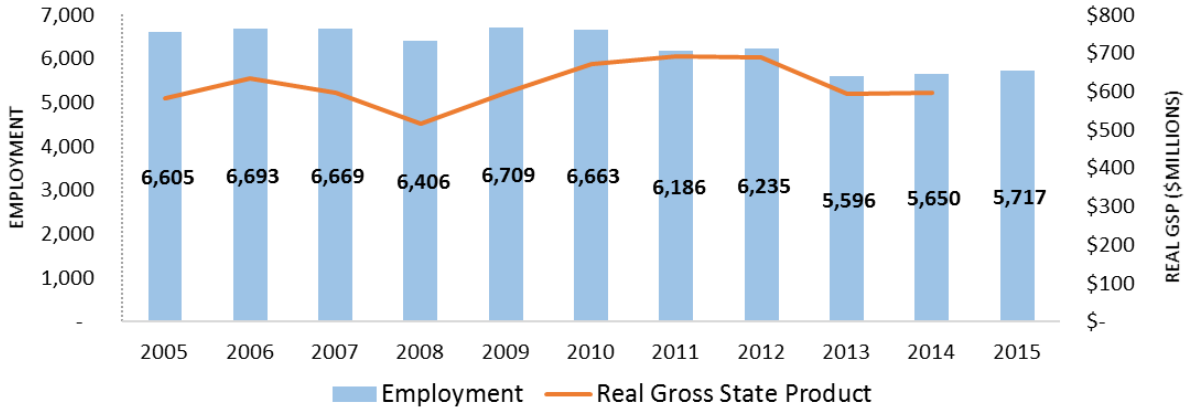
Table 7
Change In Living Resources
Establishments, Employment, and GSP

	2005	2014/15	Change	State Change
Establishments	630	561	-10.9%	16.5%
Employment	6,605	5,717	-13.4%	8.4%
GSP ($M)	$512.2	$687.9	34.3%	32.1%
Real GSP ($M)	$582.2	$597.6	2.6%	11.4%

Source: ENOW; NOEP; Authors' calculations.

While there was a slight decline in both real GSP and employment at the start of the recession in 2007, sustained decreases in employment did not begin again until 2013 (see Figure 15). This suggests that the reduction of jobs in the Living Resources sector was primarily related to trends specific to its industries, such as the tightening of catch limits or increased automation in processing, rather than macroeconomic conditions.

Figure 15
Employment and Real GSP, 2005 - 2014/2015



Source: ENOW; NOEP; Authors' calculations.

Although the number of establishments and employment in the sector has declined, there are signs that the industry is turning around. For example, the occupancy rate of processing spaces at Boston's Fish Pier rose from 67 percent in 2013 to 94 percent in 2015. These processors are mostly processing fish that is brought in from overseas. In recent years, niche seafood processors have begun to enter the market. These small companies focus on high value-added products, such as smoked haddock, salmon bacon, and a wide range of other cured fishes.

It became apparent through key informant interviews that the Seafood Processing industry is less dependent on waterfront property than in the past. In fact, much of the fish processed in Massachusetts is trucked to these facilities rather than arriving by boat, because these facilities are not primarily processing the local catch. Throughout Massachusetts' ports, "major fish processors have become more reliant on frozen fish imported from other regions due to the decline of consistent fresh fish availability from the Northeast region."[44] Thus, it is more important for processors to be close to transportation infrastructure, whether rail, truck, or air, so they can import fish and quickly get the final product to market. For example, the availability of major transportation infrastructure, particularly Logan Airport and Conley Terminal, fuels the demand for seafood processing locations in the Boston Seaport District. However, many processors are still located along waterfront piers due to long-term leases and historic agglomeration effects. Since many ports are located in major cities, where a considerable amount of transportation infrastructure is located, these locations are often convenient whether the seafood arrives by land or by sea.

Regional and National Trends

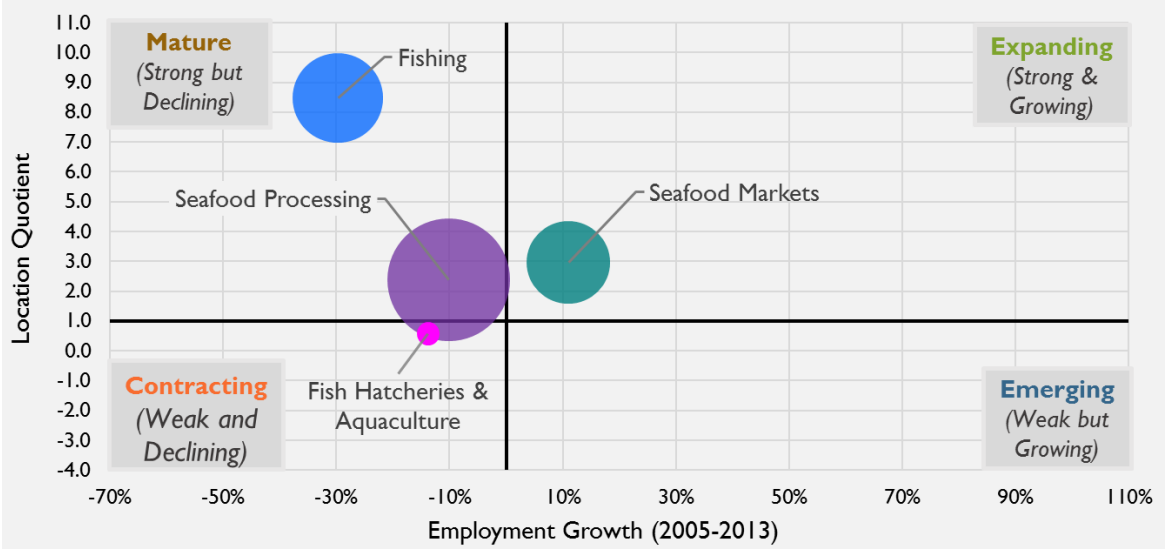
Figure 16 demonstrates the degree to which the Living Resources sector and its industries are concentrated in Massachusetts relative to the nation. With an LQ of 2.92, Living Resources is nearly three times more concentrated in Massachusetts than the nation as a whole.[45] Among the subsectors, Massachusetts is the most specialized in Fishing with an LQ of 6.01. Massachusetts also has above average employment in all of the sector's sub-industries except Fish Hatcheries & Aquaculture.

Based on employment growth and LQ, Fishing and Seafood Processing are both mature industries, having recently experienced job losses while still maintaining high LQs. The Seafood Markets industry is considered to be expanding, given the concentration of the industry in Massachusetts, and recent employment growth in the subsector. The Fish Hatcheries & Aquaculture industry is among the state's emerging industries, although it still accounts for only small levels of employment.

[44] Massachusetts Department of Transportation. (2013). *The ports of Massachusetts strategic plan: Technical memorandum 4*. Boston, MA: Massachusetts Department of Transportation.

[45] Industry statistics for the nation include shore-adjacent counties only.

Figure 16
Living Resources
Location Quotient, Growth, and Size, 2013

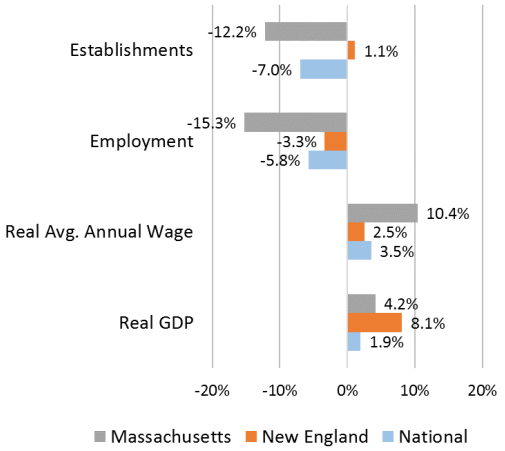


Source: ENOW; NOEP; Authors' Calculations.

Trends in the Living Resources sector in Massachusetts are generally in line with those regionally and nationally (see Figure 17). The high level of industrial concentration means that the effects of national and regional trends are frequently amplified within Massachusetts.

For instance, the Commonwealth did see a comparatively higher increase in the average annual wage for Living Resources workers (10.4% in Massachusetts, compared with 2.5% in New England and 3.5% in the U.S.), but the percent change in employment (-15.3%) was more than double that of the nation (-5.8%), and nearly five times that of the region (-3.3%). Much of this decrease in employment can be attributed to the consolidation of fishing licenses among a smaller number of larger businesses as the cost of regulatory compliance created very difficult financial and operational challenges for small businesses and independent operators in the Fishing industry.

Figure 17
Changes in the Living Resources Sector, 2005 - 2013

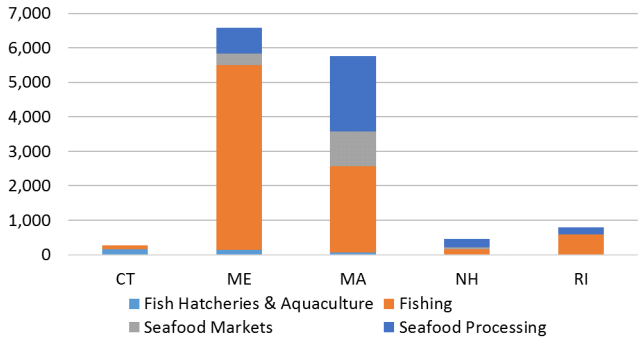


Source: ENOW; NOEP; Authors' Calculations.

Employment in the Living Resources sector in Massachusetts is larger than in most New England coastal states, with the exception of Maine (see Figure 18). However, the sector is considerably more diversified in Massachusetts, given the long history of seafood processing in Gloucester, Boston, and New Bedford. This diversification allows the Living Resources sector in Massachusetts to be more resilient to changes that affect a single subsector such as Fishing.

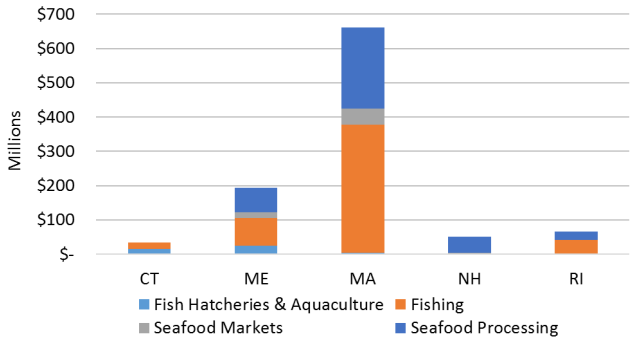
As discussed earlier, the scallop fishery is a huge driver of revenue in the Massachusetts Living Resources sector. As Figure 19 demonstrates, this gives Massachusetts an advantage over other New England coastal states in terms of Fishing industry GSP. Like employment, Massachusetts' diversification in this sector provides another advantage. Since 36 percent of GSP is produced by the Seafood Processing industry, which mostly processes seafood caught outside of the country, the sector's GSP is less prone to fluctuations in fish and shellfish prices.

Figure 18
Subsector Employment by State, Living Resources, 2013



Source: ENOW; NOEP; Authors' calculations.

Figure 19
Subsector GSP by State, Living Resources, 2013



Source: ENOW; NOEP; Authors' calculations.

In 2015, fish landed in Massachusetts accounted for 10 percent of the nation's catch by dollar value, second only to Alaska (see Table 8) and 42 percent of the New England catch (see Table 9). An examination of Massachusetts catch values reveals that the increases in sector revenue were driven by scallops, which accounted for only 8 percent of the total catch weight in 2015, but 50 percent of the total value of catch, making scallops the most valuable species caught by Massachusetts' fishermen.

Table 8
Commercial Fishery Landings by State, Ranked by Dollars, 2015

Port	Value ($Millions)	Pounds (Millions)
Alaska	$1,087.90	2,877.7
Massachusetts	$430.90	232.5
Louisiana	$295.30	909.3
Maine	$294.10	159.3
Washington	$238.10	150.7
Florida	$170.70	63.9
Texas	$155.60	70.1
New Jersey	$147.00	138.7
California	$118.20	183.5
Virginia	$108.20	372.5

Source: NOAA Commercial Fishery Statistics Database.

Table 9
New England Commercial Fishery Landings by State, 2015

Port	Value ($Millions)	Pounds (Millions)
Massachusetts	$430.90	232.5
Maine	$294.10	159.3
Rhode Island	$64.80	70.6
New Hampshire	$24.10	9.1
Connecticut	$11.70	7.8

Source: NOAA Commercial Fishery Statistics Database.

On a port-by-port basis, the Port of New Bedford leads in the nation by value of catch, which places it well above other Massachusetts ports (see Table 10). In 2015, New Bedford had a catch value $321.9 million, followed Gloucester ($44.4 million), Provincetown-Chatham ($30.6 million), Fairhaven ($17.8 million), and Boston ($16.2 million).

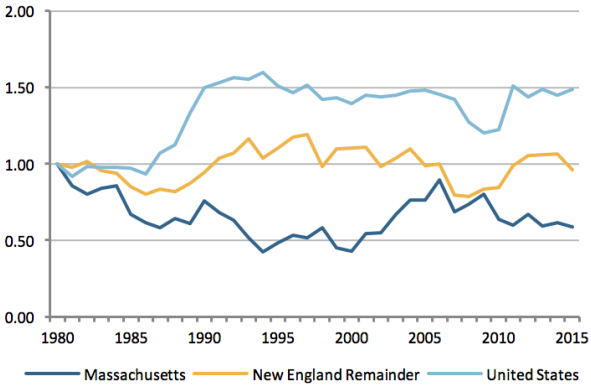
Table 10
Top Ten New England Commercial Fisheries Ranked by Dollars, 2015

U.S. Rank	Port	Value ($Millions)	Pounds (Millions)
1	New Bedford, MA	$321.90	123.8
14	Stonington, ME	$63.80	19.1
20	Point Judith, RI	$46.20	46.2
22	Gloucester, MA	$44.40	67.7
24	Vinalhaven, ME	$39.70	9.7
29	Portland, ME	$34.60	62.4
37	Provincetown/ Chatham, MA	$30.60	21.2
48	Friendship, ME	$21.80	5.2
51	Beals Island, ME	$20.70	6.0
56	Fairhaven, MA	$17.80	5.8

Source: NOAA Commercial Fishery Statistics Database.

Since scallops have a higher value by weight than any other species landed in the country, the volume of the catch in Massachusetts can decline while the value rises. For instance, in Massachusetts, the total weight of landings has never recovered to the weight of the 1980 catch, even while the rest of the region and country have exceeded this benchmark (see Figure 20).

Figure 20
Commercial Fish Landings, 1980 - 2015, Pounds Indexed to 1980

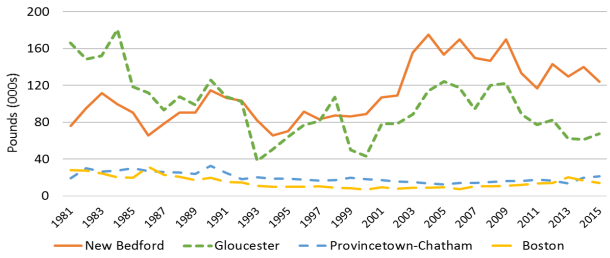


Source: NOAA Commercial Fishery Statistics Database.

Examining each of the landings by weight and value of each port in the state demonstrates the ascension of the scallop as the dominant catch (see Figure 21 and Figure 22). In the early 1980's, Gloucester was the state's top port in terms of its annual catch, with 166 thousand pounds of fish landed, more than double New Bedford's annual catch of 76 thousand pounds. However, the fortunes of these two ports have reversed, with New Bedford landing nearly twice the weight of seafood in 2015 than Gloucester (123.8 versus 67.7 thousand pounds).

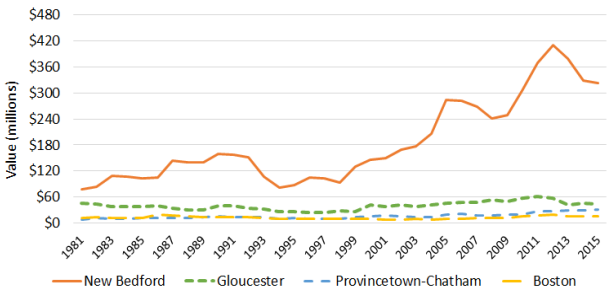
The difference as measured by value of catch is even larger, with New Bedford landing $321.9 million worth of seafood in 2015, compared to just $44.4 million in Gloucester, with the difference fueled primarily by the increasing value of scallops. The Port of New Bedford was able to capitalize on scallops and other species because it is a self-sufficient re-gional port, meaning that commercial boats have access to the full spectrum of marine services. Moreover, "the port's auction and processing facilities attract boats from through-out the Northeast," while Gloucester attracts boats from elsewhere in Massachusetts, but very few from outside of New England, particularly since the port lies north of Cape Cod.[46]

Figure 21
Weight of Landings in Massachusetts by Port, 1981 - 2015



Source: NOAA Commercial Fishery Statistics Database.

Figure 22
Value of Landings in Massachusetts by Port, 1981 - 2015



Source: NOAA Commercial Fishery Statistics Database.

Spotlight on Information Technology: Bringing the IT Revolution to Fishing and Port Operations

INEX, an internet of things (IoT) laboratory based in New Bedford, is collaborating with local fishermen, the Port of New Bedford, aquaculture firms, and others to develop new IoT technology that can monitor environmental conditions, improve operations, allow for better resource management, and automate catch and port monitoring, which would reduce the cost of regulatory compliance.

In addition to sourcing input directly from end users, partnerships with maritime professionals also provide INEX with opportunities to pilot these projects in the field. Dell Inc., a major supporter of INEX Labs, is working on hardware improvements to handle saltwater environments. Similarly, New Bedford company Blue Water Metrics, is working on sensor development to capture ocean data with applications for weather systems, offshore energy, ocean health, and more.

OPPORTUNITIES IN LIVING RESOURCE AQUACULTURE

The Food and Agriculture Organization of the United Na-tions (FAO) estimates that nearly half of the world's sea-food consumption comes from aquaculture.[47] In 2013, U.S. aquaculture production was estimated at 653 million pounds with a value of $1.38 billion, less than one per-cent of the world's aquaculture sales and volume.[48] While over half of the seafood that the U.S. imports was farmed using aquaculture, only 7.8 percent of seafood produced in the U.S. comes from aquaculture, the remainder being wild caught.[49]

[46] Hall-Arber, M., Bergeron, D., & McCay, B. (2006). *Institutionalizing social science data collection: Community panel projects.* Center for Marine Social Sciences and Massachusetts Fishermen's Partnership.

[47] National Oceanic and Atmospheric Administration. (2013). *Fisheries of the United States (FUS) report.* Silver Spring, MD: NOAA National Marine Fisheries Service.

[48] Food and Agriculture Organization of the United Nations. *Fishery statistics- global aquaculture production.* Retrieved February 13, 2017, from http://www.fao.org/fishery/statistics/global-aquaculture-production/query/en.

[49] National Oceanic and Atmospheric Administration. (2015). *Fisheries of the United States (FUS) report.* Silver Spring, MD: National Marine Fisheries Service.

