NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

TOURISM

BEACH USE

MARITIME TRADE

AQUACULTURE

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About the Narragansett Bay Watershed Economy Project:

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Table of Contents

NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Executive Summary

What is the watershed?

The Narragansett Bay watershed (NBW) is the land area that drains into the Narragansett Bay, including rivers and streams that eventually flow into it. The NBW covers over 1,700 square miles of land, 60% in Massachusetts (MA) and 40% in Rhode Island (RI), and 420 miles of coastline. Between RI and MA, 105 towns and cities are partially or entirely located in the watershed. Almost two million people reside within its borders.

Why study the economy of the watershed?

Business and industry sectors across the watershed provide immense economic benefit to the area, including providing thousands of jobs, generating billions in revenue and expenditure, and paying millions in wages. Many of these economic sectors rely on a healthy watershed ecosystem and its natural resources (natural capital), such as clean water for fishing, aquaculture, and recreation. These resources, however, are under threat from a multitude of forces, such as climate change and expanding development. While water pollution has been greatly reduced in recent decades, this trend is not guaranteed to continue. Understanding the potential economic impacts of these threats is therefore critical to informing and improving decision-making policy regarding the management and protection of the watershed's environment. The Narragansett Bay Estuary Project (NBEP) has done considerable work on the current state of the watershed as well as potential future threats that may impact its health – this report complements their findings by focusing on the economy of the watershed whose future prospects rely on its natural capital.

Watersheds of the Narragansett Bay
Source: Watershed Counts Annual Report, 2014

What are the objectives of this study?

The goal of this report is to synthesize existing data to provide a comprehensive overview of the NBW economy in one document. This report aims to:

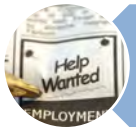
- **Identify** key industries that contribute to the economy of the watershed and rely on its natural capital.
- **Quantify** the economic impact of these industries by calculating: the number of establishments, size of workforce, and total wages for each sector using data from the Bureau of Labor Statistics, the Bureau of Economic Analysis, and various state-level reports.
- **Assess** future opportunities and threats for each industry, mainly as they relate to climate change and its impacts.
- **Provide** a comprehensive overview of the watershed's economy through an overall economic status report, as well as a detailed history of the watershed and information on its geography and demographics.

What are the major findings?

We identified 13 key sectors in the watershed that provide considerable economic benefit and rely on the watershed's natural capital: agriculture; aquaculture and shellfishing; beach use; commercial fishing; the defense industry; forestry; hunting; ports, transportation and maritime trade; recreational boating; recreational fishing; research and education; tourism; and wildlife viewing. These industries vary in size, contribution, and their utilization of the watershed and its resources, although all make an important contribution. The impact for each sector was determined by scaling county-level data for RI and MA according to their population and/or land-share that falls within the NBW. All values are in 2016 dollars unless otherwise stated.

13 key industries

$14+ billion in revenue and expenditure



97,000+ full and part-time jobs

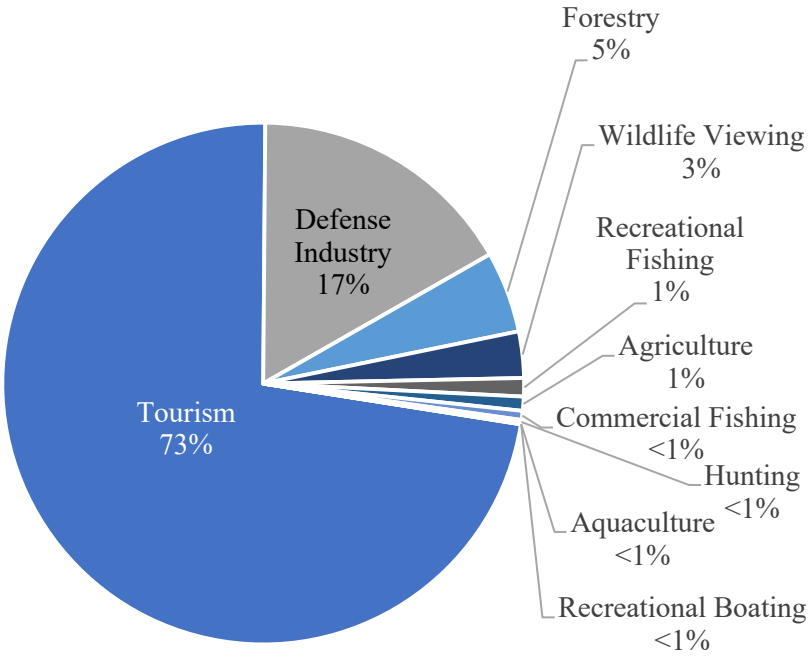
Cumulatively, there are approximately 97,000+ full- and part-time jobs in these sectors. Aggregation of regional value estimates from various sources estimates the combined revenue and expenditure of these industries at approximately $14 billion. Data sources for these aggregate estimates are listed in the Appendix of the Executive Summary.

Tourism and the defense industry have the largest contribution to expenditure/revenue (73% and 17% respectively) and employment (62% and 18%). Historically, tourism has been imperative in the watershed's economy over the past century, starting with the "summer cottages" of the wealthy elite in Newport's Gilded Age and expanding to wider audiences with public beaches and scenic venues like Rocky Point, RI. Tourism employs an estimated 60,000 people: it is the 5th highest employing industry in RI, and from 2010-2015, employment grew almost 3%, higher than the average employment growth in the state. Additionally, in RI alone, tourists

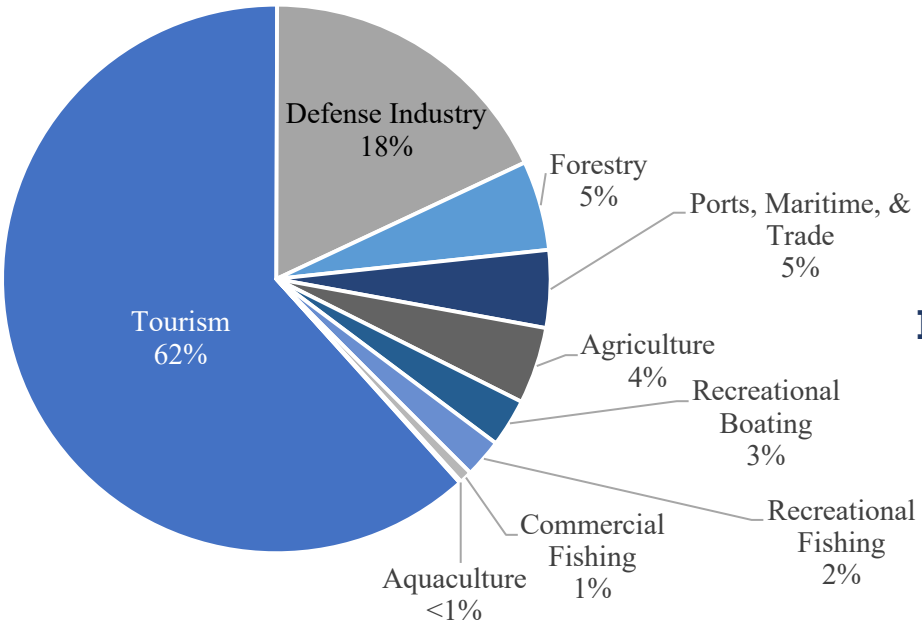
spent over $6 billion in 2015, and we estimate that the seasonal tax effect related to tourism was over $5.4 million in 2015 in the watershed. Tourism also ties into almost every other sector in this report, such as beach use and recreational boating, so its impact may be even larger than what we estimate.

Revenue and Expenditure by Sector

Total annual revenue:
$13,847,936,340
(2016 dollars)



Defense, like tourism, also has deep historical ties to the watershed, especially in Newport, RI. Dating back to times of the American Revolution, it has remained an important defense hub throughout the centuries. It is currently home to the Naval Undersea Warfare Center (NUWC) Division Newport, a leading underwater weapon testing and development institution, as well as the Naval War College. It is also home to Electric Boat General Dynamics, which manufactures Virginia Class submarines for



Employment by Sector

Total employment:
97,298

the US Navy. As of 2013, the defense sector employed 17,500 individuals, 40% of whom were in the private defense sector, with wages of over $1.1 billion. It is also one of the highest paying sectors in RI, with a private sector salary of $74,500, a Department of Defense (DoD) salary of $97,000, and a NUWC salary of $114,000. In comparison, the average salary for manufacturing was $53,000 and for leisure and hospitality it was $19,000. This same year, the defense sector also had an output of over $2.3 billion, which made up 4% of RI's total GDP. There was also $736 million in DoD contracts issued to 200+ firms through 4,768 transactions.

Meanwhile, although the remaining eleven industries do not have nearly the same impact as tourism and defense, they still provide significant value to communities in the watershed:

- **Agriculture:** employed over 2,600 people on 4,600 farms with $121 million valued in crops and livestock in 2012.
- **Aquaculture:** had 36 farms with $2.8 million in sales in 2016 (an increase in sales of 40-fold since 1995).
- **Beach use:** accommodated 20 million annual beach visitors in RI in spite of 28 combined beach closure days recorded in 2016.
- **Commercial fishing:** had 155 establishments with $85 million in wages and an annual landing value of $150 million in 2016.
- **Forestry:** had $55 million in wages in RI in 2013 and $170 million in MA in 2006.
- **Hunting:** had 26,000 active participants (19% from out-of-state) and $32 million in revenue in 2011.
- **Ports, transportation, and maritime trade:** over 200 companies and 11,000 employees are involved in the Quonset Business Park, and the Port of Davisville is a top ten automobile importer in the country (2015). Between 1994-2014, ProvPort generated 1,700 jobs and had an economic output of approximately $122 million.
- **Recreational boating:** in 2012, there were 56,000 registered recreational boats, and in 2011 there was $201 million in spending, supporting 2,700 jobs and $150 million in wages.
- **Recreational fishing:** in 2011, there were 221,600 recreational anglers who spent $136 million, supporting 2,200 jobs and $86 million in wages. Almost half of these anglers were from out-of-state.
- **Research and education:** in recent years, Rhode Island's universities and colleges received five large National Science Fund (NSF) grants for research based on NBW totaling $57 million.
- **Wildlife viewing:** in 2011, 172,000 wildlife viewers spent $400 million and a combined two million days viewing.

Potential threats from Climate Change

Current data suggests, however, that the effects of climate change, including sea level rise, increased air and water temperature, and changing precipitation patterns will have considerable impacts on these sectors by the year 2100.

How do I navigate this report?

This report consists of the following sections:

- **Introduction and Methodology**: outlines the motivation of this report, its scope, purpose, and objectives and the methodology used to calculate watershed statistics.
- **History, Demographics and Geography, and Economic Overview:** provide a history of the watershed, its land uses, its population and settlements, and its economy, as well as current sociodemographic statistics and trends and how they have shifted over time.
- **Sector reports:** each section provides in-depth analysis of the history of the industry in the watershed, its current status and trends, data sources covered, and future opportunities and threats relating to climate change.

Climate Change and Affected Sectors

9.8 ft sea-level rise	5-10° F air temperature rise
• Beach use • Defense • Ports and maritime • Research and education	• Agriculture • Forestry • Hunting • Wildlife viewing
3.6-5.4° F water temperature rise	**1-3 in. increase annual rainfall**
• Aquaculture • Beach use • Commercial fishing • Recreational fishing • Recreational boating • Tourism	• Aquaculture • Agriculture • Beach use • Commercial fishing • Recreational boating • Recreational fishing

Agriculture

Recent Trends

Despite declines over the past century, agriculture continues to be an important and growing contributor to the economy of the NBW. According to the US Department of Agriculture (USDA):

- **Crop production dominates agricultural sector in the NBW:** of 2000 farms selling agricultural products in 2012, a majority (1,176) of these farms were in MA, while 791 were in RI. MA also had more farmland—approximately 70,000 acres—while RI had about 14,000 acres. These farms produced goods, both crops and livestock, with a combined market value of $121 million in 2012 (2016 dollars). Crops comprised a majority of this value compared to livestock, which only accounted for 19% of market value in RI and 16% in MA.
- **The number of farms is increasing:** from 1997 to 2012, the number of farms increased by 44% to an estimated 4,600 farms (see graph). Despite this increase, however, the total acreage of agricultural land has remained relatively the same at ~28,000 acres.
- **Employment in farms is growing:** farms employed over 4,400 people in the watershed (1,700 in RI and 2,700 in MA). Of this 4,400, 1,700 were proprietors and 2,700 were classified as other employees. Although farming remains a small percentage of total employment in the watershed, it is growing rapidly: between 2001 and 2015, farming employment in RI increased at three times the growth rate of total employment in the state.
- **These estimates of the impact of agriculture may be underestimates:** a state-level study in 2015 found that USDA figures were underestimates of the scope of agriculture in RI. They found that 4,500 people worked in the agricultural sector, 2.6 times higher than the USDA's reported employment of 1,700. They also found that agricultural sales were $239 million, four times higher than what USDA reported. Under this assumption, the market value of agricultural products in RI would be $142 million and $321 in MA in 2012 based on the adjusted previously stated USDA figures.

Future Outlook

Urbanization and suburbanization potentially threaten the future of agriculture by reducing available land for farming: from 2001 to 2011, there was an 8.5% increase in urban land in the NBW. For example, cranberry farming (a significant portion of agricultural activity in the MA portion of the watershed) is experiencing considerable development pressure. More recently, open spaces such as farmland are under pressure as targets for renewable energy projects like large solar farms. The greatest threats and opportunities to agriculture may arise from the effects of climate change. Average summer air temperature is expected to increase 7° F in the next century. This change would make the climate of the NBW akin to that of modern-day Georgia or South Carolina. Additionally, precipitation, especially rainfall, is expected to increase up to three inches during this time. This warmer climate and increased rainfall may provide challenges for current agricultural practices in the NBW, but also new opportunities, such as the introduction of different crops.

Aquaculture

Recent Trends

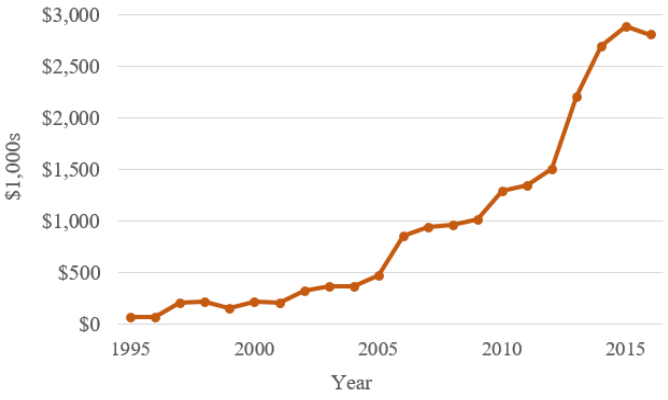
Owing to its unique geology, the NBW provides an ideal environment for shellfish cultivation, primarily of eastern oysters and blue mussels. This report focuses solely on the aquaculture farms in RI, as aquaculture in MA is mostly outside of the NBW.

In 2016, there were:

- 28+ aquaculture farms in the NBW
- 2.2 million oysters and 27,000 lbs. of mussels sold
- $2.8 million in estimated sales
- Value of sales up 4,000% since 1995

Top products:
Eastern oysters and blue mussels

- **Rhode Island defies the national trend of aquaculture decline:** in the U.S. from 2005 to 2013, the number of saltwater aquaculture farms declined by 27% and acreage fell by 34%. During the same time, the number of aquaculture farms in RI increased by 91% and acreage grew by 90%. The value of sales in this time increased 489% in RI compared to a national average of 26%. Including non-NBW areas, the number of farms in RI increased from 13 in 2000 to 70 in 2016, and acreage increased from 30 to 275 acres. Of these 70 farms, an estimated 28 farms were within the NBW. This increasing trend is in part due to improved water quality in the Bay (NBEP 2017).



Value of Aquaculture Sales in the NBW, 1995-2016 (in 2016 dollars)
Source: CRMC Annual Reports, 1995-2016

- **Aquaculture revenues are expanding:** in 1995, there were $67,000 in sales (2016 dollars) in the NBW portion of RI alone. By 2016, this figure increased 40-fold, with over $2.8 million in sales (2016 dollars) (see graph).

- **More than just oysters:** in 2016, NBW farms produced 2.2 million oysters and 27,000 lbs. of mussels. Since 2016, nine farms have expanded to also grow sugar kelp and this number is expected to increase. Currently, no farms produce fish.

Future Outlook

Shellfish in the NBW have a history of being affected by environmental pollutants, which has led to the closure of shellfish farms at various points in history. However, overall area open to shellfishing has increased in recent years due to improvement of water quality, specifically in the upper portion of the Bay. These improvements are threatened as climate change brings extreme precipitation, heat, and droughts, leading to increased stress on our oceans. Such conditions are exacerbated by increased development and more impervious surfaces, which causes polluted runoff into local waters, increasing the likelihood of toxic algal blooms which can affect shellfish. In 2016, RI experienced its first harmful algal bloom in history, which reoccurred in 2017. Outbreaks of Pseudo-nitzchia species, some of which produce domoic acid, a neurotoxin, can affect oysters, resulting in shellfishing area closures. While aquaculture has skyrocketed since 1996, this additional pressure will require farmers to consider innovative and adaptive strategies to continue the industry's growth in the region.

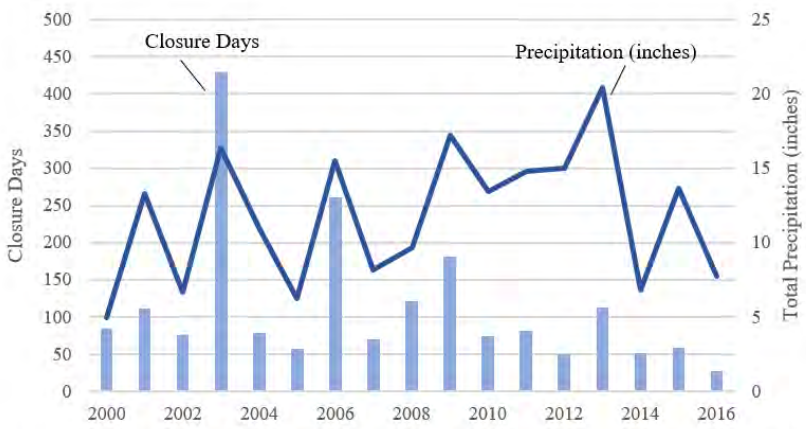
Beach Use

Recent Trends

- **Beach attendance is growing:** on average, there are 20 million visits a year to RI's 70+ beaches, 37 of which are saltwater. Attendance has increased at many beaches – statistics available for Scarborough, Fort Adams, and Goddard Park illustrate that attendance has increased 56% from 2010 to 2015, to a total of 2.5 million visitors. In Bristol, Eastons, and Sachuset beaches, this visitation generated $2.5 million in revenue in 2015 from beach passes and parking fees. Although not all beaches charge for use or parking, this figure illustrates their important contribution to the economy.

- **Beach closures matter:** beach closures peaked in 2003 with 429 combined closure days for saltwater beaches. In 2016, the number of closures dropped to 28 days (see graph). Beach closures are typically due to levels of bacterial contamination in the water that exceed safe health standards, usually induced by precipitation carrying these pollutants from human settlements into the water – these closures can be indicative of overall water health in the Bay. Proper waste management that prevents rainfall runoff is key to preventing closures. For example, programs since 2009 to abate combined sewer overflow reduced the number of beach closure days by properly handling waste.

- **Visitors also contribute to the local economy:** through activities associated with beach use, such as dining, shopping, event rentals, and hotel stays (for more information, see "Tourism" fact sheet).



Saltwater Beach Closure Days and Precipitation in the NBW, 2000-2016

Sources: MADPH, 2001-2016; RIDOH, 2017

Future Outlook

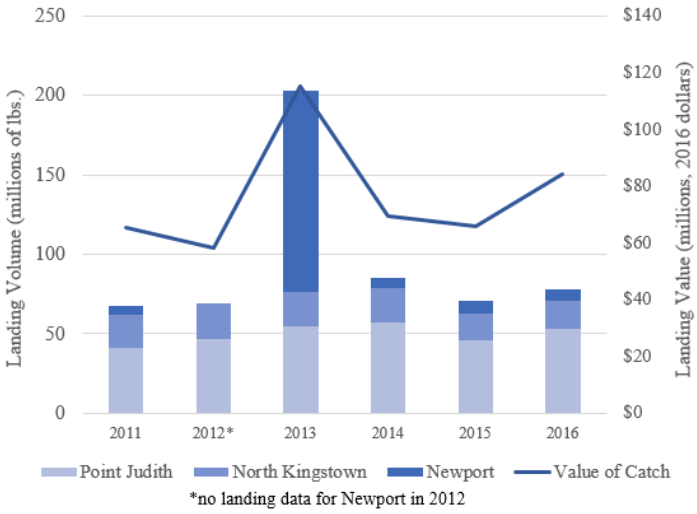
In 2016, the State of Rhode Island reduced beach pass prices by roughly half to promote tourism and increase beach accessibility. Although visitation rates may increase in the future, NBW beaches remain under threat from bacterial contamination, which is exacerbated by the effects of human development and climate change. The beaches are already vulnerable: currently 14 of the 37 saltwater beaches in the area are considered of "high concern" (1.5+ closures a year) for water contamination. Future predictions of precipitation increases and warmer water temperatures, as well as continuing influxes of human population, may elevate risks of ocean water contamination. Furthermore, sea level is forecasted to rise nearly ten feet by 2100, submerging many beaches or rendering them inaccessible. Action to preserve water quality and the overall maintenance of these beaches is imperative to ensure their continuing contribution to the watershed's economy.

Commercial Fishing

Recent Trends

- **The industry has remained relatively constant over the past few years:** Point Judith is the most productive port, with landings of 53.4 million pounds in 2016, yielding $56 million in value (see graph). Newport had 7 million pounds valued at $8 million, while North Kingstown had 18 million pounds valued at $14 million. Data for all three ports is available beginning in 2011 – as seen from the graph, catch value and volume remain relatively constant with yearly fluctuations.

- **Ports in the NBW are nationally ranked:** In 2016, Point Judith, North Kingstown and Newport ranked 18th, 34th, and 75th for landing volume out of the top 131 landings in coastal states in the U.S. For landing value, in 2016 they ranked 15th, 74th, and 92nd nationally. All three ports rose in rank for landing value since 2015. For comparison, in 1981, Newport ranked 11th and Point Judith ranked 17th of 98 in landing volume for all coastal ports.



Annual Landings and Value, 2011-2016
Source: NOEP

In 2015, there were:

1500 commercial vessels

155 commercial fishing establishments

In 2016, there were:

77 million lbs. of fish/shellfish

$78 million catch value

- **Despite national ranking, the NBW falls behind in national trends:** in the U.S., from 2006 to 2015, landing volume increased 2% while annual landing value increased by 30%. Conversely, data from Point Judith and Newport indicate that landing volume decreased 3% and landing value fell by 34%.

Future Outlook

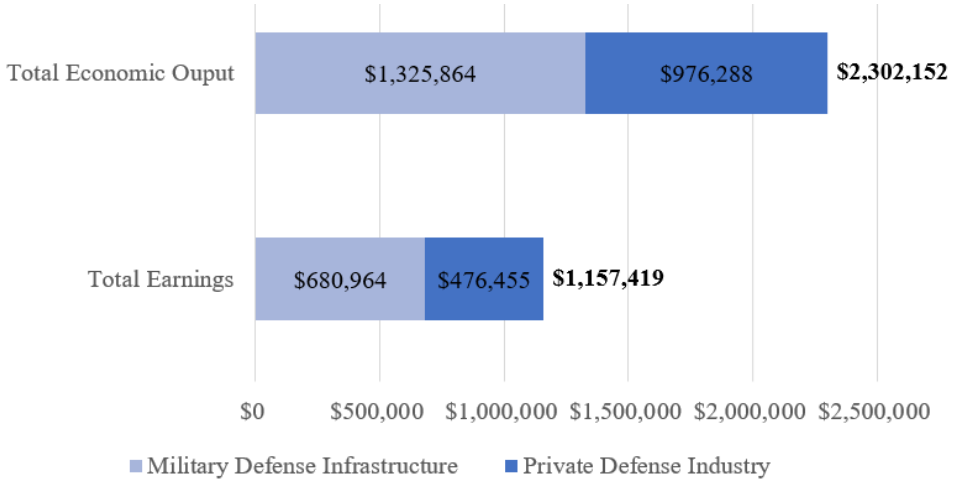
Commercial fishing is currently threatened by declining stocks as a result of overfishing, water pollution, and loss of habitat. In the future, climate change may exacerbate many stressors on fish populations, including changes in ocean pH and salinity and an increase in water temperature. In the coming century, water temperature will rise an estimated 3.6 to 5.4° F. Species composition will shift – population of warm water species like scup and summer flounder, two top grossing species in NBW commercial fishing, are likely to increase, while populations of cool-cold water species, like American lobster, are likely to decline. Together, these shifting ocean conditions and species diversity will likely impact commercial fishing, and adaptation to these changes will be key for the commercial fishing industry moving forward.

Defense Sector

Recent Trends

Data were obtained from *The Economic Impact of the Rhode Island Defense Sector* (Tebaldi, 2014)*:*

- **The defense sector contributes significantly to the local economy:** in 2013, the sector supported 17,500 jobs, which generated over $1.1 billion in wages and $2.3 billion in economic output (2016 dollars) (see graph). This includes both private contracts (37% of jobs) and military defense infrastructure employees (63% of jobs). In the same year, the defense sector contributed $2.3 billion, or roughly 4%, to the state's GDP – 42% of this contribution was from the private sector while 58% from military defense infrastructure.
- **Defense is the highest paying industry in Rhode Island:** in 2013, private sector employees earned an average of $74,500 annually, civilian employees working for the U.S. Department of Defense (DoD) earned an average of $97,000 annually, and NUWC employees earned $114,000. This is considerably higher than other critical industries in the state such as manufacturing (average full-time wage of $53,000) and leisure and hospitality ($19,000).



Total Economic Output and Earnings by RI Private and Military Defense Industries in 2013
Source: Tebaldi, 2014

- **The private defense industry is growing**: in 2013 alone, the DoD engaged in 4,768 transactions with over 200 private contractors in RI, awarding over $736 million in contracts. Currently, the private sector is growing at a faster rate than its public counterpart.

Future Outlook

Given the close proximity of infrastructure to the coastline, rising sea levels pose a major threat to the defense industry in the NBW due to climate change – one study of 18 coastal Naval installations in the U.S. predicts that flooding incidents will increase at least tenfold at most locations by 2050. The National Oceanic and Atmospheric Association predicts that sea level rise in the Northeast Atlantic will be higher than the global average, with an increase of up to 9.8 feet by 2100. Even just a one-foot rise in sea level would impact key infrastructure and buildings such as the Naval War College in Newport. Additionally, increasing frequency and intensity of storm events also pose flooding threats. These changes will likely necessitate the adaptation of defense sector infrastructure looking forward.

Forestry

Recent Trends

- **Extractive forestry generates millions in sales:** the sale of forest-based products in the RI portion of the NBW generated almost $500 million (2016 dollars) in 2013 and accounted for 3,000 jobs with $55 million in wages. Major outputs included wood products, furniture, and paper manufacturing (see graph). In the MA portion of the NBW, the forest sector employed over 2,000 people with over $170 million (2016 dollars) in wages in 2006.
- **Most forests are privately owned:** in 2013, 74% of forests in RI were owned privately, 16% state-owned, and 10% municipal-owned. In MA, 65% were owned privately, 19% state, 14% municipally, and 3% federally, with nearly 120,000 acres permanently protected.
- **Other industries rely on healthy forests:** hunting and wildlife viewing, for example, utilize forests. Recreational activities like hiking, rock climbing, and leaf peeping are very popular for residents and tourists – the economic impact of these industries were not calculated in these state-level studies.

In NBW RI in 2013, there were:

$55 million in wages* (2016 dollars)

3,000 jobs in the forestry sector

In NBW MA in 2006, there were:

$170 million in wages* (2016 dollars)

2,000 jobs in the forestry sector

*Sectors: forestry/logging, wood products, pulp/paper

Estimated Value of Forest-Based Manufacturing Sales in RI Portion of the NBW, 2013 (in 2016 dollars)
Source: North East State Foresters Association, 2015

- **Forests provide key ecosystem services:** forests filter and clean the air and water, provide habitats for numerous plant and animal species, sequester carbon, help prevent flooding, and provide myriad other direct and indirect benefits.

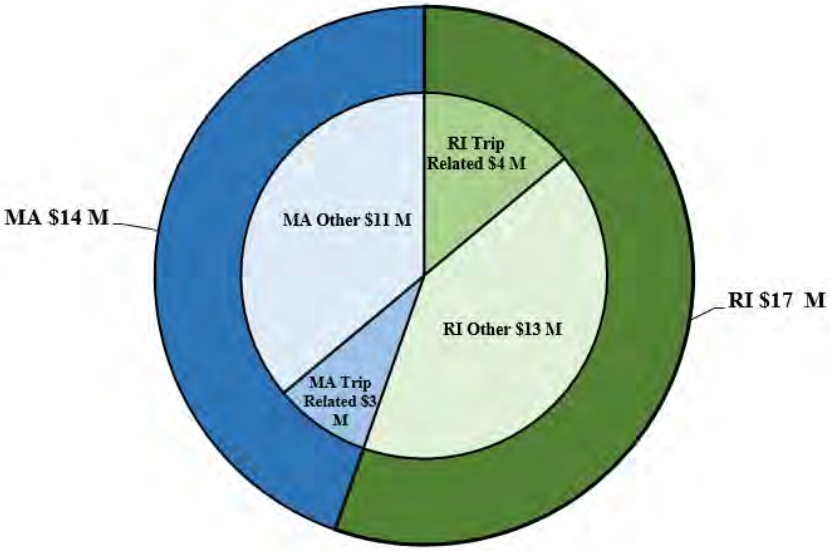
Future Outlook

Forest coverage is under threat from sprawling urban and suburban development. Forest fragmentation is an increasing concern that impacts the functions and benefits provided by forests – although overall forest coverage may be relatively constant, forests are broken into smaller patches by roads and development. Fragmenting forests impacts their ability to provide important ecosystem services like water filtration and wildlife habitats. Additionally, climate change will affect the composition and health of forests in the NBW. The temperature in the NBW is expected to increase an average of 7° F in the next century, leading to summer temperatures akin to that of modern-day Georgia or South Carolina. Precipitation patterns will also change, with increased rainfall expected. Species composition will likely shift further north as temperatures increase: northern hardwood species like maple and birch will likely decline, while species like oak and hickory take their place. This changing composition of forests may affect production of forest-based goods, and adaptation to these changes will be necessary for the continued success of the forestry industry in the NBW.

Hunting

Recent Trends

- **Hunting generates millions in revenue:** in 2011, 26,000 active hunters in the NBW generated $32 million in revenue, $7 million from trip related expenses and $25 million from equipment/other expenses (2016 dollars) (see graph). On average, these individuals spent $1,300 a year on hunting, including purchases such as firearms, ammunition, specialized clothing, permits, guides, etc. Aside from the economic benefits of hunting, it also aids in population control of animals like deer and coyote which threaten other wildlife species or damage ecosystems due to overpopulation.
- **Four of five hunters are from the NBW:** 81% of hunters in the survey live in the NBW, while the remaining 19% are tourists, indicating additional economic impact related to tourism (see "Tourism" fact sheet for more information). On average, most of these hunters reside in urban areas, are white males between 45-66 and hunted on private lands.
- **Hunting is gaining popularity:** the number of hunters increased 21% from 2001. This increase in popularity indicates a positive outlook for the continued economic impact of hunting in the NBW.



Hunting Expenditure Broken Down by State and Type of Expense in 2011 (2016 dollars)
Source: NFWS, 2013

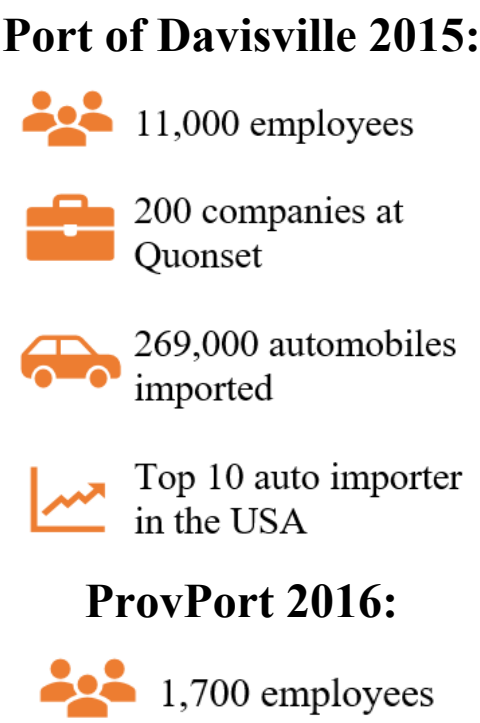
Future Outlook

Hunting relies heavily on the availability of healthy ecosystems for wildlife, mainly forests and open space. Currently, the effects of urban and suburbanization are placing strains on these resources: from 2001 to 2011, the forest coverage in the NBW decreased 4.3%. Additionally, 17% of open space in the watershed is not protected, leaving it vulnerable to development. Climate change will also have an impact on wildlife diversity and species composition in the watershed. For example, two species that are popular game in the watershed – white-tailed deer and the wild turkey – will be vulnerable to habitat relocation as temperatures increase in the area, causing them to migrate further north to remain in climates similar to that of the modern-day watershed. By 2080, it is predicted that the wild turkey will lose 87% of its current wintertime range due to increasing temperatures as a result of climate change. Additionally, warming temperatures will likely lead to increases in other wildlife, including invasive species. Measure to protect the existing habitats of these species is imperative to maintaining healthy populations and ensuring the future of hunting in the NBW.