Consequently, an opportunity exists for domestic aquaculture to fill a significant portion of the U.S. seafood demand currently fulfilled by imports. This strategy is supported by the Massachusetts Division of Marine Fisheries, which states that one of its goals is to "support continued development of an ecologically sustainable marine aquaculture industry."[50]

The Bay State is also home to one of the largest indoor reuse water aquaculture facilities in the world (see Spotlight) and a kelp farm off Martha's Vineyard. However, Massachusetts aquaculture in Massachusetts is dominated by shellfish, with more than 85 percent of the state's aquaculture operations farming oysters and clams. In 2015, the Massachusetts Division of Marine Fisheries issued shellfish propagation permits to 331 private aquaculture growers cultivating over 1,100 acres in 30 municipalities throughout the Commonwealth. These operations landed over 37 million American oysters with a value of $21.5 million, while more than 6.5 million quahog pieces were landed for a total value of 1.4 million.[51] The number of oysters landed increased by over 25 million from 2004 to 2014.[52]

While the industry's growth is encouraging, it faces several challenges, particularly as they relate to shellfish. For example, federal, state, and local permitting requirements are extensive and the process is not always clear for prospective municipalities and growers. Shellfish are also vulnerable to environmental changes, such as sea level rise, changes in intensity and frequency of heavy precipitation, rising water and air temperatures, and ocean acidification, which can destroy farms or put harvesting on hold until the environmental conditions improve.[53,54] Local opposition due to conflicting uses can also make the licensing process onerous. Other challenges relate to workforce issues, funding, marketing, competition, and insurance coverage, among others.[55]

Spotlight: Massachusetts Aquaculture and Technology

Massachusetts aquaculturists employ various technologies to create more sustainable aquaculture operations and to gain a greater share of the global seafood market. For example, Sky8 Shrimp Farm in Stoughton, Massachusetts, is one of several high-tech fish farms scattered throughout the country. Sky8 Shrimp uses high-tech systems that leave no environmental impact or disruption of coastal ecosystems to produce fresh shrimp to local consumers. Austrailis Aquaculture, Ltd. is another example of a company producing alternative farmed species to diversify the market, while leaving a minimized environmental footprint. The Turners Falls company operates one of the largest indoor re-use water aquaculture facilities in the world, growing 1,000 metric tons (2.2 million pounds) of barramundi annually, valued at $8 million in 2009. Austrailis Aquaculture uses sustainable aquaculture technology, such as innovative water reuse systems and feeds to improve the environmental performance of its farms. Another example is the EPA's recent award of $520,000 to UMass Dartmouth's School for Marine Science and Technology (SMAST) to measure the extent to which oyster aquaculture can reduce nitrogen levels. Partnering with the Westport River Watershed Alliance, this study will be conducted in the nitrogen-rich Westport River. If successful, the strategy could reduce the need for high-cost solutions to nitrogen pollution, such as expanded wastewater treatment systems.

[50] Massachusetts Department of Fish and Game. (2015). *Massachusetts Marine Fisheries 2015 annual report.* Boston, MA: Massachusetts Division of Marine Fisheries.

[51] Ibid.

[52] Massachusetts Division of Marine Fisheries (2015). DMF News. Volume 36. Retrieved January 5, 2017, from http://www.mass.gov/eea/docs/dfg/dmf/publications/1stand-2nd-qs-2015-dmf-news-web-8-3-15.pdf.

[53] The National Marine Fisheries Service ranks shellfish as the most vulnerable fish stock in the northeast. See Hickey, M., Shields, T., Mole, J., & Ford, K. (2015). *Regulation and Permitting of Aquaculture in Massachusetts.* Retrieved January 5, 2017, from http://www. waquoitbayreserve.org/wp-content/uploads/19_Ford_Aquacul-ture-Regs-Permitting.pdf.

[54] The Wellfleet OysterFest had no raw oysters in 2016 due to a suspected norovirus.

[55] Lapointe, G. (2013). White paper: *Overview of the aquaculture sector in New England (Revised).* Northeast Regional Ocean Council.

CAPITALIZING ON THE OCEAN-TO-TABLE MOVEMENT

Massachusetts exported $445 million worth of fish, crustaceans, and aquatic invertebrates in 2015, yet imported $2.0 billion worth of these same products.[56,57] This is rather surprising, considering the Bay State landed 232.5 million pounds of seafood, worth $430.9 million.[58] This places the Commonwealth first among New England states and second nationally, behind Alaska.

This raises the question of why Massachusetts' residents and visitors are not eating more of the local catch. People who love seafood, which includes many of Massachusetts' tourists, value seafood that is "fresh off the boat." So it would seem that the demand for fresh, locally caught seafood is present, if labeling could guarantee the species, origin, and freshness of the fish.

There are several market conditions that explain why the state exports so much of the local catch, but there are two factors that a targeted marketing strategy could do something about: (1) the seafood industry has been slow to jump on the locavore/direct marketing movement and (2) the tendency of consumers to shy away from lesser-known varieties of seafood. Addressing these problems through the creation of a locavore "foodie" movement, similar to the one that is happening in agriculture, has the potential to benefit both the Living Resources and Tourism & Recreation sectors through increased consumer interest and price premiums.

Efforts to promote locally sourced and fresh seafood already exist. Evidence of this can be seen in the National Restaurant Association placing "sustainable seafood" as one of its top 20 food trends for 2017, and "locally sourced seafood" as a top 10 concept trend for the upcoming year, based on surveys of professional chefs.[59] Organizations like Red's Best, Sea to Table, and the Gulf of Maine Research Institute (GMRI) all practice and support ocean-to-table consumption, a means of adding value by supplying fresh, locally sourced fish and seafood directly to the consumer. These organizations also act as independent certifiers of a seafood product's origins, an increasingly important concept as more consumers become aware of the lack of transparency created by the global seafood supply chain.

Some ocean-to-table organizations also incorporate the concept of community-supported fisheries (CSF). Much like community-supported agriculture, a CSF model requires upfront buy-in from consumers, who then receive direct access to freshly caught fish through cooperative drop-offs or direct delivery. CSFs provide a number of benefits. In the economy, they directly support fishermen through a means of stable income, and provide interested consumers with "access to high quality novel types of fish."[60] Direct marketing through venues such as CSFs and fishermen's markets is often associated with additional costs to bring the product to market, but producers are able to retain a larger portion of the retail value by reducing the number of "middlemen" in the production and distribution process. Additionally, selling in direct markets often enables producers to set their own prices, rather than accepting the wholesale price dictated by the global market.[61] Additionally, the relationship between consumer and producer creates an opportunity for education, which in turn can promote the consumption of underutilized species and lead to advocacy for better regulations and policy for the industry.

[56] Data from WiserTrade, as cited by UMass Donahue Institute, "Massachusetts Economic Due Diligence Quarterly Report for the Massachusetts State Treasurer's Office of Debt Management," Q1 2017.

[57] Some of the exported seafood is processed overseas and then returns to Massachusetts, and likewise, some of the imported seafood and processed here and then shipped elsewhere.

[58] Exports are most likely larger than fish landed because Massachusetts' fish processors process fish caught elsewhere.

[59] Shedd, L. & Kirkpatrick, J. (2016). *Chefs predict 'what's hot' for menu trends in 2017.* National Restaurant Association. Retrieved February 6, 2017, from http://www.restaurant.org/Pressroom/Press-Releases/Whats-Hot-2017.

[60] Brinson, A., Min-Yang, L., & Rountree, B. (2011). Direct marketing strategies: The rise of community supported fishery programs. *Marine Policy*, (35), 524.

[61] Pinchot, A. (2014). *The economics of local food systems.* Minneapolis, MN: University of Minnesota.

With financial support from the Commonwealth and the federal government, Gloucester Fresh was able to create a successful model for encouraging the consumption of local fish and seafood within Massachusetts, and to promote the state's brand nationally. Gloucester Fresh promotes locally underused species, such as whiting and redfish, that are often eaten by fishermen's families but not often found on restaurant menus. They also offer a CSF in Boston and the North Shore and have partnered with the Ninety-Nine Restaurant & Pub, selling 77,000 "Gloucester Fresh" haddock dinners from April to mid-June 2016. [62]

However, there are obstacles to bringing these efforts to a larger market. Bringing seafood to grocery stores and restaurants often requires longer supply chains, which makes it difficult to determine from where the seafood originated. Thus, there is an important role for government to play in developing and monitoring an "identity preservation system" in order to preserve the integrity of product differentiation and marketing claims,[63] while also enforcing Truth in Labeling laws so customers have confidence that what they order is actually local and fresh.

[62] Rattigan, D. (September 8, 2016). Gloucester fresh banks on ocean-to-table appeal. *The Boston Globe*.

[63] O'Sullivan, J. (December 31, 2016). Are there more fish in the ocean than regulators say? *The Boston Globe.*

Spotlight on Fishing: Are There Plenty More Fish in the Sea?

When determining the annual catch limits for various fish species, regulators must first determine the size of the current fish population. Scientists and fishermen often disagree on this critical number. Massachusetts' fishermen claim that the scientists' net misses large stocks of groundfish that swim beneath it and that their research vessel cannot go to key "in-shore" areas which smaller fishing vessels can reach. To help inform this debate, researchers at UMass Dartmouth have equipped a New Bedford fishing vessel with video cameras to record fish as they pass through an open trawling net. NOAA estimates put the Gulf of Maine groundfish stock at historically low levels, dictating a corresponding reduction in catch limits. As a result, "the fleet has been decreasing in size, and we're seeing less effort due to these catch limits," says Bill Hoffman, a senior biologist with the state who oversees the survey. Massachusetts fishermen hope that "new technology and an aggressive timetable will yield what they have concluded based on their own anecdotal evidence: There are more fish in the sea." [63]

6.2 MARINE CONSTRUCTION

Industry Overview

The Marine Construction industry engages in the construction of submarine oil and gas pipelines, as well as other heavy and civil engineering activities such as harbor dredging, pier and marine construction, beach nourishment, and estuary restoration.[64] The sector is comprised of 99 establishments that employ 1,922 full- and part-time workers, pay $85.3 million in total wages, and account for $91.7 million of GSP (see Figure 23). Since regulations prohibit offshore drilling in Massachusetts waters, there is limited need for the construction of submarine oil and gas pipelines. Therefore, most of the employment in this sector is in the Heavy and Civil Engineering Construction industry.[65]

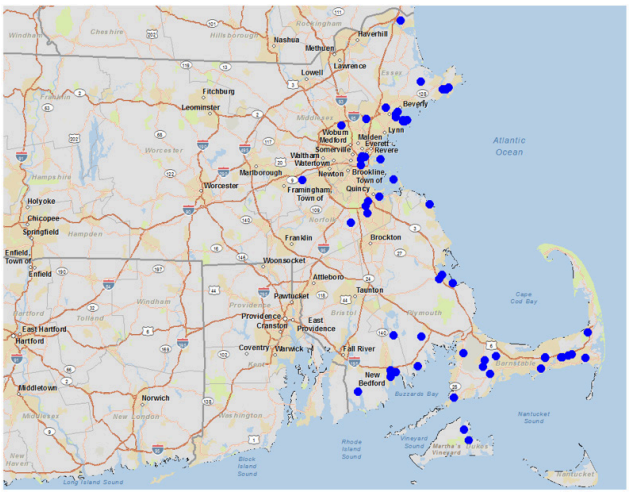
Figure 24 maps the distribution of Massachusetts' Marine Construction firms, which for the most part are concentrated around the state's larger ports.

Figure 23
Marine Construction
Establishments, Employment, Total Wages, and GSP



Source: ENOW; NOEP; Authors' calculations.

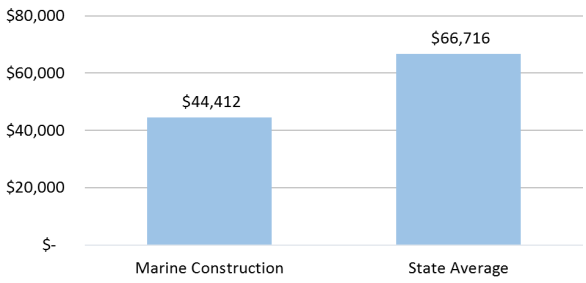
Figure 24
Location of Massachusetts'
Marine Construction Businesses[66]



Source: Public Policy Center

Average annual wages for the Marine Construction sector were $44,412 in 2015, which is below the statewide average of $66,716 (see Figure 25). While employment in the sector has increased over time, average annual wages have decreased substantially since 2008. This suggests that low-skill positions contributed to the majority of the employment increase. Lower wages may also be the result of the seasonal nature of this sector.

Figure 25
Average Annual Wage in Marine Construction, 2015



Source: ENOW; NOEP; Authors' calculations.

[64] Note that there are no sub-industries in this sector.

[65] It is likely that some of the establishments included in the QCEW data are not marine-related. However, the lack of granularity in the data does not allow these businesses to be parsed from the data. Also, some companies may occasionally engage in marine construction, but their primary business is not marine-related.

[66] Includes only marine construction businesses that are located in shore-adjacent counties.

Historical Trends

Employment in the Marine Construction sector grew by 140.5 percent from 2005 to 2015, compared to 8.4 percent of all industries statewide. However, real GSP declined by 21.2 percent over this period, while real GSP increased by 11.4 percent statewide (see Table 11) .

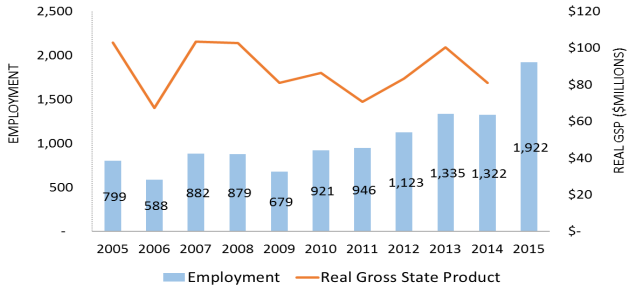
Table 11
Changes In Marine Construction
Establishments, Employment, Wages, and GSP

	2005	2014/15	Change	State Change
Establishments	99	99	0.0%	16.5%
Employment	799	1,922	140.5%	8.4%
GSP ($M)	$87.2	$91.7	5.1%	32.1%
Real GSP ($M)	$102.9	$81.0	-21.2%	11.4%

Source: ENOW; Center for the Blue Economy; Authors' calculations.

Employment in Massachusetts' Marine Construction sector appears to have been unaffected by the Great Recession (see Figure 26). From 2005 to 2015, employment in the sector grew at an average annual growth rate of 12.1 percent. This is not true of the broad construction industry nationally, which experienced a 25 percent decrease in employment from 2007 to 2011. However, from 2005 to 2015, the Marine Construction sector's contribution to Massachusetts GSP was essentially flat. This suggests the increase in construction activity is associated with lower cost end of the market.

Figure 26
Employment & Real GSP in Marine Construction, 2005 - 2014/2015



Source: ENOW; NOEP; Authors' calculations.

The Marine Construction industry has positive prospects in Massachusetts in light of three trends: a desire for port infrastructure improvements, sea level rise, and the growth of the offshore wind industry. Recent studies have identified significant capital investment needs at the state piers and Designated Port Areas, including dredging, repairing pile supports, replacing decking, and building repairs or replacements.[67,68] Investments in these areas will likely benefit Massachusetts' Marine Construction firms.

In addition, climate change, and associated melting of ice sheets, has caused the oceans to rise by 5.5 inches on average during the 100 years from 1900 to 2000. In Massachusetts, sea levels have been rising even faster, rising by 11.1 inches in Barnstable, 9.3 inches in Revere, and 8.8 inches in Boston.[69] Though bad news more generally, these trends create an opportunity for the marine construction industry as coastal communities seek ways of stabilizing the shoreline and updating vulnerable infrastructure to adapt to the changing seascape.

Another potential growth driver for the Marine Construction sector is offshore wind development. As of August 2016, state law requires utility companies operating in Massachusetts to purchase 1,600 megawatts of locally generated offshore wind power. While it is not yet clear where the components will be manufactured, the installation of offshore wind turbines and underwater cables will require a substantial number of local Marine Construction workers, many of whom, it is expected, will be retrained and redeployed from other sectors.

Regional and National Comparisons

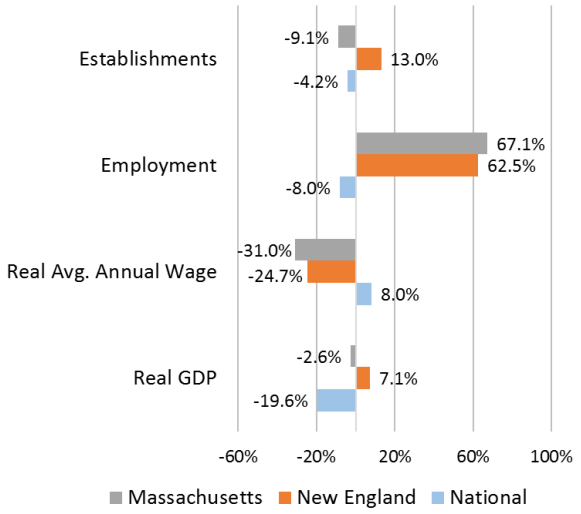
Nationally, the Marine Construction sector contracted from 2005 to 2013, with employment dropping by 8.0 percent (3,864 jobs) and revenue declining 19.6 percent (see Figure 27). This is likely the result of low oil and gas prices, which have lowered the incentive for energy companies to pursue hard-to-get offshore oil and gas. In Massachusetts, where the Marine Construction industry is not engaged in oil and gas extraction, employment increased rapidly, from 799 jobs in 2005 to 1,335 jobs in 2013, for a 67.1 percent increase. New England as a whole increased at a similar rate. However, wages declined considerably in the region and in the state while increasing nationwide. Again, this is likely due to the type of Marine Construction occurring in New England and the seasonality of the industry.

[67] Karl F. Seidman Consulting Services and UrbanFocus LLC. (2016). *Massachusetts state piers: A business and economic assessment.* MassDevelopment and the Massachusetts Executive Office of Housing and Economic Development.

[68] Martin Associates and Apex Companies. (2016). *Economic impact study of New Bedford/Fairhaven Harbor.* New Bedford, MA: The New Bedford Harbor Development Commission.

[69] Rocheleau, M. (February 25, 2016). The seas are rising fast – and even faster in Mass. *The Boston Globe.*

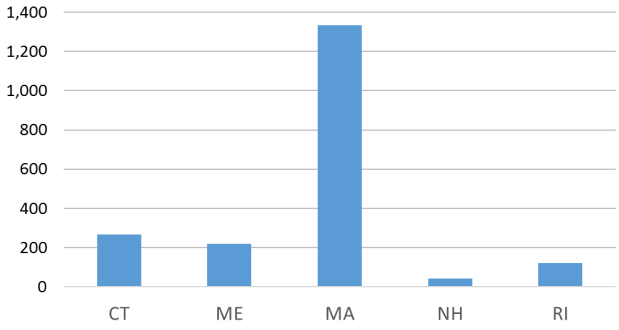
Figure 27
Changes in Marine Construction Sector, 2005 - 2013



Source: ENOW; NOEP; Authors' calculations.

Massachusetts has more employees in Marine Construction than any of the New England states in both absolute and relative terms. In absolute terms, there are five times as many employees in Marine Construction in Massachusetts than in Connecticut (see Figure 28).

Figure 28
Employment by State, Marine Construction, 2013

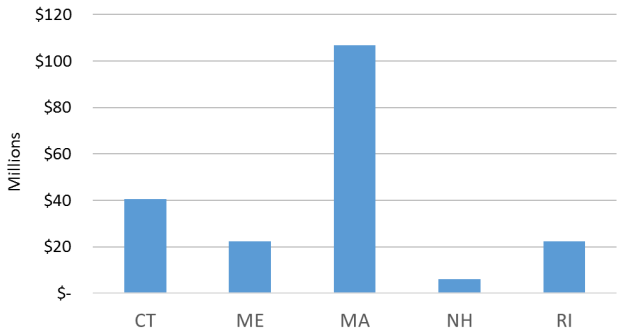


Source: ENOW; NOEP; Authors' calculations.

With an LQ of 1.22, the state also has a higher employment concentration in this sector than any of the New England states. Massachusetts' LQ means that the concentration of employment in this sector is 22 percent higher than the nation as a whole. Maine, with an LQ of 1.12, is the only other New England state where employment in Marine Construction is above the national rate.

Massachusetts also has a substantial lead in GSP attributable to this sector, though not as much of an advantage as in employment (see Figure 29). GSP attributable to Marine Construction is 264 percent higher in Massachusetts than in Connecticut.

Figure 29
GSP by State, Marine Construction, 2013



Source: ENOW; NOEP; Authors' calculations.

Spotlight on Marine Construction: The New Bedford Marine Commerce Terminal

From 2013 to 2015, a duo of marine construction firms built the 28-acre, $113 million New Bedford Marine Commerce Terminal, which is managed by the Massachusetts Clean Energy Center. The first marine terminal in the nation designed to meet the needs of the offshore wind industry, the terminal can support the massive-scale construction, assembly, and deployment of offshore wind projects. The terminal can also handle bulk, break-bulk, container shipping, and large specialty marine cargo since the maximum storage loads rival the highest load-bearing ports in the nation.

After a new state law was passed requiring utilities to purchase 1,600 megawatts of offshore wind power, the three offshore wind developers with leases in nearby waters each signed an agreement to use the terminal. In addition to the economic benefits of the construction jobs and the terminal itself, the construction of the terminal resulted in a significant environmental benefit to the City of New Bedford from the removal of industrial waste generated during the 1930s and 1940s. A total of 280,000 cubic yards of contaminated sediment was dredged from the harbor, and as a result, 18,000 tons of contaminated soil from the terminal site was disposed of in EPA-approved facilities.

6.3 OFFSHORE MINERALS

Industry Overview

The Offshore Minerals sector is comprised of 51 establishments that employ 101 full- and part-time workers, pay $7.2 million in wages, and account for $22.9 million in state GSP (see Figure 30).

Figure 30
Offshore Minerals
Establishments, Employment, Total Wages, and GSP



Source: ENOW; NOEP; Authors' calculations.

Within the U.S., the Offshore Minerals sector is the largest maritime sector by gross domestic product and Oil & Gas Extraction & Production is the largest industry within the sector. For Massachusetts, the sector does not have a major presence and is not experiencing much, if any, growth. Massachusetts does not produce its own natural gas, and oil drilling was banned from the coasts of California, Florida, and Massachusetts in 1988 by President Ronald Reagan. Sand & Gravel Mining, the one Offshore Minerals industry with some presence in the Commonwealth, has experienced multiple losses within the past few years. However, industrial sand mining has become a topic of interest because of the persistent erosion of sand from local beaches due to rising sea levels, among other factors.

This sector consists of two industries:

- Limestone, Sand, & Gravel
- Oil & Gas Exploration & Production

In Massachusetts, the Limestone, Sand, & Gravel industry accounts for the majority of employment (63%), wages (60%), and GSP (94%), but only accounts for 35 percent of all businesses in the sector (see Figure 31). An examination of the Oil & Gas Extraction & Production industry revealed that the most, if not all, businesses in the industry are either within the Geophysical Surveying & Mapping Services sub-industry, which provides services to offshore wind and other industries in need of ocean floor mapping, or they are businesses that conduct industrial R&D for the offshore oil industry.[70]

Figure 31
Offshore Minerals
Establishments, Employment, Total Wages, and GSP by Industry

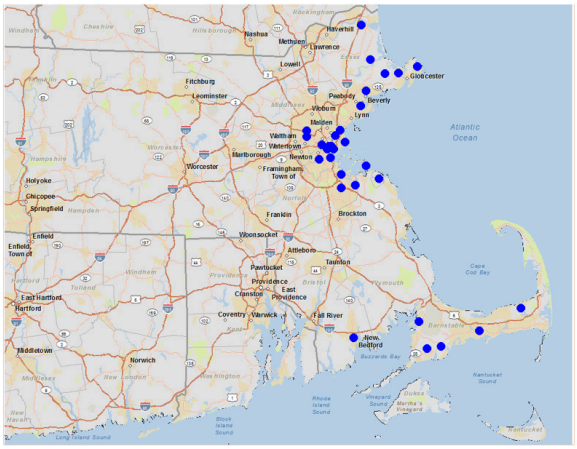


Source: ENOW; NOEP; Authors' calculations.

[70] It is also possible that some businesses that provide home heating services have been misclassified.

Figure 32 maps the distribution of Massachusetts' Marine Construction firms, which are concentrated along the state's larger ports.

Figure 32
Location of Massachusetts' Offshore Minerals Businesses [71]



Source: Public Policy Center.

Annual averages wages for the Offshore Minerals sector were $71,421 in 2015, which is slightly above the statewide average of $66,716 (see Figure 33). Not surprisingly, wages are higher in Oil & Gas Extraction & Production than in Limestone, Sand, & Gravel, due to the R&D intensive nature of employment in this industry in Massachusetts.

Historical Trends

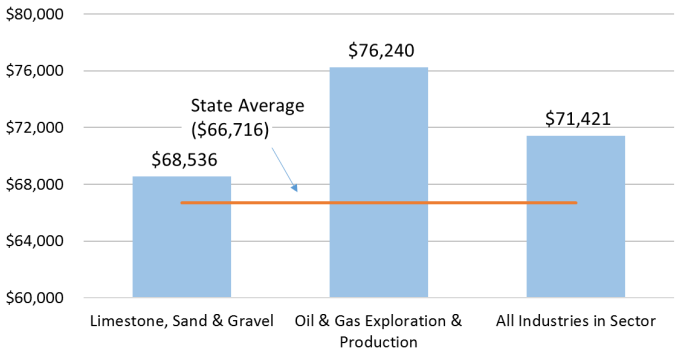
Employment in the Offshore Minerals sector dropped from 242 in 2005 to 101 in 2014/2015—a 58 percent decrease (see Table 12). Employment in this sector is highly volatile. For example, during the Great Recession, employment dropped from a high of 387 in 2007 to a low of 57 in 2009—an 85 percent decrease. Employment and the sector's contribution to GSP then stabilized starting in 2011 (see Figure 34).

Table 12
Change In Offshore Minerals Establishments, Employment, and GSP

	2005	2014/15	Change	State Change
Establishments	67	51	-23.9%	16.5%
Employment	242	101	-58.1%	8.4%
GSP ($M)	$20.3	$22.9	12.7%	32.1%
Real GSP ($M)	$30.1	$20.2	-32.8%	11.4%

Source: ENOW; NOEP; Authors' calculations.

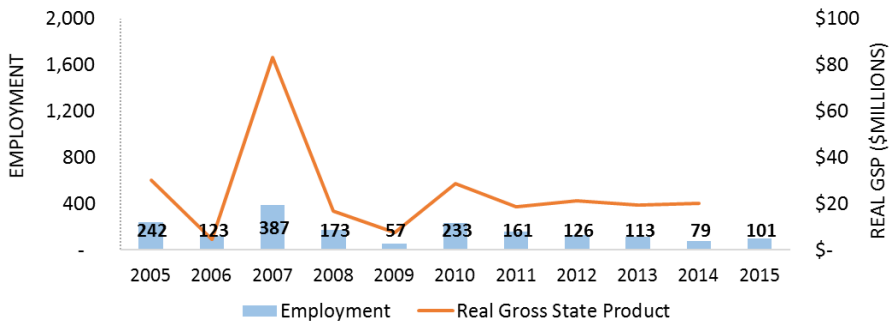
Figure 33
Average Annual Wage in Offshore Minerals, 2015



Source: ENOW; NOEP; Authors' calculations.

[71] Includes only Offshore Minerals businesses that are located in shore-adjacent counties.

Figure 34
Employment & Real GSP, 2005 - 2014/2015

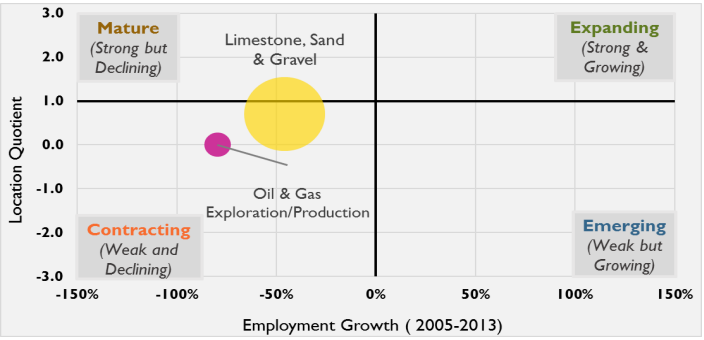


Source: ENOW; NOEP; Authors' calculations.

Regional and National Comparisons

As discussed, employment in this sector is mostly limited to the R&D branches of larger businesses, which have satellite offices in the Boston area. As oil and gas prices and investments have declined, companies may be reducing research staff to cut costs. No matter what the cause, as Figure 35 demonstrates, both industries in this sector are contracting due to employment declines and low LQs.

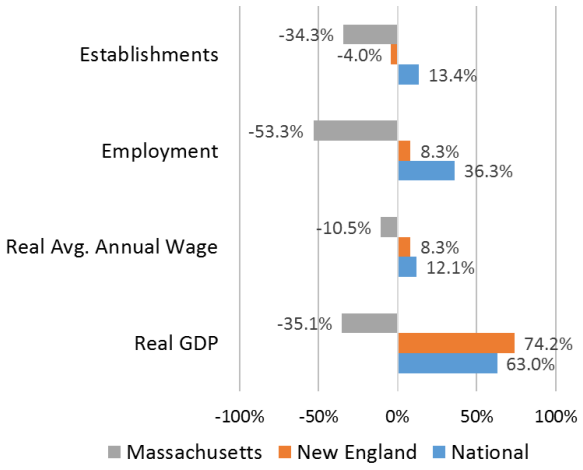
Figure 35
Offshore Minerals
Location Quotient, Growth, and Size, 2013



Source: ENOW; NOEP; Authors' calculations.

Nationally, the Offshore Minerals sector grew from 2005 to 2013. Employment grew by 36.3 percent and GSP increased by 63.0 percent (see Figure 36). The sector also expanded throughout New England, though the number of business establishments decreased slightly. Massachusetts is an exception to this pattern, with declines in every indicator.

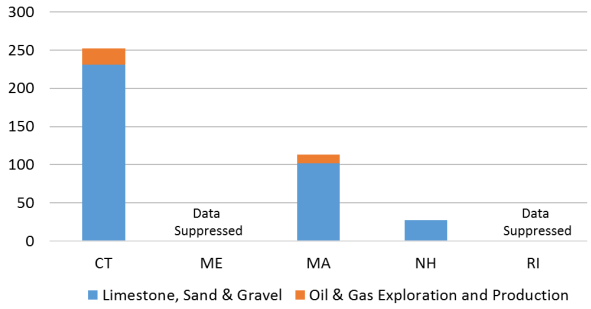
Figure 36
Changes in Offshore Minerals Sector, 2005 - 2013



Source: ENOW; NOEP; Authors' calculations.

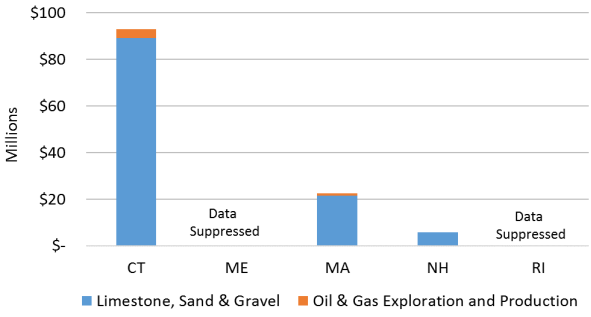
Among New England states, Connecticut has the most employment and GSP in the Offshore Minerals sector (see Figure 37 and Figure 38). Relative to the nation as a whole, the concentration of employment in the New England states is close to zero; the state with the most employment in this sector, Connecticut, has an LQ of 0.01. Other states in the region have so few businesses in the sector that data is suppressed for privacy reasons.

Figure 37
Subsector Employment by State, Offshore Minerals, 2013



Source: ENOW; NOEP; Authors' calculations.

Figure 38
Subsector GSP by State, Offshore Minerals, 2013



Source: ENOW; NOEP; Authors' calculations.

6.4 SHIP & BOAT BUILDING & REPAIR

Industry Overview

The Ship & Boat Building & Repair sector is comprised of 40 establishments that employ 375 full- and part-time workers, pay $17 million in total wages, and generate $17.9 million in GSP (see Figure 39).

Figure 39
Ship & Boat Building & Repair
Establishments, Employment, Total Wages, and GSP



Source: ENOW; NOEP; Authors' calculations.

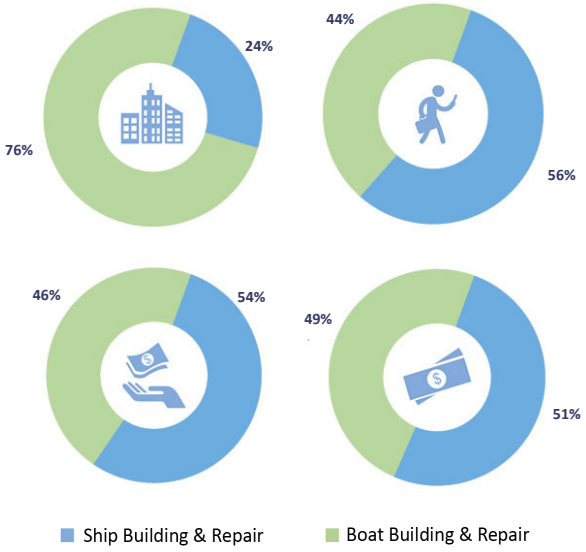
The sector consists of two industries:

- Ship Building & Repair
- Boat Building & Repair

The major difference between these two industries is the size and complexity of the vessels they produce and repair, with ships being the larger of the two.

In terms of the number of establishments, in Massachusetts the sector primarily consists of the Boat Building & Repair industry, which accounts for 76 percent of all businesses (see Figure 40). The two industries are nearly split in terms of sector employment, wages, and GSP, with Ship Building & Repair accounting for just over half of all sector workers (56%), total wages (54%), and gross product (51%). The definition of this sector does not include marinas, which are part of the Transportation & Recreation sector, but most marinas provide services that include boat repair, and thus the estimates of the size of the sector can be considered to be modest.

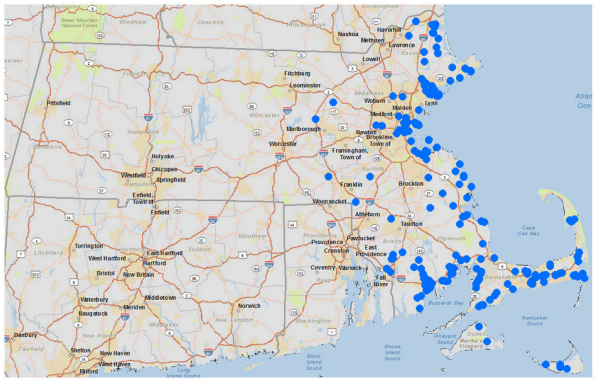
Figure 40
Ship & Boat Building & Repair
Establishments, Employment, Total Wages, and GSP by Industry



Source: ENOW; NOEP; Authors' calculations.

Figure 41 maps the distribution of Massachusetts' Ship & Boat Building & Repair firms, which are scattered throughout the state's coastal counties.

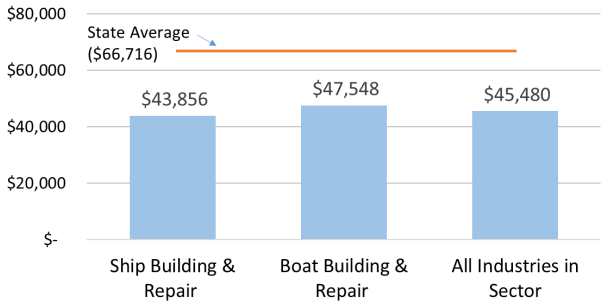
Figure 41
Location of Massachusetts'
Ship & Boat Building & Repair Businesses



Source: Public Policy Center.

While vessel construction and maintenance involves skilled labor, workers in this sector mostly fall into the categories of metal and wood or general trade workers, and sector wages reflect this. Average annual wages for all industries in the sector are below the state average of $66,716, and range slightly from $43,856 in Ship Building & Repair to $47,548 in Boat Building & Repair (see Figure 42).

Figure 42
Average Annual Wage by Industry, 2015



Source: ENOW; NOEP; Authors' calculations.

Historical Trend

This sector has been in decline in Massachusetts since the end of the nineteenth century. More recently, Ship & Boat Building & Repair saw a decrease in the number of establishments, total employment, wages, and GSP since 2005 (see Table 13). Employment losses were mostly driven by the Boat Building & Repair industry, which saw a 29.0 percent decline in employment from 2005 to 2015.

Declines in GSP, however, were mostly due to trends in Ship Building & Repair industry, where GSP decreased by 20.7 percent between 2005 and 2014. The Ship Building & Repair industry depends on large-scale projects, such as naval contracts, so it is understandable that when this industry experiences losses, they are larger than those in the Boat Building & Repair industry.

The drivers of this sector differ by industry. Since Ship Building & Repair relies heavily on government contracts, firms depend on long-term, well-paying projects to provide revenue. Indeed, Navy spending in 2014 accounted for 69 percent of total industry revenue nationwide. Boat Building & Repair, however, depends mainly on growth in the overall economy, particularly to drive the demand for recreational vessels, as well as growth in other maritime industries.

For example, this industry is tied to the Living Resources sector—when the Fishing industry is thriving, there is more business for Boat Building & Repair. It is also tied to Tourism, driven by the demand for ferries, charters, and sightseeing tours. Thus, the recession had a significant impact on sector GSP, creating a decline after 2007 (see Figure 43). Furthermore, employment numbers continued to drop even as other parts of the economy began to recover from the recession. While new niche businesses focusing on custom-made vessels could spur some growth in the Boat Building & Repair industry, it is unlikely that the same would occur in Ship Building & Repair, due to the high barrier to entry and the dominance of a small number of firms nationally. [72]

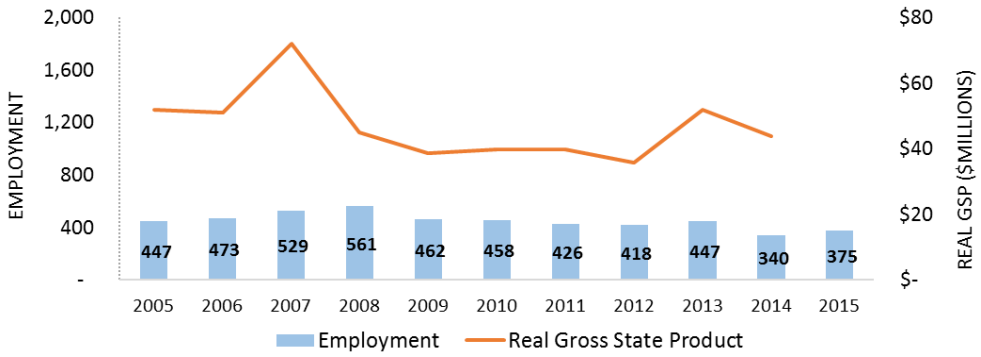
Table 13
Changes In Boat & Ship Building & Repair Establishments, Employment, and GSP

	2005	2014/2015	Change	State Change
Establishments	47	40	-14.8%	16.5%
Employment	447	375	-16.2%	8.4%
GSP ($M)	$47.3	$40.1	-15.2%	32.1%
Real GSP ($M)	$51.9	$44.0	-15.2%	11.4%

Source: ENOW; NOEP; Authors' calculations.

[72] Two firms, General Dynamics and Huntington Ingalls Industries hold more than half (56.8%) of the U.S. industry share (Geaney et al., 2015).

Figure 43
Employment & Real GSP, 2005 to 2014/2015



Source: ENOW; NOEP; Authors' calculations.