Ports, Transportation, and Maritime Trade

Recent Trends

- **Maritime trade continues its legacy as a strong contributor to the watershed's economy:** in 2015, the Quonset Business Park housed over 200 companies that employed over 11,000 people. From 1994-2014, ProvPort directly employed a total of 13,000 individuals and generated $15 million in tax revenue. A 2014 projection predicted a rise in employment of 5,500 between 2014 - 2020, with outputs expected to increase to $2.3 billion (2014 dollars). As of 2015, the port employs 1,700 individuals.
- **More broadly, maritime trade sector in RI make up 4.7% of firms in RI economy:** Sproul and Michaud (2018) reported that the maritime-trade industry is comprised of 1,712 firms that generate $2.65 billion in annual gross sales and employ 13,337 people which encompasses individuals working outside of direct employment of the ports (see "Tourism" section for more details).



- **The NBW is nationally ranked in automobile imports:** in 2015, the Port of Davisville imported 269,000 automobiles, both new and used, making it a top 10 automobile importer in the country. This is a 27% increase from 2014 and the sixth consecutive year of rise in auto imports.
- **Ports at Galilee and Newport**: while these ports contribute to the watershed's economy, they are not involved in maritime trade. Galilee mainly houses charter fishing boats, tours, and the Block Island Ferry. Newport mainly deals with tourism through its docking of cruise ships. For more information about the economic value of related sectors, see the "Tourism," "Recreational Boating," and "Recreational Fishing" fact sheets.

Future Outlook

In 2016, voters approved $50 million in support for the modernization of infrastructure at the Port of Davisville and another $20 million for the acquisition of land to expand ProvPort. This growth, however, may be impacted by the effects of climate change. The National Oceanic and Atmospheric Association predicts sea-level rise to be more intense in the Northeast Atlantic region, with an expected rise of 9.8 feet by 2100. This rise in sea-level will undoubtedly impact coastal structures and port infrastructure. This may prove to be a challenge for existing structures, but also an opportunity to use the incoming funds to ensure structures can withstand impacts of sea level rise and more severe storms. Adaptation will be necessary to continue growth of maritime trade in the NBW, an industry which has ample room to grow.

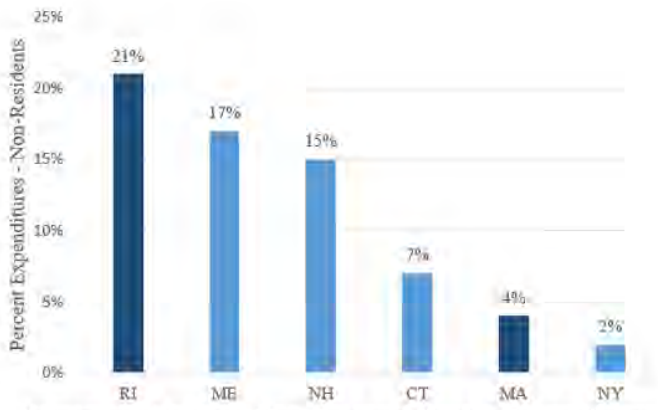
Recreational Boating

Recent Trends

In 2012, the NBW had:

- 56,000 licensed recreational boats
- 97,000 boating trips taken
- $201 million in boater spending
- 27,000 year-round jobs supported
- $150 million in wages

- **Recreational boating contributes millions to the watershed's economy:** in 2012, there were over 56,000 recreational boats registered in the NBW, with 63% in RI and 37% in MA, which took over 97,000 trips that year. Boaters spent over $650 million (2016 dollars) on expenditures such as food and lodging ($510 million in MA and $140 million in RI). This spending helped to provide over 2,700 jobs with over $150 million in annual wages.
- **Recreational boating draws in tourists:** in 2012, 21% of expenditure in RI came from nonresident recreational boaters. This is the highest nonresident spending percentage in all of New England. In MA, this figure was much lower at 4% (see graph).
- **Fishing is the most popular activity associated with recreational boating:** an average of 43% of boaters in MA and 34% of boaters in RI fish when they are on the water. Thus, the recreational boating industry has important ties to the recreational fishing industry, which also has a significant impact on the economy (see "Recreational Fishing").
- **Our numbers are conservative estimates:** a state-level study of just Rhode Island found that manufacturers, service providers, professional services, construction and transportation enterprises associated with recreational boating, as well as sole proprietors and out-of-state boaters, spent over $1 billion (2016 dollars) in the state in 2012. This supported 6,300 jobs with wages of over $291 million. Therefore, the above estimates may be conservative assumptions of the impact of recreational boating on the NBW's economy.



Percentage Share of Non-Resident Boater Expenditures in Northeast Region (2012)

Source: 2012 Northeast Recreational Boat Survey

Future Outlook

Given that recreational boating often includes activities like fishing, swimming, clamming, and sightseeing, the industry is sensitive to changes in the environment that may arise because of climate change and human developments, specifically as they relate to water quality. These include declining water clarity, rising water temperatures, and increasing pollution from human populations and development. Increased water temperature can also lead to increased occurrences of algal blooms, which impair or even close recreational waterbodies. Currently, 85% of studied estuarine waters, 40% of freshwater streams and rivers, and 80% of lakes and ponds are acceptable for recreational use in the NBW – maintaining proper water quality will help ensure these waterbodies stay safe for boaters. Additionally, rising sea level may reshape the current systems of docks and moorings, requiring changes and investments in more resilient infrastructure. Adaptation to these changes, as well as measures to protect water quality, are key in supporting the future of recreational boating in the NBW.

Recreational Fishing

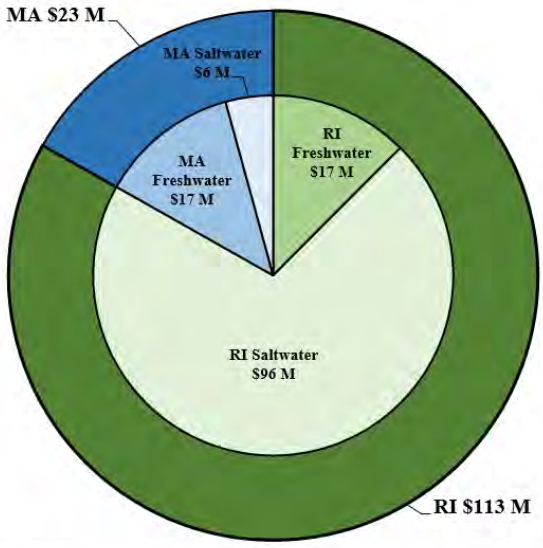
Recent Trends

In 2011, the National Fish and Wildlife Service (NFWS) published the *National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* and the American Sportfishing Association (ASA) published its own findings. Comparing the data, we found:

- **Fishermen spend millions in the NBW:** the NFWS data shows that fishermen spent $136 million (2016 dollars) in the NBW in 2011. Most of this was spending by saltwater fishermen ($103 million) compared to that by freshwater fishermen ($33 million), and most was in RI ($113 million) compared to MA ($23 million) (see graph). On average, fishermen spent $556 annually. This includes both long and short-term expenditure on items such as fishing gear, bait, gasoline, and licenses.
- **Recreational fishing supports jobs:** ASA data indicate that fishermen generated $158 million in retail sales in 2011 in the NBW. This supported 2,200 jobs and $86 million in salaries and wages. It also generated $20 million in federal tax revenue and $18 million in state and local tax revenue (2016 dollars).

In 2011, there were:

- 221,000 total anglers
- 97,000 out-of-state anglers
- $147 million in related spending
- 2,000 jobs supported
- $86 million in wages



NBW Recreational Fishing Expenditure Broken Down by State and Fresh/Saltwater Spending in 2011 (2016 dollars)

Source: NFWS, 2013

- **Recreational fishing attracts tourists:** only 41% of saltwater anglers in RI and 67% of saltwater anglers in MA were residents, a high proportion are tourists that visit the NBW to fish. Recreational fishing, especially in saltwater, is a popular activity that draws in tourists and the related economic benefit of tourism (see fact sheet "Tourism" for more information). The average saltwater angler spends 9.6 days per year on the water. Cumulatively, that's over one million trips and 1.4 million cumulative days spent fishing and bringing visitors to the region.

Future Outlook

Effects of climate change—sea level rise as well as warmer ocean temperatures, changes in salinity, pH, and oxygen levels—will play an important role in shaping recreational fishing in the NBW. The warmer temperatures may cause a species shift, as current species migrate into cooler waters and warmer-water species take their place. Additionally, recreational fishing is affected by water quality – issues such as growing populations and increased rainfall from climate change increases runoff into local surface water. Warmer waters also create environments for harmful algal blooms such as cyanobacteria, commonly known as "blue green algae," which can lead to illness in humans. Currently, 85% of studied estuarine waters, 80% of lakes and ponds, and 40% of freshwater streams and rivers in the NBW are considered "acceptable" for recreational use. These numbers are likely to be affected by the anticipated changes in water quality and effects of climate change.

Research and Education

Recent Trends

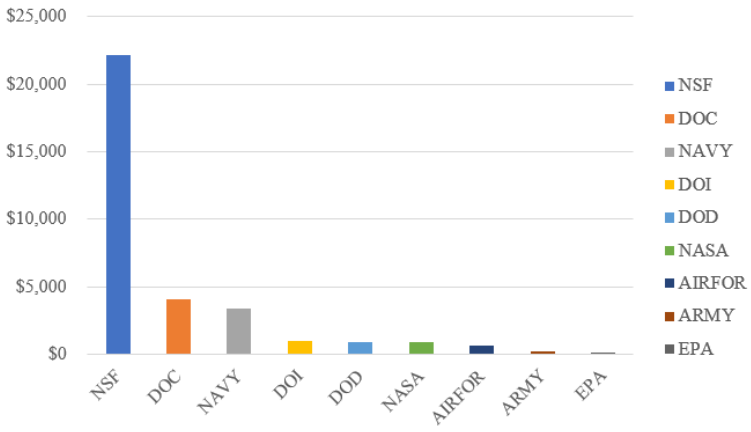
The NBW has provided researchers with an ideal environment to study a broad range of marine related subjects, ranging from the impact of climate change on coastal ecosystems to the effectiveness of marine technology. In addition, there are numerous non-profit groups, such as Mass Audubon and Save The Bay, that engage the community through activities like public school visits and hands-on site work, or Watershed Watch, a citizen science group that monitors water quality. There are also government-funded organizations, such as the Narragansett Bay Estuary Project, which carry out extensive research and community outreach on the Bay.

In recent years, scientific research in the NBW have generated:

- 5 multi-million dollar NSF grants to RI institutions
- $341 million in grants at URI from 2007-2016
- Top contributors: NSF, Department of Commerce, U.S. Navy

- **NBW academic institutions attract considerable grant money from the National Science Foundation (NSF):** in recent years, the NSF has distributed five major grants to RI institutions through its Established Program to Stimulate Competitive Research (EPSCoR) program. These grants ranged from $6-20 million, focusing on marine life science, coastal ecosystems and climate change, water quality, and the impact of dams. These projects involved collaboration from academic institutions across the state, such as Brown University, the Rhode Island School of Design, and URI.

- **URI is a major recipient of grants in the NBW:** from FY 2007 to 2016, URI received over $341 million (2016 dollars) in grants from the NSF, the Department of Commerce (DOC), the U.S. Navy, the Department of the Interior (DOI), NASA, the U.S. Airforce, the U.S. Army, and the Environmental Protection Agency. The top agencies were NSF ($185 million), the DOC ($59 million), and the Navy ($37 million).



URI Grant Sources FY2007-2016
Source: URI, Division of Research and Economic Development Annual Report FY2016

- **Non-profits have cultivated considerable networks in the community:** for example, Clean Ocean Access, conducted over 6,000 hours of outreach through 87 events as a single organization, reaching over 4,000 students from 2013 to 2017 in RI.

Future Outlook

With climate change impacting many aspects of coastal and marine ecosystems, the NBW is likely to continue to be a testbed to understand how ecosystems change, and how society and the economy adapt to changes. Compromised water quality as a result of increased precipitation, heavy storms, and increased stormwater is another pressing issue in the NBW. Ongoing work of academic institutions, government organizations, and non-profits will ideally continue to contribute valuable insight in supporting the health of marine ecosystems.

Wildlife Viewing

Recent Trends

In 2011, there were:

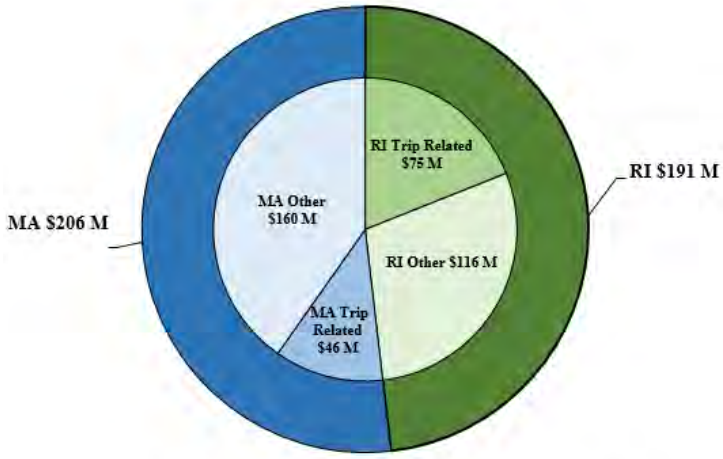
172,000 viewers visiting

2 million combined viewing days

$400 million in related spending

RI alone is home to over 800 different wildlife species

- **Wildlife viewing is in the NBW is a $400 million-dollar industry (2016 dollars):** expenditures include purchases toward lodging, equipment, transportation, and other expenses. Approximately $121 million of this was from food, lodging, and transportation, while the other $276 million was equipment and related costs. On average, each viewer spent $592 (2016 dollars) (see graph).
- **Wildlife watching draws in out-of-state visitors:** there are two types of wildlife viewers: around-the-home (<1 mile from residence) and away-from-home (1+ mile from residence). More than half of away-from-home wildlife viewers were from out of state. For residents of RI and MA, around-the-home wildlife viewing was six times more popular than away-from-home viewing. Expenses of trips that necessitate traveling away from one's residence were not included in this report.



Wildlife Viewing Expenditure in RI and MA in 2011 (2016 dollars)
Source: NFWS, 2013

- **Who's watching wildlife:** almost all wildlife viewers are white and from urban areas. More than half are female and between 45-64 years old with 4+ years of college. Most have an income below $100,000. On average, they spend 23 days a year watching wildlife.
- **State Parks generate jobs and revenue:** In RI alone, Sproul (2017) finds that 22 State Parks, many of which fall within NBW, were responsible for $312 million of economic impact and 3,709 jobs in 2016. Revenues and jobs are generated through visitors' spending at parks, beaches, bikeways and camping grounds. Similar statistics for MA were not available at the time of this study.

Future Outlook

Biodiversity is changing, due in part to climate change and increasing human developments – warmer air and water temperatures pushes some species out while drawing others in. Air temperature is expected to rise 7° F, while water temperature will rise between 3.6 and 5.4° F by the next century. These changes will affect species diversity, with new species migrating in and others moving away. Habitat loss or preservation also plays a key role in species diversity. Mass Audubon estimates that between 2005-2013, 13 acres of land were developed every day, culminating at 38,000 acres of lost forest. In recent decades, RI and MA have passed legislation to preserve fields, forests, and open space through tax incentives–such conservation efforts are vital to maintaining species diversity and preventing habitat loss, thereby supporting the future of wildlife viewing in the NBW.

Tourism

Recent Trends

The size of the tourism industry is difficult to measure precisely, since tourism transects numerous other industries. This report measured in three ways: data from two industries closely related to tourism from the Bureau of Labor Statistics, seasonal tax revenue from the Rhode Island (RI) Department of Revenue, and two 2015 reports from Tourism Economics and the Research Department of the U.S Travel Association.

In 2015 in the NBW:

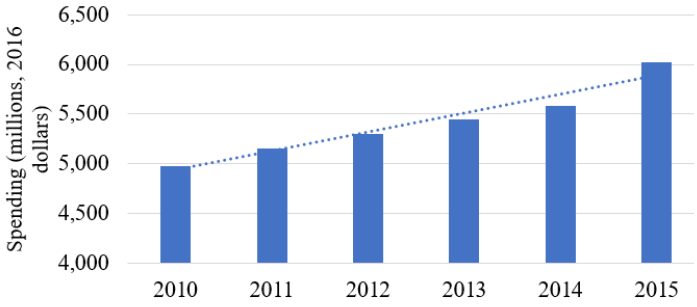
- 24 million visitors to RI
- $6 billion in revenue
- 91,000 jobs supported
- Wages of over $1.8 billion

- **Tourism creates jobs:** industries closely related to tourism (arts/entertainment/recreation sector and accommodation/food services sector) were selected to serve as proxies for the tourism sector. In 2015, in counties within the NBW, the Bureau of Labor Statistics estimates that there were over 5,500 businesses employing over 91,000 people with wages over $1.8 billion (2016 dollars). While not all of these establishments deal with tourism, these figures highlight the broad scope of businesses that interact with the tourism sector.

- **Tourism generates seasonal tax revenue**: assuming that tourism peaks in the summer, its seasonal effect was calculated on two taxes closely related to tourism in RI – the hotel tax and the meal and beverage tax. In 2015, $5.4 million (2016 dollars) in revenue was due to this seasonal effect, and it can be related to tourism.

- **Tourist spending stimulates the economy:** the journal *Tourism Economics* estimated that in 2015, the expenditure of tourists in RI was an estimated $6 billion (2016 dollars) (see graph), supporting nearly 80,500 jobs directly related to tourism in RI (60,000 specifically in the watershed) and accounting for 13% of employment in the state (Figure 1).

- **Tourism also makes its mark in the MA portion of the NBW:** In domestic tourism, the four MA counties in the NBW accounted for $2.9 billion, or 17% of total domestic tourism spending.



Tourist Expenditure in RI 2010-2015
Source: Tourism Economics, 2015

- **Arts and culture contribute to tourism and the local economy:** according to BEA data, there were 15,900 employees in RI and 19,400 in MA the Arts and Culture sector in the NBW in 2015, with almost $1 billion and $1.7 billion in wages respectively.

Future Outlook

The future of tourism is at risk from the effects of climate change, including submersion of infrastructure by storm surges and sea level rise. Additionally, many sectors related to tourism rely on a healthy environment, such as beach use and recreational fishing, yet they are under stress from the effects of climate change. These include threats to water quality arising from increasing water temperatures, which may lead to increased algal and bacterial outbreaks. Human development may exacerbate these effects – for example, increasing impervious cover from expanding human settlements leads to more pollutants running off into the water.

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[1] Source: MA - US Travel Assoc., 2015

[2] Source: RI - Travel Economics, 2015

[3] Source: Tebaldi, 2014

[4] Source: NESFA 2015

[5] Source: USFWS 2013

[6] Source: USDA, 2012 Census of Agriculture

[7] Source: NOEP, 2016

[8] Source: CRMC Annual Report, 2016

[9] Source: Starbuck & Lipsky

[10] Source: Azure Giroux Personal Communications

[11] Sources: de la Cretaz, 2010

[12] Source: RIDL, 2012 (Planning Decisions, 2014)

[13] Source: BEA, 2015

[14] Source: Southwick Associates, 2013

[15] Source: BLS

Appendix

Table A1: Revenue and Expenditure by Sector

Sector	Revenue	Explanation
Tourism	$10,057,163,000	MA - direct expenditure scaled NBW-MA portion from tourism in 2014 (~$1M),[1] RI - scaled NBW-RI from 2015 RI "visitor industry" (~$4B) and "traveler economy" (~$6B) expenditures.[2]
Defense Industry	$2,302,152,000	2013 combined military defense and private defense infrastructure. Not scaled for NBW-RI population/land area. RI only.[3]
Forestry	$697,667,000	2013 sales for total forest products in NBW-RI scaled. RI only.[4]
Wildlife Viewing	$397,736,000	2011 expenditure of wildlife viewers scaled for state NBW-RI/MA.[5]
Recreational Fishing	$157,776,900	NBW-RI/MA scaled retail sales from recreational fishers in 2011.[5]
Agriculture	$120,867,000	Scaled data for RI/MA watershed area. Total market value crops (~$100M) and livestock (~$20M) in 2012.[6]
Commercial Fishing	$77,400,000	NOEP data landing market values for 3 ports in RI 2016 - Narragansett, Point Judith, North Kingstown NOT SCALED.[7]
Hunting	$31,607,000	2013 expenditures of hunters in NBW-RI/MA scaled (includes trip related expenses (~$7.2M) and equipment/other spending (~$24.5M)).[5]
Aquaculture	$2,809,440	Scaled for NBW-RI farm gate value of aquacultural products in 2016. RI only.[8]
Recreational Boating	$2,758,000	2012 boater economic impact scaled for NBW-RI/MA[9]
Beach Use	$2,519,000	Beach revenue for 3 marine beaches (Bristol, Eastons, Sachuest/Third) in NBW in 2015 for 100-day season.[10]
Ports, Maritime, & Trade	--	No comparable data
Research and Education	--	No comparable data

The total revenue for the RI portion of the tourism sector (approximately $10 billion) was compiled using three sources. In RI, tourism is comprised of spending by “visitors” and “travelers”. Visitors are from outside 50 miles of RI, while travelers are inside 50 miles.

- Visitor spending from the RI portion of the watershed (~$4 billion for all of RI, scaled 89% for watershed portion of state ~ $3.6 billion)
- Traveler spending for the RI portion of the watershed (~$6 billion for all of RI, scaled 89% for watershed portion of state ~ $5.4 billion)
- Tourism direct expenditure in MA scaled for the watershed portion of the state (~$1 billion)

Table A2: Employment by Sector

Sector	Employment	Explanation
Tourism	60,042	MA - 2014 scaled MA-NBW employment directly from tourism (6,941),[1] RI - scaled NBW-RI combined employment 2015 from "touists" and "visitors" (53,101).[2]
Defense Industry	17,497	2013 employment combined military defense and private defense infrastructure, NOT SCALED, ONLY FOR RI.[3]
Forestry	5,135	RI - 2013 employment statistics scaled for NBW-RI, [11] MA - 2006 employment statistics scaled for NBW-MA.[4]
Ports, Maritime, & Trade	4,445	RIDL classified as employment in RI relating to maritime trade - scaled 88.9% for RI pop. In NBW (originally 5,000).[12]
Agriculture	4,401	BEA 2015 agricultural employment data scaled by population in NBW-RI/MA. This includes employment for farm proprietors (owners) employment (1,726) and other farm employment (2,675).[13]
Recreational Boating	2,758	2012 year-round jobs supported by recreational boating from report, scaled for NBW-RI/MA population.[9]
Recreational Fishing	2,208	2011 jobs supported by recreational fishing from report, scaled NBW-RI/MA.[14]
Commercial Fishing	722	BLS commercial fishing scaled for NBW-RI/MA population as of 2015, under NAICS code "fishing"[15]
Beach Use	372	We only have employment data for 6 beaches (Bristol, City Park/Oakland, Conimicut, Eastons, Narragansett, and Sachuest/Third for the 100-Day 2015 season.[10]
Aquaculture	90	Employment from 2015 CRMC aquaculture report scaled for NBW population (only RI).[8]
Hunting	--	NO COMPARABLE DATA
Research and Education	--	NO COMPARABLE DATA
Wildlife Viewing	--	NO COMPARABLE DATA

Why do this study?

For hundreds of years, the Narragansett Bay Watershed (NBW) has been the center of a robust economy in New England, relying heavily on natural resources for economic growth and expansion. A high proportion of sectors in the economy of the watershed still depend on its natural capital. Coastal tourism, the defense sector, commercial and recreational fishing, aquaculture, agriculture, and marine transportation, among other industries, are examples of key sectors in NBW that depend on clean water and beaches, sustainable fish stocks, soil, and other coastal and marine resources—i.e., the "natural capital" from the watershed. These sectors contribute to the watershed's economy by providing jobs and income to millions of people in Rhode Island and Massachusetts.

The future of the natural capital provided by NBW is at its crossroad. On one hand, state agencies, nonprofit organizations, and individuals have increased efforts to restore the health of the watershed. For instance, upgrading wastewater treatment facilities in the watershed has clearly improved the water quality of the Narragansett Bay and some of its tributaries. On the other hand, these natural resources are being threatened by a multitude of forces. Rapid urbanization and suburbanization in the past few decades have replaced a substantial amount of agricultural and forest land as well as wetlands with impervious areas, increasing the risk of water quality problems. Nearly a dozen locations in the NBW have been recently closed to shellfish harvesting due to harmful algal blooms caused by high levels of nutrient runoff from human settlements. Sea level rise, storm surges, flooding, and other effects of climate change may also have dramatic impacts on shoreline infrastructure, communities, and resources. These threats and decisions regarding how they are addressed will shape the future of the watershed and impact the health of its resources for years to come.

Many decisions made in the watershed—from creation of industrial infrastructure, land use and management, agriculture and conservation practices, to water regulations—involve tradeoffs between development and protecting the environment, which may result in impacts beyond coastal areas and across future generations. There is a clear need to understand those tradeoffs and the scale of benefits from the NBW so that decision makers and the public can make more informed choices in the future. However, no notable effort has been made to date to synthesize data and gather information, like has been done in this report, so that decision makers and the public in RI and MA can get a sense of the scope of the economy of the NBW. Understanding the economy of the NBW would have been useful for policy decisions, for instance, when there was a question about bringing in a liquefied natural gas

production facility to Providence, or the movement to retire the Brayton Point power plant in Somerset.

The overall goal of this report is to provide valuable information to decision makers, regulators, planners, and the concerned public to make effective decisions while recognizing tradeoffs and synergies that accompany these decisions. As the first step in a larger project, this report identifies and quantifies the major economic activities that depend on the natural capital of the NBW and the importance of a healthy watershed for sustained economic development. Future phases of this project will quantify non-market benefits of the NBW, including value of changes in water quality in the watershed under alternative future scenarios. Combined, the overall project is intended to provide a better answer to the question of the NBW's value. The project also intends to demonstrate how the NBW requires continual strategic investment to ensure the natural capital that we depend upon remains healthy and productive.

Objectives

The purpose of this report is to provide an economic assessment of the sectors that utilize the natural capital of the NBW. To meet this goal, this report provides an economic assessment of major watershed related uses, economic sectors, and economic impacts of these sectors on the NBW. This report has identified 13 sectors that make major and measurable contributions to the watershed's economy: agriculture; aquaculture; beach use; commercial fishing; the defense industry; forestry; hunting; ports, transportation, and maritime trade; recreational boating; recreational fishing; research and education; tourism; and wildlife viewing (Figure 1). With these sectors in mind, the goal of this report is to:

- Provide an economic history of the watershed and the key sectors.
- Assess and characterize the economic importance of activities in terms of number of establishments, employment, wages, and total revenue.
- Identify potential environmental threats and opportunities for each sector.

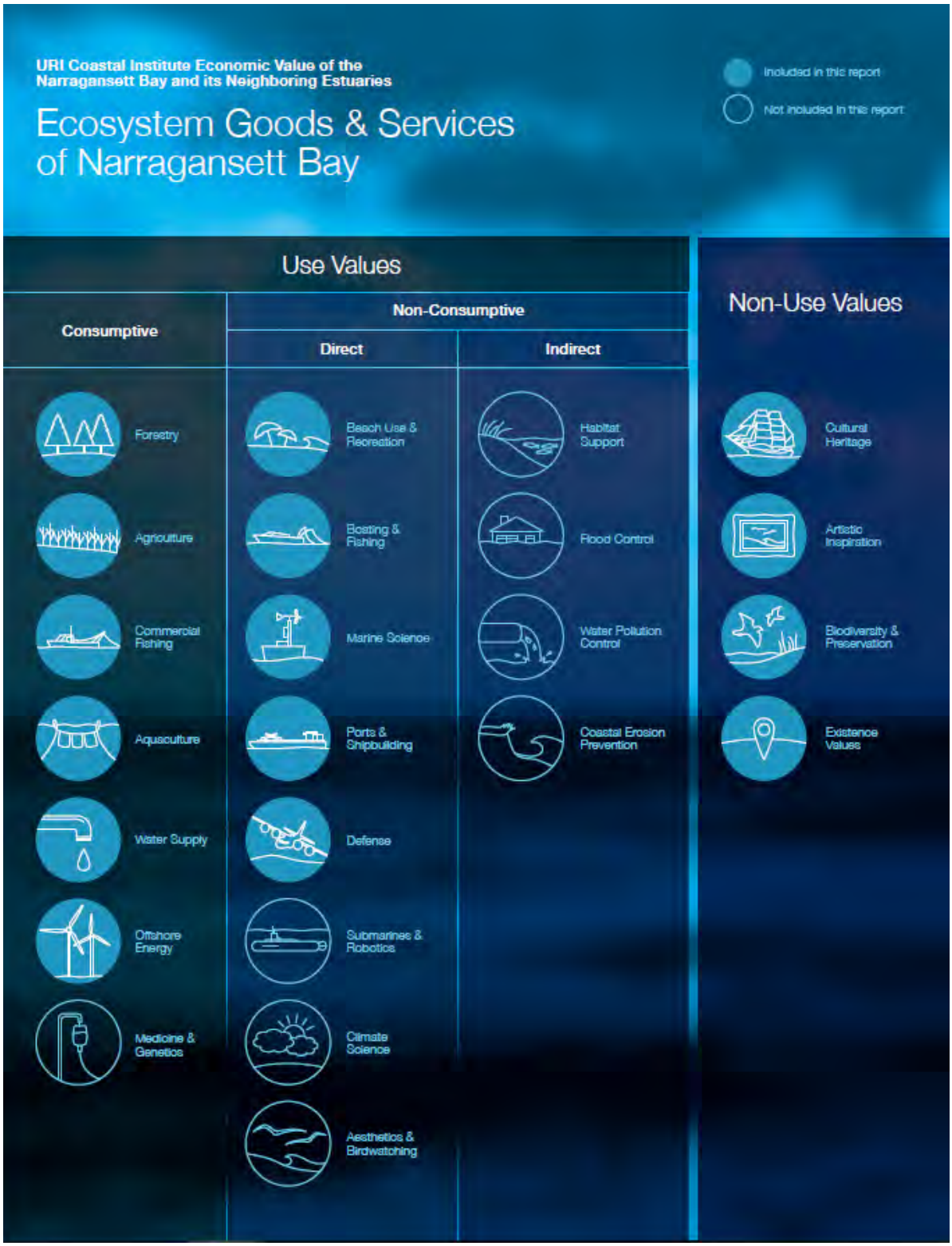

Figure 1: Ecosystem Goods and Services of Narragansett Bay

Overall findings

There are several key takeaways that have emerged from this report:

The NBW is an economic powerhouse for New England – From fueling colonial trade at its ports to powering mills during the Industrial Revolution, the NBW has supported a wide variety of economic sectors throughout MA, RI, and all of New England for centuries. Today, the economic scope of the watershed has expanded, and numerous sectors rely on the healthy natural capital that the watershed provides. No longer is it just maritime trade and commercial fishing that are reliant on the watershed, but industries such as recreational fishing, recreational boating, aquaculture, beach use, tourism, and wildlife viewing have emerged as powerful contributors to the economy, all of which rely on the resources of the watershed. Industries in the NBW have diversified watershed use through these sectors and, in turn, these sectors stimulate the economy by providing jobs, revenue streams, and a source of continuous innovation. For example, the tourism sector generate approximately 37,500 jobs in the NBW, aquaculture generated $2.8 million in sales in 2016, and the defense sector employed over 17,500 individuals in 2013. These figures are just highlights of the significant economic impact of the NBW, which are elaborated on in various sections in this report.

Revival and growth of economic sectors in the NBW – Activities within the NBW contribute significantly to the economies of both RI and MA, and this contribution is growing for many sectors. Industries such as the tourism, defense, and aquaculture have a history of boom and bust, but have cultivated new market and development opportunities in recent years. For instance, the aquaculture sector has experienced substantial growth in recent decades—the market value of aquaculture sales in the NBW increased from $67,000 in 1995 to $2.8 million in 2016 (2016 dollars), a 4,000% increase. This growth is expected to continue in upcoming years as aquaculture is expected to supply 60% of fish consumed by the year 2030. This growth is paralleled by industries such as the defense sector where private defense contracts nearly doubled between 2006 and 2015, from $136 million to $262 million (in 2016 dollars). Other industries, such as ports, transportation, and marine trade, have additional sources of growth—the sector is expected to expand due to an increase in demand for submarine building, which is a specialty of Electric Boat in Quonset, RI, and millions in recently approved government support for expansion and modernization. These statistics represent just a sliver of the opportunities for growth experienced by economic sectors in the NBW.

"Only in the NBW" – The NBW provides a unique experience for those who partake in its wide offering of unique recreational, leisure, and research activities, including locals and out-of-state residents alike. Visitors can take a trip to the Newport Mansions, partake in a regatta on the bay, and spend the afternoon on Scarborough beach—experiences that, collectively, are not available outside of the NBW. The beautiful and unmatched scenery of the NBW draws in visitors for activities such as recreational fishing, which generated $147 million in angler spending in 2016, or beach use, which attracted more than three million visitors in 2015. Aside from recreational and leisure activities, the NBW also attracts significant research opportunities due to its unique location and environment. These projects have been funded by institutions such as the U.S. Environmental Protection Agency

(EPA) and the National Science Foundation (NSF). It also offers unique learning experiences, whether it is through non-profit organizations such as Save The Bay teaching students about marine life with hands-on activities along the shore or Watershed Watch educating the public about water quality monitoring and the importance of healthy watersheds.

Potential environmental threats and opportunities – Sea level rise and changing landscapes from urbanization and suburbanization are major stressors to the key sectors in the NBW. Potential environmental threats and opportunities for each sector covered in this report were evaluated using the most recent assessment of the NBW, "State of the Narragansett Bay and Its Watershed" published by the Narragansett Bay Estuary Program (NBEP). For each section, the potential future threats and opportunities are outlined as they relate to climate change, including factors such as changing land use patterns, precipitation, temperature changes, and sea level rise. For instance, beaches within the NBW are highly susceptible to sea level rise, and the beaches of today may disappear in the next century; shellfishing may be affected by increased prevalence of disease and harmful outbreaks (RI has experienced two outbreaks of a toxic algae in less than a year—this type of algal bloom had previously never been found in RI waters). Despite these negative impacts, there may be some sectors that are more affected than others, or some that may potentially experience positive shifts from the warmer temperatures. For instance, the NBW's agricultural sector may reap benefits from warmer temperatures and increased precipitation, allowing for potentially longer and more favorable growing seasons. The impact of climate change and its effects on these industries is highly uncertain, however, generalizations can be made regarding their effect on the sectors outline in this report.

Data gaps and limitations

There are a number of data gaps in assessing the economic sectors in NBW. First, data for the number of establishments and employment in many sectors are incomplete and understated. Complete information is not available because a substantial portion of firms and employment are independent contractors for whom payments received need not be reported to government agencies for the purpose of public use. We anticipate that this problem is substantial particularly for sectors such as commercial fishing, agriculture, and tourism. Second, data that do exist for each sector are often not reported at the watershed level and, instead, are reported either at the state, county, or census district levels. Currently available information does not allow for a precise determination of the proportions of economic activity in the NBW that are watershed-dependent. Statistics for the watershed in this report have been predicted proportionally to population or land area. Further data gaps include a lack of information on some consumptive and non-consumptive use of the watershed. For example, beach use statistics like visitation numbers and revenue are not required reporting for beaches in the watershed. As a result, in instances such as this, generalizations may be made using available data.

The estimates presented for each sector are as comprehensive as possible; however, some values are not included due to a lack of data through inaccessibility or non-existence for several economic sectors and, for this reason, estimates presented are not precise measurements. Notes are made in each

section if this is the case as well as a description of what steps were taken to ensure the most comprehensive data were provided for the related industry.

How to use this report

The rest of this report has five major sections:

- **Methodology**: describes the approach used for calculating statistics for employment, size of industry, and wages as well as the rationale behind this method, including definitions of the watershed and its boundaries, land mass, and population.
- **History**: provides a comprehensive narrative about the history of the watershed, including its land use, settlement patterns, populations, and industrial evolution.
- **Economic Overview**: provides a summary of the history of the watershed's economy, the forces that helped shape it, and how the economy got to be where it is today.
- **Geography and Demographics**: characterizes land use in the watershed as well as current socioeconomic and demographic characteristics of the watershed's population and how they have shifted over time.
- **Industry sections**: for each of the thirteen industries, there is a section containing: an overview, a brief history, data sources, current status and trends, and future opportunities and threats as they relate to the industry.

The Narragansett Bay Watershed Economy Project was conceived and partially supported by the Coastal Institute at the University of Rhode Island under the leadership of Dr. Emi Uchida. In addition, this project was supported, in part, under Assistance Agreement No. SE - 00A00252 awarded by the U.S. Environmental Protection Agency (EPA) to Mass Audubon. Additional project partners include the URI Graduate School of Oceanography, the URI Coastal Resources Center, the Natural Capital Project at Stanford University, and the George Perkins Marsh Institute at Clark University. The views expressed in this project are solely those of the authors. It has not been formally reviewed by EPA. Additional information is available at www.nbweconomy.org.

NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Geography and Demographics of the Narragansett Bay Watershed

The Narragansett Bay watershed (NBW) is the area of land that drains water into Narragansett Bay, including all the rivers and streams that eventually flow into it (Figure 1). The NBW covers more than 1,700 square miles, with 60% of the watershed located in Massachusetts (MA) and the remaining 40% in Rhode Island (RI). There are ten counties and 105 cities and towns that are partially or entirely located in the watershed.

Figure 1: Watersheds of the Narragansett Bay
Source: Watershed Counts Annual Report, 2014

Located at the heart of the watershed is the 200 square mile Narragansett Bay, with a saltwater coastline approximately 420 miles long (about the distance of a car ride from Providence to Washington, D.C.).[i] The bay extends 28 miles into the interior of RI and is considered the state's chief geographic feature, often referred to as the Grand Canyon or Niagara Falls of the region.[1] The bay is an estuary, a semi-enclosed body of water where freshwater from rivers mixes with and dilutes saltwater of the sea. The estuarine features of the NBW—including over 100 distinct bays, islands, points, rivers, coves, and harbors—attract residents and over 1.9 million visitors annually to the region for a variety of recreational and commercial purposes.[2] The estuarine rivers that feed the Narragansett Bay are the Seekonk, Palmer, Pawtuxet, Warren, Lee, Cole, and Taunton. The major basins that flow into the Narragansett Bay and are part of the NBW are the Blackstone River Basin, the Taunton River Basin, the Pawtuxet River Basin, and the Narragansett Bay Basin (Table 1).[3]

Table 1: Major Basins in the Narragansett Bay Watershed

	Blackstone River	Taunton River	Pawtuxet River	Narragansett Bay
Square miles	475.6	474.6	231.9	524.1

Source: State of Our Watershed, 2017

Within these major basins are smaller watersheds. These include the Hunt River Basin, Moshassuck River Basin, Ten Mile River Basin, Woonasquatucket River Basin, and Warren River Basin.[4] In total, these rivers input approximately 2.4 billion gallons of freshwater daily to the Narragansett Bay. This amount of freshwater input has led to low salinity levels in the Narragansett Bay, creating an ideal habitat for organisms such as quahogs, crabs, shrimps, and lobsters.[5]

The fertile soil and relatively moderate coastal climate of the NBW have supported agriculture throughout history, including the robust livestock operations in colonial times to vineyards, horticulture, and other agricultural activities today.[6] In total, there are more than 1,090,000 acres of land in the NBW: nearly 380,000 acres are urban lands (35%), 425,000 acres are forested (39%), and over 150,000 acres are impervious such as buildings, roads, parking lots, and paved surfaces (14%). Between 2001 and 2011, almost 30,000 acres (nearly 8%) of the NBW were developed, while forested lands decreased by nearly 19,000 acres (4%) during the same time period.[7]

The biological and geographical richness and diversity of the NBW have played an important role in supporting the evolution of vibrant economies in RI and southern MA since the time of the earliest settlers. Early natives settled on the shores of the upper bay in summers, where they would feed off of the shellfish and find the needed resources for transportation, shelter, and heat in the region's forests. Early European settlers took advantage of the lower bay's islands and protected harbors with access to the open sea to create a vibrant colonial economy around a leading colonial port in Newport.

[i] The coastline is 560 miles long including islands - farther than a car ride from Providence to Richmond, VA.

Activity would later shift to the upper bay and beyond—to Providence, Pawtucket, Fall River, Worcester, Taunton, and Brockton—where the watershed would power the beginning of the nation's Industrial Revolution.

The impact that economic activity has had on the watershed is evident in the pattern of land development (Figure 2). In the older industrial centers (Worcester, Fall River, Taunton, and Providence), the intensity of impervious surfaces is highest, and it tapers off as you move away from those cities.

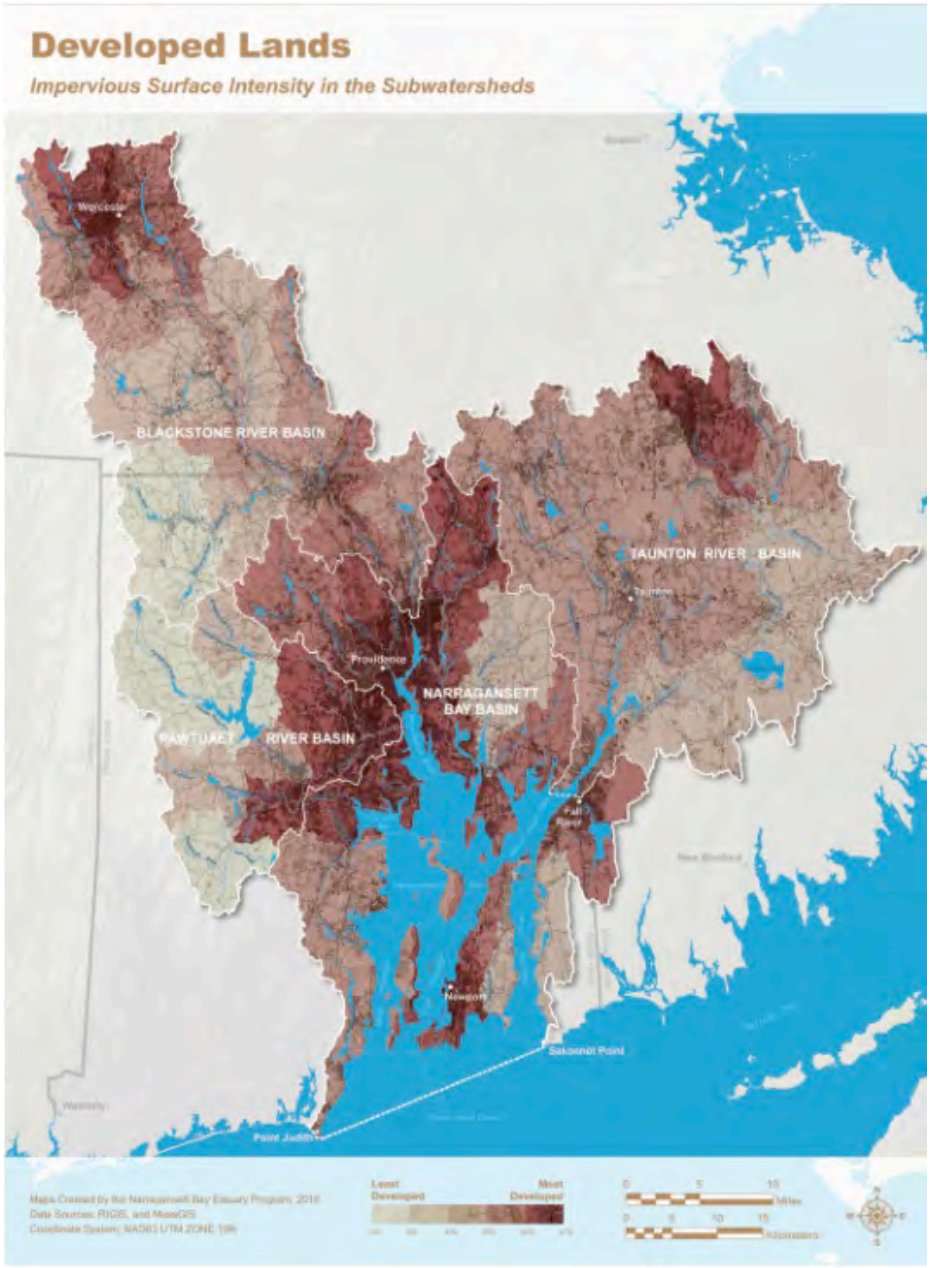

Figure 2: Impervious Surface Intensity in the NBW
Source: Narragansett Bay Estuary Program (NBEP), 2017

There are some notable areas, however, where the intensity of the impervious cover is unexpectedly low. For example, the western Pawtuxet River Basin is substantially less developed despite the close direct distance to Providence. Data shows that there is protected open space, even in areas close to Providence (Figure 3). This preservation of open space has increased in recent years, largely due to state, local, and non-profit efforts.

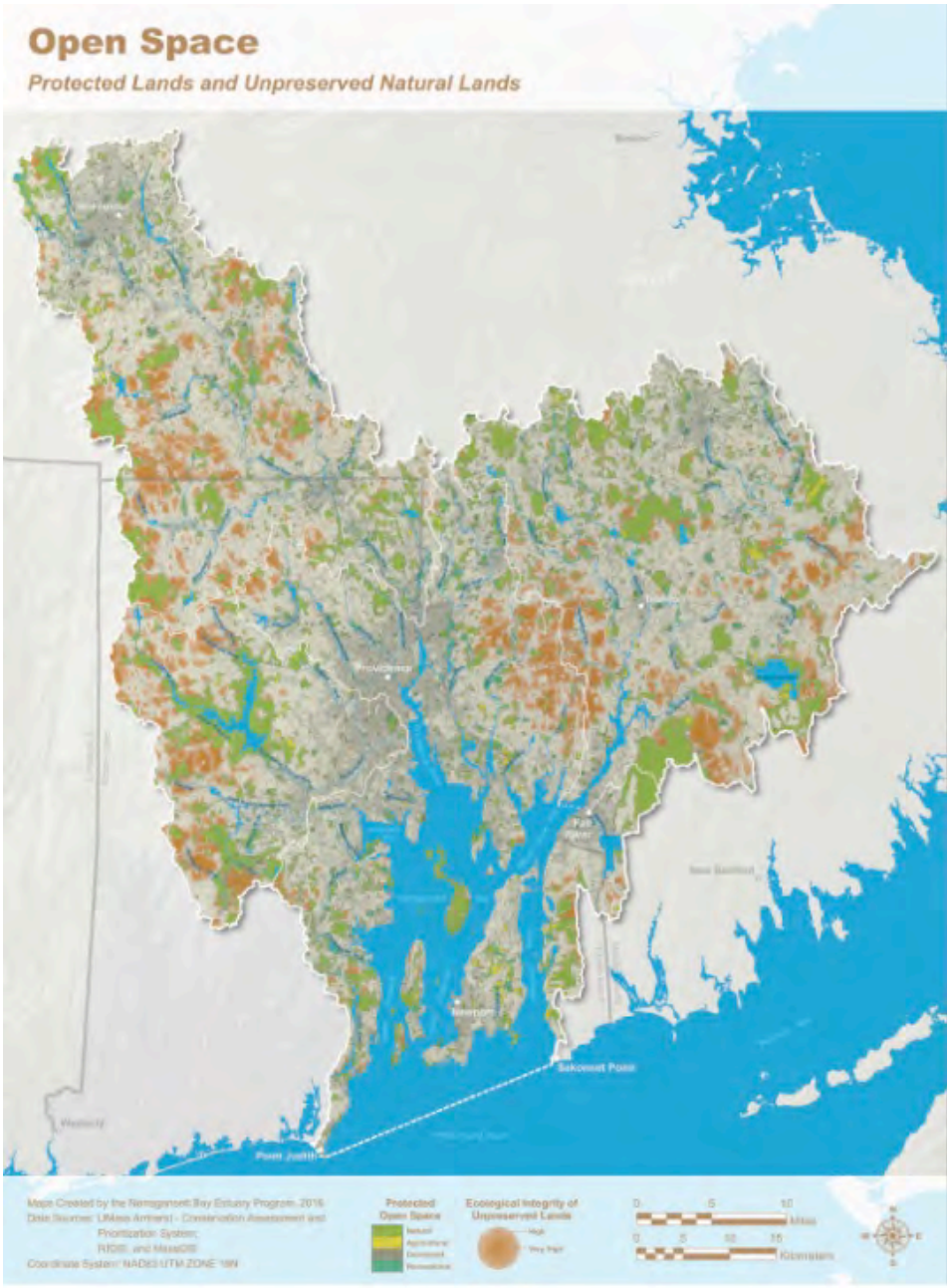

Figure 3: Protected and Unpreserved Natural Lands in the NBW
Source: NBEP, 2017

The People

Like many places in the United States, the NBW is home to a large and diverse population. Coastal areas such as the NBW have long been home to a disproportionate share of the nation's population. Shoreline counties in the U.S. account for less than 10% of the nation's land area yet are home to nearly 40% of the nation's population.[8] This can be seen in population distribution in MA and RI where nearly 60% of the population in the states' 2015 population of 7,850,720 lived in shore-adjacent counties.[ii]

An exact number for the population of the NBW does not exist. The watershed's boundaries do not match political boundaries that are the basis of all demographic and economic data. This presents a problem when estimating either the population or the level of economic activity within the watershed because economic and demographic data are available only at the state, county, and community levels. At the county level, all five of RI's counties—Bristol, Kent, Newport, Providence, and Washington—plus five of MA's counties—Bristol, Middlesex, Norfolk, Plymouth, and Worcester—have land in the NBW. At the community level, there are 105 cities and towns with varying amounts of land within the watershed (Figure 4). In RI, 34 of its 39 cities and towns are at least partially within the watershed, while in MA, 71 of its 351 cities and towns are in the NBW.

[ii] The shore-adjacent counties concept is used by NOEP in their estimates of the coastal and marine economies.

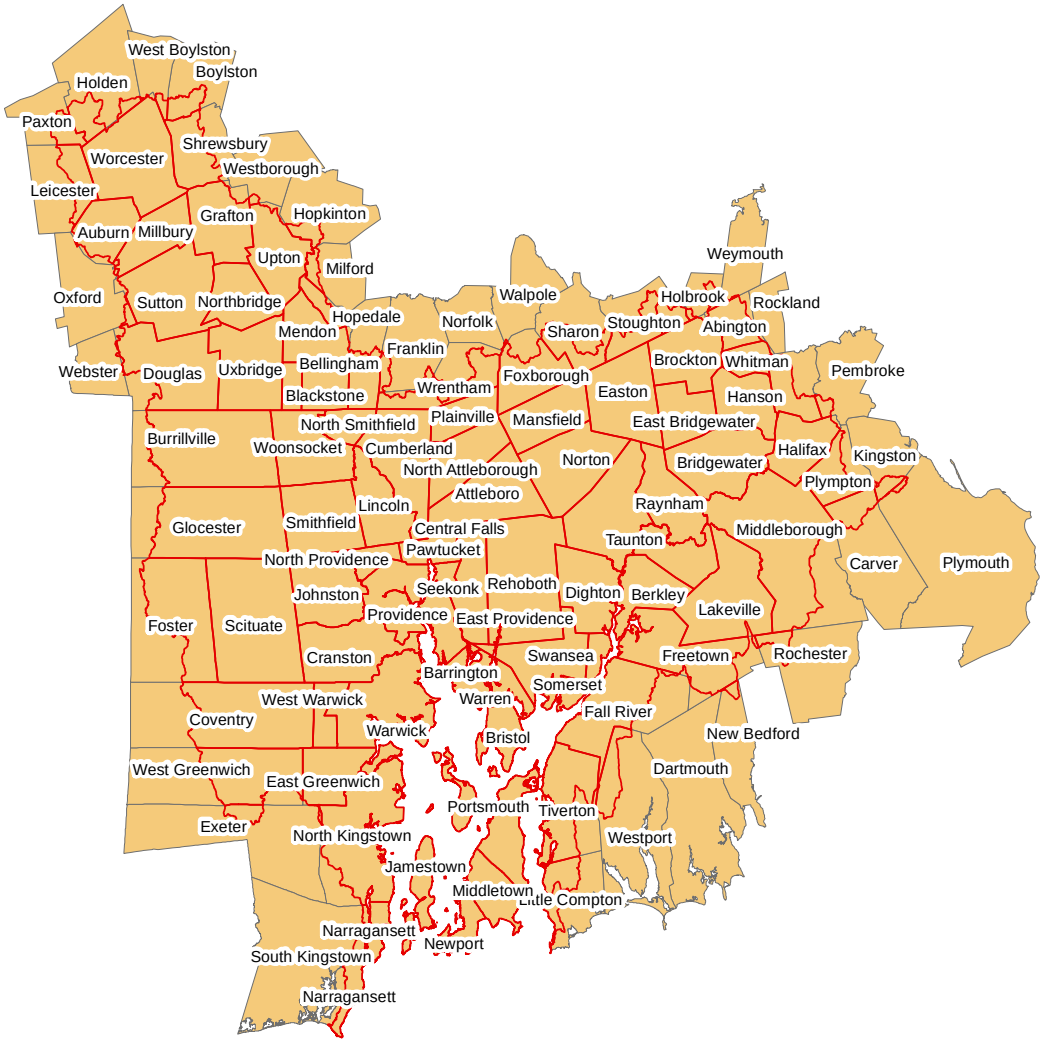

Figure 4: Cities and Towns in the NBW
Source: NBEP, 2017

Scituate, RI and Swansea, MA are two examples of cities/towns whose boundaries fall completely within the watershed, while South Kingstown, RI is only partially in the watershed and New Bedford, MA is barely in the watershed (Figure 4). By adding together the communities' land that fall within the watershed, we estimate the percentage of a county's land that fall in the NBW. For example, all of the land in Bristol County, RI is within the watershed, while 36% of the land in Plymouth County, MA is within the watershed.

To convert these land percentages into demographic and economic percentages, the assumption is made that within the communities, population and economic activity are distributed evenly across the city or town. For example, in West Greenwich, RI, 47% of the land is in the watershed, so 47% of the population is assumed to be in the watershed. Once these numbers have been computed at the city

and town level, we have an estimate of the percentage of population in a county that is in the NBW (Table 2). There are substantial differences in some of these numbers; for example, in Washington County, RI the percentage of the population in the watershed (29%) is substantially higher than the share of land (16%). This differential exists because the more populous communities within the county are within the watershed. These percentages will be used consistently in the report, and in some instances when data are available only at the state level, the same approach is taken when aggregating the county data to the state level. In RI, 88% of the population is in the watershed, and in MA it is 15%.

Table 2: Land and Population Within Watershed

Counties	Area	Population
Bristol, RI	100%	100%
Kent	74%	91%
Newport	82%	93%
Providence	96%	99%
Washington	16%	29%
Bristol, MA	72%	66%
Norfolk	19%	10%
Plymouth	36%	44%
Worcester	20%	42%

Source: NBEP, 2017

In 2015, the population of the two states was nearly 7.9 million, with 86% in MA (Table 3). Within just the 105 cities and towns in the NBW, the 2015 population was 2.6 million, with 71.5% in MA. Not all of the land in these 105 cities and towns is within the watershed, as some cities and towns only lie partially within the NBW, so the population estimate for the watershed is nearly 2 million, with 52% of the people living in MA.[iii]

Table 3: Population in 2015

	Massachusetts	Rhode Island	Watershed
Population States	6,794,422	1,056,298	7,850,720
Population in Watershed Cities & Towns	1,610,256	1,009,041	2,619,297
Population in Watershed	1,004,959	938,526	1,943,485

Source: U.S. Census Bureau

The NBW's population is highly concentrated, especially in RI where 67% of the watershed's population is in Providence County, which is slightly more than the combined share of Bristol and Worcester counties in MA (Figure 5). Within these counties, population is concentrated in the eight core cities (Worcester, Brockton, Fall River, Taunton, Providence, Pawtucket, Woonsocket, Central Falls). These cities represent less than 8% of the watershed communities but are home to 28% of the watershed's population. Within these core cities, the concentration is substantially higher in RI. The

[iii] The estimates are computed by assuming that the population is distributed evenly across land, so if 3% of the land is in the watershed, the 3% of the population is in the watershed.

City of Providence accounts for 57% of all core population in RI, while cities of Fall River and Worcester combined account for 64% of the MA core.

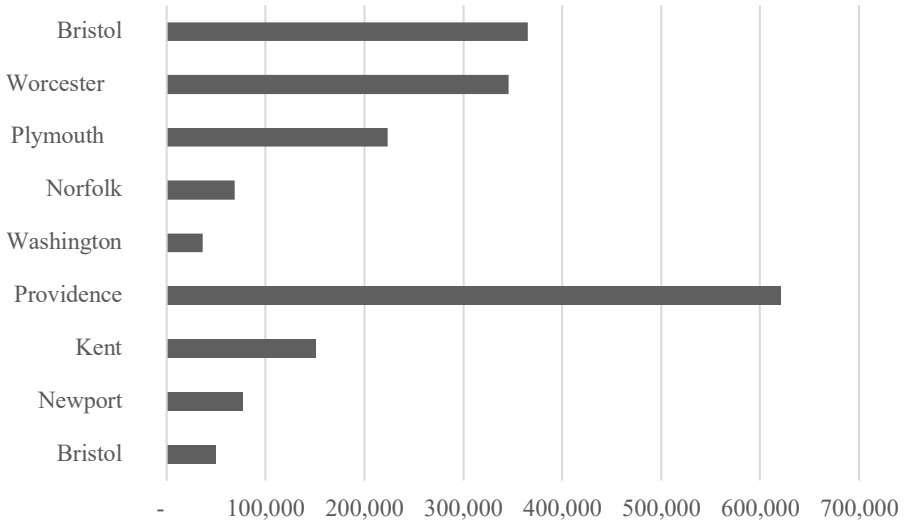

Figure 5: NBW Population in 2015
Source: U.S. Census Bureau

The 7.9 million people in the two states are packed into a relatively small area of about 8,900 square miles (RI and MA ranked 2nd and 3rd in the country in terms of population density). Within the watershed, this squeeze is even tighter, and the population density is higher than the whole of the two states. In RI there are 1,376 people per square mile in the watershed, which is four times higher than the density in cities/towns in the state that are not in the NBW. In the MA portion of the watershed, the population density is 953 people per square mile, slightly higher than the average overall density of 839 people per square mile in MA (including watershed and non-watershed counties).

There is also considerable variation of population density within the watershed, especially in RI where densities range from sparsely populated communities such as Foster and West Greenwich, with densities below the New Hampshire average of 148 people per square mile, to congested cities of Providence and Central Falls, with densities of nearly 10,000 and 16,000 people per square mile. In MA the range is narrower, extending from densities of nearly 4,000 and 3,000 people per square mile in Brockton and Fall River to less than 200 people per square mile in Plympton (Figure 6).[9]

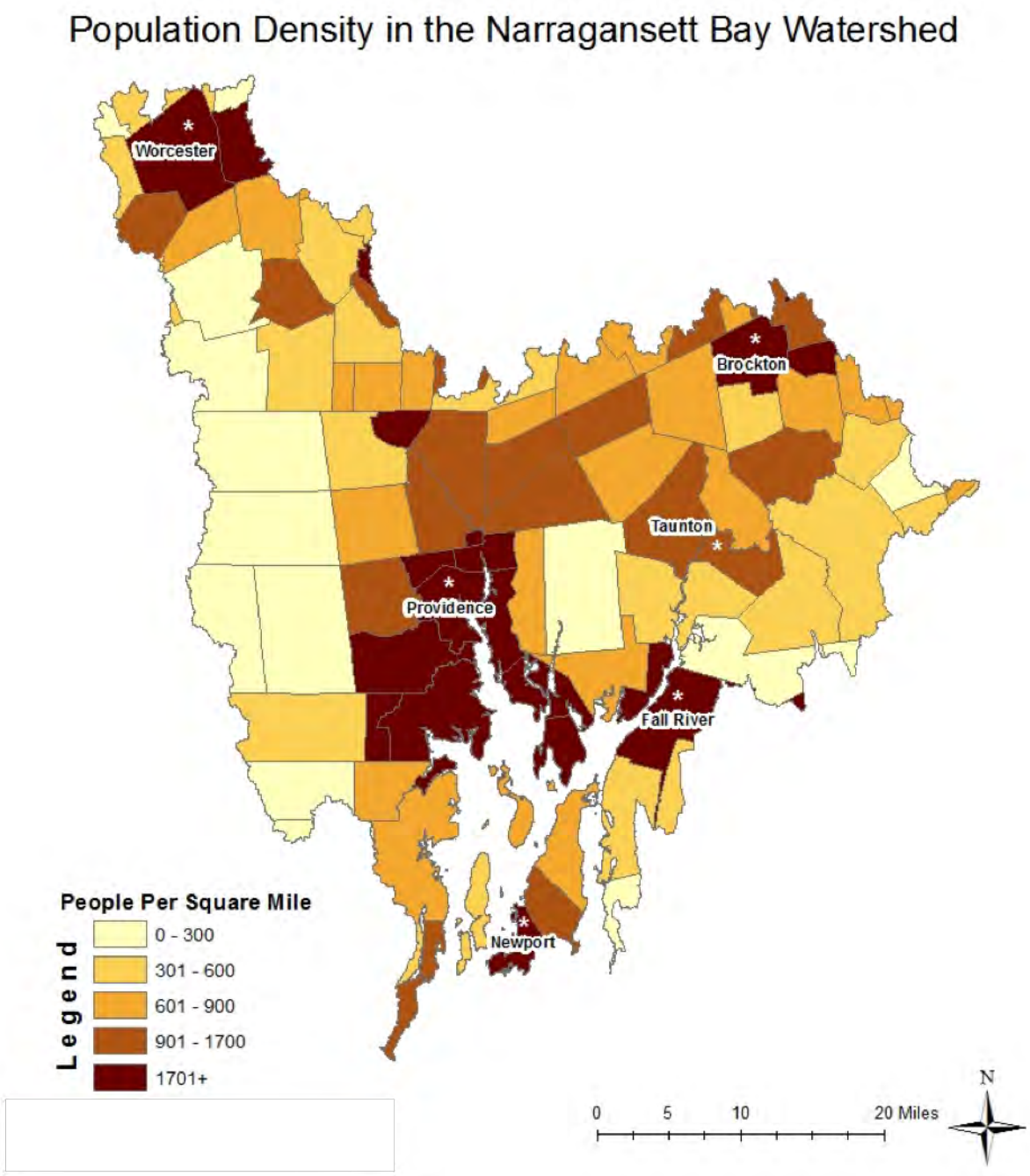

Figure 6: Population Density in the NBW

These densities can be expected to increase with projected population growth, although growth in RI and MA is expected to remain well below the national average. Between 1970 and 2010, population in coastal MA and RI increased substantially slower than in most shoreline areas except those in the Midwest along the Great Lakes, which experienced declines.[10]

In MA and RI, between 1990 and 2015, the population increased by 830,831—an increase of 11.8% (Table 4). In MA, the population was growing more than twice as fast as in RI, and it accounted for 94% of the combined RI/MA growth. In the 105 cities and towns within the NBW, the population increased by 254,115, nearly 30% of total growth in the two states. Growth in the watershed, which is the city and town data adjusted for area in the watershed, was a bit slower. In those 25 years, the NBW population increased by 173,262, with approximately 21% of the growth in RI.[11]

Table 4: Population Change: 1990- 2015[iv]

	Rhode Island		Massachusetts		Watershed	
	Change	% Change	Change	% Change	Change	% Change
Population in States	52,834	5.3%	777,997	12.9%	830,831	11.8%
Population in Watershed Communities	46,720	4.9%	207,395	14.8%	254,115	10.7%
Population in Watershed	35,728	4.0%	137,534	15.9%	173,262	9.8%

Source: NOAA, 2013

This disparity in population growth is also seen at a smaller scale in the NBW (Figure 7). At the county level, only one county experienced population declines—Newport, RI—which was still feeling the effect of the Navy's relocation of the Cruiser Destroyer Force Atlantic from Newport and Middletown to Norfolk, VA (Table 5). Among the other four counties in RI, growth rates ranged from less than 1% in Bristol and Kent Counties to nearly 9% in Washington County. Growth was concentrated in Providence, however, where more than 90% of all growth occurred. In MA, there was little variation in growth rates, with the highest rate in Worcester County.

Table 5: Watershed Population Change: 1990-2015

Rhode Island	Change	% Change	Massachusetts	Change	% Change
Bristol	225	0.46%	**Bristol**	46,202	14.50%
Kent	941	0.63%	**Norfolk**	9,696	16.40%
Newport	-5,210	-6.37%	**Plymouth**	28,503	14.70%
Providence	36,882	6.25%	**Worcester**	52,192	17.80%
Washington	2,890	8.71%			
RI Watershed	35,728	3.96%	**MA Watershed**	136,593	15.90%

Source: NOAA, 2013

At the community level in RI, eight cities and towns experienced population declines between 1990 and 2015, with the biggest losses on Aquidneck Island where the county experienced a 6.4% decline. More recently, from 2010-2015, these losses became more widespread with 14 of the state's cities and towns experiencing population decline. The biggest gains, meanwhile, were in the non-NBW communities in the state. This is especially true in Washington County where population expanded faster than in the NBW. In MA, population growth was faster and also more widely dispersed. There

[iv] At the national level, in 2010 35% of the White population lived in coastal communities, while for Black or African Americans, Hispanics, and Asians the numbers were 47%, 49% and 60%.

were only three communities that lost population, with Fall River accounting for over 90% of the loss. Meanwhile, growth was centered in the smaller towns with a 1990 population of less than 10,000, with one cluster south of Worcester and one cluster around Taunton. The population in these towns increased 33%, about twice the overall rate of increase.