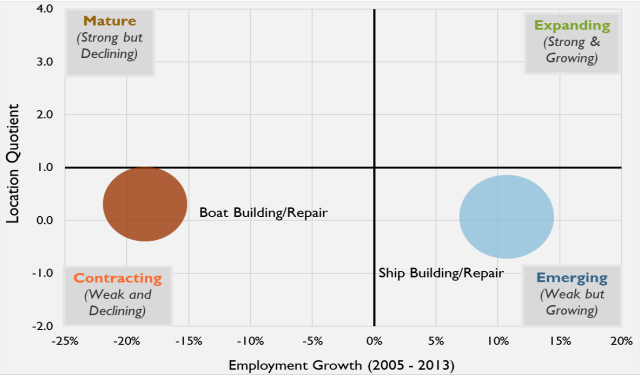
There is some indication that a shortage of qualified workers is creating difficulties for employers. Data from a survey of employers and interviews with industry stakeholders revealed that employers are finding it increasingly difficult to find experienced builders. For instance, 80 percent of respondents to a recent survey conducted by the Massachusetts Marine Trades Educational Trust indicated that the growth of their businesses was inhibited by an inability to hire qualified employees. Builders need to be highly trained since most construction of boats and ships is still done by hand.[73]

Likewise, some stakeholders are concerned about being unable to find replacements for the aging workforce. With few vocational programs available at the high school level, it is unclear from where the new generation of boat and ship builders and repairers will come. However, key informants and survey respondents indicate that a willingness to work in the field was the biggest prerequisite, and that companies are willing to provide training to build the skill levels of new employees.

Regional and National Trends

At one time, Boat & Ship Building & Repair was a major industry for Massachusetts, but now Massachusetts' firms are much more likely to make the high tech marine navigational equipment than the boats and ships themselves (see Section 7.0). Indeed, the LQ for the sector and its industries demonstrates the lack of specialization in Ship & Boat Building & Repair in Massachusetts (see Figure 44). In Massachusetts, Boat Building & Repair's share of employment is slightly below one-quarter (0.22) of the national rate. While Ship Building & Repair is classified as an emerging industry due to rising employment, the increase in absolute terms is modest (+23 jobs).

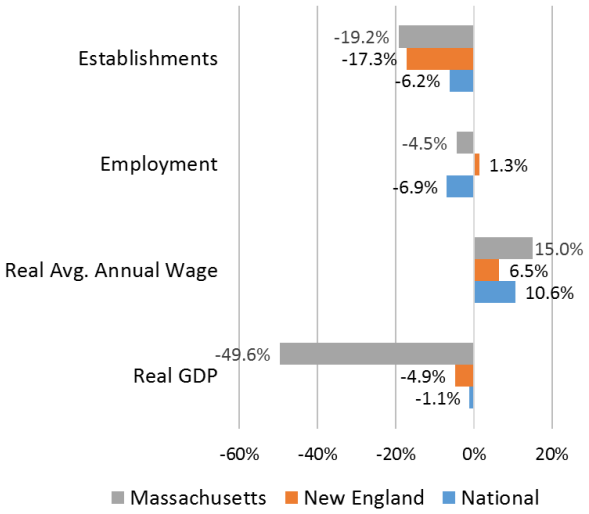
Figure 44
Ship & Boat Building & Repair
Location Quotient, Growth, and Size, 2013



Source: ENOW; NOEP; Authors' calculations.

Massachusetts experienced larger losses in this sector than the nation and region (see Figure 45). The sector suffered a decline of nearly half its GSP from 2005 to 2013 (-49.6%) while regionally and nationally the sector's GSP increased. Similarly, Massachusetts saw a 19.2 percent decrease in establishments compared with a loss of 17.3 percent in the region and 6.2 percent nationwide. Also, while the real average annual wage increased in Massachusetts at higher rate, it is unclear whether this is the result of broad wage increases for all workers, or a substantial increase for high-wage earners in the sector.

Figure 45
Changes in Ship & Boat Building & Repair, 2005 to 2013

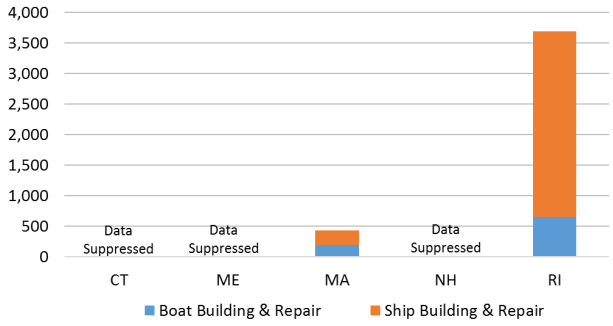


Source: ENOW; NOEP; Authors' calculations.

[73] Massachusetts Marine Trades. (April 2016). *Workforce Survey.* Massachusetts Marine Trades Educational Trust.

Since Massachusetts no longer has a naval shipyard or any major recreational boat builders, the state does not have the capacity to compete with other New England states in this sector (see Figure 46). Rhode Island has a strong presence in Boat Building & Repair in places like Bristol and Newport, and a large Ship Building & Repair industry at Quonset Point. Similarly, Connecticut is home to General Dynamics' Electric Boat, which produces the Navy's submarines, and Maine is home to General Dynamics' Bath Iron Works, which produces the Navy's guided missile destroyers. Due to data suppression, these employers are not included in the analysis, but recent reports on work being done at Bath Iron Works state that the facility employs "nearly 6,000" people,[74] and that Electric Boat has "more than 14,000 employees" between facilities in Connecticut and Rhode Island.[75]

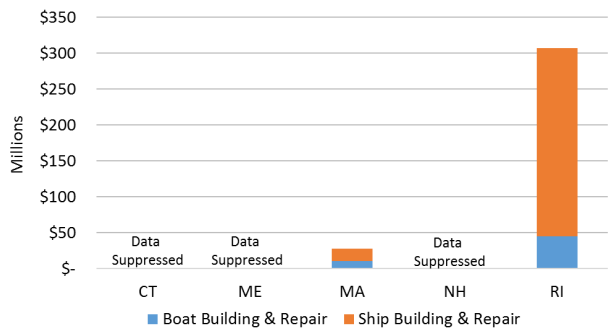
Figure 46
Subsector Employment by State,
Ship & Boat Building & Repair, 2013



Source: ENOW; NOEP; Authors' calculations.

Similarly, subsector GSP by state shows that Massachusetts lags well behind Rhode Island, and although data suppression does not allow comparisons with Maine and Connecticut, it is likely that the revenue generated by the major naval shipyards in these states also outpaces the smaller businesses in Massachusetts (see Figure 47).

Figure 47
Subsector GSP by State,
Ship & Boat Building & Repair, 2013



Source: ENOW; NOEP; Authors' calculations.

Spotlight on Boat & Ship Building: "Fast Cat" Ferries

Although shipbuilding has declined in Massachusetts, one Somerset-based company, the Duclos Corporation, (DBA Gladding-Hearn Shipbuilding) has bucked the trend, building ships and boats on the Taunton River since 1955. Today, it is the leading supplier of fast catamarans on the East Coast and the Great Lakes. The company manufactured the ferries operated by the Massachusetts Bay Transit Authority—the only vehicles in their fleet that were locally made.[76] They also manufacture the majority of the ferries connecting Massachusetts to its islands, where annual ridership continues to grow. This is an example of the linkages between Tourism and economic opportunities in other sectors of the Maritime Economy. Duclos is also well positioned to take advantage of the new offshore wind industry, making catamarans specifically designed to meet the U.S. Coast Guard requirements and to interface with the wind farm pylons, allowing for the transfer of construction crews, technicians, and cargo.

[74] Miller, K. (May 5, 2014). Bath Iron Works hiring 600 more to work on six ships simultaneously. *Portland Press Herald.*

[75] General Dynamics. *Electric Boat history.* Retrieved January 5, 2017, from http://www.gdeb.com/about/history/.

[76] Although the newer Green Line trolleys were assembled in Littleton, by Italy's AnsaldoBreda.

6.5 TOURISM & RECREATION

Industry Overview

The Tourism & Recreation sector is comprised of 4,556 establishments that employ 70,628 full- and part-time workers, pay $1.77 billion in total wages, and account for $3.34 billion in GSP (see Figure 48).[77]

Figure 48
Tourism & Recreation
Establishments, Employment, Total Wages, and GSP



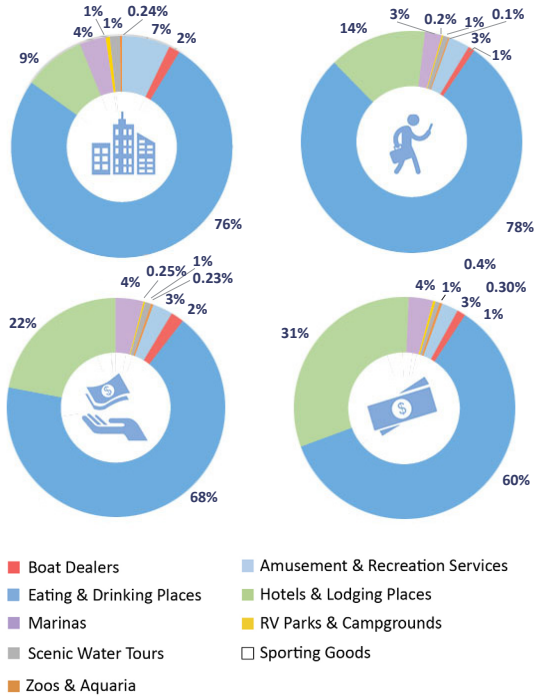
Source: ENOW; NOEP; Authors' calculations.

The Tourism & Recreation sector consists of nine industries:

- Amusement & Recreation Services (e.g. scuba instruction, and boat rentals)
- Boat Dealers
- Eating & Drinking Places
- Hotels & Lodging Places
- Marinas
- Recreational Vehicle Parks & Campsites
- Scenic Water Tours
- Sporting Goods Retailers (e.g. fishing/diving gear)
- Zoos & Aquaria

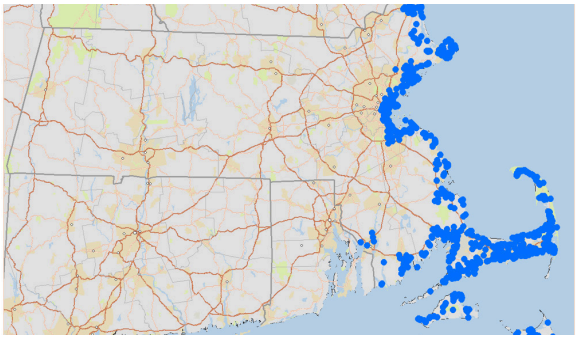
The Eating & Drinking industry comprises 78 percent the sector's employment, followed by Hotels & Lodging (14%). The remaining seven industries comprise only 8 percent of the sector's employment (see Figure 49). As one would expect, tourism businesses are located along nearly all of the state's coastal areas (see Figure 50).

Figure 49
Tourism & Recreation
Establishments, Employment, Total Wages, and GSP by Industry



Source: ENOW; NOEP; Authors' calculations.

Figure 50
Location of Massachusetts' Coastal Tourism & Recreation Businesses



Source: Public Policy Center.

[77] As noted earlier, the Tourism & Recreation sector only includes businesses located in short-adjacent ZIP codes.

Most of the industries in this sector are interconnected with other industries in the Maritime Economy. Marinas, while a small industry, are indicative of this interconnectedness. Their presence in a coastal community not only supports other industries in the Tourism & Recreation sector, such as Eating & Drinking places, but also the Boat Building & Repair, Fishing, and Marine Construction industries, among others. Marinas also play an important role in the branding of Massachusetts as a destination for maritime vacationers by providing a variety of locations for "day cruisers" to stop. Port directors noted that these types of tourists account for an increasing share of summer visitors.

Average annual wages for all industries in the sector are below the statewide average and range from $21,678 in Eating & Drinking to $53,235 in Zoos & Aquaria (see Figure 51). Importantly, the wage data may convey an overly pessimistic view of employee earnings since the tourism industry is very seasonal, particularly on Cape Cod and the Islands. Consequently, QCEW average annual wage statistics probably overstate the wage differential for Eating & Drinking places (the sector's largest industry), since many of the region's restaurants are seasonal operations that pay out their "annual" wages over a shorter period.[78] Wage data also do not include tips, which can account for a substantial portion of employee earnings in restaurants and bars. In addition, much of the Cape and Islands' seasonal workforce consists of students, retirees, and moonlighters who are supplementing their income.

Historical Trends

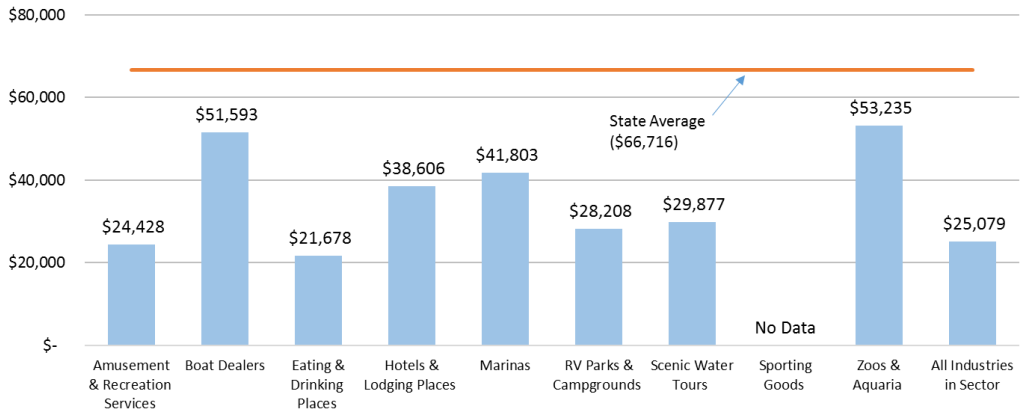
Establishments, employment, and GSP all grew in the Tourism & Recreation sector from 2005 to 2014/2015 (see Table 14). Sector employment increased at a faster rate than the nation as a whole (22.4% versus 5.8% for all industries nationwide).[79] In addition, the number of establishments grew by 11.4 percent, along with GSP (45.6%), and real GSP (14.5%).[80]

Table 14
Change In Tourism & Recreation
Establishments, Employment, and GSP

	2005	2014/15	Change	State Change
Establishments	4,088	4,556	11.4%	16.5%
Employment	57,717	70,628	22.4%	8.4%
GSP ($M)	$2,293.0	$3,339.0	45.6%	32.1%
Real GSP ($M)	$2,672.4	$3,060.3	14.5%	11.4%

Source: ENOW; NOEP; Authors' calculations.

Figure 51
Average Annual Wage by Industry, 2015



Source: ENOW; NOEP; Authors' calculations.

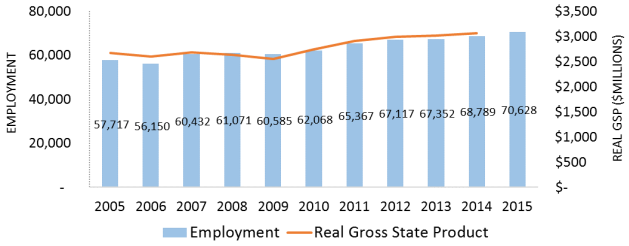
[78] Borges, D., & Barrow, C. (2000). *Help wanted! Cape Cod's seasonal workforce.* Dartmouth, MA: Center for Policy Analysis.

[79] National source: Bureau of Labor Statistics, Current Employment Statistics. Total Non-farm employment, not seasonally adjusted.

[80] Real GSP applies the BEA chain-weighted index methodology based to 1997.

The Tourism & Recreation sector is highly dependent on the vitality of the economy as a whole since leisure activities are dependent on consumers' disposable income. However, and perhaps counterintuitively, the sector's annual employment and GSP reveal that the sector did not suffer greatly from the Great Recession. Indeed, despite a small dip in GSP from 2007 to 2009, the statewide Tourism & Recreation sector has grown steadily since 2005 (see Figure 52).

Figure 52
Employment & Real GSP, 2005 to 2014/2015

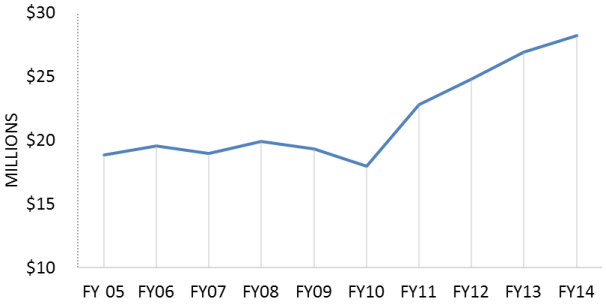


Source: ENOW; NOEP; Authors' calculations.

Room tax revenues are another proxy for tourism vitality. These data show that revenues for Barnstable County, which is highly dependent on the tourism sector, declined only slightly during the recession and continued its upward trajectory as the economy recovered (see Figure 53). A similar trend can be seen in Martha's Vineyard and Nantucket.

The sector's ability to weather the economic downturn on the Cape and Islands is partly the result of spending by wealthier tourists, particularly from New York and New Jersey,[81] who retained more disposable income for leisure activities throughout the economic downturn.[82] Other areas of the state, such as Boston, are less dependent on outside tourist dollars to support the Eating & Drinking sector, and have probably been supported by local spending as much as by out-of-state visitors.

Figure 53
Barnstable County Room Tax Revenues, 2005 - 2014

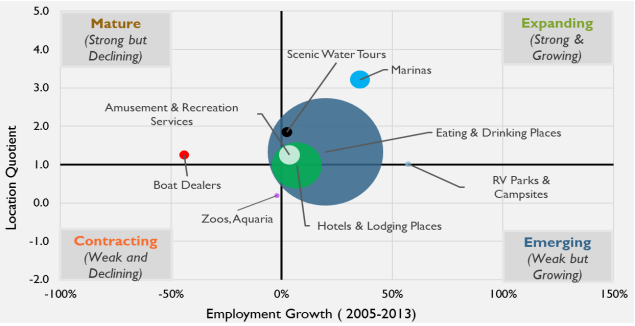


Source: Massachusetts Office of Travel and Tourism.

Regional and National Trends

Massachusetts' Tourism & Recreation sector has an LQ of 1.27, meaning the state is more specialized in these industries than the nation as a whole. Most industries within the sector are in a period of expansion, meaning that they have high LQs and have shown recent employment growth (see Figure 54).

Figure 54
Tourism & Recreation
Location Quotient, Growth, and Size, 2013



Source: ENOW; NOEP; Authors' calculations.

The Tourism & Recreation sector posted employment growth of 16.7 percent from 2005 to 2013, which slightly outperforms the nation and New England.[83] The number of establishments grew at a slower rate than the nation and the region, although GSP growth was much higher, which again may be a sign that the state's maritime-related tourism industry is attracting more affluent visitors (see Figure 55).

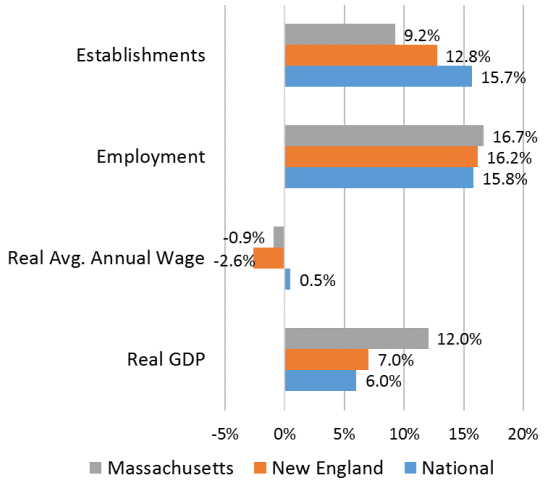
Across all New England states, Eating & Drinking establishments make up the majority of Tourism & Recreation sector employment (see Figure 56). Bay State employment in this industry alone is greater than the total Tourism & Recreation employment of the other New England coastal states combined.