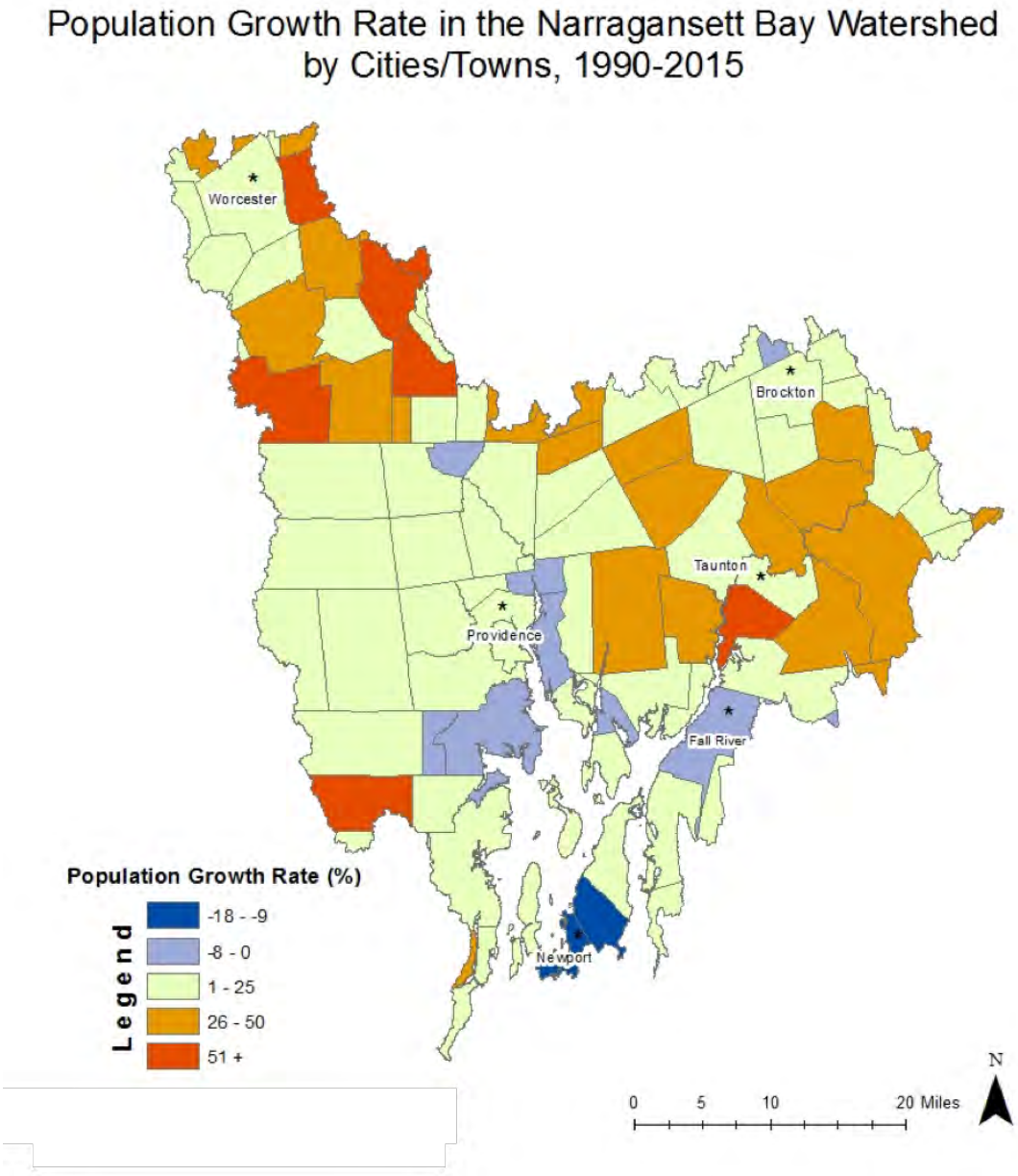

Figure 7: Population Growth in the NBW by Cities/Towns, 1990-2015

As a result of this growth, population within the NBW remains highly concentrated—a pattern reminiscent of the Industrial Era. In RI in 2015, 67% of the watershed's population was in Providence County and more than 33% was in the cities of Providence, Cranston, and Warwick. This reflects the

highly concentrated growth between 1990 and 2015. Providence County accounted for 85% of the state's population growth in this period, and more than 33% was in the City of Providence. In MA, about 70% of the 2015 population was in Worcester and Bristol Counties,[v] and more than 33% of the million people living in the MA watershed lived in the cities of Worcester, Brockton, and Fall River.[vi]

The people that comprise the population in the NBW are also quite diverse. In the NBW, significant differences exist between the demographic profiles of the industrial cities of Providence, Pawtucket, Woonsocket, and Central Falls in RI and Worcester, Brockton, Fall River, and Taunton in MA and the rest of the watershed. These eight cities were the core of the region's manufacturing sector 100 years ago, and their profile today is a legacy of their history as primary destinations for nonwhites and immigrants who settled in the area to work in the region's factories. Today, these core cities are home to slightly over 1/3rd of the watershed's population but nearly 2/3rds of the watershed's nonwhite population. In those core cities, 36% of the population is nonwhite, and in Brockton and Providence, the share is over 50%. In the remaining communities, 92% of the population is white, and in 1/4 of these communities, it is greater than 96% (Figure 8).[vii]

[v] These figures are based on U.S. Census data that have been adjusted by the area of each city and town that is in the watershed. For example, West Greenwich in RI is 47 % within the watershed, so the town's 2015 watershed population is 47% of the total population of 6,134.

[vi] The population figures here are not the actual population because they have been adjusted to reflect the share of the land in the watershed. For example, New Bedford had a population of 94,958, but only 4% of the land was in the watershed so in our numbers New Bedford's population is 3,762. .All of the demographic data for the cities and town are from the Census using Quick Facts http://www.census.gov/quickfacts/table/PST045215/00. There are no data for communities with population of 5,000 or more. This gives U.S. info on most of the cities & town – but not all. The web site city-data.com has extensive data on even the small one so this was used for the missing demographic data except for aged 65+. For this variable, the closest town was used.

[vii] The city and town population shares are from the 2010 Census. The watershed data, meanwhile has been adjusted to reflect only the population in the watershed so the not in watershed includes shares of the watershed cities and towns not in the watershed plus the cities & towns not in the watershed.

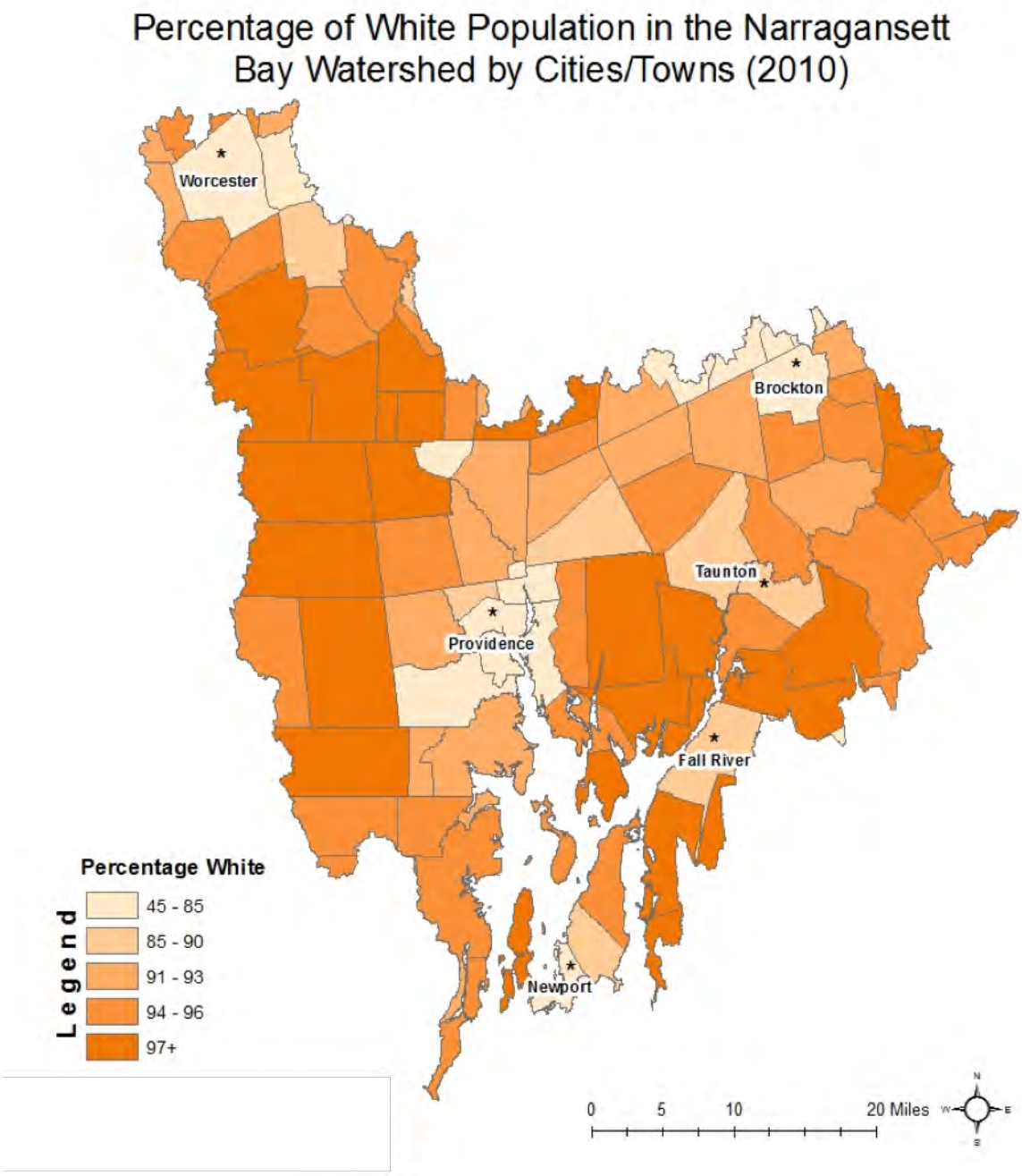

Figure 8: Percentage of White Population in the NBW by Cities/Towns, 2010

A similar pattern exists with the foreign-born population—the core cities with high concentrations of nonwhites also have high concentrations of foreign-born individuals. About one of every eight residents in the NBW is foreign-born, but in the core cities where nearly 2/3^{rds} of the watershed's foreign-born population live, the number is closer to one of every four. The highest concentrations are in Central Falls (38%) and Providence (30%) (Figure 9).

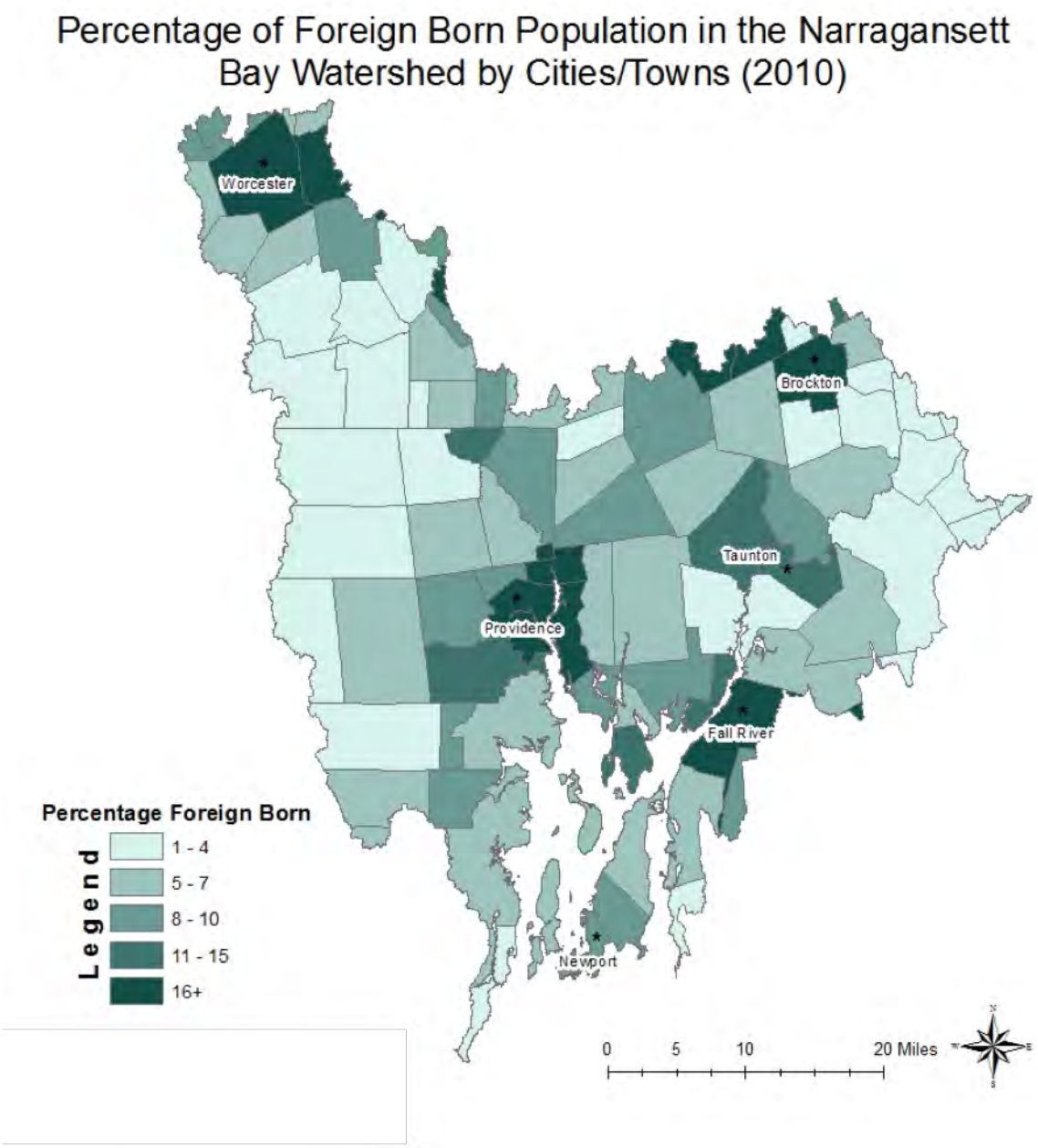

Figure 9: Percentage of Foreign Born Population in the NBW by Cities/Towns, 2010

The legacy of the manufacturing sector in these core cities is also evident in education levels (Figure 10). The indicator is the percentage of those 25 years of age or older who have at least a bachelor's degree; in the watershed, 31% of people have a bachelor's degree. In the areas outside of the core cities, 35% of the population has a bachelor's degree. This is 50% higher than the rate in the core cities. There are, however, a few "outliers"—communities with high levels of foreign-born population and high education levels. In the NBW, there are 15 communities where more than 50% of the population has a bachelor's degree, and in 12 of them, the share of foreign-born individuals in the population averages 6.5%. In Sharon, Westborough, and Shrewsbury, however, the foreign-born

share averages 20%. This suggests there are two waves of foreign-born individuals in the region—those related to the first wave of immigrants that ended about a century ago who worked in factories, and those in the second wave who began arriving in large numbers in the 1980s who work in the tech sector. In each of those three towns, the Asian share of the population is substantially higher than the state average—twice the rate in Sharon and three times in Shrewsbury and Westborough.

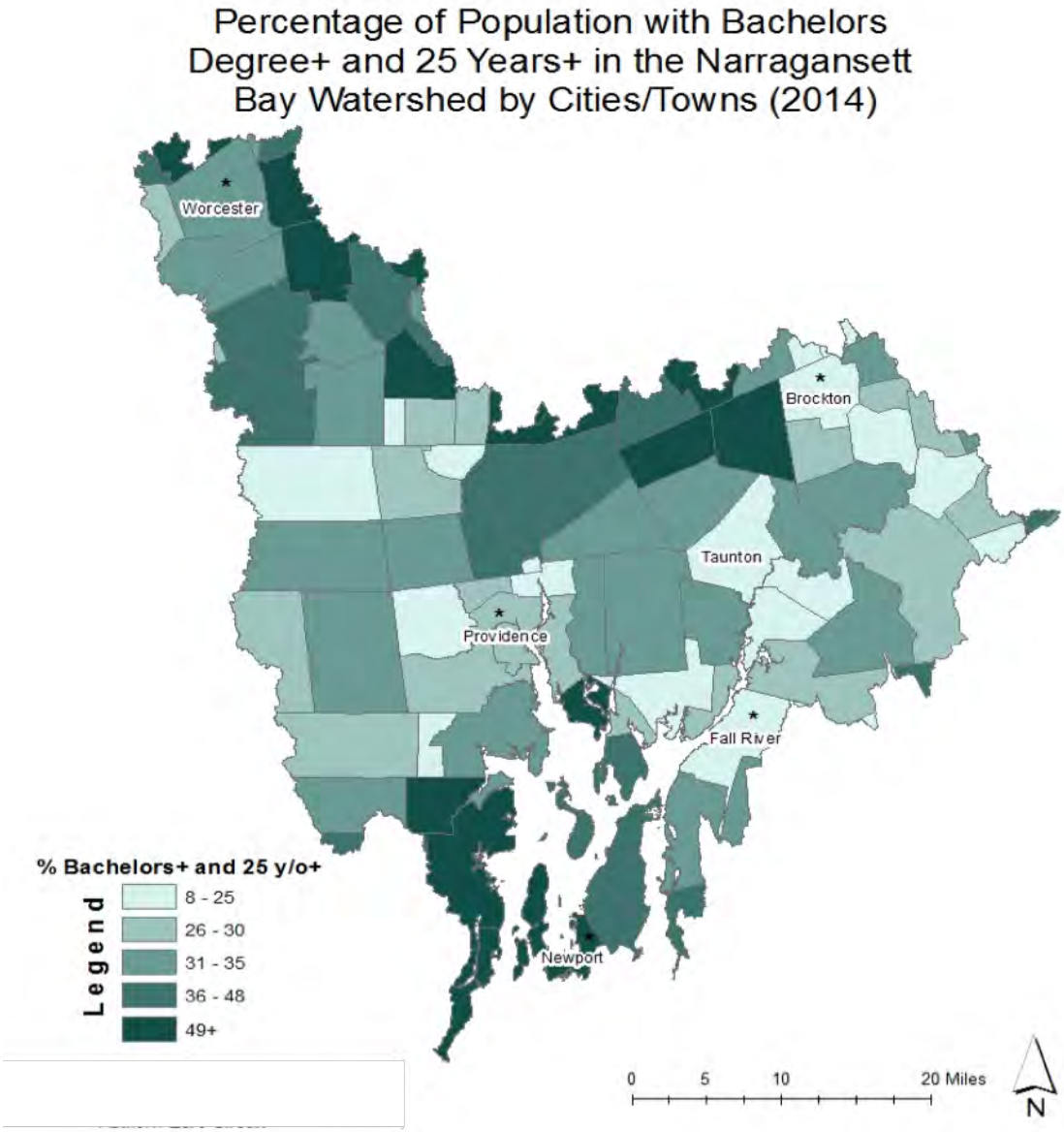

Figure 10: Percentage of Population with Bachelor's Degree+ and 25 Years+ in the NBW by Cities/Towns, 2014

There are also significant differences in age across the watershed, and here we use the share of the population 65 or older as the metric (Figure 11). With that metric, MA and RI are both older than the U.S. average, and within the watershed, RI is slightly older than MA, and the core cities are slightly younger than the remainder of the watershed. There is, however, quite a bit of variance in both groups.

The elderly's share of the population in the densely populated core cities of Providence and Central Falls is among the lowest in the watershed, as well as in some of the most sparsely populated towns, such as West Greenwich and Douglas. The older communities, meanwhile, are all relatively small communities. In RI, the communities with the highest percentage of those over 65 are North Providence (19.5%,), Tiverton and Little Compton (19.4%), and Johnston (19%), while in MA, the oldest is Somerset (21.5%).

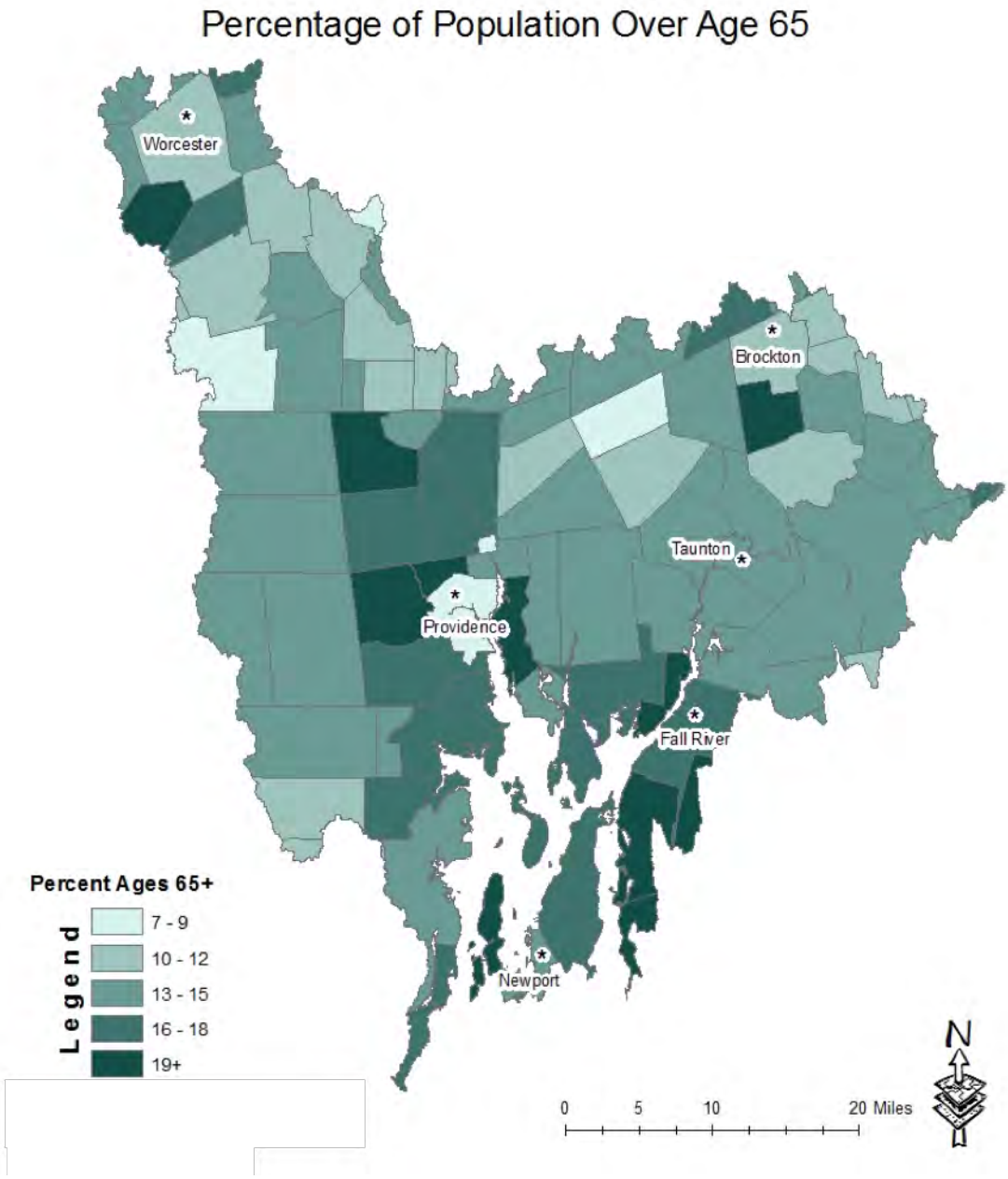

Figure 11: Percentage of NBW Population Over Age 65

These demographical differences across the NBW are also reflected in income and poverty statistics (Figure 12). The poverty rate is higher in RI (14.3%) than in MA (11.6%), although both states are

below the U.S. average of 14.8%. Within the watershed, however, there are six communities in RI and five in MA with poverty rates above the U.S. average. Poverty rates are highest in the core cities where all rates were in double-digits. The highest rates in MA were in Fall River (23%) and Worcester (22%), while in RI the rates in all four core cities exceeded 20%, and in Providence and Central Falls the rate was 30% or higher. At the other end of the scale, there were 29 cities and towns in MA and four in RI with poverty rates below 5%. In MA, these communities were spread across the watershed, while in RI they were in the areas surrounding Providence, Barrington, Gloucester, Smithfield, and North Smithfield.

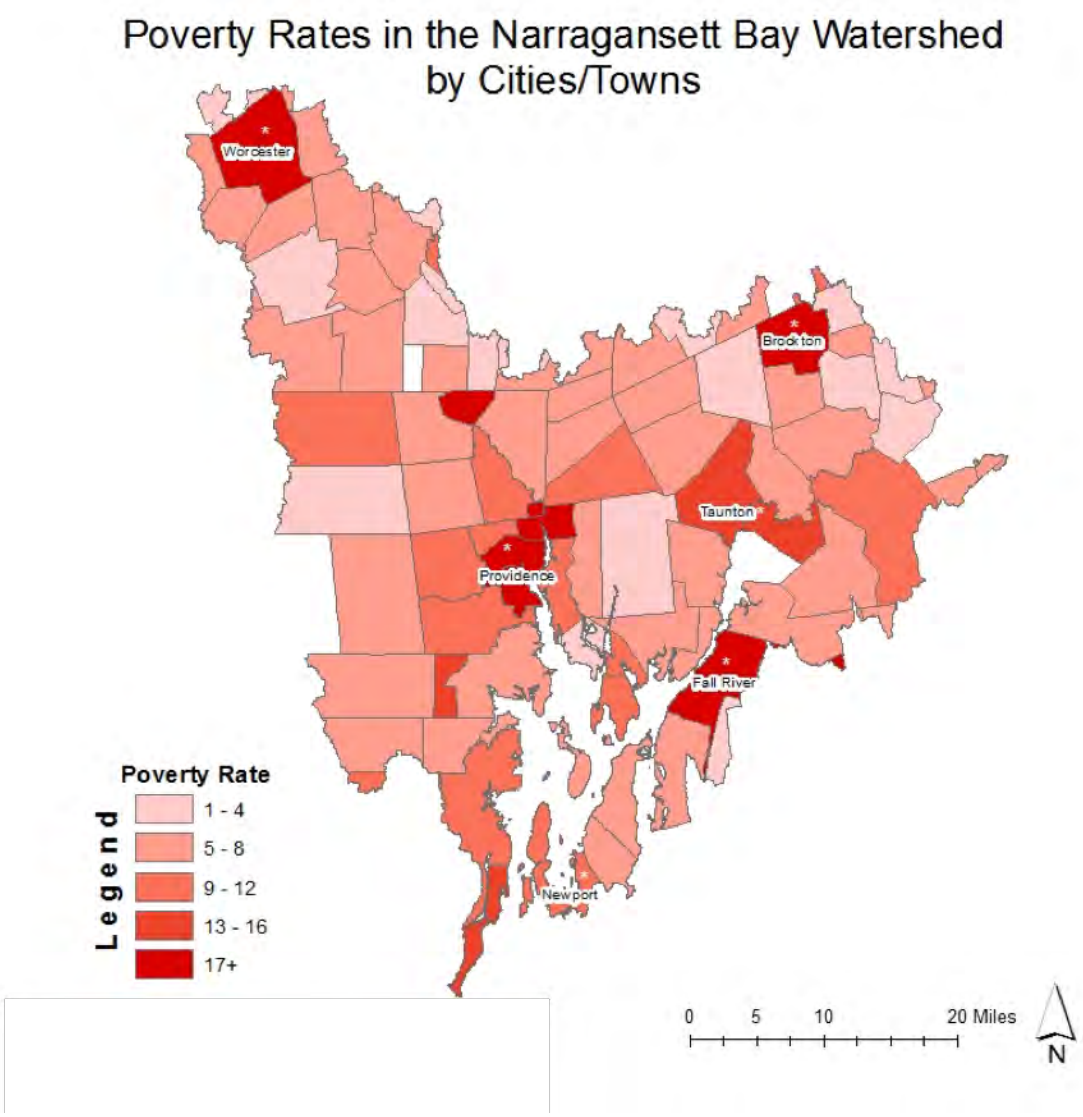

Figure 12: Poverty Rates in the NBW by Cities/Towns

Income distribution follows a pattern similar to the poverty rate distribution in the NBW (Figure 13). In both MA and RI, median family income is above the U.S. average ($53,482), although it is 21%

higher in MA ($67,846) than in RI ($56,423).[viii] Within the NBW, there are 13 communities—six in MA and seven in RI – with median incomes below the national average. Included in this 13 are all of the eight core cities and New Bedford, plus Webster, MA, and West Warwick, and East and North Providence, RI. The high-income communities, meanwhile, have well-above state averages for homeownership rates and are within commuting distance of Providence, Boston, or Route 495 in MA. In MA there are six communities with median incomes more than twice the national average and only one in RI with a median income above $100,000.[ix]

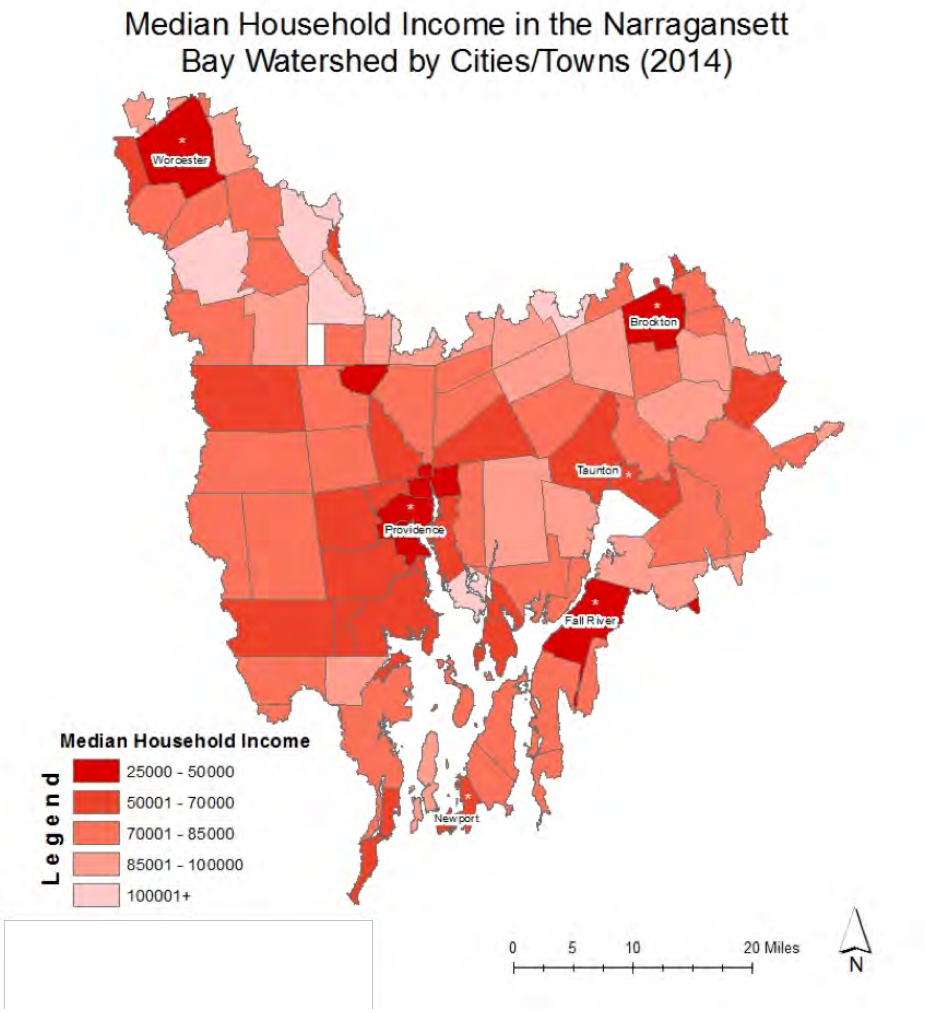

Figure 13: Median Household Income in the Narragansett Bay Watershed by Cities/Towns, 2014

It is also possible to examine, at least at the county level, the sources of income based on Bureau of Economic Analysis (BEA) data on the composition of income and wages. The largest component of income in all counties is net earnings from work, which ranged from 69% in Providence, RI to 58% in Norfolk, MA. At the state level, this share was substantially higher in RI than MA, suggesting more

[viii] These figures are from the U.S. Census and they are for the years 2010-2014.
[ix] The communities in MA are Mendon, Upton, Hopkinton, Norfolk, Sutton, and Sharon, and in RI it is Barrington.

Rhode Islanders depend on their paycheck as a main source of income. A second source of income is dividends, interest, and rent, with large variations across counties. In Bristol and Providence counties in RI, less than 15% of income comes from dividends, interest and rent, while in Washington and Norfolk counties, they account for more than 25% of income. This is consistent with the fact that these are the watershed counties with the highest median family income, and therefore experience the highest returns to capital (interest).

Table 6: Composition of Net Earnings: 2015

	Net Earnings	Dividends, Interest, and Rent	Transfers
Bristol	65%	13%	22%
Kent	68%	22%	9%
Newport	68%	16%	16%
Providence	69%	14%	17%
Washington	60%	27%	12%
Bristol	66%	16%	19%
Norfolk	58%	26%	16%
Plymouth	61%	15%	24%
Worcester	64%	21%	15%

Source: BEA

It is more difficult to interpret the transfer component of income because it includes sources that reflect age (Social Security and Medicare) and sources that reflect the lack of earnings (unemployment benefits, workers' compensation, and Medicaid). Within the NBW, more than 1/5th of income comes from transfers in Bristol, RI and Plymouth, MA, both of which have lower than average poverty rates and above average elderly shares of the population. The county with the smallest share from transfers is Kent, RI with 9%.

The watershed is clearly a diverse region, with significant variations in the demographics between the two states and across the cities and towns. There are especially large differences between the demographics of the region's older, core cities and the more sparsely populated communities distant from these cities. At the state level, RI's population is growing slower, more ethnically diverse, a bit older, more likely to be foreign-born, and more concentrated in the older urban core. Rhode Islanders also have higher rates of poverty, lower incomes, and more of that income comes from wages and salaries, although these differences are smaller than the core-noncore differences.

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[2] Sources: Raposa & Schwartz, n.d.; RIDEM, 2009.
[3] Source: NBEP, 2017.
[4] Source: Raposa & Schwartz, n.d.
[5] Sources: Chintala, et al., 2016.
[6] Source: NBEP, 2017.
[7] Source: NBEP, 2017.
[8] Source: NOAA, 2013.
[9] Source: Carroll, M., 2013.
[10] Source: NOAA, 2013.
[11] Source: NOAA, 2013.

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NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

History Overview

Humans have always congregated in watersheds and along coasts, drawn there by a wide array of life-supporting goods and services such as water, wildlife, and vegetation to nourish and shelter them. The same applies to the Narragansett Bay watershed (NBW), where people have been harvesting shellfish from the shores of Narragansett Bay for at least the last 2,700 years.[1] By 1600, as many as 30,000 people may have lived in southern New England, about as many as live in South Kingstown today, with 4,000 Narragansetts in the West Bay and 1,500 Wampanoags in the East Bay.[2] Their numbers were small, as was their ecological footprint of harvesting fish and shellfish from the bay's waters and game from the lands they cleared to farm the fertile soil.[3]

Their efforts were appreciated by Giovanni da Verrazzano. Here is how he described Aquidneck Island to King Francis in 1524:

> We frequently went five to six leagues into the interior and found it as pleasant as I can possibly describe, and suitable for every kind of cultivation grain, wine, or oil. For there the fields extend for XXV to XXX leagues; they are open and free of any obstacles or trees, and so fertile that any kind of seed would produce excellent crops.[4]

The balance between the environment and the economy noted by Verazzanno would be tested, however, with the arrival of European settlers. They came in large numbers, and with a larger ecological footprint as they shifted from a subsistence to a pre-industrial economy. This would be the first major transition in the watershed's economy and would establish the region as an important economic center in the emerging national economy; by the 18th century, Providence was described as "one of the most wealthy and enterprising places in the union".[5]

Colonial Pre-Industrial Era

In 1635, William Blackstone settled along the banks of the Blackstone River. A year later, Roger Williams bought land along the lower section of the Moshassucket River near College Hill and established a settlement he called Providence Plantation. [6] Two years later, Aquidneck Island, the island that had caught Verrazzano's attention, was first settled. These settlers had all left the Boston

region in search of religious freedom and established an area that would become an attraction for other dissidents—much as the world's cities do today.

This openness to others and their religions would prove to be a catalyst to the area's economic growth, as would the watershed's fertile land, temperate climate, long growing season, and a cluster of islands with no natural predators, providing the region with a comparative advantage in livestock. As early as 1675, Newport was described as a town with "more sheep than in any place in New-England," and before long, there was a surplus of livestock.[7] By the late 17th century, Newport merchants had established markets for the region's agricultural surplus and demand for a shipbuilding industry that extended as far north as Taunton. The early trade with the West Indies would morph into the highly profitable triangle trade of the early 18th century, and it supported craftsmen such as the world class furniture makers whose work can still be seen in museums today. By mid-century, Newport was exporting more chairs than Boston,[8] and those same conditions that supported agriculture and trade helped establish Newport as a very early resort attracting wealthy southerners looking to escape the summer heat.

Newport emerged as one of colonial America's leading cities along with Boston, New York, Philadelphia, and Charleston. It supported growth across the watershed that was considerably faster than in the New England region as a whole (Figure 1). On the eve of the American Revolution in 1770, Rhode Island's (RI) population was nearly 180 times larger than in 1644, when Providence and Aquidneck Island merged to form the Colony of Rhode Island and Providence Plantations (Figure 1).[9] By 1790, the watershed was home to two of the nation's largest cities—Newport and Providence, but there were early signs of the ecological damages accompanying economic growth and the vulnerability of that growth to external developments.

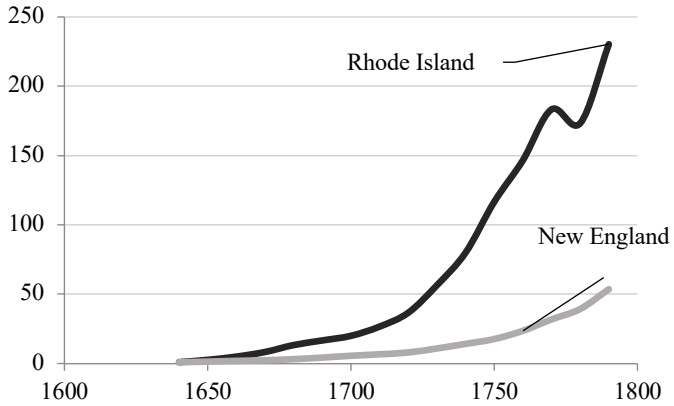

Figure 1: RI & New England Population Indexes
Source: US Census Bureau

One early indicator of that damage was the manure generated by the animals, which took its toll on the watershed.[10] A second indicator can be seen in the significant dip in the population around the time of the Revolutionary War. The watershed fueled rapid growth in the region's agricultural and

maritime economy, but the war with England was devastating and revealed the vulnerability of a region that was heavily dependent on international trade. Continued growth of a trade-based economy in Newport would be limited by a rising anti-slavery movement that would mean lost markets, a very small hinterland that would limit the growth in the livestock for sale, the expansion of trade from the Indies to Asia that increased the risk of international trade and the need for deeper pockets than available in Newport to finance that trade, and the end of favorable treatment that accompanied American independence that would increase competition and limit markets for the region's exports. The future, as described by Treasury Secretary Alexander Hamilton in his Report on Manufactures, was in manufacturing.

> The foregoing considerations seem sufficient to establish, as general propositions, that it is the interest of nations to diversify the industrious pursuits of the individuals who compose them; that the establishment of manufactures is calculated not only to increase the general stock of useful and productive labor, but to improve the state of agriculture in particular, certainly to advance the interests of those who are engaged in it...[11]

Industrial Era

The national economy shifted to manufacturing as the Industrial Revolution moved from England to America. This started when Samuel Slater, who had emigrated to New York City with a desire to make a fortune, inked a deal to create the nation's first mechanized cotton spinning factory on the banks of the Blackstone River in Pawtucket, RI. Slater, with years of work in mills in England, had the knowledge of machinery to spin cotton into yarn; Moses Brown, with money that had come from his involvement in trade, had the funds needed to finance the venture; the watershed, with many fast moving and falling rivers, would provide the power. The Industrial Revolution would take place on the banks of the watershed's rivers that were soon to be crowded with factories. Pawtucket in 1796 (Figure 2) was described by a visitor:

> There is probably no spot in New England of the same extent, in which the same quantity or variety of manufacturing business is carried on. In the year 1796, there were three anchor forges, one tanning mill, one flouring mill, one splitting mill, three fulling mills, a clothier's works, one cotton factory, two machines for cutting nails, one furnace for casting hollow ware – all moved by water.[12]

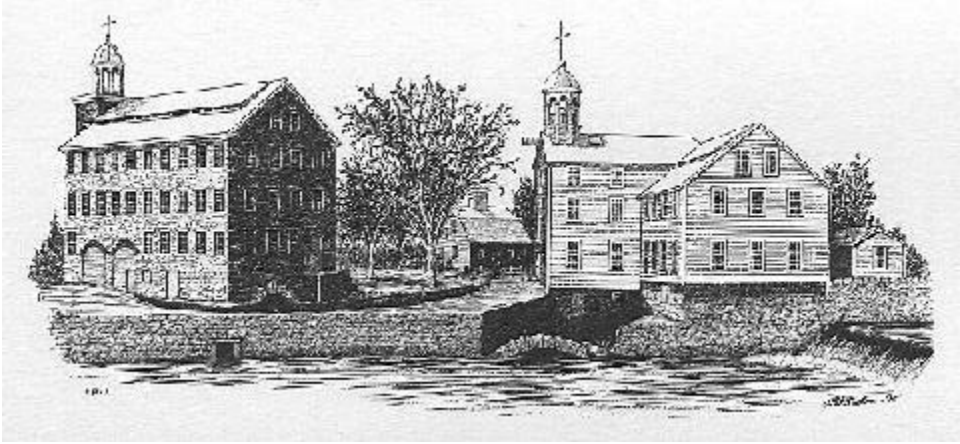

Figure 2: Slater Mill, Pawtucket, RI
Source: Slater Mill Historic Site

The extent of the concentration in the upper bay is clear in the population growth. In the early years of the Industrial Era—1800 to 1830—the movement of people to emerging industrial centers was well under way. Growth was fastest in Providence: population in Providence County increased 80% in those 30 years (Figure 3).[13] This growth was twice as fast as the state average (41%), and the growth within the City of Providence was 1.5 times as fast as the county's rate (121%). By 1830, Providence had twice as many residents as Newport and had risen to number twelve on the list of the nation's largest cities. Other centers were also appearing with some of Providence's growth spilling over into Kent County, and the cities of Taunton and Fall River in Bristol County and Worcester in Worcester County had also begun their economic climb and made it to the list of largest American cities.

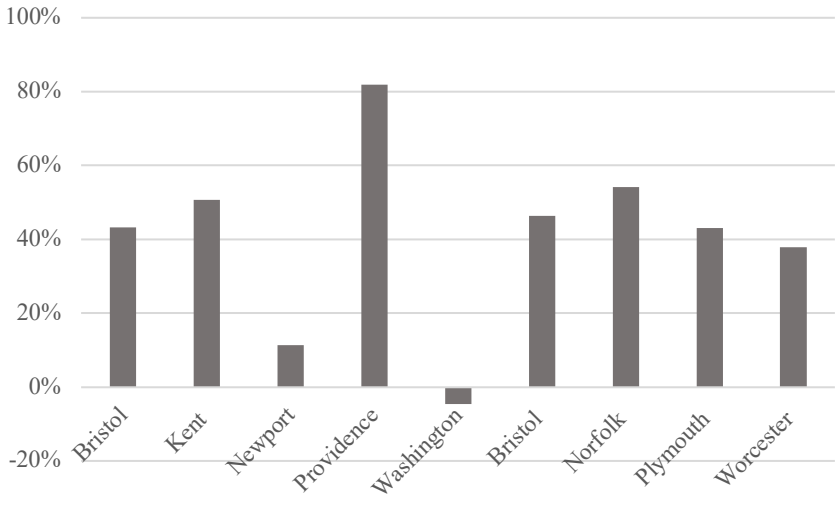

Figure 3: Population Growth Rates: 1800-1830
Source: RI Population by City, Town, and County: 1790 – 2010, n.d.

Providence, at that time, was rife with entrepreneurs and immigrants in search of success—Slater and Brown in textiles, Dodge and Lowe in jewelry, Corliss in steam power, and Browne and Sharpe in machine tools, for example (Figure 4). The economic transition was happening and it was centered in Providence, where growth accelerated from 41% to 76% between 1830 and the start of the Civil War in 1860. More than 80% of the state's population growth was in Providence County, and more than half of that was in the City of Providence. Providence quickly emerged as one of the three major U.S. centers along with New York City and Philadelphia, and five cities within the watershed made it to the list of the nation's 80 largest cities: Worcester (#36), New Bedford (#40), Taunton (#58), Fall River (#66), North Providence (#79). Newport, meanwhile, with the transition from a maritime to industrial economy, fell from #11 to #82.[14]

Once again, however, the region faced serious constraints in the face of continued growth. In the earlier transition the constraint was the size of the market. Now, it was a shortage of resources. To sustain this growth, two constraints would need to be relaxed: there needed to be a new source of energy to power the mills' machines and a new source of labor to work those machines. The power constraint was solved by George Corliss, yet another entrepreneur in search of funding who had been drawn to Providence. Within a few years of his arrival in 1844, Corliss had a patent and a new company producing steam engines. Slater had experimented with steam power in 1827, but it was Corliss' engine that finally freed mills from the need to locate on the watershed's increasingly crowded rivers.

Providence, which had been approaching the limits of water power, was now able to sustain its growth with a diversified economy that was unusual in the region. One of those industries was jewelry. Some early entrepreneurs chose Providence because of its reputation of refinement and science, its strong core of jewelers from the maritime era, and its access to external markets.[i] Another major sector was the machine tool industry that had a long history in the watershed extending at least as far back as the discovery of iron ore on the banks of the Forge River and the establishment of an iron forge in 1652 in what is now Raynham, Massachusetts (MA). A machine tool industry was essential to support the rise of manufacturing, and Providence had a leading machine and precision tool manufacturer once Browne & Sharpe opened its doors in Providence in 1833.

The labor constraint, meanwhile, was initially solved by farm-to-factory migration. Slater, in addition to his knowledge of machinery, had brought the outlines of a production model that became known as the "Rhode Island System." It was a system based on the employment of entire families, and soon those families were moving to work in mills, many of which were in cities, and a number of the smaller, more rural communities were losing people. The biggest losses were in Exeter, Glocester,

[i] At the end of the 18th century, Nehemiah Dodge had discovered a method for making gold plate and a cheaper grade of jewelry. This novelty made Dodge one of the founders of the jewelry industry in Providence, the center of less expensive jewelry and innovation with more than 200 firms employing 7,000 workers. Dodge's practice was further refined when an English jeweler Thomas Lowe came to Providence with a new process of sweating a sheet of gold onto another metal surface to produce a gold-plated substance.

and Charlestown, where population dropped by nearly 1/3rd. In addition, Jamestown, West Greenwich, and Foster had declines exceeding 20% between 1800 and 1860.[15]

There were, however, limits to this growth. The watershed could no longer meet the demand for workers, and the solution was immigrant labor. Between 1820 and 1860, more than nine million arrived in the U.S., with many heading to the watershed. After completing work on the Erie Canal in 1825, the Irish arrived to build the Blackstone Canal to expand Providence's hinterland by giving it access to the interior as far as Worcester, MA. The Erie Canal had created a canal boom, but the Blackstone Canal linking Providence with the interior was no more successful than the Pennsylvania Canal linking Philadelphia to its hinterland because of climate and terrain problems. Immigrants began arriving in such large numbers that by 1910 "only one-third of the population was of 'old Yankee' stock."[16] Woonsocket, where there had been active recruitment of citizens from Quebec, had earned the title of the "most French city in the United States with 72% of its population holding French surnames."[17] Fall River, meanwhile, "had achieved distinction as a major center of immigration in the United States. No municipality of comparable size held such an array of emigrants—who came from eighteen different nations. Among its 12,762 male textile operatives, only 3.6% had native-born parents."[18]

Figure 4: Corliss Steam Engine Co., Providence, RI
Source: New England Wireless & Steam Museum

With these constraints relaxed, the landscape changed dramatically. Factories powered by steam and linked to distant markets by railroads and steamships opened up across the watershed, although Providence remained a center of the growth. In 1850, nearly 150,000 people lived in all of RI and 500,000 in the nine watershed counties in both RI and MA. In the next 50 years Providence County's population grew by almost 250,000 people—nearly 86% of the state's growth. In 1900, RI was near the top of many lists: the highest ratio of wage earners to the population, the highest value of manufactured goods per capita, 1st in the jewelry and silverware industries, 2nd in dyeing and finishing textiles, and 4th in cotton goods.[19]

To the north, Worcester gained access to Boston with railroads after the ill-fated Blackstone Canal, and by 1900 its population had risen from 17,000 to 118,421. In the northeastern reaches of the watershed, Brockton had become the "Shoe City" by rising to the top of the national rankings in shoe and boot production by 1900. Further down the Taunton River, the city of Taunton, with a long history of iron works, had become the "Silver City" and home to Reed and Barton silversmiths.[20]

Figure 5: Fall River Line
Source: The Esoterica Curiosa Blog

Further south on the Taunton River, where it reaches the Narragansett Bay, is Fall River, which "made a heroic contribution to American manufacturing supremacy, the course of the nineteenth century, Yankee efficiency, ingenuity, technical ability, self-confidence, nurtured an infant mill industry and shaped the Spindle City … into the country's largest textile center"[21] (Figure 5). A city of 11,524 in 1850, about one-quarter the size of Providence, Fall River had been well positioned for the shift to steam power. From its location on the Taunton River, the city was linked to Boston in the north by the Fall River Railroad and to resources (cotton and coal) and markets (New York City) in the south via the Fall River Line of steamships that were "peerless among the marine architectural triumphs of the world."[22] By 1900, Fall River's population had grown to 104,863 and its factories were generating 8.6% of the value of the nation's cotton goods, 85% more than second place Philadelphia. Also making it to the top ten list of cotton goods manufactures were the four watershed cities of New Bedford (4th), Pawtucket (7th), Taunton (9th), and Warwick (10th).[23]

These success stories are reflected in the graph of population growth below.[ii] Between 1860 and 1920—roughly the beginning of the Civil War to the end of World War I—population in the watershed counties nearly doubled with the addition of 1.2 million residents. Growth also remained heavily concentrated in and around the watershed's major cities. In MA, this was a period of increasing concentration in Worcester and Bristol Counties where Worcester and Fall River are located. In 1860 these counties had accounted for 42% of the watershed's population, but in the next sixty years 75% of growth was in these counties (Figure 6). The concentration was even higher in RI, where 85% of the growth was located in Providence County, and half of that was in the City of

[ii] Middlesex was dropped from the list because there was only one small town in the watershed.

Providence. By 1900, Worcester, Providence, and Fall River all had over 100,000 residents and were ranked in the top 35 of the nation's largest cities.

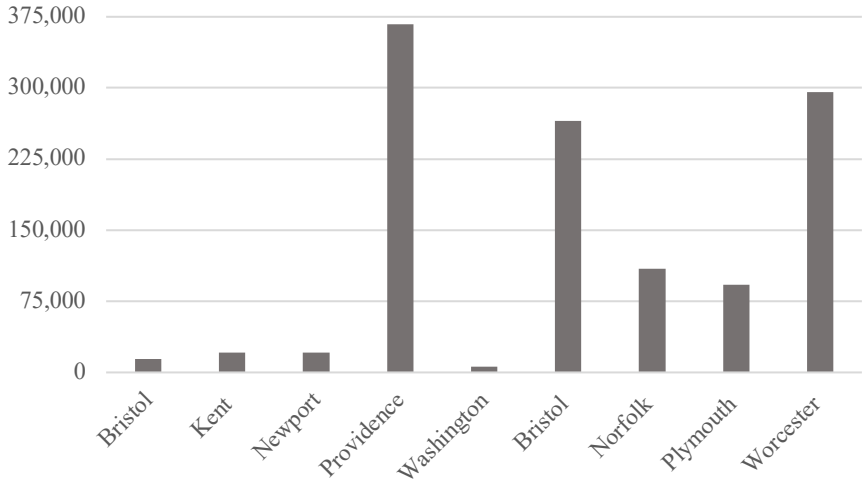

Figure 6: Population Growth: 1860-1920
Source: US Census Bureau, 1975

With this concentration of people and industry in the watershed's large industrial centers, power and wealth shifted away from those with close connections with water. The watershed's economy had become more detached from its key assets. The protected harbors and falling rivers no longer had the pull they once had. This is visible in the changes in where people lived, which was near to where they worked. In this period, populations moved away from the RI cities and towns identified as being dependent on the marine environment. At the turn of the 19th century at the peak of the maritime economy, nearly 1/2 of the state's people lived in marine-dependent cities and towns. A hundred years later at the turn of the 20th century, when the industrial economy was nearing its peak, that share had fallen to 17% (Figure 7). The center of power had shifted north, away from those whose livelihood was directly tied to a healthy watershed, to those whose livelihood was dependent on the watershed's absorptive powers.

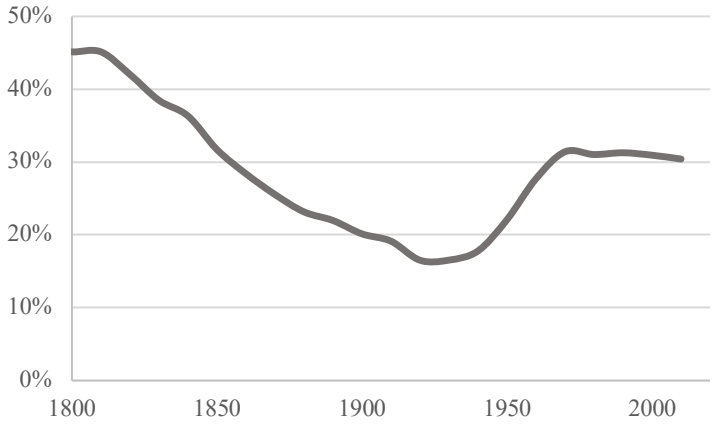

Figure 7: Share of RI's Population in Marine Dependent Cities & Towns
Source: US Census Bureau

Once again, this growth came at the expense of more rural areas. In RI, where there is population data for cities and towns, the number of communities that lost population increased from eight in the 1800-1860 period to eleven in the 1860-1920 period, with actual losses increasing five-fold. This is consistent with state data on the decline of farms in both states during this period. Farmland had fallen 41% in RI and 26% in MA between 1850 and 1920. As large as these declines were, they probably underestimate the magnitude of the decline given that an increasing share of farmland was actually woodland. In the same 70 years in both states, improved farmland fell around 60%.

There was also a darker side to this remarkable growth not adequately reflected in the traditional measures of economic success: the watershed that had sustained this growth had also been badly damaged by it. There is some evidence of the economy's adverse effect on the environment in the declining size of the shells harvested from the bay before Europeans arrived and the runoffs from the livestock industry harming its waters after the Europeans had arrived and established a vibrant mercantile economy centered in Newport. With this growth came indoor plumbing and industrial pollution that overwhelmed the watershed's absorptive powers. An early sign of this was a series of cholera epidemics in Providence. By then the city's rivers were as "filthy as any common sewer, and the stench arising from it at times pervades the whole neighborhood. . . . At any time, dogs, cats, and hogs may be seen in the water in every stage of decomposition . . . ."[24] A Public Health Commission was established to address the problem, and within twenty years a system of sewers had been constructed to disperse pollution further down the bay. In another 30 years the first sewage treatment system employing chemicals was in place at Fields Point.[25]

Figure 8: Narragansett Bay Oyster Company
Source: Providence Public Library

By the late 1800s, RI was not only number one in jewelry manufacturing, but it was also number one in oyster production (Figure 8). The brackish water in the upper bay gave the shellfish a favored flavor, which attracted outside investments to the industry. It also attracted immigrants to work in the shucking houses, many of whom were from Cape Verde and lived in the Fox Point area of Providence.[26] By the century's end there were over 60 oyster shucking houses, East Greenwich Bay was home to Scalloptown, and the watershed was experiencing the "golden age of the oyster."[27] At its peak in the 1900s, the oyster industry was the state's largest industry on land or sea, employing over a thousand people with an annual output of 1.4 million bushels of oysters, worth upwards of $4 million and occupying almost 21,000 leased acres.[28] The boom, however, would not last. In 1895 restrictions were imposed on harvesting off Fields Point and by 1910 conflicts between the industrialists and fishers ended up in court. The end was inevitable, however, as increased runoff from deforestation changed the composition of the bay and damaged the industry.[29]

While farming and the watershed's ecosystem may have been victims of the watershed's industrialization, a new industry was emerging in the watershed, one that would eventually become very important to the watershed's economy—tourism and recreation. With the growth of manufacturing came higher incomes and a shorter workweek (although those incomes were low and hours long by today's standards). The average annual earnings for manufacturing workers in 1910 were $487, which translates into $14,102 in 2016 dollars.[iii] For these earnings, they were working 289 days and 9.9 hours a day, which is a workweek of about 5.5 days.[30] By today's standards, it is hard to understand how families living on these low earnings had enough discretionary income to support a recreation and tourism industry, but people were able to do it. In large numbers, they

[iii] There is a BLS calculator for years after 192, so to get from 1900 to 1913 the data from the Minneapolis Federal Reserve Bank, https://www.minneapolisfed.org/community/teaching-aids/cpi-calculator-information/consumer-price-index-1800. These data were then converted to today's $s using the 1990 data from the U.S. Census, Historical Statistics of the United States, Colonial Times to 1970, http://www.census.gov/library/publications/1975/compendia/hist_stats_colonial-1970.html and then the CPI calculator https://data.bls.gov/cgi-bin/cpicalc.pl

boarded boats and trolleys to enjoy the amusements and shore dinner halls in Rocky Point in Warwick, Fields Point in Providence, and later Crescent Point, Boyden Heights, and Vanity Fair in Riverside (Figure 9). Further south, majestic hotels opened in Narragansett and Jamestown to serve a wealthier clientele, and further east Newport had become the "City by the Sea." Newport remained a preferred destination of those with the means to seek relief from summer heat as the Fall River Line, along with bales of cotton as cargo heading east to the mills in Fall River and bolts of cotton textiles headed to New York City, ferried the era's robber barons who were building summer "cottages" in Newport.

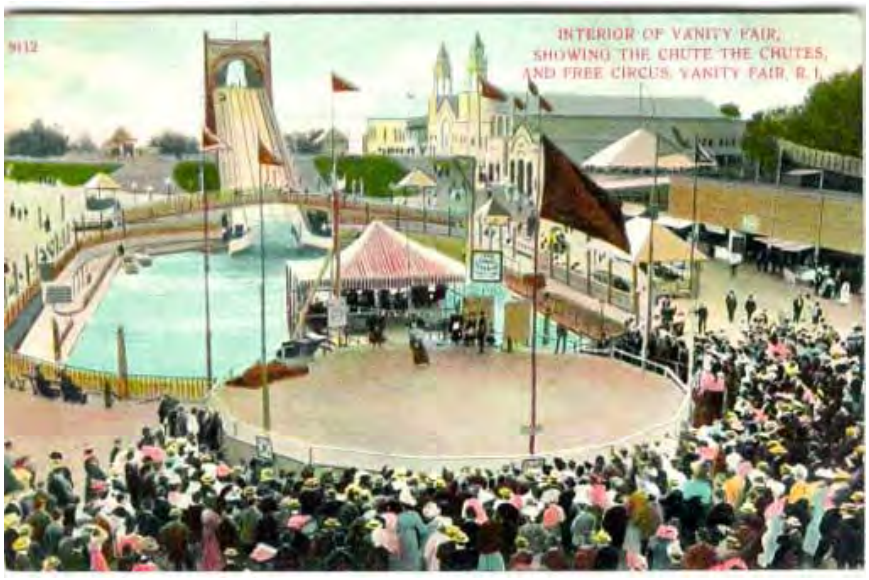

Figure 9: Vanity Fair, RI
Source: Old Post Card

The rise of tourism was not enough, however, to overcome weaknesses in the regional economy. By 1920 it was not only the oyster industry in the bay that had passed its peak, but tourism had as well. The engine of economic growth was now slowing, and while the previous transition—from mercantile to industrial economy—had been remarkable, the region now faced yet another transition period. Manufacturing was the future after Slater's mill opened in 1790, and while nowhere made the transition to an industrial economy better than the watershed, manufacturing was not its future in 1920. Demographic and technological change together with public policy shifts would greatly reduce the locational advantages upon which the watershed's firms had built their success. This time it was to a post-industrial world, and this would not be nearly as smooth as the last transition.

Post Industrial Era

Just as the watershed had been on the leading edge of the move to an industrial economy, in the 1920s it was on the leading edge of a transition to a post-industrial society. Once again, the watershed was facing uncertain times. A surge from wartime spending for WWII extended the life of many factories,

but it was only temporary. By 1950, the numbers made it very clear to the newly formed Council of Economic Advisors that is was enough of a problem to form a committee to explain the decline of New England's economy and maybe identify ways to change the trajectory. It was not a watershed problem—this was a regional problem that was simply more pronounced in the watershed.

Demographic trends were poor. Since Slater's mill opened, the center of the country had moved 600 miles west by 1920—from just outside Baltimore, MD to just outside Bloomington, IN—which left the region's factories far from emerging markets. Its supply of workers was also at risk. For 100 years, immigrants had been drawn to the region's factories in such large numbers that by 1920 more than 1/3rd of the region's population was foreign-born, nearly twice the national average. Its economy had become dependent on immigrants, but new restrictions in the National Quota Act of 1924 would reduce the supply of workers and drive up wages, which were already well above those in the south where governments imposed fewer restrictions on work and pay.

Transportation advances were unfavorable. Technological advances in transportation and communications combined with massive investments in infrastructure drove down the cost of traveling long distance. In the 19th century this brought bigger markets, but by the 20th century it was bringing more competitors. Massive infrastructure investments in rails had increased the competitive position of southern factories.

Industry mix was poor. In the 19th century the textile industry matured. With that maturity came a weakening of the forces that had bound the factories together in the watershed. The textile industry was the region's largest:[31] in 1919, more than one of every three wage earners was in the cotton and worsted goods industries. Adding in related sectors, such as knit goods and cotton lace, the share approaches one of every two. Factories were there because much of the 19th century was a period of rapid technological change in the textile industry, first in spinning and then in weaving. In new industries, or industries experiencing a rapid rate of change, there are great advantages to a clustering of firms. All industries employ a mix of skilled and unskilled workers, and in an industry's early days it depends heavily on skilled workers. They built the machinery that was often custom built for each factory, so the factories would be small because it was difficult to retrofit a factory to the new machinery, and the "life expectancy" of the new machinery was short. For this reason, supply chains were short and factories clustered together in the region's major cities that were often specialized in specific industries—Shoe City, Silver City, and Spindle City.

As the industry matured and the rate of technological change slowed, the factories grew bigger. In 1919, the average cotton goods establishment employed over 425 people, while the average for all industries was 56. For the jewelry industry, which still relied on skilled artisans, the average employment was 36. Factories also employed large numbers of women and children, many of whom lived in mill housing and shopped in mill stores (Figure 10). Shutdowns became a regular occurrence as the textile industry was again on the move, and this time it was out of the watershed. In the new environment, the decision by American Printing Company, Fall River's largest employer in its largest industry, to open a factory in Tennessee in the early 1920s before moving its operations out of Fall

River, would be duplicated by many others. And those factories are still on the move, most recently from China to Vietnam and Bangladesh. Unfortunately for the watershed, the legacy of rapid industrial growth came to an end when outsourcing of manufacturing became increasingly popular in the 1920s. As a result, employment in local factories started to decline as manufacturing jobs shifted to different countries. In 1920, fewer than 1/3rd of the nation's workers were employed in manufacturing, and in the watershed, more than half of the workers were employed in manufacturing; this rate was higher in the watershed's big industrial centers such as Fall River where more than seven of every ten workers were employed in manufacturing.[32]

Figure 10: Workers at the Globe Yarn Mills, Fall River, circa 1882
Source: Fall River Historical Society

As factories closed, population growth slowed as more people were pushed out by their inability to hang on without work while fewer were pulled in by the prospect of a job. Overall population in the watershed's cities and towns managed to increase by nearly 700,000, but in six of the eight core cities, population declined by 170,000. The big three—Providence, Worcester, and Fall River—all suffered double-digit losses. Providence lost more than 1/3rd of its population in these 50 years, as the exodus from the cities and factories had begun to accelerate.

Those leaving for jobs would now be joined by those moving to the suburbs. The investment in railroads, which rewrote where people worked and lived in the previous era, was now being followed by a massive investment in the interstate highway system that would rewrite it again. The cost of traveling would continue to fall, except where it had previously fallen most on long distance travel, it would now fall fastest on short distance travel. The centripetal forces would now be overwhelmed by the centrifugal forces and the beginning of urban sprawl (Figure 11). People were leaving the cities, but not going too far. Nearly 25% of RI's growth was in Warwick, with another 25% in Cranston and East and North Providence. In the MA portion of the watershed, the largest gains were in the areas surrounding Boston including Brockton.

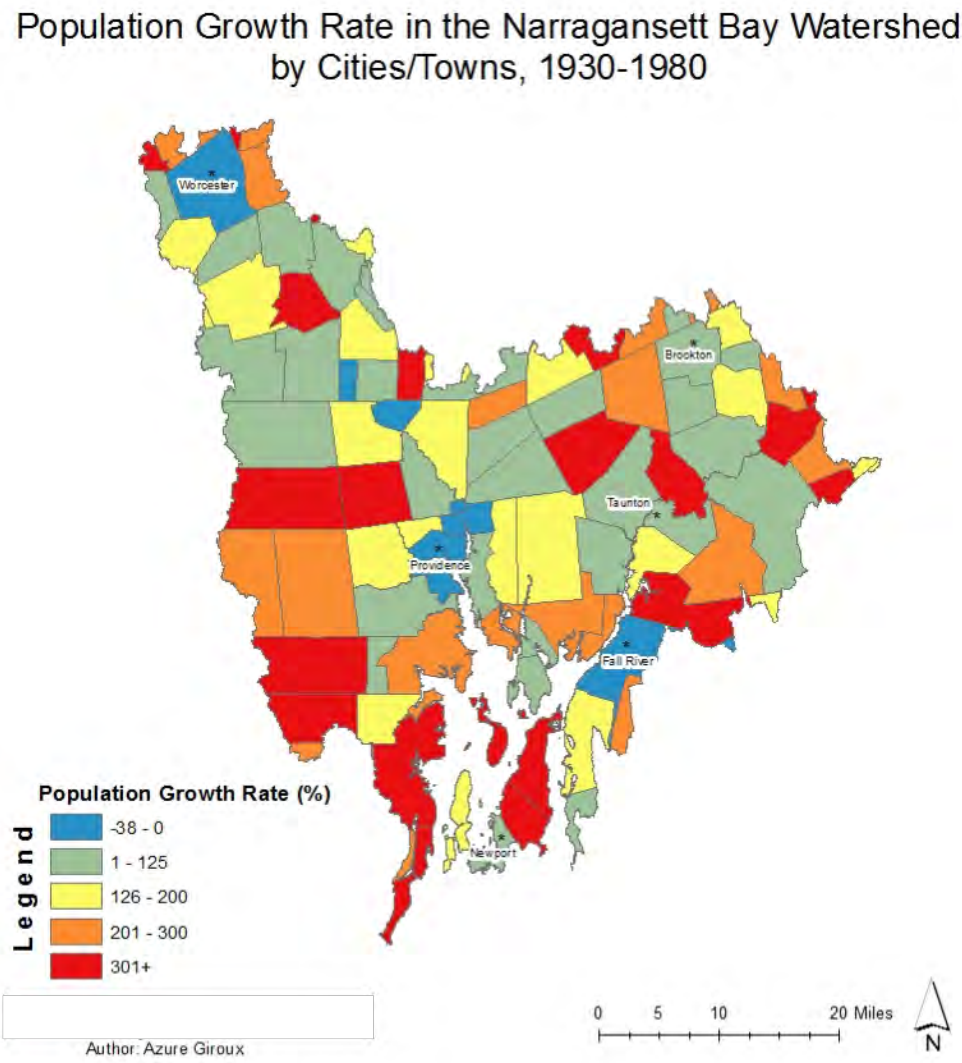

Figure 11: Population Growth Rate in the NBW by Cities/Towns, 1930-1980

There were also a few other communities in the watershed that showed exceptional growth. Middletown and Portsmouth on Aquidneck Island and North Kingstown all had growth rates that exceeded 300%, and Middletown's reached almost 600%. This reflects one of the bright spots in the local economy—the defense industry—which has a long history in the watershed. The British recognized its strategic value, which is why they occupied Newport during the Revolutionary War. Since then, state and federal governments have funded the building and rebuilding of several forts to protect Narragansett Bay. During the Civil War, the Naval Academy was temporarily moved to Newport (1861-65), and by that decade's end the Navy had established a Torpedo Station on Goat Island.