[81] Nearly 3.5 million New York and New Jersey residents visited Massachusetts in FY 2015. Source: TNS, Travels America, from Massachusetts Office of Travel & Tourism 2015 Annual Report (See http://www.massvacation.com/wp-content/uploads/2016/09/2015-annual-report-9-27-16.pdf).

[82] This is supported by Barnstable County RevPAR data (Revenue per available Room), which increased by 56.1 percent from July 2009 to July $202.66. See, http://www.whycapecod.org/cape-cod-tourism-stats.

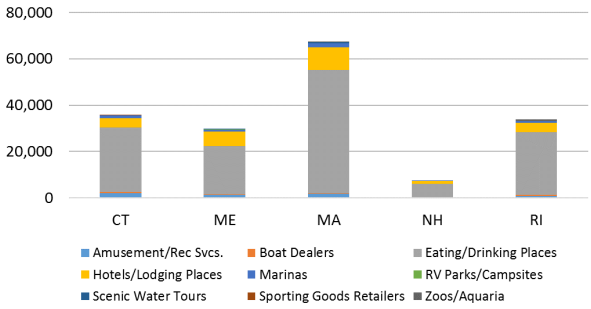
[83] Note that 2014 and 2015 NOEP data is not available on the regional and national level.

Figure 55
Changes in Tourism & Recreation Sector, 2005 to 2013



Source: ENOW; NOEP; Authors' calculations.

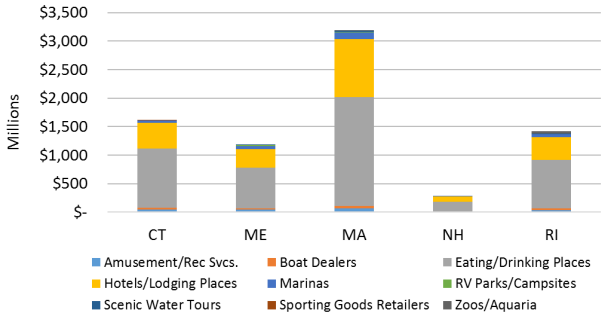
Figure 56
Subsector Employment by State,
Tourism & Recreation, 2013



Source: ENOW; NOEP; Authors' calculations.

Unsurprisingly, Massachusetts also has a higher GSP compared to other New England states (see Figure 57). Notably, the Hotel & Lodging industry accounts for 32 percent of sector GSP in Massachusetts, which is much higher than the other coastal states.

Figure 57
Subsector GSP by State,
Tourism & Recreation, 2013



Source: ENOW; NOEP; Authors' calculations.

While Tourism & Recreation is an important economic driver for Massachusetts, particularly for the Cape and Islands, the sector is not without its challenges. For example, coastal communities that are dependent on scenic tourism have to maintain coastal and ocean resources in a way that makes them accessible to visitors while mitigating the negative impacts of increased use.

In communities dependent on maintaining a supply of lodgings for seasonal visitors, housing affordability is also a growing concern. The Cape Cod Commission describes the Cape as a resort community, with a high percentage of second homeowners, high housing costs, and low local wages.[84] This creates challenges related to maintaining suitable housing for low-wage service workers who prefer to live locally. Additionally, local zoning rules in many towns prevent more than a few unrelated people from living together.

Consequently, housing affordability has emerged as a significant issue for the Cape and Islands, particularly in the context of lower wages compared to the state as a whole. However, since coastal communities are dependent on natural resources to attract tourists, new development is constrained for practical and environmental reasons.

Without adequate workforce housing and year-round jobs to make permanent residency a viable option for low-wage Tourism & Recreation workers, employers on Cape Cod, the Islands, and other tourist destinations rely on foreign temporary workers, who enter the U.S. through the H2B visa process.[85] During key informant interviews, some respondents reported that the process was too cumbersome and some suggested that the foreign labor pool does not provide a sufficient, dependable supply of workers year after year.[86] There is some indication that these workers come in limited numbers due to the lack of affordable, on-season housing options.[87]

[84] Cape Cod Commission. (2014). *Affordable housing on Cape Cod: Why are we more like Aspen, Key West, or the Tetons than Amesbury, Kingston, or Templeton?* Barnstable, MA.

[85] Borges, D., & Barrow, C. (2000). *Help wanted! Cape Cod's seasonal workforce.* Dartmouth, MA: Center for Policy Analysis.

[86] Visa delays spur fears of Outer Cape worker shortage. (February 18, 2016). *Provincetown Wicked Local.*

[87] H2B Visa Delay May Mean Short-Staffing in Early Weeks of Summer. (April 2, 2015). *Cape Cod Sunday Journal.*

6.6 MARINE TRANSPORTATION

Industry Overview

The Marine Transportation sector is comprised of 248 establishments that employ 11,739 full- and part-time workers, pay $1.2 billion in total wages, and accounts for $2.3 billion in GSP (see Figure 58).

Figure 58
Marine Transportation
Establishments, Employment, Total Wages, and GSP



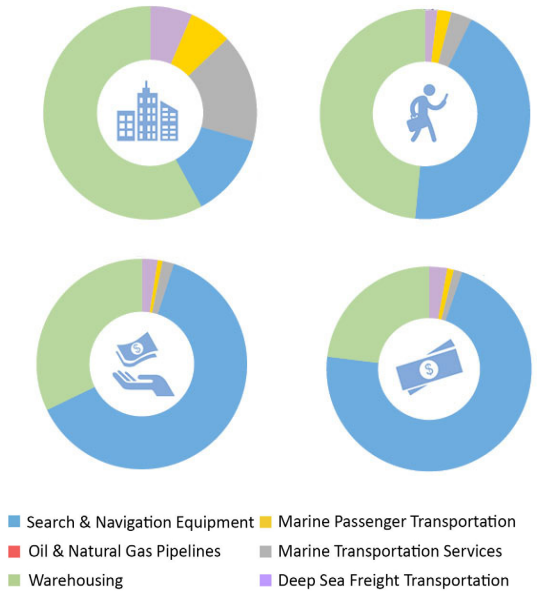
Source: ENOW; NOEP; Authors' calculations.

The Marine Transportation sector consists of five industries:

- Deep Sea Freight
- Marine Passenger Transportation
- Marine Transportation Services
- Search & Navigation Equipment
- Warehousing

The Warehousing subsector comprises 49 percent the sector's employment,[88] followed closely by the Search & Navigation Equipment subsectors, at 44 percent (see Figure 59). The remaining three sectors comprise only 7 percent of the sector's employment. Search & Navigation Equipment is included the Marine Transportation sector, since the largest dollar volume of marine-related products is sold for applications in commercial transportation. However, it differs from the other Marine Transportation industries in that Search & Navigation Equipment companies primarily develop and manufacture new technology.

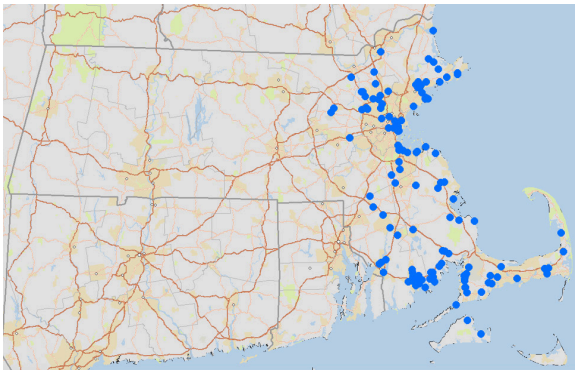
Figure 59
Marine Transportation
Establishments, Employment, Total Wages, and GSP by Industry



Source: ENOW; NOEP; Authors' calculations.

Figure 60 maps the distribution of Massachusetts' Transportation businesses, which are scattered throughout the state's coastal counties.

Figure 60
Location of Massachusetts'
Marine Transportation Businesses[89]



Source: Public Policy Center.

[88] Warehousing includes marine-specific warehousing such as icehouses and refrigerated storage, but also includes general, land-based warehouses. Unfortunately, industry classifications do not permit the isolation of marine-specific warehousing numbers, but the inclusion of only shore-adjacent counties mitigates this problem somewhat.

[89] Includes only Marine Transportation businesses in shore-adjacent counties.

Average annual wages for the Marine Transportation sector in Massachusetts are above the statewide average, at $102,227. Wages by industry range from $35,673 in Marine Passenger Transportation to $145,289 in Search & Navigation Equipment (see Figure 61).

Historical Trends

Employment and GSP in the Marine Transportation sector grew from 2005 to 2014/2015, even as the number of business establishments decreased (see Table 15). During this time, sector employment increased at a faster rate than the nation as a whole (9.5% versus 5.8% for all industries nationwide).[90]

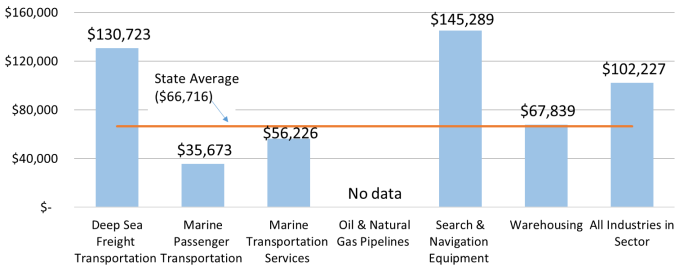
Table 15
Change In Marine Transportation
Establishments, Employment, and GSP

	2005	2014/15	Change	State Change
Establishments	296	248	-16.1%	16.5%
Employment	10,718	11,739	9.5%	8.4%
GSP ($M)	$1,382.7	$2,267.3	64.0%	32.1%
Real GSP ($M)	$1,131.5	$2,470.6	118.3%	11.4%

Source: ENOW; Center for the Blue Economy; Authors' calculations.

From 2008 to 2011, the Marine Transportation sector shed jobs, a period that included the Great Recession. Nationally, the sector experienced job losses, dropping 9 percent. A similar pattern occurred in Massachusetts, with employment dropping 17 percent from 12,800 to 10,600 jobs (see Figure 62). From 2011 to 2013, employment stabilized in Massachusetts. Growth returned in 2014 and 2015, though not enough to recover the peak levels of employment experienced in 2006.

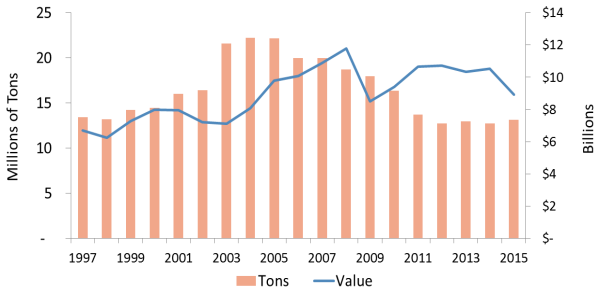
Figure 61
Average Annual Wage by Industry, 2015



Source: ENOW; NOEP; Authors' calculations.

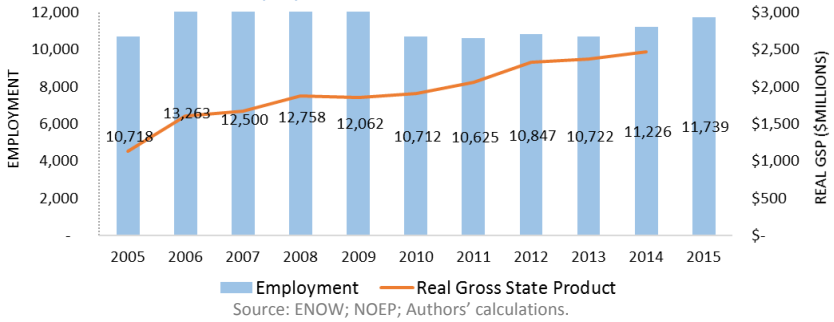
Employment in Deep Sea Freight Transportation and related services is driven by the volume of imports and exports coming into and out of Massachusetts' ports. While other Massachusetts ports also engage in marine and ocean trade, the Port of Boston accounts for more than 95 percent of all tonnage statewide. The total volume of imports and exports peaked in 2004 at 22.2 million tons (see Figure 63). Since then, the tonnage has decrease by 41 percent to 13.1 tons in 2015. It is not surprising then, that employment in the Deep Sea Freight Transportation industry decreased by 49 percent from 2006 to 2015.[91] Despite the decrease in tonnage, the value of cargo has increased overall, at a 2 percent average annual growth rate.

Figure 63
Imports plus Exports, Massachusetts, 1997 – 2015



Source: NOEP Analysis of US Census Bureau Data.

Figure 62
Employment & Real GSP, 2005 - 2014/2015



Source: ENOW; NOEP; Authors' calculations.

[90] National source: Bureau of Labor Statistics, Current Employment Statistics. Total Non-farm employment, not seasonally adjusted.

[91] 2006 is the earliest year for which there is data.

Export tonnage actually increased over this time, rising by 44 percent from since 2004 and 147 percent since 1997. However, freight activity in Massachusetts is dominated by imports, which accounted for 88 percent of total tons and 90 percent of total value in 2015 (see Figure 64). As a result, the demand for Deep Sea Freight employment is more impacted by changes in imports than exports.

Figure 64
Imports vs Exports, Millions of Tons,
Massachusetts, 1997 - 2015



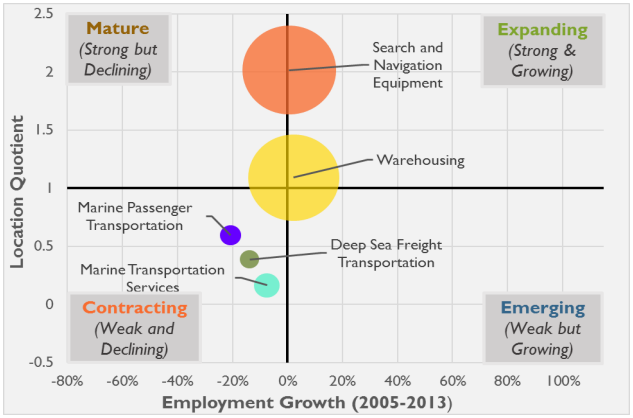
Source: NOEP Analysis of US Census Bureau Data.

Employment in the Marine Passenger Transportation industry is strongly influenced by commuting and tourist trips to the state's islands. Tourism in Massachusetts' coastal areas increased by 14.5 percent from 2005 to 2015. However, employment in Marine Passenger Transportation declined 21.4 percent over the same period.[92] Despite this, there are signs of growth in the industry. For example, annual ferry ridership with the Steamship Authority, which manages many ferries connecting Massachusetts to the islands, has increased at an average annual growth rate of 1.4 percent, from 2.3 million in 2005 to 3.0 million in 2015. In 2016, ferry operator Seastreak revived its New Bedford to Nantucket ferry service, leading to record ridership numbers of nearly 120,000 passengers for the summer, well above the 70,000 passengers during the previous summer.

Regional and National Trends

Overall, the concentration of employment in this sector in Massachusetts is about average when compared to the nation as a whole (LQ = 1.03). Massachusetts specializes in the Search & Navigation Equipment component of this sector, in which employment has been stable and concentration is over twice that of the nation (LQ = 2.02) (see Figure 65). Massachusetts is underrepresented in Deep Sea Freight (LQ = 0.39), but recent employment growth in this industry could be a promising signal.

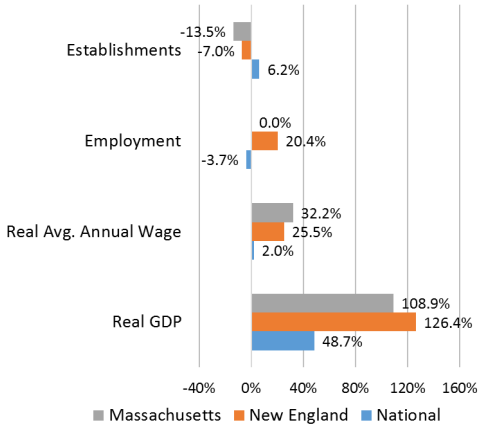
Figure 65
Marine Transportation
Location Quotient, Growth, and Size, 2013



Source: ENOW; NOEP; QCEW; Authors' calculations.

Employment in Marine Transportation in Massachusetts was essentially the same in 2013 as in 2005. This performance places the state above the nation, where employment declined by 3.7 percent, but below New England (including Massachusetts), which experienced a substantial increase of 20.4 percent, most likely fueled by Marine Technology research in several states with strong ties to the Navy. Both Massachusetts and New England outpaced the nation in terms of the growth in GSP and wages, with New England increasing more than Massachusetts (see Figure 66).

Figure 66
Change in Marine Transportation Sector, 2005 - 2013

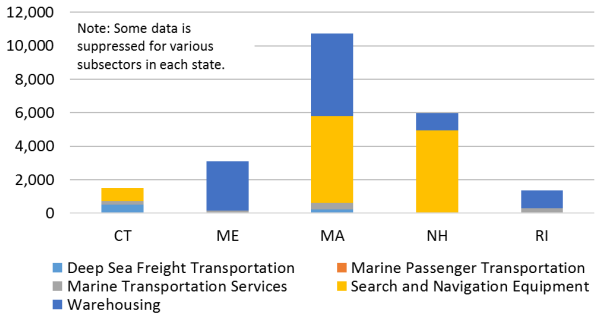


Source: ENOW; NOEP; Authors' calculations.

[92] This likely underestimates the true number of employees since many ferry services are managed by transit authorities or municipal entities, and thus are not captured by the data. This includes the ferries run by the Massachusetts Bay Transit Authority (MBTA) and Massport, and the land-side activities that are managed by municipalities. (See MassDOT. (2012). *Ferry Transportation in Massachusetts.* Boston, MA. Massachusetts Department of Transportation.

Massachusetts employs substantially more people in Marine Transportation than any of the New England states (see Figure 67). Employment in Marine Transportation is 78 percent higher in Massachusetts than in second place New Hampshire. Most of the state's advantage is in Search & Navigation Equipment and Warehousing. New Hampshire is home to slightly fewer employees in the Search & Navigation Equipment industry than Massachusetts (4,962 vs. 5,201). Relative to the size of the workforce, New Hampshire is much more specialized in Search & Navigation Equipment than Massachusetts (LQ = 10.13 vs. 2.02), but both states are well above the national average concentration.

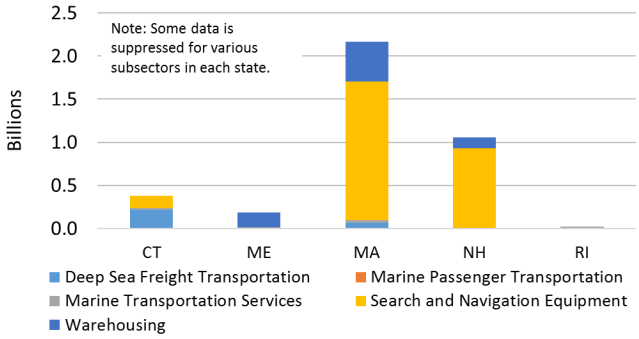
Figure 67
Subsector Employment by State,
Marine Transportation, 2013



Source: ENOW; NOEP; Authors' calculations.

Massachusetts' lead is even more substantial in GSP attributable to Marine Transportation, which is over twice that of New Hampshire (see Figure 68). Most of the Marine Transportation GSP in Massachusetts is in the Search & Navigation Equipment subsector, which accounts for 74 percent of the sector total. Massachusetts Search & Navigation firms are more productive than in neighboring states, returning $308,000 of GSP per employee, versus $188,000 in New Hampshire and $174,000 in Connecticut.

Figure 68
GSP by State, Marine Transportation, 2013



Source: ENOW; NOEP; Authors' calculations.