By the outbreak of WWI, the Navy had opened a recruit training station in Newport (1884), the Naval War College in Newport (1885), and a coaling station in Melville that attracted battleships to the bay,

a precursor to the arrival of the USS Massachusetts to Battleship Cove in the early 1960s. In WWI, 7,215 men were stationed in Newport and an average of 15,000 men were arriving each month for training: [33] this in a city with a population of only 30,000 in 1920. This would look small, however, during WWII as the Navy expanded its operations in Newport County where 200,000 recruits received their training during the war. Many of them lived in Quonset huts, while many others worked at the Quonset Point Naval Air Station and the Construction Battalion Center at Davisville (Seabees) that were both built then. The Torpedo Station on Goat Island that had opened in 1869, would employ more than 13,000 people at its peak during the war.

The buildup can be seen in the population growth of North Kingstown and Newport between 1940 and 1960. In these 20 years, the population in Newport and Middletown increased almost 80%. This increase was more than four times faster than overall growth in the state, while in North Kingstown it increased over 300%. These were spectacular numbers, even more impressive than manufacturing's earlier growth. Unfortunately, like the textile industry, the external environment changed and the defense sector began its decline. In 1973, Quonset Point and Davisville closed and the Navy moved its fleet from Newport to Norfolk, VA and the regional economy slowed. In the 1970s, employment growth in the region was well below the national rate—40% lower in RI and 50% lower in MA—and by the peak of the 1980 recession both states had double-digit unemployment rates. The transition to a post-industrial economy was not going nearly as smoothly as the earlier transition, and the search was on for a way to revitalize the economy (Figure 12).

In RI, the state's economic crisis deepened in the 1970s and was cited as the reason why the state's voters chose to embrace the Greenhouse Compact. This was a plan to speed up the transition and, interestingly, at the center of their plan was the recommendation to increase risk taking behaviors. This was an essential ingredient in a mix that produced the two previous economic successes. Another was identifying industries in which to invest, and at that time the list included tourism, fishing, boatbuilding, jewelry, and wholesaling. The Compact proposal failed, but other reports have followed with new lists of industries in which the state should invest. The most recent was *Rhode Island Innovates: A Competitive Strategy for the Ocean State* in 2015.[34] Citing much the same problem—an underperforming economy—another set of industries in which to invest was proposed. The industries were different, but at the center of their vision was another link to the region's past successes. Growth in the 21st century will depend on the nurturing of industry clusters, just as it did in the 19th century.

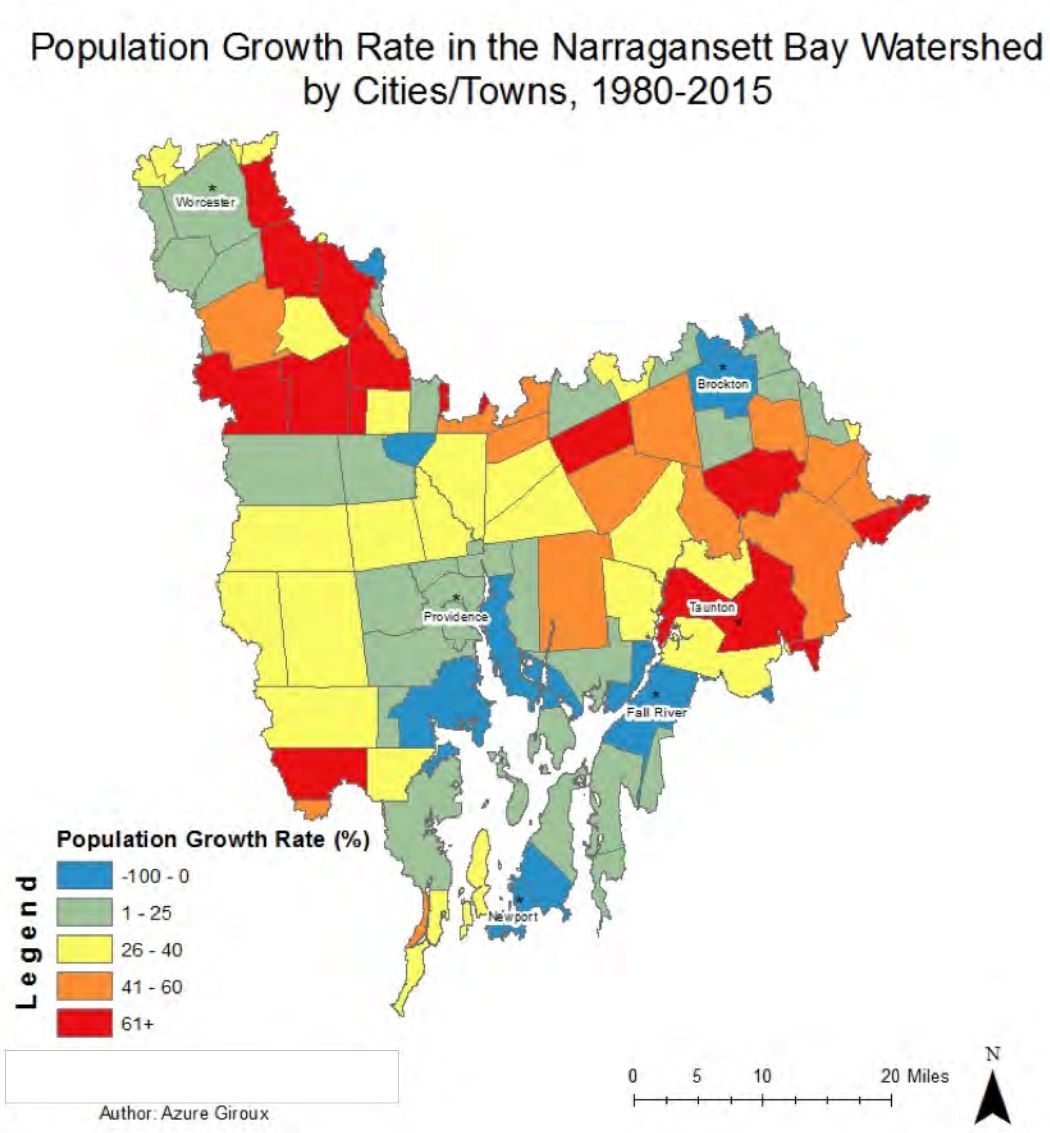

Figure 12: Population Growth Rate in the NBW by Cities/Towns, 1980-2015

In the early 1980s the world was taking notice of the "Massachusetts Miracle." Policy makers across the country and in Europe wanted to know how a declining region rediscovered economic growth. Not much of that growth filtered far down into the watershed, however, because in the state the growth industries were clustering, and they were doing so around Boston and Route 495—America's Technology Highway. This is why the northern reaches of the watershed have experienced above average growth.

The Future

There was no one in 1650 that envisioned a thriving economy centered in Newport, and there was no one a hundred years later that could have envisioned a thriving economy centered in Providence, and there is no one today who can envision the watershed's economy in 2050. As a result, it is uncertain if policy makers in the watershed will do a better job of identifying sectors than they have in the past. There is, however, an important lesson to take away from the past: the watershed has been a catalyst to eras of remarkable growth in the past and there is a chance it could do so in the future. There is no guarantee, however, because growth in the past has taken a toll on the environment and the same forces are in play today. While some of the damage has been reversed, there is reason to believe it will be more difficult to do so in the future. The environment is not unlimited. As development occurs, and retaining walls and septic systems are built, fields are paved over, and forests cut down, it will be harder to reverse the damage to the watershed and the projections for government finances suggest the government will not play the role they have played in the past.

There are, however, reasons to be optimistic. The history of growth in the watershed increases the possibility of another successful economic transition. Here are a few of the take-aways.

Comparative advantage matters. What are the strengths of the NBW? What is its comparative advantage? The watershed remains a key resource: once it was a great harbor and then it was a series of falling rivers, and both times that comparative advantage fueled remarkable growth. The watershed by itself is neither a necessary nor sufficient condition for growth, but it can play a key role in the watershed's economic future.

Being first matters. This was true when Newport's merchants helped revolutionize, and it was true when the industrialists of Providence, Worcester, and Fall River revolutionized manufacturing, and it will be true in the hypercompetitive future. The difference will be the speed at which competitors arrive to erode the monopoly profits going to those early innovators. It is hard to predict the speed of change, but it seems certain the region will be able to sustain its above average income only if there is an ample supply of entrepreneurs operating in the new "new economy." There has to be a new cluster—a set of industries on the cutting edge that employ highly paid skilled workers. The good news is some of those may exist. One is a research cluster, and at this time there is the concentration of universities that could form the nucleus of such a cluster.

A second is one that is closely related to what in the past has been called the Water Cluster and a Marine Trade Cluster.[35] These are a set of industries with strong ties to Narragansett Bay, and in 2012 the estimate was that the Marine Trade Cluster would support nearly 7,000 jobs with a payroll of over $25 million.[36] A third—and there is some overlap between this and the other two—would be a defense/technology cluster. This would be similar to the blue tech that exists in San Diego. There is a long history of defense presence in the area, and since 1970 it has shifted away from Navy personnel to private-sector high-tech firms. In 2013, it is estimated that the direct impact of the defense spending was nearly 17,500 jobs with nearly 40% of that in the private sector.[37]

Demographics matter: New England is aging rapidly, growing slowly, and diversifying quickly. This is also the case in the watershed, and while slow growth will put less pressure on the watershed's environment, it will slow economic growth. One way to reverse this is to reverse the outflow of young, college educated youth from the area. The region attracts some of the best and brightest to its institutions of higher education, but they do not often stay. This is a problem, as skilled labor is a scarce resource in the world today. If there is to be another period of great success in the watershed's future, those students will have to come for education and stay to work. The bad news is this is a very mobile group, and the region has seen what greater mobility could do to the region. The good news is that skilled, mobile college grads weigh quality of life higher in their location choices today, and the quality of life in the watershed should be enough to attract them, just as the falling waters attracted those early industrialists.

Another demographic will impact growth—a legacy of a high concentration employed in factories is a significant number of individuals with limited educational background, so success in the future will also require a number of jobs with low barriers to entry. The good news here is that the watershed can generate a number of jobs with low barriers to entry.

At this point it should be clear there is a link between the economy and the environment, one that is not always appreciated or understood. It is the goal of this report to quantify as best as possible that linkage to improve the odds that the region can realize its potential and avoid choices that would reduce those odds.

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Methodology Overview

There is a tendency for people to congregate along coasts and waterways, and the same holds true for industries; in 2014, the coastal economy contributed 84% to total U.S. Gross Domestic Product (GDP) and 82% to total U.S. employment.[1] Within these coastal states, the shore-adjacent counties comprised 37% of overall employment on only 17.5% of U.S. land area.[2] This concentration of economic activity near the water is no different in southern New England within the Narragansett Bay watershed (NBW); since the earliest days, the NBW has been the center of a robust economy.

Quantifying the link between the environment and economy, however, is quite difficult. The efforts to do this began in earnest in the 1970s, and multiple approaches have developed since this time. This report uses an approach similar to one designed by the National Ocean Economics Program's (NOEP) work "to provide policymakers with reliable and consistent data on the value of the oceans and coasts of the U.S."[3] The key difference between this report and NOEP's, however, is that NOEP focuses on oceans and this report focuses on a watershed. NOEP estimates the value of the goods and services supplied by the environment for which there are no prices or revenues—there are no markets to assign prices as estimates of their value. Recreational fishing is a prime example: there is no market to capture the value received by someone standing on the bank of Moswansicut Pond sand fishing for perch or the shore in Narragansett fishing for striped bass. Yet there is no question it is valued by the fishers. Methods exist to estimate nonmarket values such as these, and this will be the focus of the later reports.

This report provides an assessment of the economic sectors in the NBW that rely heavily on its natural capital. This is not equivalent to the value of the watershed; rather, this report captures the size of the economic activities that show up in markets. There are no markets that value the entire fishing experience, as many values in this experience are intangible and hard to capture (e.g., the emotional benefits fishers receive from partaking in the activity), but markets do exist that capture the value of fishers' purchase of a rod or reel from a sporting goods store, bait from a bait and tackle store, or the number of employees and wages earned by those employed in bed-and-breakfasts and museums catering to tourists. When estimating the market activity associated with the watershed, there are two important issues to be resolved: what measures of economic activity will be used and what activities will be included.

In terms of the measures of economic activity, there are two general approaches that are used in this report—some sections include both while others include one or the other. The first is the consumer approach, which is based on measures of expenditures of individuals on things such as the rod and reel, bait, or a round of golf. These would eventually show up in Gross State Product (GSP) supplied by the Bureau of Economic Analysis (BEA), which is the state equivalent of Gross Domestic Product (GDP). In 2015, GSP in Massachusetts (MA) and Rhode Island (RI) totaled nearly $540 billion—slightly less than the GSP of New Jersey, which has the nation's 8th largest economy. Growth in the states' GSPs since 2000 was slower than the national rate of 28%, but that was due in large part to the slower growth in population. After adjusting for population growth, GSP per capita in the two states grew faster than the national average of 11.9%: MA at 17% and RI at 13%. This is the primary measure of economic activity at the national level.[4] In some studies, estimates of GSP are found by employing simulation models.

The second approach is the industry approach, which is based on measures of the number of establishments, their revenue, value added from selling items such as bait, rods and reels, overnight accommodations, or food and drinks, the number of workers employed in those establishments, and the wages they earn. The stories based on these two approaches are similar: more sales translate into higher levels of production to fill the orders, which is picked up in higher levels of GSP. Higher production, meanwhile, leads to new establishments and/or additional workers, which generates higher wage income. The primary source of the data employed in this study is the Bureau of Labor Statistics (BLS), which is also used by the Labor Departments in both MA and RI and in most comparable studies. These employment numbers are based on employer surveys of wage and salary workers who are in jobs covered by unemployment insurance and are recorded at the location of the job and not one's home, as is the case with the population numbers. In 2015, employment in the U.S. was approximately 142 million, while in MA and RI it was 3.4 million and almost 470,000 respectively.

In this report, a combination of the two approaches is used. The numbers reported come from primary government sources, industry data, published reports, and surveys. The approach taken and the sources of data follow, and then an overview of the economy in the watershed—what industries are there and how are they performing—is included.

Measuring the Watershed's Economy

This report captures the economic value of the watershed through a number of industries, including:

1. Living Resources (commercial fishing, aquaculture, forestry, aquaculture, and agriculture)
2. Tourism and Recreation (hunting, recreational fishing, recreational boating, wildlife viewing, and beach use)
3. Ports and Marine Transportation and the Defense Sector
4. Research and Education

The above classification was chosen because it has been widely accepted and used in numerous studies of estuaries, bays, and watersheds including studies of the Economic Value of the Barnegat Bay Watershed, the Delaware Estuary Watershed, the Christina River Watershed (2013), and the Massachusetts Marine Economy. In the analysis of the Peconic Estuary System, Grigalunas and Diamantides focused on two broad groups.: the first group was sectors dependent on estuaries and related to marine waters, and the second group was sectors related to tourism and recreation.

Data sources

Because the NBW spans across parts of two states, there are no existing measures of its economy that are readily available. In this report, the data used to measure the industries in the regional economy are provided by the BLS's Quarterly Census of Employment and Wages (QCEW). The data are the same as used by the Labor Departments in both MA and RI and in most comparable studies. There are three primary measures of the economy's size: the number of government and private establishments, which is generally a single unit such as a store, a farm or a factory; the level of employment, including the number of jobs filled by both part-time and full-time workers who are covered by unemployment insurance; and annual wages, which provides a measure of the income generated in those jobs. It is important to note that in some instances, data included in the report for MA and RI may come from different sources, and due to differences in data collection and methodology, the two data sets may not be comparable. A note is made in the report when this is the case.

Regardless of the measure used, to estimate the size of the watershed economy, one needs data at high levels of industry detail and geographic detail, such as how many people are employed in marinas in Newport, RI. Unfortunately, while this is the most comprehensive data available, there are significant limitations that do not let us achieve this level of precision.

County level data: QCEW includes data with industry detail released at the county level, and county boundaries do not coincide with the watershed's boundaries. For example, only a small portion of Washington County, RI is in the watershed. Therefore, it is necessary to generate an estimate of activity in the watershed section of the county. In this report, county employment is adjusted based on the percentage of the county's population living within the watershed. This is done under the assumption that population is evenly distributed throughout the county. For this reason, county level data will be supplied along with estimates for the watershed.

Disclosure: There are instances where, for confidentiality reasons, certain data are not available even at the county level. For example, it would be ideal to know how many workers are employed in fish processing by communities, but oftentimes there are not enough firms in the communities for the government to disclose that information.

Industry classification: In this report, the NAICS classification of industries is used, and this does not always allow us to identify those activities tied to the watershed. For example, there is no way to separate out marine related businesses under "search, detection & navigation instruments" since this would include both nautical and aeronautical sectors.

Coverage: QCEW data are based on the quarterly reports of employers paying unemployment that is estimated to account for 90% of all employees. Major exclusions include proprietors and unincorporated self-employed, which can be significant in some of the watershed's industries. The primary exclusions are for the self-employed, both proprietorships and unincorporated self-employed. Nationally, self-employed estimates are about 8% of those employed, but are likely to have a bigger presence in the watershed given the seasonal nature of much work and the structure of industry in the region.[i] There are also exclusions for some farm and domestic workers and some railroad works and retired servicemen.[ii] Included in the wage statistics are actual wages plus a number of additional forms of compensation including bonuses, stock options, severance pay, profit distributions, cash value of meals and lodging, tips and gratuities.

Of the limitations, the coverage issue is the most limiting in this analysis; because the number of excluded operations can be significant, employment estimates in the report will be underestimates. Estimates of the size of the proprietorships have been generated by the Bureau of Economic Analysis, which also is based on the employer survey in BLS QCEW data. The more restrictive measure, and the one with finer industry and geographic detail, is published by the BLS. These data are based on the number of workers in jobs covered by unemployment insurance, which excludes self-employed and any proprietorships that are included in the BEA approach.

The difference in the two can be significant. In 2015, based on the BEA data, there were over 190 million people employed in the US, with 22% of those in proprietorships—about the same percentage as in MA and RI (Table 1). This share of employment in proprietorships is growing and this growth is expected to continue. Between 2000 and 2015, employment in partnerships increased 53% nationally, more than seven times as fast as in wages and salary jobs. In the two watershed states, the differential was even higher, especially in RI where all employment growth was in proprietorships. In MA, two-thirds of all new jobs were in proprietorships.

[i] At the BLS site there is a description of the characteristics of the data. https://www.bls.gov/cew/cewbultncur.htm#Comparison There are also a report on the size of the self employed https://www.bls.gov/spotlight/2016/self-employment-in-the-united-states/pdf/self-employment-in-the-united-states.pdf

[ii] A description of the QCEW data is available at https://www.bls.gov/opub/hom/cew/concepts.htm

Table 1: Total State Employment: 2015
BEA Wages & Salary and Proprietorship Employment

	US	RI	MA
BEA Employment	190,195,400	623,519	4,542,723
Wage & Salary	147,634,000	498,383	3,608,821
Proprietorships	42,561,400	125,136	933,902

Source: BEA

At the county level, there is considerable variation in the scope of proprietorships in both states. The counties in both states with the historically important core manufacturing centers have a below average share of employment in proprietorships: 18% in Providence, RI and 19% in Bristol, MA (Table 2). At the other end of the spectrum are Bristol, RI and Plymouth, MA where proprietorships account for 33% and 25% of employment.

Table 2: Total County Employment: 2015
BEA Wages & Salary and Proprietorship Employment

	Total	Wage & Salary	Proprietors
Bristol	22,895	15,265	7,630
Kent	98,401	79,017	19,384
Newport	56,495	43,485	13,010
Providence	366,821	301,649	65,172
Washington	78,907	58,967	19,940
Bristol	288,580	232,403	56,177
Norfolk	472,337	363,606	108,731
Plymouth	266,297	199,252	67,045
Worcester	446,874	355,777	91,097

Source: BEA

There is also quite a bit of variability in growth rates across the counties. In three counties in RI, growth in proprietorships outweighed employment losses in wages and salary jobs (Kent, Newport, and Providence), while in MA the share of job growth in proprietorships ranged from 87% in Bristol County to 46% in Plymouth County (Table 3).

Table 3: Total County Employment Growth: 2001-2015
BEA Wages & Salary and Proprietorship Employment

	Total Employment	Wage and Salary	Proprietors
Bristol	6.5%	0.0%	44.4%
Kent	2.8%	-3.4%	39.2%
Newport	4.1%	-1.6%	29.5%
Providence	4.6%	-1.8%	50.2%
Washington	22.7%	17.2%	42.7%
Bristol	6.7%	1.0%	39.0%
Norfolk	14.6%	5.0%	65.0%
Plymouth	18.8%	12.8%	41.0%
Worcester	9.8%	3.9%	41.0%

Source: BEA

It is also possible to identify the sectors where proprietorships are most numerous by comparing BLS and BEA employment data at the state level. The sectors in both where total employment is at least 50% higher than wage and salary employment are construction and arts and recreation. In MA, this is also the case in finance and insurance, while in RI, it is the professional, scientific, and technical services sector. The sectors in both RI and MA where there is very little difference between the two measures—where proprietorship and self-employment are small—are accommodations and food services, manufacturing, health care, and wholesale trade.

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[1] Source: Center for the Blue Economy, n.d.

[2] Source: Kildow et al., 2014.
[3] Source: Center for the Blue Economy, 2017.
[4] Source: BEA, n.d.

The Narragansett Bay Watershed Economy Project was conceived and partially supported by the Coastal Institute at the University of Rhode Island under the leadership of Dr. Emi Uchida. In addition, this project was supported, in part, under Assistance Agreement No. SE - 00A00252 awarded by the U.S. Environmental Protection Agency (EPA) to Mass Audubon. Additional project partners include the URI Graduate School of Oceanography, the URI Coastal Resources Center, the Natural Capital Project at Stanford University, and the George Perkins Marsh Institute at Clark University. The views expressed in this project are solely those of the authors. It has not been formally reviewed by EPA. Additional information is available at www.nbweconomy.org.

The Economy of the Narragansett Bay Watershed

The Narragansett Bay watershed (NBW) stretches across Massachusetts (MA) and Rhode Island (RI). The data from this report are derived from the Bureau of Economic Analysis:[1] in 2015, in these two states, 3.9 million people were employed in 274,000 establishments where they earned $252 billion in wages (Table 1). In the nine counties with land in the watershed, there were 1.5 million people employed in 111,000 establishments where they earned over $81 billion in wages. Using the same proportionality approach as in the demographic estimates, in the NBW 810,000 people were employed, earning wages totaling more than $41 billion. Of these totals, RI accounted for slightly more than half of the employment and wages in the watershed and slightly less than half of the establishments.

Table 1: MA & RI Economies in 2015

	Establishments	Employment	Wages ($1000s)
MA	237,928	3,428,020	228,622,040
RI	36,347	469,981	23,804,908
Total	274,275	3,898,001	252,426,948
MA Counties	79,444	1,082,772	58,280,387
RI Counties	31,908	459,436	23,038,690
Total Counties	111,352	1,542,208	81,319,077
MA Watershed	29,820	400,557	20,358,618
RI Watershed	27,937	409,927	20,816,458
Total Watershed	57,757	810,484	41,175,076

Source: BEA

As with population, employment is highly concentrated within the watershed. Three counties (Bristol and Worcester in MA and Providence in RI) account for 70% of employment and wages in the watershed, and about 41% are in the eight core cities. The concentration is especially high in RI, where 36% of all jobs and 40% of total wages in the RI watershed are generated in the City of Providence (Figure 1).

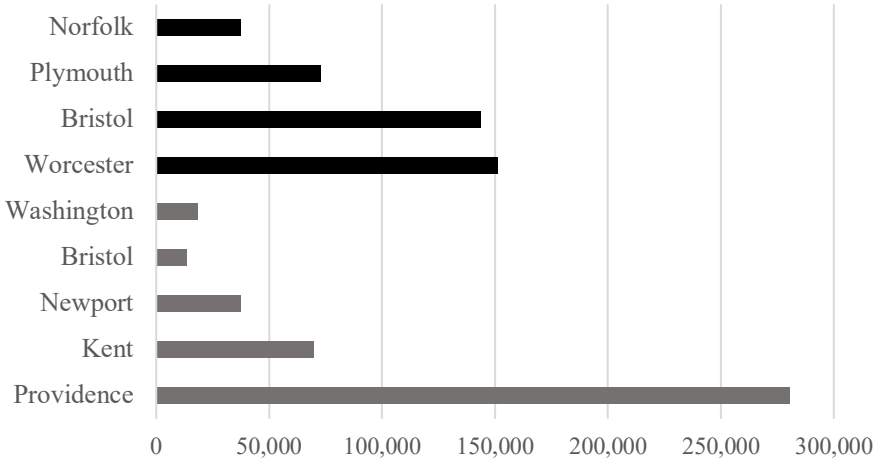

Figure 1: Employment in NBW by County: 2015
Source: BEA

It is also possible to examine the composition of the economic activity in two ways: by industries and by the private and public mix. In terms of industries, the ranking depends upon the metric. The largest employer in the NBW is health care and social assistance, which employs nearly one of every five workers. This is a remarkable change from a century ago when the watershed's core cities heavy relied on manufacturing for jobs. In 1920, 72% of Fall River's employment was in manufacturing, and in Providence and Worcester it was roughly 50%. Retail trade and accommodations and food services are two and three on the ranking by size. Manufacturing, which was once the watershed's largest activity, has fallen to fourth.

The rankings look substantially different; however, when wages are the metric, health care is still the largest (17% of all wages), while manufacturing is second largest (11%); educational services (9%) and finance and insurance (8%) come in at third and fourth (Table 2). Retail, on the other hand, slips to 6th on the ranking due to low average wages, falling behind professional and technical services which is 5th.

Table 2: Establishments, Employment, and Wages in the Regional Economy

	Establishments	Employment	Wages
Total, all industries	57,757	810,484	$41,175,076
Agriculture, forestry, fishing and hunting	355	1,718	$110,829
Mining, quarrying, and oil and gas extraction	29	290	$17,604
Utilities	134	3,243	$321,103
Construction	5,683	34,962	$2,146,565
Manufacturing	2,547	70,056	$4,377,032
Wholesale trade	2,750	27,491	$1,956,740
Retail trade	6,725	96,119	$2,822,970
Transportation and warehousing	1,328	24,175	$1,105,104

Information	904	13,887	$956,369
Finance and insurance	2,382	36,647	$3,213,313
Real estate and rental and leasing	1,647	8,767	$422,982
Professional and technical services	6,205	36,739	$2,867,071
Management of companies and enterprises	361	18,315	$2,308,820
Administrative and waste services	3,331	40,965	$1,446,047
Educational services	974	68,624	$3,635,211
Health care and social assistance	10,659	152,643	$7,152,584
Arts, entertainment, and recreation	930	15,003	$416,930
Accommodation and food services	4,652	76,490	$1,398,687
Other services, except public administration	5,226	29,690	$902,041
Public administration	944	34,261	$2,415,824

Source: BEA

These averages hide a substantial variation across counties, and there is some evidence of specialization between the two states. RI has above average shares of employment in finance and insurance, management of companies and enterprises, and public administration. All of these industries have above average earnings, and in accommodations and food services and arts, entertainment, and recreation that have lower than average earnings. MA, meanwhile, has above average shares in wholesale trade, professional and technical services, and education, which have higher than average earnings, and in retail and agriculture with lower than average earnings.

More specifically:

1. Health care and social assistance is highly concentrated in the counties with the largest cities. Nearly one of every four workers in the industry are in Providence, Worcester, and Bristol Counties.
2. Accommodations and food services are overrepresented in RI, which reflects the importance of tourism in the state. In Newport County, a major tourist destination, nearly 18% of the county's employment is in accommodations, while in the watershed it is 8.7%. One indicator of the importance of the industry to Newport is the fact that 5,000+ jobs are in Newport County because of the above average concentration of employment in the county. This represents nearly one of every seven jobs in the county.
3. Construction is overrepresented in MA, which is likely due to the more rapid demographic and economic growth in the MA portion of the watershed.
4. Retail is overrepresented in MA. The high concentration of retail in the state is likely a reflection of the malls in Seekonk located close to Providence. In RI, the malls in Kent County are reflected in more than one of every seven jobs in retail.
5. Agriculture, forestry, fishing, and hunting are overrepresented in MA. Bristol County has more than 50% of the watershed's employment in the industry.
6. Newport County's robust tourism business is reflected in the county's above average share of jobs in the retail trade, accommodations and food services, and arts, entertainment and

recreation, services sectors. These three sectors account for nearly 1/3rd of the county's employment, but only 1/4th of watershed employment.

7. Providence County remains the center of the region's economy with close to 50% of all watershed jobs in finance and insurance, management of companies, and administrative services. It is also a political and educational center with a concentration of universities in the city. Nearly 4% of employment in educational services and public administration are in Providence County.

The mix of public-private industry also varies considerably across the watershed (Figure 2). The private sector generates about seven of every eight jobs in the watershed, ranging from 90% in Kent County to 81% in Newport. The Newport County figures represent its big defense presence, both private and public. Nearly 25% of the federal government's watershed employment is in Newport County, where nearly one of every eight workers is a federal government employee. In the watershed as a whole, this ratio drops to less than one of 50. Another indicator of the defense sector's presence is the high concentration of employment in professional and technical service in Newport County (for more information on this, please see the Defense section of this report). Nearly 14% of employment is in this sector in Newport, while in the watershed the figure is less than 5%. Another indicator of the presence of a large defense structure and its outsized impact on the economy is the fact that 73% of the civilian employees at Naval Undersea Warfare Center (NUWC) in Newport are classified as STEM (science, technology, engineering, and math) occupations that have an average annual wage 66% higher than the state average.[2]

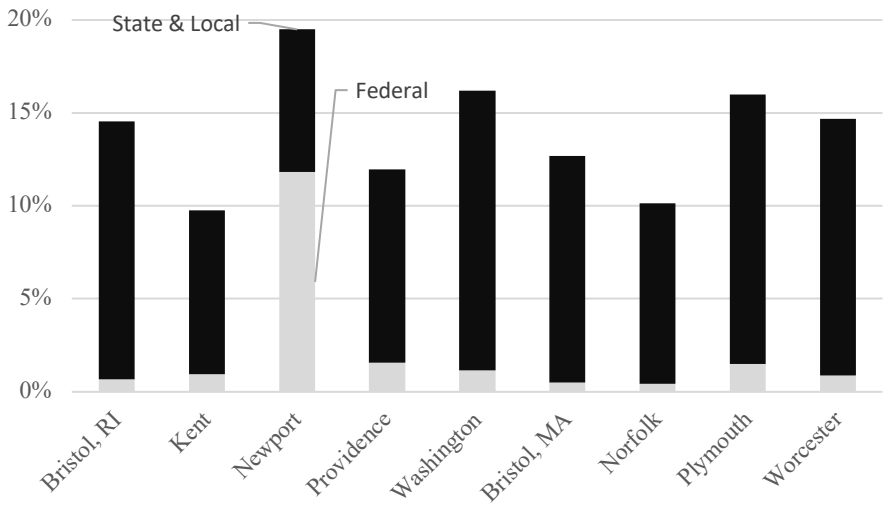

Figure 2: Government Share of Employment: 2015

Across the watershed, there is a considerable variation in the average size of establishments and in wages earned (Figure 3). Once again, the core cities that are hubs of these industries are different, and in this case the average size of establishments in the core cities are above watershed

averages. The largest difference is in RI where the average size is 30% above the watershed average, and within RI it is the largest in the City of Providence. There are some outliers also, such as Hopkinton, MA. This is a relatively small town with only 517 establishments. One of those is EMC, which has an operation there with between 5,000 and 10,000 jobs, so the average firm size is uncharacteristically high.

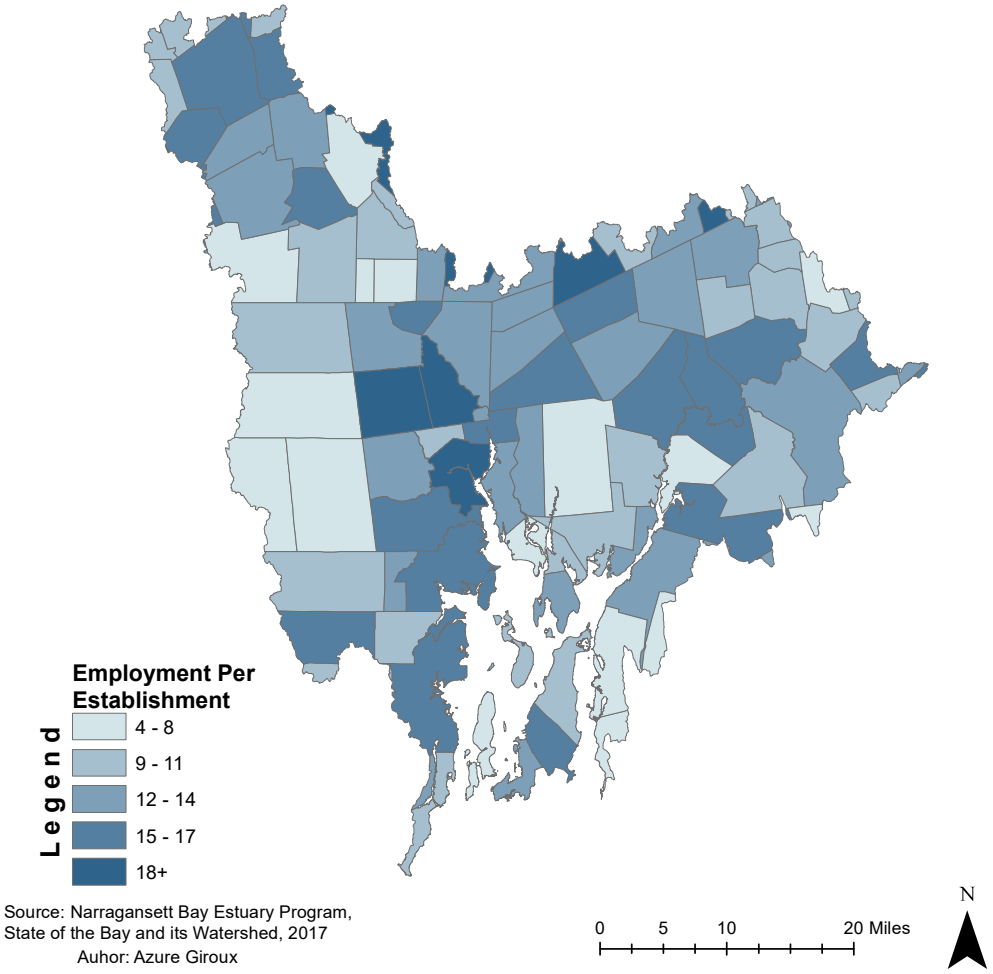

Figure 3: Employment per Establishment in the Narragansett Bay Watershed Regional Economy by Cities/Towns

There are also substantial differences in average wages that reflect a combination of regional differences in the composition of employment and in local pay rates (Figure 4). This composition varies because of substantial differences in wages across industries, which can be seen in the wages per employee available at the county level. Average wages per worker in the watershed is $50,800, with accommodations and food service coming in a distant last in terms of average earnings at nearly $18,700. Arts, entertainment, and recreation at nearly $28,000 and retail trade at slightly more than $29,000 are the only others averaging less than $30,000. In management of companies and enterprises, the sector's share of wages is more than twice the 2.2% share of employment because the average earnings of employees are over $126,000.