Improvements to port infrastructure are particularly important to the competitiveness of this sector. Port capital investments might include upgrades such as repairing pile supports, decking and bulkhead repairs, and building renovations or replacements.

Interviews reveal that some of Massachusetts' ports are turning away marine traffic because they do not have enough space, berths, or water depth. According to the port director for Massport, "The industry is evolving to larger and larger container ships, and we need to increase our water depth in order to handle these ships, and larger ships means more capacity for imports and exports through the Port of Boston."[93] Additionally, dredging has been cited in recent studies as important to the success of businesses operating out of the Port of New Bedford.[94,95]

Also, some bridges pose height and width restrictions to the passage of larger vessels. This was an issue for the Chelsea Street Bridge in Boston, which was reconstructed to allow for smoother and safer passage of fuel barges. A similar problem is being faced by the New Bedford – Fairhaven Bridge, which "was completed in 1903 and is currently classified as functionally obsolete," limiting the size of vessels that can access the northern area of the port.[96]

[93] Bodley, M. (June 16, 2016). Fish Pier's seafood business evolving with the industry. *The Boston Globe.*

[94] Karl F. Seidman Consulting Services and UrbanFocus LLC. (2016).Massachusetts state piers: A business and economic assessment. MassDevelopment and the Massachusetts Executive Office of Housing and Economic Development.

[95] HR&A Advisors, Inc. (2009). New Bedford Harbor Study. A Comprehensive Analysis of Growth Potential for Existing and Potential Port Industries. New Bedford, MA: The New Bedford Harbor Development Commission.

[96] Martin Associates and Apex Companies. (2016). *Economic impact study of New Bedford/Fairhaven Harbor.* New Bedford, MA: The New Bedford Harbor Development Commission.

7.0 MARINE TECHNOLOGY IN THE MASSACHUSETTS INNOVATION ECONOMY

Fueled by its world class higher education institutions, research organizations, and technology companies, the state's Marine Technology cluster is a significant contributor to the state's Innovation Economy. The cluster spans a wide variety of fields, including robotics, oceanography, renewable and non-renewable energy, biotechnology, communications hardware, information technology, advanced materials, and civil engineering. As a result, the cluster contributes to a more diversified, resilient economy that is less impacted by downturns in any one industry. While federal defense spending has been the cluster's primary growth driver, marine renewable energy, adaptation to sea level rise, and other technical fields provide new growth opportunities for the cluster.



While the diversity of the Marine Tech Cluster presents a strategic opportunity, it complicates an accurate characterization. Since most data is only available in broad categories, any portrayal is prone to errors of inclusion or exclusion. However, it is fair to say that Massachusetts has a strategic advantage in this field. The state is home to the Woods Hole Oceanographic Institute (WHOI), the largest oceanographic research center in the country, and has the largest offshore wind potential of any state in the contiguous United States.

Massachusetts is also widely acknowledged as an international leader in the Marine Robotics industry — a market expected to reach $4.6 billion by 2020, up from $2.2 billion in 2015. [97,98] There are generally two types of marine robotics platforms; remotely operated underwater vehicles (ROVs) and autonomous underwater vehicles (AUVs). While Massachusetts is not a major player in the ROV market, it does supply many of the ROV components to manufacturers. However, the Bay State leads the world in the design and manufacturing of AUVs, with the leading manufacturers of AUVs - Kongsberg Hydroid, Teledyne Benthos, and Bluefin Robotics - all located in the state.

While smaller than the ROV market, it is anticipated that the AUV industry will outpace the ROV market in the coming years, with AUV demand expected to grow 49 percent by 2020, fueled primarily by commercial markets.[99] This is partly attributable to new technologies that allow AUVs to explore deeper ocean depths, where AUVs are cheaper to deploy than ROVs. This capability is particularly important to the oil and gas industry, which increasingly explores for oil and gas at deeper ocean depths. Future market opportunities for AUVs will also likely come from new government and military applications, inspection and maintenance of offshore wind farms, deep ocean mining, and environmental monitoring.

The Marine Robotics industry falls under the Search, Detection Navigation, & Instrument Manufacturing industry classification. Companies in this industry employed approximately 5,193 people in Massachusetts in 2015 and paid average annual wages of $145,285, more than twice the statewide average. The industry also accounted for approximately $2.40 billion in total output and $1.28 billion in Gross State Product, which represents approximately 0.30 percent and 0.26 percent of the statewide totals respectively.[100]

Importantly, data such as these do not account for Marine Technology's impacts on other sectors, which are significant because the industry has a high degree of backward linkages and provides high value services. For example, although Massachusetts has a very small presence in the Offshore Minerals sector, its manufactured components are essential for the offshore oil and gas production industry. These figures also do not include the millions of research dollars awarded annually that support large levels of employment in higher education and other oceanographic organizations and enterprises, which is discussed next.

[97] ABI Research. (2016). *The Massachusetts robotics cluster.* Massachusetts Technology Collaborative.

[98] There are generally two types of UUVs; remotely operated underwater vehicles (ROVs) and autonomous underwater vehicles (AUVs).

[99] World AUV Market Forecast. Douglas-Westwood. 6th Edition.

[100] Source: NOEP; Implan, U.S. Bureau of Economic Analysis, Authors' calculations.

7.1 RESEARCH AND DEVELOPMENT FUNDING

The Commonwealth's Marine Technology cluster is highly dependent on federal funding, both for higher education and for private companies. The state is a leading recipient of federal dollars for oceanographic research, and future funding is essential if Massachusetts' Marine Technology cluster is to remain competitive.

R&D Funding for Colleges and Universities

California was home to the greatest amount of academic R&D spending in oceanography in absolute terms in 2014, with a total of $187.5 million in research expenditures. Massachusetts follows closely behind with $164.8 million of research expenditures (See Table 16).

Table 16
Total Oceanographic R&D Expenditures
Top Ten States, 2014

State	Expenditures (Thousands)
California	$187,484
Massachusetts	$164,851
Texas	$113,042
Washington	$58,481
Florida	$58,352
Maryland	$56,428
New York	$56,250
Hawaii	$55,980
Alaska	$35,350
Virginia	$33,070

Source: NSF Survey of R&D Expenditures at Universities and Colleges-Higher Education Research and Development Survey, 2010-2014.

Hawaii was home to the greatest concentration of oceanographic research in 2014 relative to the size of the state economy, with $732 of research expenditures per million dollars of GSP (see Table 17). Measuring academic oceanographic research as a proportion of the state GSP moves several small New England states to the top ten list, specifically Rhode Island, New Hampshire, and Maine.

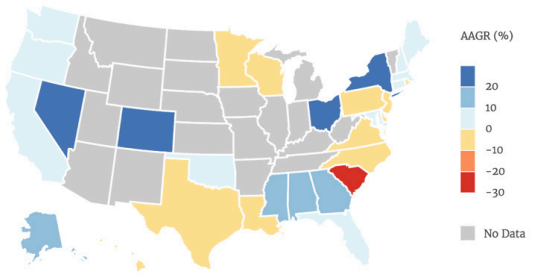
Table 17
Oceanographic R&D Expenditures per Million GSP,
Top Ten States, 2014

State	Expenditures per Million GSP
Hawaii	$732
Alaska	$609
Rhode Island	$515
Massachusetts	$361
New Hampshire	$275
Maine	$265
Mississippi	$252
Delaware	$204
Maryland	$161
Washington	$138

Source: NSF Survey of R&D Expenditures at Universities and Colleges-Higher Education Research and Development Survey, 2010-2014.

Figure 69 shows the change by state in academic oceanographic research expenditures per million of GSP from 2010 to 2014. In New England, spending increased in Connecticut, Massachusetts, Maine, and New Hampshire, while it decreased in Rhode Island.

Figure 69
Oceanographic R&D Expenditures at Colleges & Universities by State, 2010-2014
Average Annual Growth Rate [101]

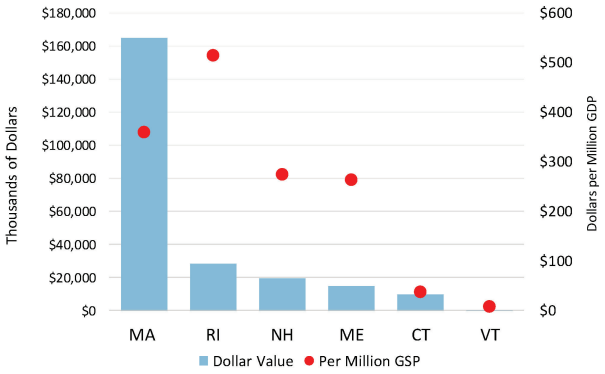


Source: NSF Survey of R&D Expenditures at Universities and Colleges-Higher Education Research and Development Survey, 2010-2014.

[101] Only reported for states reporting oceanographic research expenditures all five years.

Colleges and universities in New England spent over $917 million on oceanographic R&D in 2014, with Massachusetts representing 60 percent of the total (see Figure 70). However, adjusting for the size of the economy, Rhode Island takes the lead, with $515 of oceanographic R&D at their academic institutions per million dollars of GSP.[102]

Figure 70
Oceanographic R&D Expenditures at Colleges & Universities in New England, 2014



Source: NSF Survey of R&D Expenditures at Universities and Colleges Higher Education Research and Development Survey, 2010-2014.

WHOI accounted for 86 percent of the state's total oceanographic R&D expenditures in colleges and universities (see Table 18). During this same year, the University of Massachusetts Dartmouth, the Massachusetts Institute of Technology, the University of Massachusetts Boston, and Northeastern University also reported substantial levels (greater than $1 million) of R&D expenditures related to oceanography (see Table 18).

Northeastern University and Clark University stand out for the rate at which their oceanographic research spending increased from 2010 to 2014. At Northeastern University, the Marine Science Center first opened their doors in 1969, but from 2010 to 2014 they grew from four research-active faculty to eleven and underwent a significant facility renovation, expanding their research capacity. They have also been positioning themselves to benefit from increased funding for research on urban coastal sustainability. The steady increase in oceanographic research at Clark University is driven by their top ranked geography department, which is engaged in research investigating how climate change affects arctic and coastal ecosystems.

Table 18
Oceanographic R&D Expenditures at Colleges & Universities in Massachusetts (Thousands of Dollars)

	2010	2014
WHOI	$133,864	$141,788
UMassD	$11,751	$8,812
MIT	$6,617	$7,182
UMassB	$4,030	$3,978
Northeastern	$487	$2,889
Clark	$0	$183
Other	$23	$19
Mass. Total	$156,772	$164,851

Source: NSF Survey of R&D Expenditures at Universities and Colleges Higher Education Research and Development Survey, 2010-2014.

Funding Sources for Oceanographic R&D

Funding for R&D comes from various sources, including but not limited to federal, state/local government, business, nonprofit, and institutional funds.[103] The majority of the college and university oceanographic R&D activities are federally financed, accounting for 76 percent of Massachusetts' oceanographic R&D expenditures (see Table 19). While precise data on the sources for these funds is not readily available, it is clear that federal marine-related R&D funding is primarily awarded by the National Science Foundation (NSF), the U.S. Navy, and NOAA.[104]

Table 19
Oceanographic R&D Expenditures at Colleges & Universities in Massachusetts by Funding Source

	2010	2014
Federal	81%	76%
State/Local Govt.	1%	1%
Business	1%	3%
Nonprofit	1%	0%
Institutional	10%	12%
Other	6%	8%
Total	$156,772	$164,851

Source: NSF Survey of R&D Expenditures at Universities and Colleges Higher Education Research and Development Survey, 2010-2014.

[102] The New England total was more or less flat from 2010 to 2014, with an average annual growth rate (AAGR) of 0.7 percent.

[103] The definition of funding sources is based on the Higher Education Research and Development Survey definitions.

[104] Wood Hole Oceanographic Institute. (2015). *Woods Hole Oceanographic Institute annual report 2014. Falmouth, MA.*

Nationwide, federally funded oceanographic R&D expenditures reported by higher education institutions changed little from 2010 to 2014, with an average annual growth rate of 0.19 percent. In New England's coastal states, federally funded R&D expenditures going to oceanographic R&D increased in New Hampshire (AAGR = 5.3%), and Connecticut (AAGR = 32.8%), decreased in Rhode Island (AAGR = -2.3%) and was more or less level in Massachusetts and Maine (AAGR within ± 1.0%).

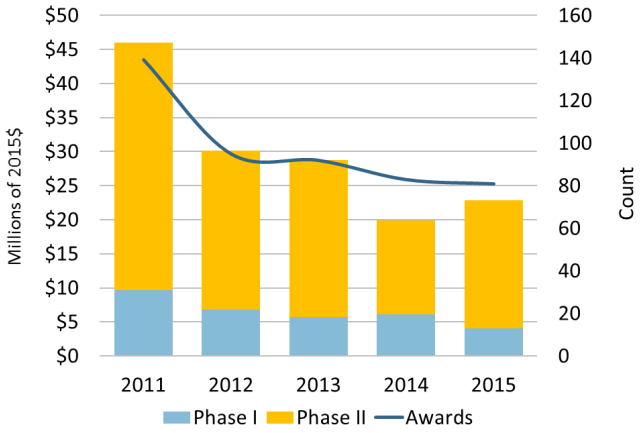
SBIR/STTR Awards

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are highly competitive federal grant programs that enable small companies to conduct proof-of-concept research on technical merit (Phase 1) and idea feasibility and prototype development (Phase 2), building on Phase I findings. Both programs aim to increase the number of small businesses engaged in federally funded R&D.

Additionally, the STTR program aims to facilitate the transfer of technology developed by a research institution through small business entrepreneurship. Consequently, STTR funding requires a partnership with an institution that is a nonprofit college, university, or research organization, or a federally funded R&D center.

In 2015, Massachusetts companies were awarded 500 SBIR/STTR awards.[105] Of these, 81 were maritime-related, bringing in $204 million of investment in new technologies (see Figure 71). This represents 11 percent of all SBIR/STTR money coming into the state. Between 2011 and 2015, maritime-related awards accounted for between 8 percent and 15 percent of all Massachusetts' SBIR/STTR funds.

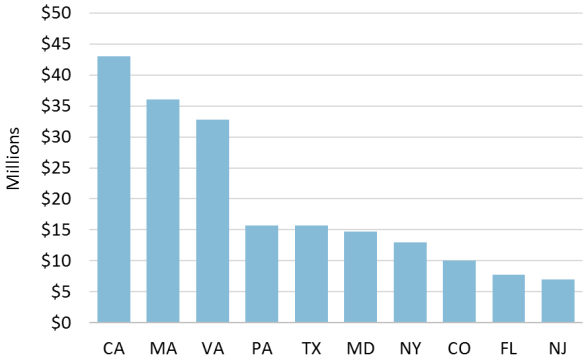
Figure 71
Massachusetts Maritime-Related Awards,
Millions of 2015 Dollars



Source: U.S. Small Business Association.

The U.S. Navy awards the vast majority of maritime-related SBIR/STTR dollars, though some of the awards are for technologies related to their flight program. Still, these awards are a reasonable proxy for maritime-related awards that enables one to make consistent comparisons between states. With $36 million received in 2015, Massachusetts ranks second among U.S. states in the total dollar value of SBIR/STTR Awards awarded by the Navy (see Figure 72).

Figure 72
Value of U.S. Navy SBIR/STTR Awards per
Million Dollars of GSP
Top Ten States, 2015



Source: U.S. Small Business Association.

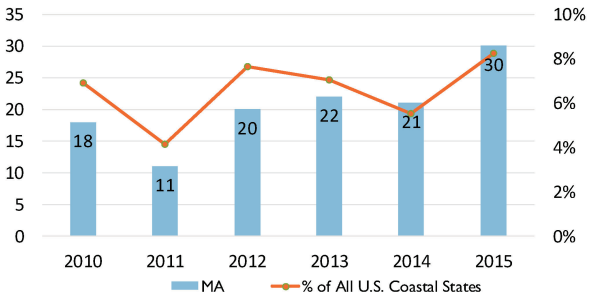
[105] More on the SBIR/STTR methodology can be found in *Volume II: Technical Appendices* on the Public Policy Center website.

7.2 MARINE TECHNOLOGY PATENTS

A patent is a tool for inventors and entrepreneurs to profit from new ideas, and as such, they indicate the extent to which new ideas are being translated into marketable products. The PPC analyzed the U.S. Patent and Trademark Office (USPTO) database to identify 1,846 marine patents out of 451,231 patents filed in coastal states from 2010 to 2015, for an overall ratio of 1 Marine Technology patent per 244 patents.[106]

In Massachusetts, of the 34,466 patents awarded between 2010 and 2015, 122 were found to be marine-related, for a ratio of 1 Marine Technology patent per 283 patents—a slightly lower rate than the coastal state average (see Figure 73). However, Marine Technology patenting in Massachusetts has increased substantially overtime, from 18 in 2010 to 30 in 2015 (67% increase).[107]

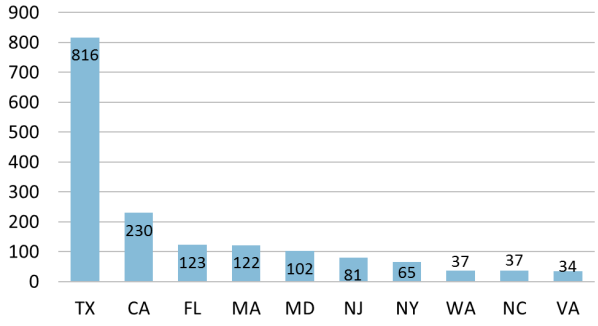
Figure 73
Marine Technology Patents in Massachusetts, 2010-2015



Source: USPTO and PPC Analysis.

The state with the highest number of marine patents from 2010 to 2015 was Texas, with 816, representing nearly half of all marine patents identified (see Figure 74). Offshore oil and gas patents accounted for a significant proportion of Texas' marine patents.

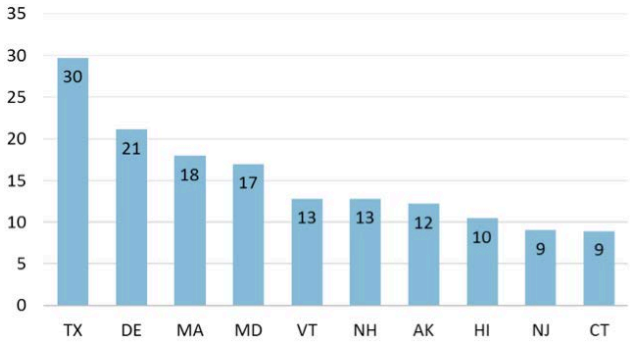
Figure 74
Number of Marine Patents,
Top Ten Coastal States, 2010-2015



Source: USPTO and PPC Analysis.

On a per capita basis, Texas and Delaware were the only states to have a higher rate of marine-related patents than Massachusetts in 2015 (see Figure 75). The calculated ratio of six marine patents per million residents in Texas represented a decrease from previous years, possibly attributable to the downturn in oil prices reducing investment in oil and gas R&D.

Figure 75
Marine Patents per Million Residents,
Top Ten Coastal States, 2015



Source: USPTO and PPC Analysis.

[106] Like with industry classifications, the patent classifications designated by the U.S. Patent and Trademark Office (USPTO) do not align well with marine technology. As a result, a web-scraping and dictionary matching algorithm, followed by manual screening to remove false-positives, was utilized to identify marine technology patents. More about the scraping methodology can be found in Volume II: Technical Appendices on the Public Policy Center website.

[107] These estimates are likely conservative, since many marine-related technologies, such as those associated with biotechnology and communications, may not contain any clear marine-related search terms.