At the community level, there are nine communities in MA with average wages below $37,000, and four of those are in Bristol County. In RI, there are eight of these communities spread across the state, with no concentration in any one area. At the other end of the wage distribution, there are three communities in RI and seven in MA where average wages exceed $67,000. In MA, these communities were concentrated near Route 495 where six were located, while in RI the highest wages were in West Greenwich, Smithfield, and Woonsocket.

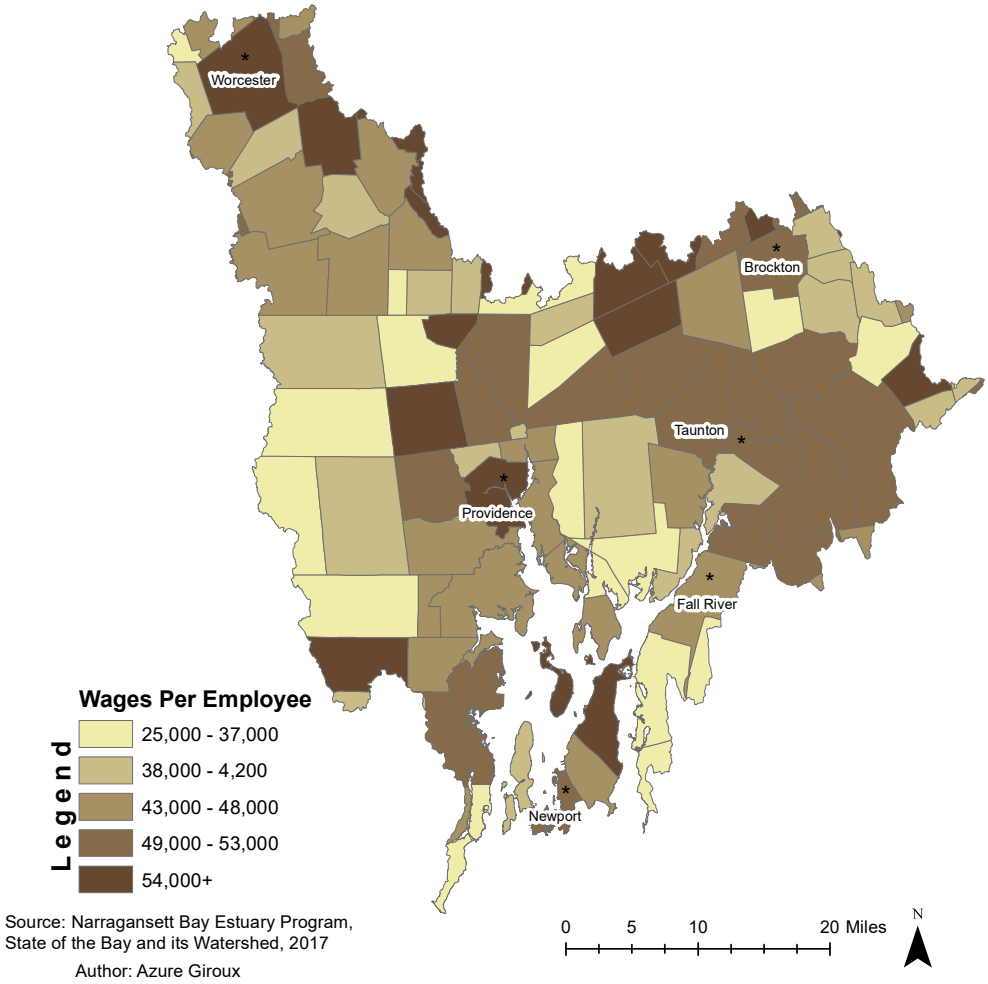

Figure 4: Wages per Employee in the Narragansett Bay Watershed Regional Economy by Cities/Towns

Finally, there is also a significant difference in growth between the two states (Figure 5). Between 2002 and 2015, employment in the watershed increased by 10,100 as a result of employment gains in MA, offsetting the losses in RI. In both states, employment losses were spread widely across the watershed's communities, with 22 communities in MA and 12 in RI experiencing employment losses. The losses were biggest in the core cities. RI's four core cities lost nearly 11,000 jobs, with half of those losses in Pawtucket and another 40% in Providence. In MA, there was virtually no

change in employment in the core cities, with losses in Fall River and Taunton offset by gains in Brockton and Worcester. The largest gains, meanwhile, were in Washington County, RI and Plymouth County, MA where employment increased 21% and 12%, respectively.

In both states, employment growth has been slowed by declines in federal government employment, although the declines were far sharper in MA. More than 80% of the federal losses were in Norfolk and Plymouth, and all of the watershed counties in MA experienced job losses. In RI losses in Bristol and Providence offset gains in Newport, Washington, and Kent.

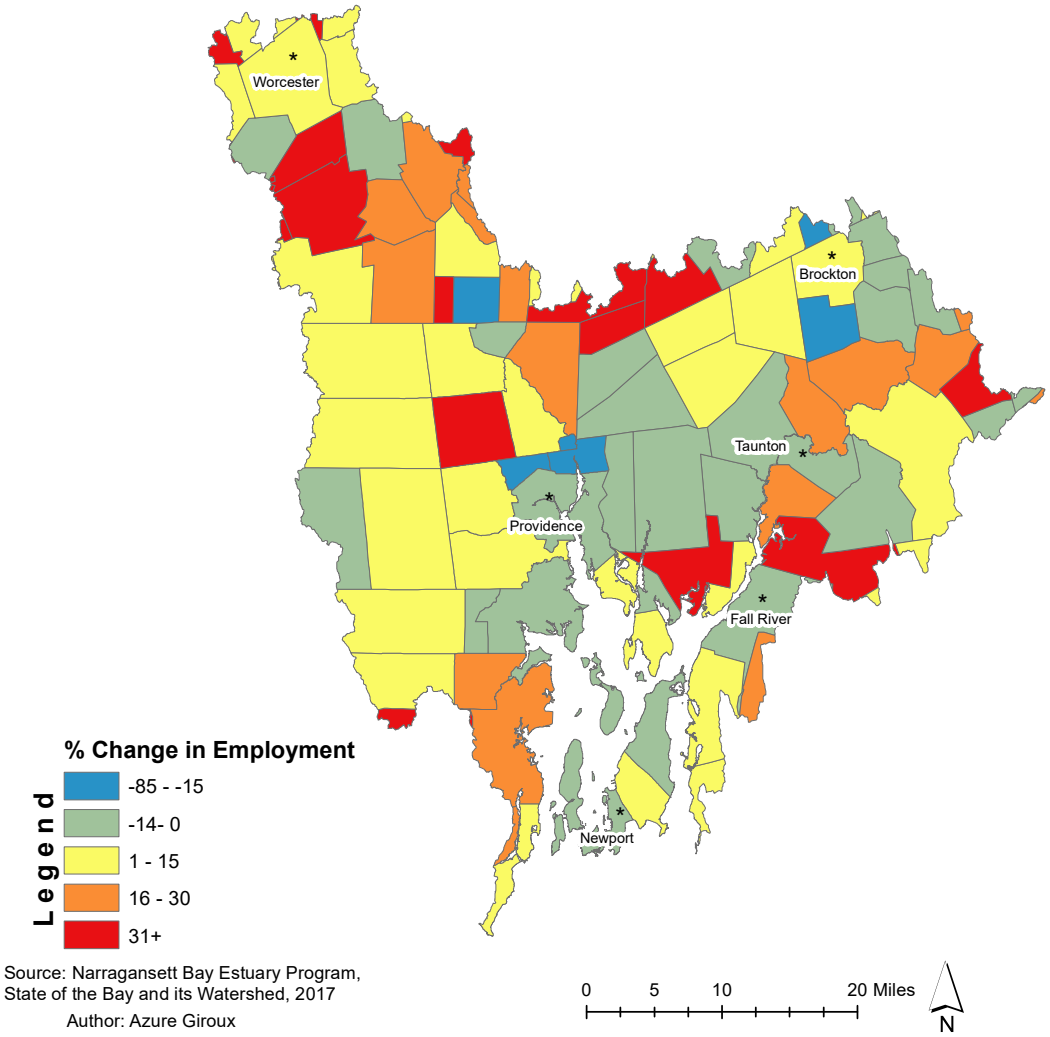

Figure 5: Percent Change in Employment in the Narragansett Bay Watershed Regional Economy by Cities/Towns

The watershed's economy, like its population, is diverse, and is growing slowly. Economic activity also remains highly concentrated in the core industrial cities where manufacturing is a declining sector.

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[1] Source: BEA, n.d.
[2] Source: Tebaldi, 2014.

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NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Agriculture Overview

Given the loamy soil and temperate climate, lands in the Narragansett Bay watershed (NBW) have a long history of being inhabited and cleared for agricultural production and trade, dating back to settlement of native tribes. During early agricultural times, there were fewer farms, but the average farm size was large, covering 80-100 acres.[1] Over time, however, the agricultural industry met challenges due to industrialization and competition from large-scale farms in the Western U.S. These factors led to a decrease in farm numbers and size, as farmers left their businesses to move to the West or work in factories.[2]

Despite past challenges, modern-day agriculture is experiencing a revival. This is in part due to the "go local" and farmers' market movements. The number of farms in Rhode Island (RI) and Massachusetts (MA) has been growing since 1992 and has strong potential for continued growth.[3] For example, in 2012, nearly 2,000 farms employed over 4,400 individuals in the NBW. These farms generated a total annual market value of $121 million (in 2016 dollars).[4] However, due to evidence provided by an RI agricultural economic impact study, these should be considered significant underestimates.[5] These underestimates are due to perceived inaccuracies in Federal Government figures, as it is difficult for a statistical example to be representative of the state as a whole.

History

Throughout history, the growing-conducive climate and soil of the NBW have made it an ideal agricultural zone. Native tribes, such as the Algonquins, Narragansetts, and Wampanoags, would burn forest underbrush to clear land for farming. In 1524, Italian explorer Giovanni da Verrazzano entered Narragansett Bay, stating to King Francis that the area was "suitable to every kind of cultivation—grain, wine, or oil."[6] In the Massachusetts Bay Company of 1629, the Puritans were primarily agricultural people with most inhabitants living in villages and on their privately-owned fields. In addition to farming for sustenance, industrial agriculture has also been prevalent in the NBW for centuries. Agriculture for business dates to the 17th century when Roger Williams discovered the fertile land with a lack of predators and ideal grazing pastures on Prudence, Patience, and Hog Islands. These characteristics made RI the most important producer of livestock in New England by 1661 and helped power the early, rapid growth of Newport.[7]

By the 18th century, agricultural businesses in the NBW fell upon hard times due to the dominating merchant and industrial economies and the agricultural states of the West making it hard to compete on a large scale.[8] In response to this, starting in 1770, NBW agriculture changed from extensive—small inputs (time, materials, manure/soil enhancers) relative to land area—to intensive—large inputs relative to land area—and specialized farming practices.[9] This switch diminished acreage of farms, but the decline in land area was offset by efficiency gains with crops producing higher net income per acre.[10]

The same trend of increasing efficiency continued into the 20th century in the RI portion of the watershed. During this time, Irish potatoes, corn for silage, apples, and clovers and timothy for hay were the most widely produced agricultural goods. In 1920 in RI, for example, 2,987 farms produced over 293,000 bushels of Irish potatoes, and in 1930 1,044 apple orchards produced 216,226 bushels of apples, 509 farms produced over 42,600 tons of corn for silage, and 789 farms produced 18,450 tons of clover and timothy for hay.[11] Some of these goods experienced a decline in production over the decades; for example, in 1969, the number of farms producing apples dropped to 29, which produced almost 90,000 bushels on 23,000 acres. The same applies to hay production, which dropped to 137 farms producing almost 8,000 tons on 4,000 acres. Other goods, such as corn and Irish potatoes, experienced increased output despite dwindling acreage due to the aforementioned increase in efficiency. For example, the number of farms producing Irish potatoes dropped to 54 in 1969, although they produced 1.7 million bushels on 4,500 acres. Similarly, 99 farms produced 50,825 tons of corn for silage on just over 3,000 acres of land.[12] Shortly after this, in the 1970s and 80s, when potato farming was declining (by 1992, 19 farms produced 625,000 bushels of potatoes on 1,300 acres), nursery and greenhouse related activities, such as sod production, became more prominent, especially as empty potato and dairy farms were converted to sod farms.[13] To this day, potato and apple production remains low, while as of 2012, hay, sod, corn for silage, and nursery crops were the top acreage crops in RI.[14] This increase in sod production and nursey and greenhouse products also goes hand-in-hand with increasing suburbanization—a 1972 study found that 55% of the state's nurseries were established between 1950 and 1969. Suburbanization is tied with a shift in agricultural products—while production of crops such as potatoes may have declined, the production of other agricultural products, such as flowers and plants produced in greenhouses, rose with the spread of suburbanization as these new settlements required manicured lawns and controlled vegetation.[15]

Along with this suburbanization, however, came actions to protect and aid agricultural lands in the NBW, including the Farm, Forest and Open Space Act (RI), the Farmland Preservation Program (RI), Right to Farm Acts (RI, MA), Agricultural Preservation Restrictions (MA), and Farm Viability Enhancement Program (MA).[16] These acts encouraged the preservation of farm land through incentives such as tax breaks. Since the various acts and programs were enacted, agriculture in the NBW has experienced a revival after decades of decline (Table 1). In 2012, there were nearly 4,600 farms in the NBW, an increase of 44% from the 3,191 farms in 1997. Despite this increase, farm acreage in the NBW has remained essentially constant during this time period, changing from 279,116 acres to 279,746 acres.[17]

Table 1: Percentage Changes in Farm Numbers and Size in RI and MA, 1950-2012

	1950-1997	1997-2012
	MA	
Number of Farms	-79%	+36%
Acreage in Farms	-65%	-6%
Average Size Farms	+36%	-41%
	RI	
Number of Farms	-72%	+69%
Acreage in Farms	-71%	+26%
Average Size Farms	+2%	-25%

Source: USDA, 1950, 1997, 2012 Census of Agriculture

Today, not only is the agricultural sector in the NBW surviving, it is thriving. Across towns and cities within the watershed, there have been increases in farmers' markets, community supported agriculture (CSA) programs, and farm stands. These increases can in part be attributed to the larger farmers' market and "go local" movements that have been gaining in popularity in recent years.[18] The desire to eat healthier is another possible reason for the increase in local farmers' markets. Within the NBW, 59.7% of adults in MA and 62.7% of adults in RI are overweight/obese, and one way to battle this statistic is to eat more natural, fresh, and local foods.[19] With the concept of eating food grown locally catching on, there must be enough supply to meet demand.

Agriculturists in the NBW have become more innovative and have started to capitalize on the increasing demand for local agricultural products. To address the issue of short growing seasons and lack of storage crops, several NBW growers are participating in a USDA-funded pilot to test high tunnels, a non-fossil fuel-based approach to winter food.[20] In addition, within the watershed there exist many programs that connect and benefit farmers, communities, and shoppers in the region. These include a local food cooperative, farmers' market both online and in person, and farms offering CSA shares.[21] [22] This local mentality paired with tremendous positive energy behind the movement has positioned the watershed as a national leader in food-planning efforts concerning local food and agriculture. Given these factors, it is an area well positioned for growth and innovation.[23]

Data Sources and Limitations

Estimates of the economic impact of agriculture within the NBW include sales, number of farms, and employment. These data are derived from local studies and national studies at the state and county level, including the United States Department of Agriculture (USDA) Census, the Bureau of Economic Analysis (BEA), and the Economic Impact of Rhode Island Plant-Based Industries and

Agriculture. The USDA Census contains data on total number of farms, acreage of farms, and market value of agricultural products sold between 1992 and 2012. The BEA data provided information on employment on farms, including proprietors, between 2001 and 2015. Finally, the RI Economic Impact study provided data on the overall value of RI agriculture in 2012, including sales and employment.

To estimate the agricultural economic impact value within the NBW using published data at the county level, county figures for 2012 were adjusted by the share of the land area within the watershed.[i] For example, nearly 72% of the land in Bristol County (MA) is located within the NBW. Therefore, the USDA estimate of 717 farms in the county translates into 513 farms in the watershed portion of Bristol County (for a map of the watershed, please reference the "Geography" section).

However, due to conclusive evidence provided by the RI Economic Impact study, these should be considered significant underestimates. These underestimates are due to perceived inaccuracies in Federal Government figures, as it is difficult for a statistical example to be representative of the state as a whole. In addition, underreporting due to proprietorship can also be a reason for underestimates in the agricultural industry.

For additional information on the methodology employed in this report, please reference the "Methodology" section.

Current Status and Trends

A good indicator of the success and economic impact of the agricultural industry in the NBW is examining recent growth. Over the last two decades, the number of farms has increased in all watershed counties. Between 1997 and 2012, total number of farms in the NBW counties increased by 44% with changes varying by county (Figure 1).[24]

To understand the large economic impact of agriculture in the NBW today, the market value of agricultural products sold, number of farms, and total acreage of farms are estimated (Table 2). Based on previously stated assumptions, the lower-bound estimated total annual market value of agricultural products in 2012 was $121 million (in 2016 dollars). Of these sales, 83% of the sales were in crops. Agricultural sales took place on nearly 2,000 farms in the NBW, totaling nearly 85,000 acres. In RI, Providence County has the highest number of farms in addition to the highest market value. In MA, Bristol County has the highest number of farms, yet Plymouth County has the highest total market value of agricultural sales. [25] Plymouth County is home to cranberry production with 2,990 acres of cranberry bog in the Taunton River Basin. In 2017, the gate value of cranberry production in this area was approximately $13.8 million.

[i] In Rhode Island, results are: Bristol (100%), Kent (74.67%), Newport (82.37%), Providence (95.69%), and Washington (16.48%). In MA, results are: Bristol (71.55%), Norfolk (18.88%), Plymouth (36.34%), and Worcester (20.30%). Middlesex is excluded due to being <1% within the watershed.

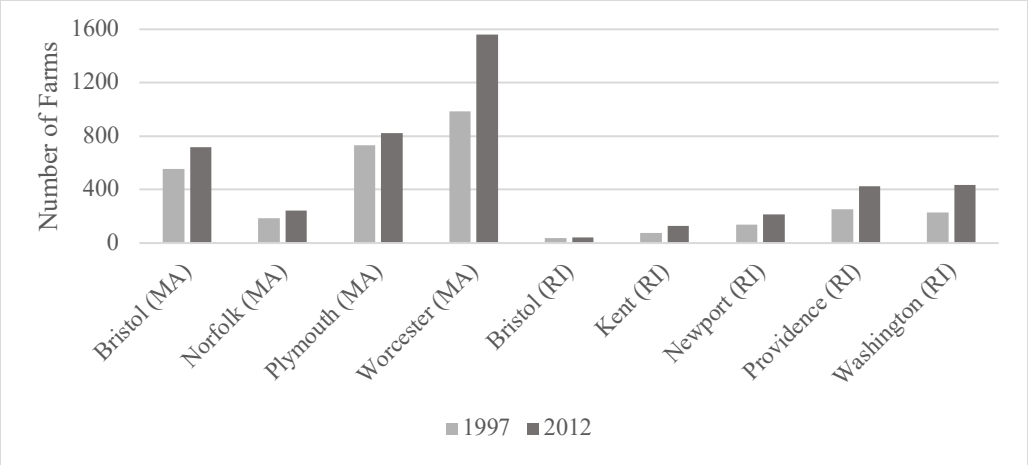

Figure 1: Growth in Number of NBW Farms by County, 1997-2012
Source: USDA, 1997 & 2012 Census of Agriculture

Table 2: Estimated Agricultural Impact in the NBW by County (2012) (in 2016 dollars)

County	Number of Farms	Land (Acres)	Market Value of Sales ($1000s)	Crops ($1000s)	Livestock ($1000s)
			RI		
Bristol	42	(D)	$2,790	$2,244	$546
Kent	94	(D)	$3,398	$2,730	$667
Newport	176	9,521	$12,596	$10,464	$2,132
Providence	407	(D)	$14,081	$10,955	$3,125
Washington	72	4,501	$4,121	$3,485	$637
Total, RI	791	14,022	$36,986	$29,878	$7,107
			MA		
Bristol	513	24,949	$28,163	$22,361	$5,803
Norfolk	46	1,784	$2,467	$1,870	$597
Plymouth	300	23,271	$41,056	$37,861	$3,195
Worcester	317	20,666	$12,195	$8,396	$3,798
Total, MA	1,176	70,670	$83,881	$70,488	$13,393
Total, All	**1,967**	**84,692**	**$120,867**	**$100,366**	**$20,500**

Note: (D) Data withheld to avoid disclosing data for individual farms.
Note: Counties are scaled by the ratio of watershed area to county land area.
Source: USDA, 2012 Census of Agriculture

Farming employment is also an important aspect to investigate when estimating the economic impact of the agricultural industry. In the NBW, employment on farms, including proprietors, is a small percentage of overall employment. Despite the small percentage of total employment, farms still employed over 4,400 individuals in the NBW in 2015 (Table 3).[26] Of this number, farm proprietor employment totaled over 1,700, nearly 40% of all agricultural employment. This is substantially

higher than other economic sectors and demonstrates the large amount of self-employed, small farms in the watershed. In addition, the high number of farm proprietor employment in part reflects an undercount of employment in the agricultural sector and the low costs of entry. In RI, Providence County has the highest number of total agricultural employment. In MA, Bristol County has the highest number of total agricultural employment .[27]

Table 3: Estimated Agricultural Employment in the NBW by County (2015)

County	Farm Proprietors Employment	Farm Employment
	RI	
Bristol	32	34
Kent	82	103
Newport	150	290
Providence	372	511
Washington	63	106
Total, RI	699	1,044
	MA	
Bristol	473	778
Norfolk	33	76
Plymouth	229	379
Worcester	292	398
Total, MA	1,027	1,631
Total, All	**1,726**	**2,675**

Note: Counties are scaled by the ratio of watershed area to county land area.
Source: BEA

The recent expansion of the agricultural sector in the NBW can be further witnessed through employment growth. Between 2001 and 2015, farming employment in RI grew three times faster than overall employment growth in the state (Figure 2). In the MA portion of the watershed, double-digit declines in Bristol and Norfolk counties offset large gains in Worcester county. This amounts to a net decline of 1% in farm employment.

As a complement and counterpoint to the USDA Census and BEA, RI conducted its own original study in 2015 estimating the overall value of RI agriculture in 2012.[28] This report gave conclusive evidence of severe underestimation of the economic impact of the agricultural sector in RI, given that the 2012 census uses lower-bound estimates while the 2015 report uses mean estimates, making it a more accurate estimation of the impact of agriculture in the state. This report estimated that agricultural sales in RI reached $239 million and that the agriculture sector accounted for over 2,500 jobs plus an additional 2,000 jobs held by farm owners, operators, and their family members for a total of over 4,500 jobs. These estimates were valued at four times the USDA's estimates for output

and 2.6 times the USDA's calculations for the number of jobs.[29] [ii] If the same underestimation assumptions are applied to the portions of RI and MA within the NBW, the estimated agricultural market value of sales would be nearly $142 million in RI and over $321 million in MA.

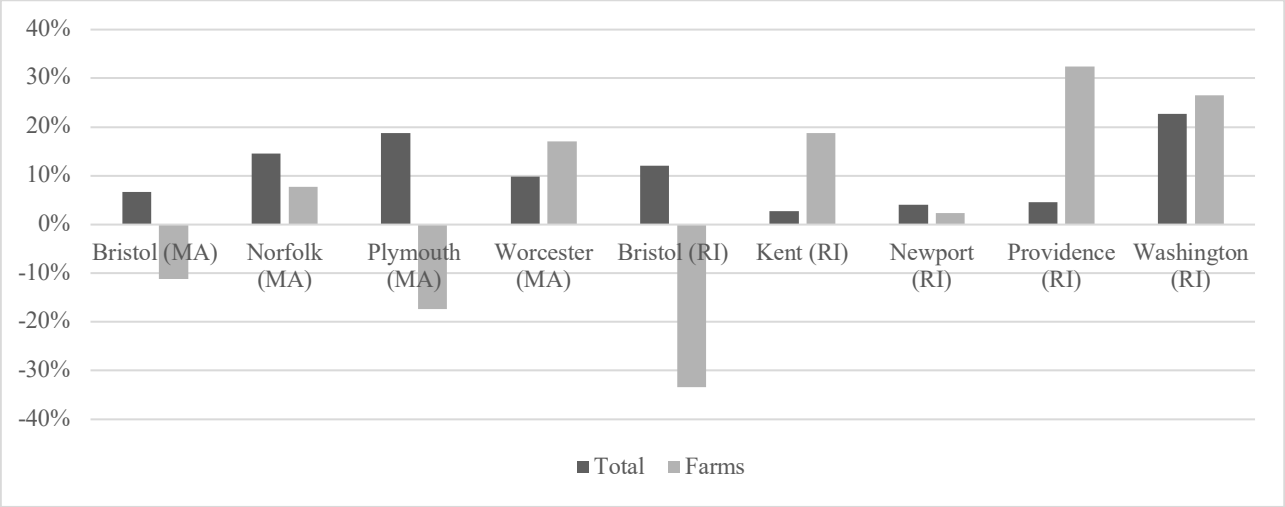

Figure 2: Total and Farm Employment Growth in NBW Counties, 2001-2015
Source: BEA

In terms of subsectors, greenhouse, bursary, and floriculture production is the largest subsector, generating an estimated $110.1 million in sales and 1,251 jobs. This is followed by crop production ($63.1 million, 776 jobs), animal production ($44.1 million, 336 jobs), grape vineyards ($18.5 million, 65 jobs), and aquaculture ($3.0 million, 105 jobs; for more information specifically on aquaculture, please reference the "Aquaculture" section of this report).

Future Threats and Opportunities

Land use | Temperature | Precipitation

As population in the NBW increases, land use patterns change. Although population growth has historically occurred in urban areas, recent trends show signs of settling in previously underdeveloped areas away from urban centers ("suburbanization"). This expansion and development decreases the amount of natural land and, along with it, the amount of land available for agriculture. For example, Mass Audubon estimated that between 1999 and 2005, about 10,000 acres of agricultural land in MA were developed for human use. This trend goes hand in hand with the 8.5% increase in urban land in the NBW from 2001 to 2011, up to approximately 380,000 acres, or 35% of total land coverage.[30] For example, cranberry farming (a significant portion of agricultural activity in the MA portion of the

[ii] The USDA estimate of 1,743 jobs for RI contains proprietors and other employees. For purposes of comparison, the 2,000 jobs of proprietors/family members were added to the RI state-level estimate of 2,563 jobs, totaling 4,563 jobs. Although USDA figures are not exactly comparable to the state-level study figures, they provide some insight into the discrepancies and underestimation of the USDA report.

watershed) is experiencing considerable development pressure. Furthermore, a recent challenge facing farmland is the placement of renewable energy projects. In the past few years in RI, the government has recognized the importance of balancing the need for renewable energy and preserving farmland; it is becoming increasingly lucrative for farmers to place renewable projects, such as wind turbines and solar fields, on their land to help mitigate farming expenses and increase income. In 2017, the RI General Assembly amended the Farm, Forest, Open Space Land program, which provides tax incentives to preserve these lands, to allow participants to continue claiming tax exemptions if the total acreage of the land is less than 20% renewables.[31] Additionally, in July 2018, RI Governor Raimondo announced a new initiative that incentivizes construction of renewable projects on brownfields, carports, and rooftops as a way to protect green space, such as farmland, from being developed for these renewable energy projects.[32]

Along with these potential threats to available agricultural land, however, comes the opportunity for increased agricultural activity through changing climate patterns. From 1960 to 2015, the air temperature in the NBW increased by 2.5-3° F. This rate is expected to accelerate in coming years with a predicted 5 to 10° F increase within the next 100 years; a 7° F increase most likely. This average increase in temperature would leave Rhode Island with a climate similar to that of modern-day South Carolina or Georgia.[33] Furthermore, accompanying this warmer weather will be an overall increase in precipitation. RI and MA currently receive approximately 40 inches of precipitation per year and this is predicted to increase by one to three inches in the future. Furthermore, there will be a decrease in snowfall, an increase in rain during winter months, and the potential for drought in summer months.[34]

As stated above, this change in weather and precipitation patterns provides the opportunity for agriculture similar to that of South Carolina, which grows tobacco, tomatoes, cotton, corn, soybeans, melons, hay, peanuts; in 2017 alone, agriculture contributed nearly $1.3 billion to the state's economy. However, it is important to note that aside from climate, South Carolina has soils that are conducive to the growth of these agricultural products and their viability on soil in the NBW may not be as productive.[35]

Overall, although population growth and urban sprawl pose threats to agricultural land, proper management can help protect and maintain this land and the newfound opportunities that come with it as a result of climate change. Changes in climate and precipitation will also present new opportunities and potential shifts in the agricultural sector within the NBW.

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[8] Source: Pastore, 2014.
[9] Source: Jones, 1991.
[10] Source: Sproul & Elsner, 2013.
[11] Sources: USDA 1920 Census of Agriculture, 1922; USDA 1930 Census of Agriculture, 1932
[12] Source: USDA 1969 Census of Agriculture, 1972
[13] Sources: USDA 1992 Census of Agriculture, 1994; Sproul & Elsner, 2013
[14] Source: USDA 2012 Census of Agriculture, 2014
[15] Source: Payne, n.d.
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[19] Source: KFF, 2015.
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[30] Source: NBEP "Land Use," 2017
[31] Source: Faulkner, 2018.
[32] Source: Office of Energy Resources, 2018.
[33] Source: NBEP "Temperature," 2017
[34] Source: NBEP "Precipitation," 2017
[35] Source: NASS USDA, 2017.

Appendix:

Table A1: Growth in Number of MA and RI Farms in NBW Counties, 1992-2012

	Bristol	Kent	Newport	Providence	Washington	Bristol	Norfolk	Plymouth	Worcester
Farms, 1992	27	70	120	232	200	523	186	668	997
Farms, 2012	42	126	214	425	436	717	245	825	1560

Source: USDA, 1992 & 2012 Census of Agriculture

Table A2: Agricultural Impact in MA & RI NBW Counties, 2012

County	Number of Farms	Land (Acres)	Market Value of Sales ($1000s)	Crops ($1000s)	Livestock ($1000s)
			RI		
Bristol	42	(D)	$2,669	$2,147	$522
Kent	126	(D)	$4,353	$3,498	$855
Newport	214	11,559	$14,630	$12,153	$2,477
Providence	425	(D)	$14,079	$10,954	$3,125
Washington	436	27,305	$23,921	$20,229	$3,692
Total, RI	1,243	69,589	$59,652	$48,981	$10,671
			MA		
Bristol	717	34,869	$37,658	$29,899	$7,759
Norfolk	245	9,448	$12,498	$9,473	$3,025
Plymouth	825	64,032	$108,083	$99,671	$8,412
Worcester	1,560	101,808	$57,478	$39,575	$17,903
Total, MA	3,347	210,157	$215,717	$178,618	$37,099
Total, All	**4,590**	**279,746**	**$275,369**	**$227,599**	**$47,770**

(D) Data withheld to avoid disclosing data for individual farms.
Source: USDA NASS, 2012

Table A3: Agricultural Employment in MA & RI NBW Counties, 2015

County	Farm Proprietors Employment	Farm Employment
	RI	
Bristol	32	34
Kent	110	139
Newport	183	354
Providence	389	535
Washington	380	645
Total, RI	1,094	1,707
	MA	
Bristol	658	1,082
Norfolk	171	399
Plymouth	629	1,039
Worcester	1,434	1,956
Total, MA	2,892	4,476
Total, All	3,986	6,183

Source: BEA

Figure A4: Total and Farm Employment Growth in NBW Counties, 2001-2015

County	All Employment, 2001	All Employment, 2005	Farm Employment, 2001	Farm Employment, 2005
Bristol	20,427	22,895	51	34
Kent	95,683	98,401	117	139
Newport	54244	56495	346	354
Providence	350,604	366,821	404	535
Washington	64,285	78,907	510	645
Bristol	270,561	288,580	1,219	1,082
Norfolk	412,189	472,337	370	399
Plymouth	224,100	266,297	1,256	1,039
Worcester	406,906	446,874	1,672	1,956

Source: BEA

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NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Aquaculture Overview

Owing to the climate, geology, and various biological characteristics, shellfishing and aquaculture— the farming of aquatic organisms— have a rich and important history in the Narragansett Bay watershed (NBW). Humans have been harvesting wild shellfish of the Narragansett Bay and surrounding waters for at least 2,700 years and privately farming oysters for over 200 years (Figure 1).[1]

The story of aquaculture and shellfishing contains multiple oscillations, but overall embodies a successful story of resurgence. In the past, aquaculture was a booming industry in the NBW due to the desirable flavors the waters produced in the shellfish. However, the bubble burst and aquaculture faced risks of collapse due to the rise of the industrial fishing, technology improvements, and market imperfections. Overcoming the various ebbs and flows, aquaculture has persevered during the past two decades, especially in Rhode Island (RI). Today, aquaculture farms in the watershed are flourishing. In 2016 in the NBW, 36 aquaculture farms on 140 leased acres existed with 90 employees generating $2.81 million in sales.[2]

In addition to high profitability, shellfish aquaculture is a sustainable method of food production that provides affordable, healthy, and locally raised protein; it also provides important ecosystem services such as fish habitats and water purification.[3] Today, the aquaculture industry is thriving globally due to increasing world populations and the demand for seafood to feed the masses, with aquaculture filling that need.[4] Over the last three decades, world aquaculture production has been expanding and by 2030 is expected to supply over 60% of fish destined for direct human consumption.[5]

This growing trend of aquaculture can also be seen within NBW with aquaculture farms increasing in number more than tenfold and overall employment increasing threefold in the last two decades. In addition, RI is looked to as a national model for “boat to table” seafood direct marketing initiatives and leads the country in the number of farms that sell products directly to consumers.[6] With increasing global demand for fish and shellfish through farming as well as growing demand for local food at restaurants, farmers markets, and retailers, the aquaculture industry in the NBW is well positioned to attract investment in the future.