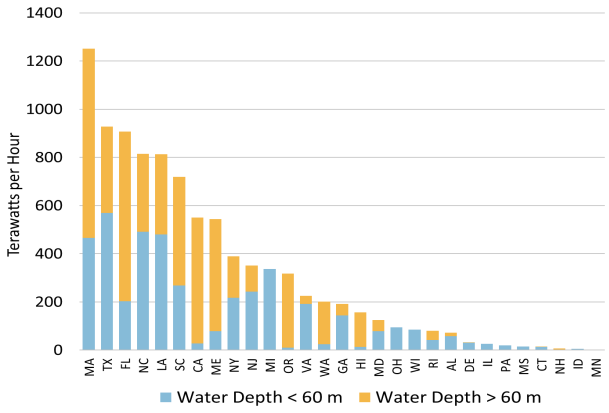
7.3 NEW OPPORTUNITIES IN MARINE RENEWABLE ENERGY

Massachusetts is on the cusp of becoming a national leader in the development of marine renewable energy. Renewable sources for marine energy production include tides, waves, ocean thermal energy, currents, salinity gradients, and ocean wind, which is currently the most well-developed.

Offshore Wind Energy

While there are over 50 offshore wind (OSW) farms worldwide and global OSW energy has tripled in the last five years, to date the U.S. has only one operational OSW farm, in the waters off Block Island.[108] The National Renewable Energy Laboratory (NREL) estimates that Massachusetts has the largest technical OSW potential of any state in the contiguous U.S., which if harnessed, could produce over 1,000 terawatt hours per year (TWh/yr) of electricity (see Figure 76).[109] By comparison, Massachusetts consumed 54.5 TWh of electricity in 2014.[110] Therefore, OSW energy could potentially generate over 18 times the state's existing electricity consumption, making it a potential export industry for the state. As it currently stands, Massachusetts produced only 57 percent of its electricity consumption in 2014.[110]

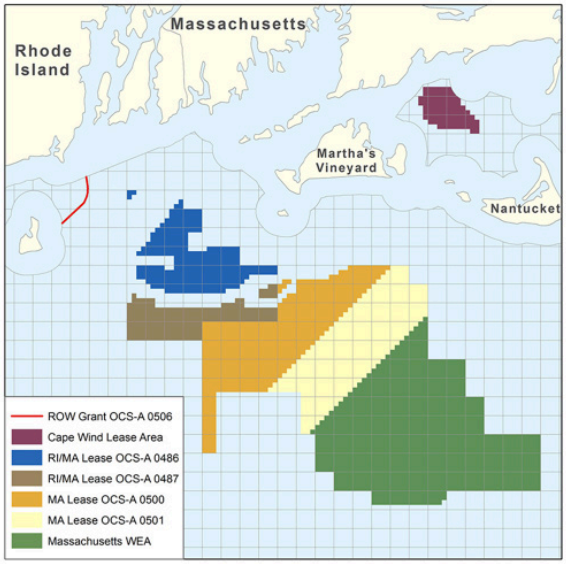
Figure 76
Technical Offshore Wind Potential by State and Water Depth (TWh/yr)



Source: National Renewable Energy Laboratory, 2016.

In 2013, the Bureau of Ocean Energy Management (BOEM) held its first competitive offshore commercial wind lease sale, auctioning off 164,750 acres within the "area of mutual interest" identified by Rhode Island and Massachusetts in a Memorandum of Understanding between the two states in 2010 (see Figure 77). Two of the lease areas in the Massachusetts Wind Energy Area (WEA) were auctioned off in 2015 and there are two remaining lease areas in the WEA. While there are not any wind farms currently operating within these WEAs, development is expected to accelerate thanks to a 2016 bill passed by the Massachusetts state legislature and signed into law by the Governor requiring the state's major electrical utilities to enter into long-term contracts to procure 1,600 megawatts of locally generated OSW power.

Figure 77
Offshore Wind Project Areas



Source: Bureau of Ocean Energy Management.

[108] IRENA. (2016). Innovation Outlook: Offshore Wind. International Renewable Energy Agency. Abu Dhabi.

[109] With the exception of Alaska, which has yet to be assessed.

[110] U.S. Energy Information Administration. *Massachusetts electricity profile 2014.* Retrieved January 15, 2017, from https://www.eia.gov/electricity/state/massachusetts/.

Consequently, Massachusetts is positioned as a premiere location to capitalize on the economic development opportunities in OSW. Massachusetts has the advantage of two critical pieces of offshore wind innovation infrastructure: the Massachusetts Clean Energy Center's (MassCEC) Wind Technology Testing Center in Charlestown, which offers a full suite of certification tests for turbine blades up to 90 meters in length, and testing and prototype development methodologies to help the wind industry deploy the next generation of land-based and OSW turbine technologies; and the New Bedford Marine Commerce Terminal, a multi-purpose facility designed to support the construction, assembly, and deployment of offshore wind projects.

The MassCEC is funding an analysis of infrastructure and workforce factors affecting the expansion and optimization of an OSW industry and supply chain in Massachusetts so that the state can maximize the project's impacts. Importantly, operations and maintenance of OSW farms account for about 50 percent of the jobs related to wind energy, and these jobs last as long as the wind farm is in existence. Thus, part of the MassCEC study is to evaluate workforce requirements and determine education and training requirements so that local workers can be prepared for expected employment opportunities.

Tidal Energy

Tidal energy is produced by the surge of ocean waters during the rise and fall of tides. The key advantage of tidal energy is that, unlike solar and wind power, tidal energy is incredibly predictable, enabling utilities to predict energy output many years into the future. While tidal range technologies have been developed and deployed worldwide since the middle of the 20th century, new tidal current technology is still in development. Given the limited tidal energy potential and the robust innovation ecosystems present in Massachusetts, most of the economic activity around tidal energy is in developing technologies, designing and building equipment (sensors, turbines, protection devices, etc.), and characterization of the ocean environment (e.g. modeling and monitoring), rather than actual deployment.

However, delivering a proof-of-concept and attracting capital are both challenges for the industry. "There is no standard test for turbines, making it hard for generating venture capital," said Marine Renewable Energy Collaborative (MRECo) Director, John Miller. "There are a number of companies we know of that have designs they'd like to commercialize."[111] Currently, makers of tidal turbines have to lease a ship to bring their equipment to an offshore location or build their own site along the shoreline.

To help test new technology developed by Bay State entrepreneurs, MRECo will soon install the nation's first permanent facility to evaluate turbines in real world conditions at the west end of the Cape Cod Canal, near the Buzzards Bay Railroad Bridge. The canal will provide "an ideal location" because of the speed of the tidal flow and the simple trestle-like testing stand, which provides an easier and cheaper means for companies and researchers to subject prototypes to real-world conditions.[112]



Wave Energy

Wave energy, as its name suggests, is electricity that is derived from the mechanical energy of waves. This clean, renewable energy is plentiful, being measured in terawatts (TW) instead of megawatts, and has the potential to replace 25 to 30 percent of current electricity generation in the U.S. Wave energy has additional benefits related to its predictability, consistency, and low visual impact. Massachusetts has the most wave energy among East Coast states, with 36 TWh available annually. However, it has the worst conditions of any state in terms of the percent that is technically recoverable. Additionally, the immaturity of this technology means that its costs remain prohibitively high.[113]

[111] Maas, S. (April 8, 2016). Canal will be proving ground for tidal turbines. The Boston Globe.

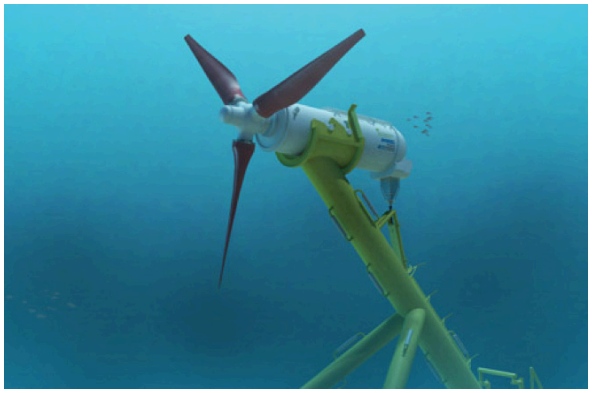
[112] Ibid.

[113] Electric Power Research Institute (EPRI). (2011). *Mapping and Assessment of the United States Ocean Wave Energy Resource. Technical Report.* Palo Alto, CA. Additionally, the immaturity of this technology means that its costs remain prohibitively high.

7.4 CHALLENGES IN THE MARINE TECHNOLOGY CLUSTER

Overcoming challenges related to technology transfer and commercialization is essential if Massachusetts' Marine Technology cluster is to fully realize its economic development potential. Many organizations and companies are small, which means that "science/engineering-centric people have to multi-task the business, regulatory, and legal issues involved."[114] For example, with limited business development capacity, it can be difficult for marine tech firms to determine which type of funding is most appropriate, such as loans, partnerships, venture capital, or public offerings. It can also be a challenge to determine how to raise capital without endangering or losing patents and other intellectual property.[115]

In addition, for most of these small Marine Technology companies, there is not yet a clear path to scale or to extend the industry beyond its traditional reliance of defense contracts. As Robert Curtis, CEO of the former Regional Technology Development Corporation once noted, "technology transfer is a two-way street that involves not only identifying, vetting, and pushing research innovation out to industry, but also industry pull —stimulating market applications by actively identifying technology needs that will enhance the products and services of companies and other institutions"—something for which a company focused on product development has little to no time or expertise.[116]



Access to capital is also an impediment to growth, a fact cited by many key informants, who noted that venture capitalists do not generally fund projects that are small and do not have a clear path to scale. Compounding the issue is that the financial world is not as knowledgeable about marine technology in comparison to other industries, such as pharmaceuticals or information technology, which have an abundance of resources devoted to organizing and promoting their industry. This idea of cohesiveness was echoed by key informants, who noted that while there is more interconnectedness in the Marine Technology cluster than in the past, there remains an opportunity to develop targeted and clear messaging to stakeholders. Since the industry is focused on R&D not necessarily lobbying and advocacy, there may be a role for the Commonwealth to play in bringing the industry together to advocate for this currently somewhat fragmented industry.



Despite these challenges, marine technology firms do not view themselves as part of a niche industry and they see new markets emerging. The most promising future applications will likely be in commercial and not recreational applications. For example, underwater noise technology for noise control engineering and weather-related applications have been cited as promising markets. There are also opportunities for the application of marine technology to "help solve fundamental and complex problems in areas such as ocean energy, aquaculture, and environmental monitoring."[117]

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[114] Doliner, H. (2014). Marine technology transfer: Leveraging challenges into opportunities. *Sea Technology.*

[115] Ibid.

[116] Woods Hole Oceanographic Institution. (March 4, 2009). WHOI and RTDC announce technology transfer partnership. Retrieved February 13, 2017, from http://www.whoi.edu/page.do?pid=11795&tid =7342&cid=55726.

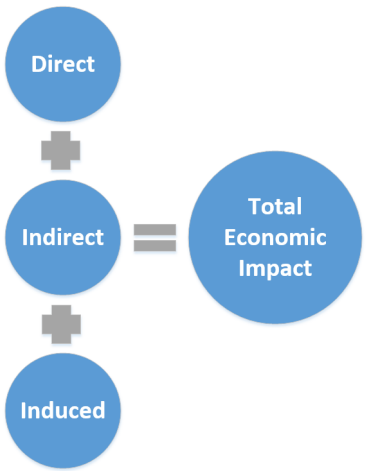
[117] Ibid.

8.0 ECONOMIC IMPACT OF THE MASSACHUSETTS MARITIME ECONOMY

Economic impacts measure how spending associated with an industry flows through an economy. These impacts are expressed primarily in terms of the output, employment, and labor income generated by that activity:

- Output represents the total estimated value of goods and services, or sales, produced by a business establishment.
- Employment refers to the number of full- and part-time jobs created by a business's activity, including wage and salary employees and self-employed persons.
- Labor Income includes all forms of labor income, including employee compensation (wages and benefits) and proprietor's income.

The economic impact of the Massachusetts Maritime Economy is calculated using IMPLAN economic modeling software, a commonly used input-output modeling program that describes the flow of money between sectors within a region's economy. The total economic impact of an industry is composed of the direct impact, indirect impact, and induced effects that are derived from this model:



- **Direct effects** result from expenditures associated with the maritime economy.
- **Indirect effects** result from the suppliers from which the maritime economy purchases goods and services, including the workers in these supplier industries needed to meet the demand of the maritime industries. These "2nd round" impacts would not occur but for maritime economy operations.
- **Induced effects** are the economic activity (including employment) that results from the spending of the employees of maritime economy suppliers.
- The **total economic impact** is the sum of direct, indirect, and induced effects.

8.1 TOTAL ECONOMIC IMPACTS

In 2015, the Massachusetts Maritime Economy generated a total statewide economic impact of $17.336 billion in output (sales), 135,924 jobs, and $6.839 billion in labor income (see Table 20). Or put another way, with 90,482 workers, $9.828 billion in output, and $3.924 billion in labor income (direct impacts), maritime related businesses supported an additional $7.508 billion in output, 45,442 jobs, and $2.915 billion in labor income in the Massachusetts economy (indirect and induced impacts) (see Figure 77).[118]

Table 20
Economic Impact of the Massachusetts Maritime Economy

Impact Type	Employment	Output ($billions)	Labor Income ($billions)
Direct Effect	90,482	$9.828	$3.924
Indirect Effect	17,339	$3.286	$1.298
Induced Effect	28,103	$4.222	$1.618
Total Effect	135,924	$17.336	$6.839

Source: IMPLAN, Authors' calculations.

[118] A detailed methodology can be found in *Volume II: Technical Appendices* on the Public Policy Center website.

8.2 ECONOMIC IMPACT BY SECTOR

Table 21 and Table 22 highlight the employment and output impacts by the six major maritime sectors. The Tourism & Recreation sector accounts for the highest proportion of the employment impacts (69.3%) and output impacts (49.6%). The Transportation sector accounts for only 20.0 percent of the employment impacts, but accounts for 34.7 percent of output, which is primarily a result of higher valued services.

Table 21
Employment Impacts By Sector

	Living Resources	Marine Construction	Minerals	Ship/Boat Bldng/Repair	Tourism & Recreation	Transportation	Total
Direct Effect	5,717	1,922	101	375	70,629	11,740	90,482
Indirect Effect	2,197	447	32	182	8,267	6,214	17,339
Induced Effect	2,409	869	50	189	15,291	9,294	28,103
Total Effect	10,323	3,238	183	746	94,187	27,248	135,924
Sector % of Total	7.6%	2.4%	0.1%	0.5%	69.3%	20.0%	100.0%

Source: IMPLAN, Authors' calculations.

Table 22
Output Impacts By Sector ($Millions)

	Living Resources	Marine Construction	Minerals	Ship/Boat Bldng/Repair	Tourism & Recreation	Transportation	Total
Direct Effect	$1,196.3	$295.2	$20.2	$89.3	$4,776.5	$3,450.6	$9,828.2
Indirect Effect	$371.9	$81.3	$6.8	$36.0	$1,577.4	$1,212.5	$3,285.9
Induced Effect	$361.7	$130.3	$7.5	$28.4	$2,297.4	$1,396.8	$4,222.1
Total Effect	$1,929.9	$506.7	$34.6	$153.7	$8,651.3	$6,059.9	$17,336.2
Sector % of Total	11.1%	2.9%	0.2%	0.9%	49.6%	34.7%	100.0%

Source: IMPLAN, Authors' calculations.



8.3 ESTIMATED STATE AND LOCAL TAX IMPACTS

The IMPLAN model estimates the amount paid in state and local taxes as a result of economic activities in the Maritime Economy.[119] Tax revenues include those paid by the Maritime Economy's employees and businesses and taxes generated through the economic activities created in other areas of the economy through indirect and induced impacts. Specifically, the estimated tax payments in this analysis include:

- Personal income tax: state and local income taxes paid by maritime economy employees and proprietors.
- Payroll tax: both the employee and employer paid portions of Social Security taxes.
- Sales tax.
- Property tax.
- Indirect business tax.
- Corporate tax: corporate profits and dividends.
- Fees/fines & other taxes: motor vehicle license fees, other taxes, fees/fines, licenses, and permits.

The IMPLAN model estimates that the amount paid in state and local taxes from the maritime sector totals $938.7 million. State and local tax payments include $198.0 million in personal income tax, $10.4 million in payroll tax, $234.9 million in sales tax, $381.1 million in property tax, $48.7 million in indirect business taxes, $40.8 million in corporate taxes, and $24.9 million in fees, fines, and other taxes (see Table 23).

Table 23
Statewide Tax Impacts

Type	Amount
Personal Income Tax	$ 198,011,387
Payroll Taxes	$ 10,445,641
Sales Tax	$ 234,867,426
Property Tax	$ 381,136,396
Indirect Business Taxes	$ 48,653,371
Corporate Taxes	$ 40,776,771
Fees, Fines, & Other taxes	$ 24,858,502
Total	$ 938,749,495

Source: IMPLAN, Authors' calculations.

[119] Estimates are made by applying statewide average tax rates to the income and sales related to maritime economy. These estimates, particularly local property taxes, are not as detailed as tax-specific analysis would yield and accordingly should be interpreted with caution.

9.0 SURVEY OF MARITIME ECONOMY BUSINESSES

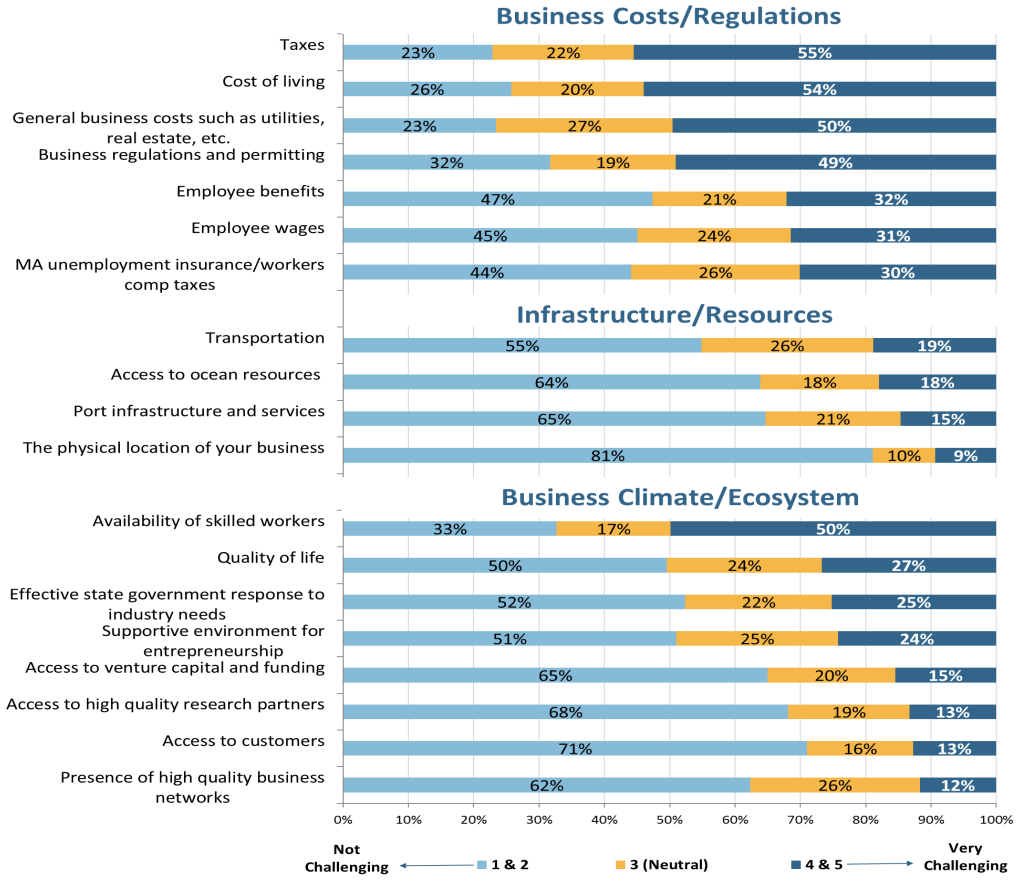
The PPC conducted a scientifically valid telephone survey of the state's maritime businesses to identify challenges and opportunities in the Maritime Economy. Importantly, respondents were screened so that only individuals who considered their business to be part of the Massachusetts Maritime Economy were interviewed. A total of 735 surveys were completed.[120]

The composition of the respondents had the following characteristics. Nearly all respondents hold a senior position in their company. Ninety-four percent (94%) of the businesses are headquartered in Massachusetts and 86 percent report that nearly all of their total business operations are performed in the state. Two-thirds (66%) have less than ten employees and 75 percent have been in business for more than 10 years. Seventy-one percent (71%) report that employment levels at their business have remained the same in comparison to a year ago and 66 percent expect the number of people working for their company to remain the same over the next three years.

9.1 BUSINESS CHALLENGES

Respondents were read a list of issues that may pose a challenge to the future success of their business in Massachusetts and asked "Please tell me how challenging you believe each of the issues is on a scale of 1 to 5, with 1 being not challenging and 5 being very challenging." The figure below organizes the results by three major themes: Business Climate/Ecosystem, Infrastructure/ Resources, and Business Costs/Regulations, with the lower (1 and 2 on the 1 to 5 scale) and upper (4 and 5 on the 1 to 5 scale) categories combined for readability.

Figure 78
Business Challenges



[120] More about the survey's methodology, the survey questionnaire, and the full set of results, including open-end responses, can be found in *Volume II: Technical Appendices* on the Public Policy Center website.

9.2 BUSINESS OPPORTUNITIES

There is a vast amount of collaboration and knowledge sharing in the marine sciences, with Massachusetts institutions of all types participating in collaborative endeavors throughout New England and across the nation. The nature of these relationships are varied and include collaborations between and among educational and research institutions, business associations, and government entities. [121]

The survey asked respondents about various partnerships and collaborations to explore the connections between maritime businesses, research organizations, and industry associations. The responses reveal that:

- Only four percent of businesses have a formal partnership with an institution of higher education, with most of these businesses being in the Fishing and Marine Technology industries. Among the businesses that have a partnership, 55 percent report that these partnerships are very important to their business' success.
- Forty-seven percent (47%) of businesses are a member of an industry association, and almost half of this group (49%) report that these associations are very important to their business' success.
- Only 11 percent are familiar with government programs that support business. Among those that are familiar, 39 percent report that these programs are very important to the success of their business.
- Thirty-six percent (36%) report that the jobs in their business require specific educational credentials or technical certifications. These credentials and certifications are varied, with respondents listing over 100 unique credentials and certifications.
- Seventeen percent (17%) of businesses report that they have an internship or apprenticeship program.

These results show that opportunities exist for the state to facilitate new relationships and partnerships between maritime businesses. The state can also play a role in supporting the development of capacity among industry associations, since connections with industry associations are important to respondents. In addition, because over a third of businesses report that the jobs in their business require specific educational credentials or technical certifications, the state can work to develop and expand the capacity of specialized training programs. This is particularly salient since workforce issues are cited by many respondents as a major challenge to the success of their business.

9.3 CRITICAL POLICY AREAS

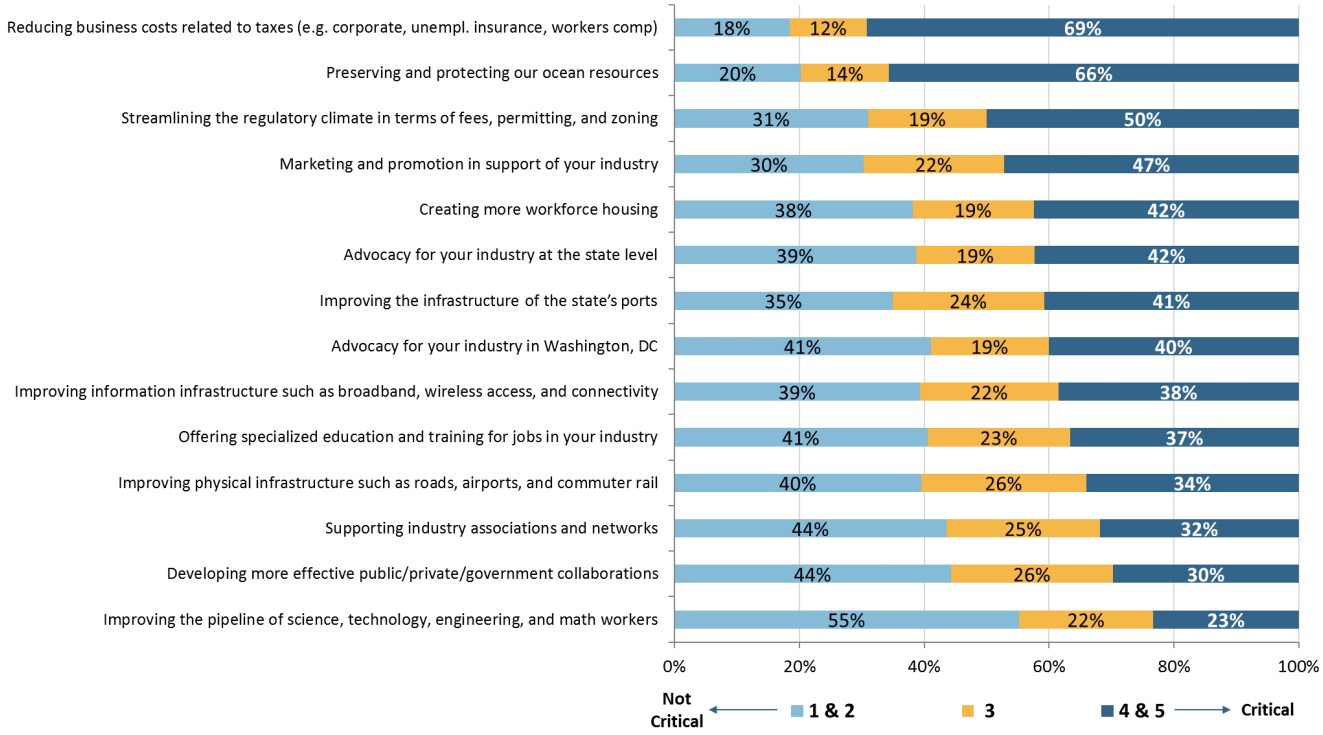
Respondents were read a list of policy areas that might be considered by the Commonwealth and asked how critical each of these is to their business on a scale of 1 to 5, with 1 being not critical and 5 being critical. The most critical policy areas cited by respondents relate to reducing business costs, preserving and protecting ocean resources, streamlining the regulatory environment, and the need for more marketing and promotional support of their industry.

Figure 79 combines the policy area scale for readability, with the lower (1 & 2 on the 1 to 5 scale) and upper (4 & 5 on the 1 to 5 scale) categories combined. Reducing business costs and preserving ocean resources are consistently cited as the major challenges across each sector. Specifically, respondents from the Living Resources sector indicated that policies surrounding the protection of marine resources are critical to their success, which suggests that new preservation policies could have the support of these businesses so long as they do not increase the cost of regulatory compliance. As discussed earlier, the Ship & Boat Building sector requires a workforce trained in techniques specific to its industries, which explains why this sector gave the highest value to policies regarding specialized education and training.

[121] Specific types of collaborations, partnerships, and other resources specified by respondents can be found in *Volume II: Technical Appendices* on the Public Policy Center website.

Figure 79

Please tell me how critical each of these policy areas is to your business on a scale of 1 to 5, with 1 being not critical and 5 being critical.



9.4 GREATEST STRENGTHS OF DOING BUSINESS IN MASSACHUSETTS

Respondents were also asked to list what they believe is the greatest strength of doing business in Massachusetts. The number of responses was extensive and the word cloud below displays the major issues by font size. The most cited strengths are location, access to the ocean and coastal areas, and access to customers/tourists (see Figure 80).

Figure 80

Greatest Strength of Doing Business in Massachusetts



9.5 STATE ACTION TO HELP BUSINESSES SUCCEED

Respondents were also asked to report the one action the state could take to help their business succeed. As with much of the survey, business costs are the primary concern of respondents across all sectors, including issues related to taxes and permitting. Respondents also report that housing affordability and general business affordability are salient issues (see Figure 81). [122]

Figure 81
Greatest Strength of Doing Business in Massachusetts



[122] *A detailed list of responses by sector for each word cloud is* available in *Volume II: Technical Appendices,* available on the Public Policy Center website.

10.0 POLICY IMPLICATIONS

The research presented in this report is designed to assist the Seaport Economic Council in understanding the current state of the Massachusetts Maritime Economy and to provide evidence to inform the development of a statewide growth strategy for the sector. Several broad policy implications that imply a series of strategic objectives emerged from our research.

1. Preservation and protection of ocean and coastal resources

The sustainability of ocean and coastal resources is the cornerstone of a vibrant maritime economy. While non-market impacts were not a focus of this report, impacts such as clean water, pristine beaches, and healthy fish and shellfish stocks are essential public resources that support a vibrant maritime economy. This fact was echoed by survey respondents, 66 percent of whom cited "preserving and protecting ocean resources" as a critical or very critical issue to the success of their businesses. A significant number of respondents also highlighted access to the ocean (n=77) or the availability of marine resources (n=15) as the greatest strength of doing business in Massachusetts.

However, while the ecological sustainability of the ocean and coastal resources is vital to nearly every maritime industry, it is often the very economic activities undertaken by these businesses that stress ocean resources. Consequently, policies that balance ocean and coastal economic activities with environmental sustainability will help to ensure the vitality of the Maritime Economy well into the future.

2. Maintenance of a stable and predictable business cost and regulatory environment

State policies that stabilize business costs support a positive business environment. Survey respondents report that general business costs pose one of the greatest challenges to their Massachusetts business. For example, 54 percent of respondents rate "taxes" as challenging or very challenging to the success of their business and 50 percent rate "general business costs" the same. Sixty-nine percent (69%) also cite "reducing business costs related to taxes" (e.g. corporate taxes, unemployment insurance, and workers' compensation) as the most critical policy issue related to the success of their business. These sentiments were expressed across all the maritime sectors.

In terms of the regulatory environment, 49 percent of respondents rate "business regulations and permitting" as challenging or very challenging to the success of their business, while a significant number of respondents commented in open-ended responses that state and federal regulations place an onerous burden on their business and hamper business growth. These sentiments were also expressed in several of the key informant interviews, particularly regarding new regulations that are implemented without input from business owners. State efforts to maintain a more stable and predictable business cost and regulatory environment may support growth and strengthen the competitiveness of Massachusetts' marine-related businesses.

3. Advocacy for continued federal research funding, which is vital to the Marine Technology cluster

Applied and basic research are the foundation of Massachusetts' Marine Technology cluster. To conduct this research, both public organizations and private businesses are highly dependent on federal funding. For example, Massachusetts' higher education institutions reported $165 million in R&D expenditures related to oceanography in 2014, of which 76 percent was federally-financed. In addition, Massachusetts companies were awarded 81 maritime-related SBIR/STTR awards in 2015 bringing in $204 million of investment in new technologies. State advocacy for these federal funds will ensure that the Massachusetts Marine Technology cluster remains at the forefront nationally.



4. Addressing port infrastructure constraints to promote growth

Port capacity and growth potential is limited by infrastructure constraints. Forty-one percent (41%) of survey respondents report that "improving the infrastructure of the state's ports" is a critical or very critical policy area. In addition, key informants at the state's ports cited the need for dredging and other port improvements to expand operations and to attract a greater number of ships and/or larger ships. It was noted that Massachusetts ports are currently turning ship traffic away because they do not have the space or water depths to meet demand.

There is no one size fits all solution in terms of capital needs, as each port has unique physical infrastructure, water depths, and facilities that meet varied water-dependent uses.[123] Dredging has been cited in recent studies as important to the success of businesses operating out of the Port of New Bedford and Plymouth.[124,125] Other capital investments might include repairs to pile supports, decking, bulkhead, and buildings. Future port investments might also support emerging industries, such as offshore wind. The Marine Commerce Terminal in New Bedford is an example of state investment in this emerging industry and continued support of the state's ports can be a catalyst for further economic development.

5. Capacity of specialized sector-specific training programs

Workforce issues were cited by many respondents as a major challenge to the success of their business. Thirty-six percent (36%) of survey respondents report that the jobs in their business require specific educational credentials or technical certifications. Over 120 different credentials and certifications were identified by respondents, including Captain's License, Welder Certification, Mechanic's License, Associate's degree, Yard Crew Certifications, among others. Key informants expressed concern about the skills of future employees, and a common refrain during interviews was "Where are my future workers going to come from?" Specialized training programs at the state's vocational high schools and community colleges was cited as a possible resource, although many employers also noted that they are willing to pay for employee training. Whatever the solution, the state should support the development and expand the capacity of specialized training programs to meet the needs of growing Maritime Economy employers.

6. Flexibility in harbor area zoning, particularly in Designated Port Areas

Massachusetts established ten Designated Port Areas (DPAs) to promote and protect water-dependent industrial uses. The two central principles of the state's DPA policy are to promote water-dependent industries as an important sector of the state's economy and to prevent the loss of areas that have desirable attributes. The policy is designed to "avoid the conversion of these areas to incompatible residential, commercial, and recreational uses so that future marine industrial uses would not have to develop new areas for such use."[126]

While many waterfront parcels within the state's DPAs continue to be used predominately for marine industrial activities, some port cities are considering a transition toward more innovation-oriented maritime industries, such as research and education, or mixed-use development and more public spaces.[127] Successfully doing so will require more flexibility than is currently permitted. Waterfront redevelopment is particularly salient since many legacy industries such as seafood processing no longer require waterfront access to operate, yet these facilities consume large swaths of space in some DPAs. Allowing non water-dependent uses will allow the DPAs to reflect new economic realities that can support more flexible economic development initiatives, particularly in Gateway Cities that struggle economically.

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[123] Massachusetts Department of Transportation. (2013). *Ports of Massachusetts strategic plan.* Technical memorandum number 4 (Revised Draft). Massachusetts Department of Transportation.

[124] Karl F. Seidman Consulting Services and UrbanFocus LLC. (2016). *Massachusetts state piers: A business and economic assessment.* MassDevelopment and the Massachusetts Executive Office of Housing and Economic Development.

[125] Martin Associates and Apex Companies. (2016). *Economic impact study of New Bedford/Fairhaven Harbor.* New Bedford, MA: The New Bedford Harbor Development Commission.

[126] Massachusetts Office of Coastal Zone Management. (2011). *Policy guide.* Massachusetts Office of Coastal Zone Management.

[127] Metropolitan Area Planning Council & the City of Gloucester. *The new maritime port economy (2012)*. Gloucester, Massachusetts.

7. Strengthening connections within the Marine Technology cluster

As noted, the Marine Technology cluster is highly dependent on federal funding, both for private business and non-profit organizations. In addition, key informants note that access to capital is an impediment to commercialization, since venture capitalists and large banks do not generally fund small projects that do not have a clear path to scale. This is especially challenging when competing for investment capital against larger, more developed industries such as Information Technology and Biotechnology. The cluster is also confronted with various workforce, compliance, and regulatory issues.

However, key informants note that the Marine Technology cluster is somewhat fragmented, and that businesses and organizations are primarily focused on R&D rather than advocacy. Consequently, there is a role the state can play to strengthen connections within the cluster, with the goal of developing a cohesive industry strategy with clear messaging to stakeholders.



8. Capacity development for technology commercialization and transfer

Evidence from key informant interviews suggests the need for increased capacity with respect to commercialization and technology transfer in order to help companies grow to scale. This lack of capacity is partly due to the small size of many technology businesses, which must focus on product development rather than commercialization, and to the industry's traditional reliance on short-term defense contracts. State programs that foster commercial development of marine-related technologies will ensure that Massachusetts remains in the forefront in the Marine Technology field.

9. Capitalizing on the Ocean-to-Table Movement

Massachusetts residents are not eating most of the seafood that is landed in the state. While market forces dictate where locally-landed seafood is sold, addressing this problem through the creation of a locavore "foodie" movement has the potential to benefit both the Living Resources and Tourism & Recreation sectors through increased consumer interest and price premiums. While isolated efforts to promote locally-sourced and fresh seafood already exist, these efforts should be supported and expanded on as a means of diversifying and strengthening the industry through the cultivation of a more sophisticated regional demand for local seafood.



11.0 CONCLUSION

For centuries, the people of Massachusetts have looked to the ocean as an essential economic resource and an important element of their very identity. While the composition of the Maritime Economy has changed over the years, the Commonwealth maintains a strong connection to the sea through Marine Technology, the strength of a mature Living Resources sector, and a thriving coastal Tourism & Recreation industry. On the horizon, marine renewable energy in the form of offshore wind, tidal, and wave energy holds great promise as Massachusetts is poised to take the lead in these nascent industries .

While the historical significance of the Massachusetts Maritime Economy cannot be overlooked, its current significance is often overshadowed by relatively new industries and clusters. Yet, the Maritime Economy remains an important economic driver in the state, generating a total statewide economic impact of $17.336 billion in output, 135,924 jobs, and $6.839 billion in labor income in both maritime and non-maritime sectors. The Maritime Economy's strength is also evident in its ability to expand significantly between 2005 and 2015, a period that included the Great Recession. Despite a slight downturn in 2009, the Massachusetts Maritime Economy showed overall growth during what was otherwise a very challenging period. This vitality can also be seen in the superior performance of the Massachusetts Maritime economy when compared to our neighbors in other New England coastal states. Compared to the national maritime economy, the Massachusetts Maritime Economy also performed comparatively well, with higher employment, wage, and GDP growth from 2005 to 2013. Massachusetts also benefits from a higher concentration of employment in maritime industries relative to the nation, particularly in the Living Resources, Tourism & Recreation, and Marine Construction sectors.

The significant presence of Marine Technology firms in Massachusetts reflects the state's commitment to fostering innovation and its vaunted strengths in R&D. Marine Technology businesses are major players in the state's innovation economy, and this sector pays an average wage that is more than double the state average. While the Marine Technology cluster is a key component in raising Massachusetts' presence in the global innovation economy, these well-paying jobs represent a small, albeit growing portion of the Maritime Economy.

By far, the largest employer in the Massachusetts Maritime Economy is the Tourism & Recreation sector, which employs the majority of maritime workers. While it may not deliver high wages overall, the size of the Tourism & Recreation sector demonstrates that Massachusetts has been able to parlay its substantial maritime resources and over 1,500 miles of coastline into a vibrant tourism industry that serves both Bay State residents and visitors from the nation and abroad. Importantly, the economic activities in this sector support jobs in many other maritime and non-maritime sectors, from oyster farmers, fisherman, and bait-shop owners, to boat captains, contractors, and real estate agents.

However, maritime employers are not without their concerns. Our analysis documents a number of challenges related to business costs, regulations, and the availability of skilled workers. Business leaders also identify policies that preserve and protect ocean resources as being very critical to their prospects. After all, it is the ocean itself that is the cornerstone of Maritime Economy. Despite these challenges, the results of our research make it clear that the Massachusetts Maritime Economy is strong and resilient and is positioned to remain an economic force for decades to come. It is our hope that the results of the research summarized in this report will inform state and local policymakers as they work together to develop a growth strategy for the Massachusetts Maritime Economy, which builds upon existing strengths, helps to address major policy challenges, and positions the Commonwealth for future success in this critically important sector of the Massachusetts economy.



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