Figure 1: Ancient Oyster Shell
Credit: Prentice Stout

History

There is a long history of consumption and production of shellfish in the NBW, particularly in RI (while shellfishing does play an important role in MA, it is mostly along Cape Cod; a majority of the MA portion of the NBW is not adjacent to the ocean and, as a result, this report focuses on aquaculture in RI). Roger Williams noted in his 1643 treatise that the Narragansett Tribe would wade in and dive for shellfish, eating the meats and using the shells in a similar fashion to currency.[7] These quahog shells, known as wampum, were sacred objects to Natives given as a tribute, but Europeans mistakenly thought they were equivalent to money. In later years, precious metals decreased, which did lead to wampum filling in as a replacement for coins.[8] The trend of harvesting wild oysters for consumption and using the shells as raw material continued through the early colonial period. In the early 1700s, oyster shells were so plentiful that they were burned whole and ground down for use in masonry mortar as limestone was not readily available in southern New England. However, this practice was outlawed in 1734 for being a wasteful use of marine resources.[9]

As colonial populations grew and technology improved, and as no aquatic property rights existed, wild oyster beds fell victim to the problem of overfishing. Realizing the seriousness of the issue, lawmakers acted to reverse depletion through statutes and mandates such as the 1798 law closing oyster beds to harvesters during the spawning season.[10] A grant of exclusive private harvesting rights was also issued in 1798, establishing RI's first recognized oyster aquaculture farm and shifting interests from shellfish harvesting to farming.[11] Private aquaculture farms increased in acreage yet farmers paid no lease fee, creating tension between aquaculturists and wild shellfish fishermen.[12] This market imperfection led to the Oyster Act of 1844, establishing an annual fee structure for leases. Unfortunately, problems persisted and by 1859 no more oyster aquaculture leases existed, due in part to poaching from fishermen and pollution of oyster grounds.[13] To revive the aquaculture industry, the Oyster Act was amended in 1864 and lease fees collected increased in response. By 1869, when the average rate of laborers was less than $0.16/hour, almost $2,000 was collected in aquaculture leases, equivalent to $36,000 in 2016. [14]

Aquaculture continued to flourish in the late 1800s and early 1900s. Due to the geology of the area (pockets of the NBW accumulate mud and sand, which creates model habitats for shellfish), the NBW became an ideal region for the cultivation of shellfish, producing a palatable *terroir*.[15] This desirable

flavor of oysters from the waters led to Connecticut growers rushing to claim leases in the Narragansett Bay. During this period, aquaculture became the third largest industry in RI, employing over 1,000 people with an annual output of 1.4 million bushels of oysters and 1.3 million gallons of shucked meats worth over $100 million in 2016.[16] Between 1899 and 1902, oyster farming leases increased in acreage more than 300% and at the industry's peak in 1911, leased plots covered almost 2,000 acres (Figure 2) or more than 20% of the entire bottom of Narragansett Bay.[17]

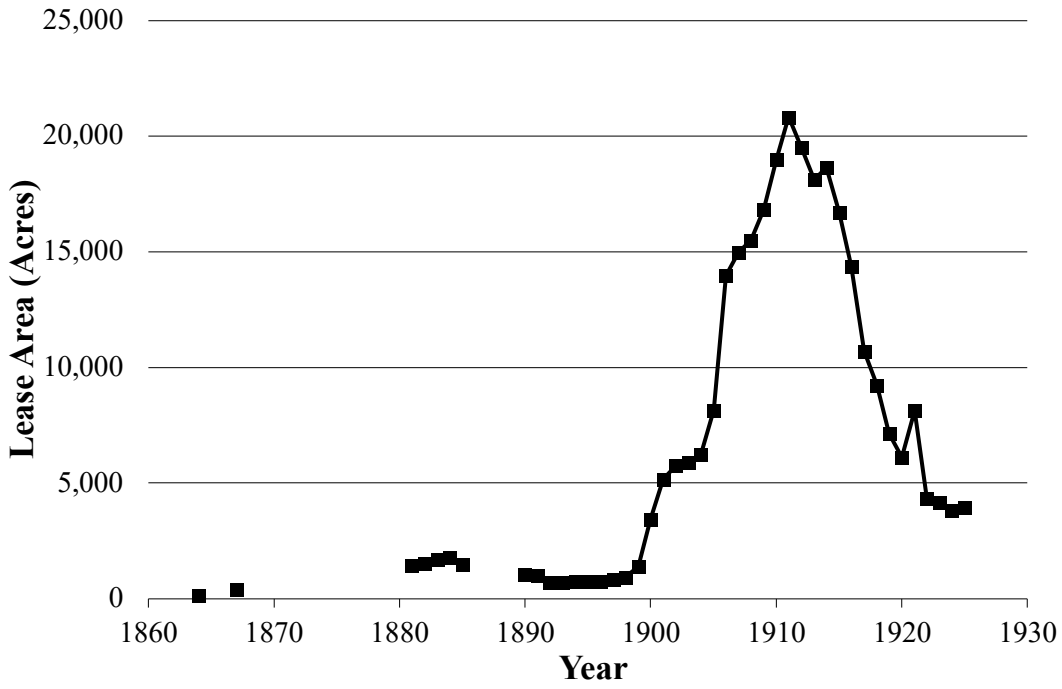

Figure 2: RI Aquaculture Industry by Area of Oyster Farming Leases, 1864-1925
Source: Rice, 2006

As the aquaculture industry was growing and leased acreage increased, industrialization was also gaining ground, and dumping chemicals, metals, and sewage into the very waters where shellfish were being farmed became increasingly common. With pollution levels in the upper bay increasing, farmers were forced further south into the deep waters and sandy bottoms of the lower bay, which are not naturally productive areas for oysters.[18] Unfortunately, the rise of industrial shellfishing and the absence of consideration for long-term environmental effects aided in the downfall of the aquaculture industry. In the early 1900s, the oyster aquaculture bubble burst, immensely decreasing the number of leased acres and collapsing the industry after 1920 (Figure 2) due to factors including increase in raw sewage inputs, factories discharging metal effluents, and effects of soil erosion. The last oyster aquaculture farm gave up its leases and ceased operations in 1954, officially ending the industry's heyday.[19]

From 1954 until 1971, when the Coastal Resources Management Council (CRMC) was established, interest in aquaculture remained almost nonexistent. The CRMC was tasked with managing

aquaculture leases and by 1976 renewed interest in shellfish leases emerged. This trend continued until the 1980s when aquaculture laws were revised and lease application procedures were made more rigorous, including the implementation of public hearings and intensive application reviews. These modifications caused leaseholders to cease production or move elsewhere by 1990.[20]

Despite the hiatus and challenges facing aquaculture farmers the industry has made a successful comeback, seeing a steady and healthy rate of growth since policy efforts in the 1990s and the incorporation of the Ocean State Aquaculture Association. The Legislative Commission on Aquaculture was also formed in the mid-1990s, studying opportunities and constraints of the industry.[21]

Since aquaculture law revisions in 1996, aquaculture has flourished in RI. In the last two decades, the industry has grown rapidly in sales value, increasing from $84,000 in 1995 to $5.5 million in 2016. During the same period, the number of farms has increased from five to 70 and acreage has increased from nine to 275.[22]

Data Sources and Limitations

In this report, estimates are provided for the economic impact of aquaculture within the NBW, which includes market value, employment, number of farms, acres of farms, and oysters sold. These data are derived from local studies and national studies at the state level, including multiple CRMC Annual Status Reports and the United States Department of Agriculture (USDA) 2013 Census of Aquaculture.

The USDA Census of Aquaculture is beneficial for seeing statewide and countrywide trends in the aquaculture industry, but there exists a discrepancy in numbers of farms and market value when compared to the CRMC reports. For this reason, the CRMC data are used in lieu of the USDA data for RI as a local, in-depth study is more ideal for this report.

To estimate the size of the aquaculture industry in the watershed, this report only examines aquaculture operations in RI, as no aquaculture operations in Massachusetts fall within the NBW study area.[23]

In addition, not all RI aquaculture operations are located within the NBW study area; many acres are in the Salt Ponds Region outside of the watershed (for a map of the NBW, please see the "Geography" section of this report). Of the total aquaculture acres in RI, 49% are located within the Salt Ponds Region. For this reason, the following assumption was made: most data are scaled by the ratio of total aquaculture acreage located within the NBW— 51%— to total figures provided by CRMC reports (unless otherwise noted). Based on this assumption, the economic impact of aquaculture is estimated for the NBW, assuming that aquaculture data (acreage, sales, and farms) is consistently distributed in the area covered by the data set (thereby allowing for 51% of these figures to proportionately represent the watershed). For additional information on methodology used in this report, please refer to the "Methodology" section.

Current Status & Trends

The growing trend of aquaculture at the global level can be seen within the NBW. In the last two decades, the aquaculture industry in the watershed has increased in market value, employment, number of farms, and total farm acres leased. Currently, oysters are the primary product cultivated by aquaculture farms in the NBW and, as a result, many figures in this report can be attributed to the cultivation and sale of eastern oysters (7.8 million oysters were sold in 2016 in RI, at least 2.2 million of which was in the NBW portion of RI). Aquaculture farms in RI also cultivate other species, although at much lower rates; it is not uncommon for farms to harvest hard clams (70,500 were sold in 2016) as well as blue mussels (27,000 pounds were sold in 2016). Furthermore, some aquaculture farms are branching out from cultivating just shellfish—a small number of farms are growing sweet kelp. From 2015 to 2016, nine more farms added kelp to their list of products with an increasing number of farms expected to produce kelp in coming years. Although oysters make up a large portion of aquaculture products, there are additional species that contribute to the diversity of the aquaculture industry in the NBW.[24]

RI has shown rapid growth in the number of aquaculture farms, number of cultivated acres, and sales, a stark contrast compared to national trends. Between 2005 and 2013, the number of saltwater aquaculture farms in the U.S. declined by 27% and the number of acres decreased by 34% (Figure 3). During the same period, RI aquaculture farms and total acreage increased by 91% and 90% respectively. Values of sales in the same period increased by 489% in RI compared to the national trend of 26%.[25]

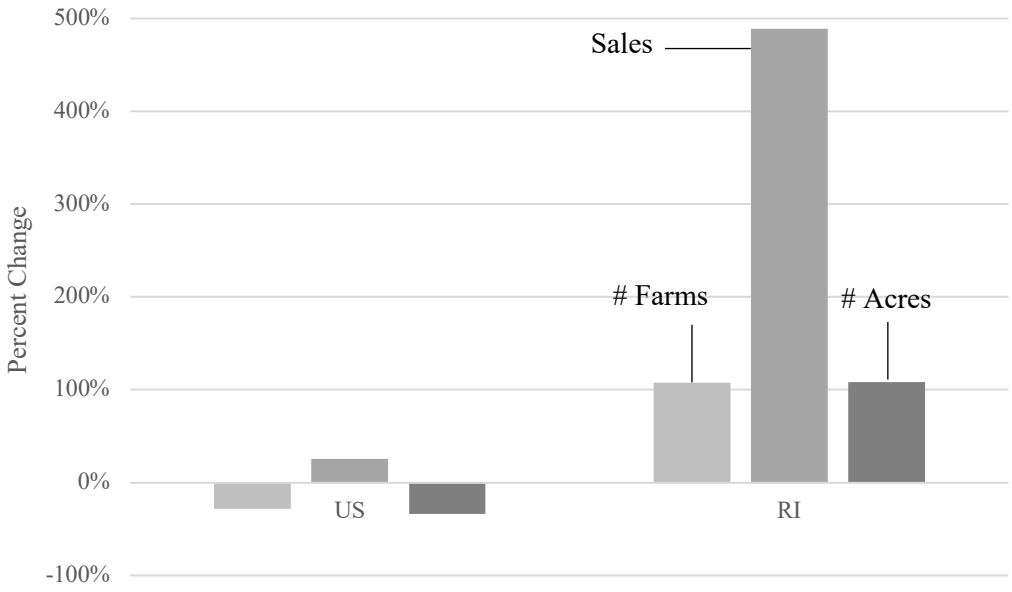

Figure 3: Percentage Change in Aquaculture Farms, Sales, and Acres in U.S. and RI, 2005-2013

Sources: Census of Aquaculture, 2013; Beutel, 2013; Alves, 2005

In all of RI in 2016, there were 70 aquaculture farms on more than 274 leased acres with 177 total employees. These farms produced nearly eight million oysters for consumption and totaled $5.5 million in sales.[26] Within the NBW (Mount Hope Bay, Sakonnet River, and Narragansett Bay) during this same year, there were 28 farms on 134 acres of land. Twenty-four of these farms cultivated oysters, three cultivated blue mussels, two cultivated clams, one cultivated steamers, and one cultivated bay scallops.[1] Combined, these farms sold over 2.2 million oysters and 27,000 pounds of mussels.[27] Using total RI values to calculate the number of farms, employees, and sales in the NBW portion of the state using these data indicates that there were 36 farms on 140 acres with 90 employees and $2.8 million in sales. As previously stated, the following estimates are calculated by taking the proportion of the NBW in RI (51% of total area) and scaling total RI figures by this amount. Although this is not entirely accurate, it gives some idea as to the trends and a general estimate of the importance of the aquaculture in the NBW.

These numbers are the result of remarkable growth in recent years. Since 1995, market value of sales generated by aquaculture industries in the NBW have increased by more than 4,000%, from $67,000 in 1995 to $2.8 million in in 2016 (Figure 4).[28] The largest increase of nearly 200% occurred between 1996 and 1997. This jump was due to the formation of the regulatory RI Aquaculture Working Group by the CRMC (a response to the state having the lowest aquaculture production in the country), which worked in conjunction with URI and RWU to regulate and manage the state's shellfishing and aquaculture industries.[29]

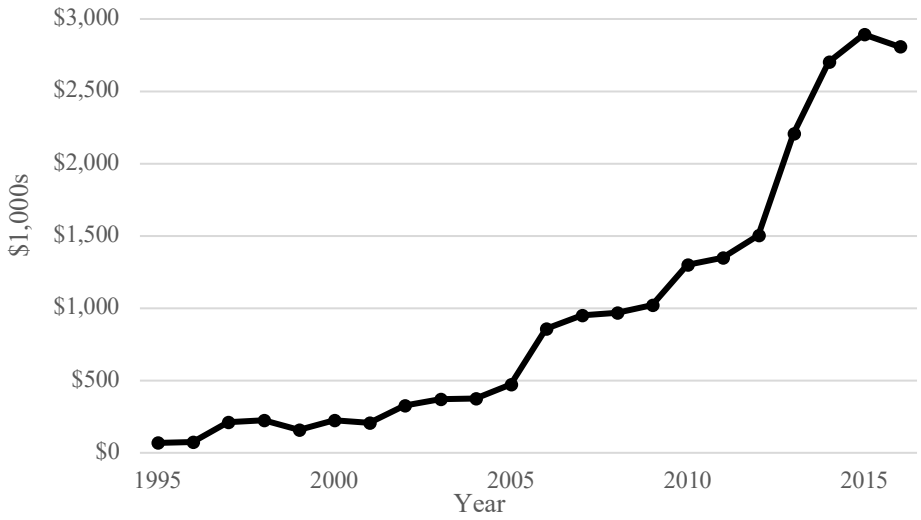

Figure 4: Inflation-Adjusted Market Value of Aquaculture Sales in the NBW, 1995-2016 (in 2016 dollars)
Source: CRMC Annual Reports, 1995-2016

[1] These figures are not from the 51% scaling, but are exact numbers extracted from aquaculture farms specifically in Narragansett Bay, Mt. Hope Bay, and Sakonnet River.

Since 2000, when the CRMC began documenting employment numbers, total employment in the watershed has increased more than 600% from 13 in 2000 to 90 in 2016 (Figure 5). The percentage increases are not as large as total sales, but the growth trend is similar with the largest increase of 43% occurring between 2005 and 2006.[30]

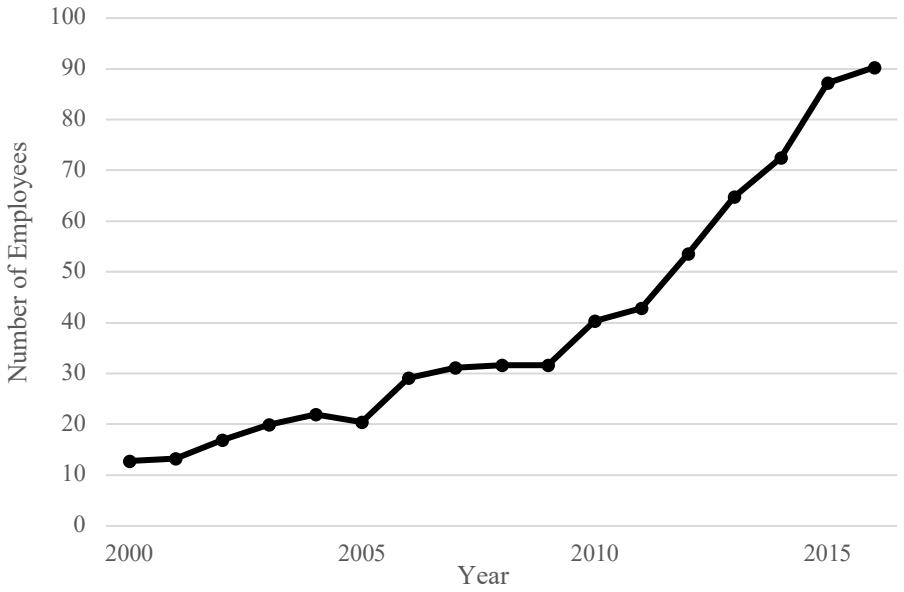

Figure 5: Aquaculture Employment in the NBW, 2000-2016
Source: CRMC Annual Reports, 2000-2016

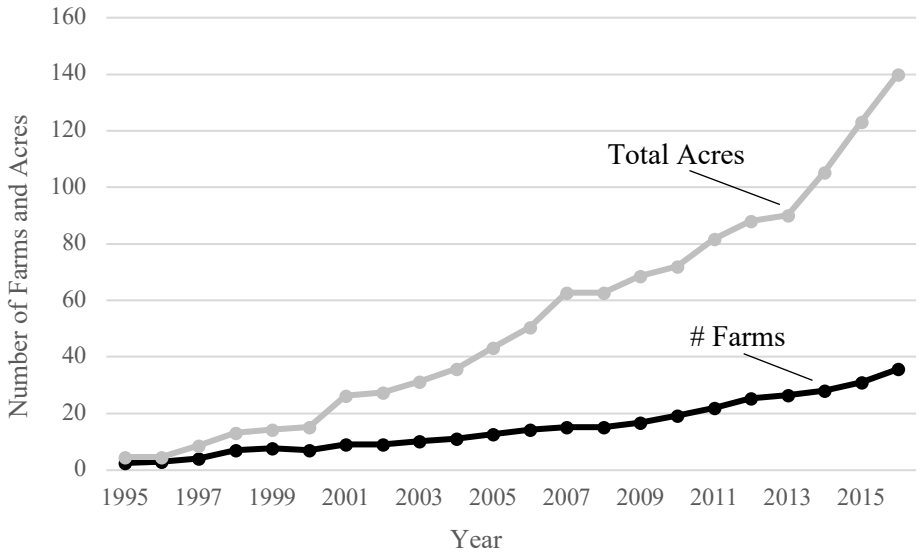

Figure 6: Aquaculture Farms and Acres in the NBW, 1995-2016
Source: CRMC Annual Reports, 1999-2016

In addition to growth in market value of sales and number of employees, total aquaculture operations and leased acres have rapidly increased in the last two decades (Figure 6). Between 1995 and 2016, total number of aquaculture farms in the NBW increased from three to 36, and total leased acres increased from five to 140.[31]

Since aquaculture law revisions in 1996, the aquaculture industry in the NBW has flourished on all fronts. In the last two decades, the industry has grown the most rapidly in sales value, increasing over 4,000% from $67,000 in 1995 to $2.8 million in 2016 (Figure 4). During the same period, total number of leased acres increased nearly 3,000% from five to 140, and total number of aquaculture farms in the NBW increased 1,300% from three to 36 (Figure 6). Although employment has witnessed the least amount of growth, between 2000 and 2016 it increased more than 600%, from 13 in 2000 to 90 in 2016 (Figure 5).[32]

Overall, the aquaculture industry in the NBW embodies a story of resurgence and growth in the past century. Despite past challenges, aquaculture farms in the watershed have grown rapidly from almost non-existent in 2000 to a sizeable industry by 2016, with direct economic impacts of $2.8 million in sales, 36 aquaculture farms, 140 leased acres, and 90 employees.[33] With increasing global demand for fish and shellfish through farming as well as growing demand for local food at restaurants, farmers' markets, and retailers, the aquaculture industry in the NBW is well positioned to continue growth and attract continual investment in the future.

Future Threats and Opportunities

Temperature | Population Growth | Shellfishing areas

As previously stated, aquaculture has flourished in recent years. This continued growth, however, may be threatened by the effects of climate change on aquaculture areas and cultivated species. For example, of the 70 aquaculture farms in RI, a majority cultivate oysters on coastal waters, making them susceptible to changes in marine environments that are difficult to control or prevent. Shellfishing and aquaculture in the NBW has a history of sensitivity to outside pollutants and threats. For example, in the early 1900s, residents in the area noticed problems with shellfish populations that arose from increased urbanization and fecal pathogens and pollutants entering the water. In 1925, the National Shellfish Sanitation Program was established to address this issue, although it continues to affect shellfish in the NBW. As of 2015, 76% of the NBW was open to shellfishing (either approved or conditionally approved—this "approved" status is conditional on acceptable levels of contaminants and fecal pathogens found in water). As discussed in previous sections, as human populations increase and settlements expand, water quality is threatened, and this threat is exacerbated by the effects of climate change (e.g., increased runoff from storm activity, warmer waters conducive to bacteria growth, etc.). In summary, the effects of growing population, enhanced by climate change, pose a major threat to water quality and therefore the aquaculture industry.

Furthermore, the effects of climate change on marine waters, including increasing water temperatures, changes in ocean currents, acidification, and increased storm activity near coastal areas, can have a direct impact on aquaculture in the NBW. For example, warmer waters may increase the likelihood of harmful algal blooms, outbreaks of bacteria, or increased instances of toxic algal blooms, known to be harmful to humans if consumed. In 2016, RI experienced its first Pseudo-nitzchia (toxic algae) bloom in the state's history. The algae produce a neurotoxin called domoic acid, which affects shellfish and migrates up the food chain in the marine environment (potentially spreading to humans if they consume contaminated shellfish). This outbreak led to a temporary shellfishing ban and no humans tested positive for the toxin. Although this was the first outbreak of its type in RI waters, a subsequent outbreak occurred in spring 2017, less than a year later. Scientists believe that toxic algal blooms may become more common in the area as sea temperatures rise, creating a welcoming environment for algae to grow.[34] Warmer waters also increase the spread of diseases that affect marine life. These two factors—harmful algal blooms and disease/pathogens/bacteria—are believed by the Food and Agriculture Organization of the United Nations to be the biggest risk factors affecting aquaculture in temperate regions.[35] Additionally, there are other environmental factors that, although may not be as threatening as those mentioned above, will still impact aquaculture in the NBW. Ocean acidification leads to a depletion of available calcium carbonate, the main element that comprises shelled mollusks' shells. Reduced levels of available calcium carbonate as a result of ocean acidification may be a limiting factor for the growth of future shellfish populations; RI is especially vulnerable to ocean acidification, as a recent study found that the state is one of the top 15 at-risk areas for ocean acidification in the country.[36] [37]

Although some of these risk factors cannot be prevented, there are some preventative measures that can be taken to reduce the impact of these threats. For example, disease-resistant oysters can be used and proper handling techniques by shellfishermen (such as flash freezing and placing oysters on ice immediately after harvest) can help reduce the occurrence of vibrio.[38] In addition, constant monitoring will be key to ensuring the health of farms and species involved.

Overall, a culmination of factors in the future, ranging from population growth to an increase in ocean temperatures, may have an impact on the current state of shellfishing and aquaculture in the NBW. The exact impacts may be difficult to predict, although it seems highly likely that the industries will experience shifts and potential problems in the future due to these effects.

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Appendix

Table A.1: Aquaculture Farms, Sales, and Acres in U.S. and RI, 2005-2013 (in 2016 dollars)

	US	RI
Number of Farms, 2013	3,093	52
Number of Farms, 2005	4,309	25
Sales, 2013 ($1000s)	$1,411,236	$4,511
Sales, 2005 ($1000s)	$1,357,125	$924
Total Acres, 2013	462,729	177
Total Acres, 2005	693,053	85

Sources: Census of Aquaculture, 2013; Beutel, 2013; Alves, 2005

Table A.2: Aquaculture Sales, Farms, Acres, and Employment in RI, 1995-2016

	Sales ($1000s)	Number of Farms	Total Acres	Employment
1995	$131.6	5	9	-
1996	$140.4	6	9	-
1997	$410.8	8	17	-
1998	$435.4	14	26	-
1999	$308.4	15	28.25	-
2000	$442.1	14	30	25
2001	$405.9	18	51.5	26
2002	$639.7	18	53.75	33
2003	$725.4	20	61.13	39
2004	$733.0	22	70.3	43
2005	$924.7	25	85	40
2006	$1,611.1	28	99	57
2007	$1,858.5	30	123	61
2008	$1,899.3	30	123	62
2009	$2,003.0	33	134.5	62
2010	$2,544.1	38	141	79

2011	$2,646.3	43	160.3	84
2012	$2,950.4	50	172.55	105
2013	$4,325.9	52	176.55	127
2014	$5,296.2	55	206.2	142
2015	$5,673.2	61	241.4	171
2016	$5,508.7	70	274.53	177

Sources: CRMC Annual Reports, 1999-2016

The Narragansett Bay Watershed Economy Project was conceived and partially supported by the Coastal Institute at the University of Rhode Island under the leadership of Dr. Emi Uchida. In addition, this project was supported, in part, under Assistance Agreement No. SE - 00A00252 awarded by the U.S. Environmental Protection Agency (EPA) to Mass Audubon. Additional project partners include the URI Graduate School of Oceanography, the URI Coastal Resources Center, the Natural Capital Project at Stanford University, and the George Perkins Marsh Institute at Clark University. The views expressed in this project are solely those of the authors. It has not been formally reviewed by EPA. Additional information is available at www.nbweconomy.org.

NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Beach Use Overview

The Narragansett Bay watershed (NBW) is gifted with a magnificent shoreline over 560 miles long with more than 100 marine and freshwater beaches (for a map of the NBW, please see the "Geography" section of this report).[1] Access to high quality beaches is an essential part of the heritage of Ocean and Bay State residents. In fact, visiting beaches and swimming in salt and freshwater have immense social value and are among the most popular water-based activities for residents in the area.[2] Out-of-state tourists are also drawn to these beaches, contributing significant economic value to the area. Visitors travel to locations such as Cedar Cove, Narragansett Town Beach, and Goddard Memorial State Park, partaking in recreational activities that include sunbathing, swimming, walking, yoga, kayaking, fishing, and surfing.

Recreational beach use in the NBW brings significant economic value to the region. While comprehensive data of beach use and revenue do not exist, data for seven beaches in eastern and southern Rhode Island (RI) show that over three million individuals visited these beaches during the summer of 2015. An additional three beaches in western RI brought in over $2 million (in 2016 dollars) in beach revenue. It is important to note that the economic value of visiting and swimming at marine and freshwater beaches in the NBW depends on water quality. Clean coastal waters are vital for human and ecosystem health; aesthetically pleasing waters that are safe for swimming are catalysts for a healthy watershed economy through beach user expenditures and job creation in fishing, tourism, and hospitality industries.[3] In the past, beach closures due to unsafe levels of bacteria have been an issue for monitored marine beaches in the watershed. However, in recent years, in part due to the completion of the combined sewer overflow abatement project, overall water quality has been improving at NBW beaches.

History

For centuries, the beaches of the NBW have attracted people to the region both to live and to visit. Beginning in the latter half of the 19th century, there was a rise of interest in leisure activities and areas within the NBW became destination hotspots for vacationers. For those with a taste for luxury shore resorts and beaches, Newport drew their interest, with activities ranging from sailing races to yacht clubs (Figure 1). Those with more adventurous tastes could visit northern Narragansett Bay

beaches to swim at Crescent Park in East Providence, the "Coney Island of the East Coast," or Rocky Point Park in Warwick.[4]

Figure 1: Dunes Club Beach (Narragansett, RI)
Credit: Sean McMahon

As populations and economies grew in the NBW, so did indoor plumbing and downstream pollution. This led to marine beach water quality issues, including waterborne epidemics in the mid-1800s and the closure of Crescent Park in 1979. Acceptable water quality remains a struggle today for NBW beaches, especially those located in the upper bay. Oakland Beach and Conimicut Point Beach in Warwick have the highest rate of marine beach closures in the NBW, and swimming is no longer allowed in Rocky Point due to poor water quality.[5]

Due to the passage of the Beaches Act in 2000, state health departments have monitored bacteria levels, closing beaches when levels exceed those that are safe for swimming (Figure 2). Since 2000, the number of saltwater beach closure days in the NBW peaked at 429 in 2003. To combat closures, RI and Massachusetts (MA) communities have taken steps to reduce bacteria flow into waters, including the construction of the combined sewer overflow tunnel in 2009 in RI. Largely due to these efforts and investments, the number of beach closure days has declined. The five-year average after building the sewer overflow tunnel (2010-2014) is 46% lower compared to the prior five-year period (2005-2009).[6]

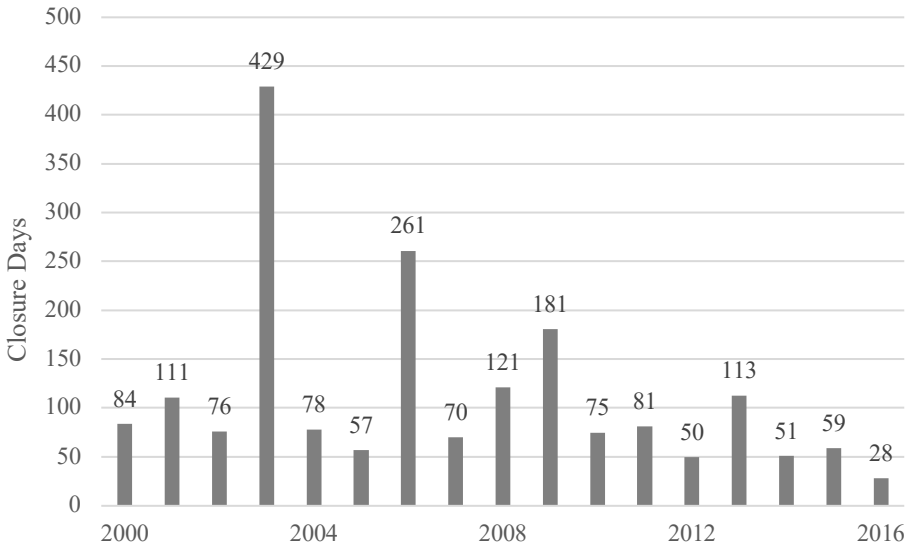

Figure 2: Number of Beach Closure Days at Marine Beaches in the NBW, 2000-2016
Sources: MADPH, 2001-2016; RIDOH, 2017

Data Sources and Limitations

The economic impact of recreational beach use within the NBW is measured using estimated attendance rates and beach revenues. These data are derived from Watershed Counts, the Narragansett Bay Estuary Program (NBEP), the Environmental Protection Agency (EPA), RI Department of Environmental Management (RIDEM), RI Department of Health (RIDOH), MA Department of Public Health (MADPH), and personal communication with managers of various beaches throughout the RI portion of the watershed. Data for RI beaches are also obtained from a 2017 report by Tom Sproul, *The Economic Impact of Rhode Island State Parks.*

Data are limited for recreational beach use participation and expenditures in the NBW for various reasons. First, few public beaches within the NBW charge fees to step on to the beach. Many charge parking fees, but do not tally individuals in each vehicle and not all beachgoers park where fees are required. Secondly, many NBW beaches are privately owned with no attendance figures. Thirdly, information is not available for beach use that takes place at public access points throughout the NBW that are not formally designated beaches. For example, the town of Narragansett alone has 36 entrances that provide access to NBW beaches.[7] In addition, while stringent water quality monitoring programs exist for marine beaches within the NBW, there is no mandated attendance reporting system. Finally, due to a lack of federal funding, information is not available for the significant recreational beach use that takes place at the approximately 75 monitored public and private freshwater beaches throughout the NBW, leaving communities and organizations to fund their own bacteria monitoring programs. For this reason, data is much more limited for freshwater beaches than

saltwater beaches.[i 8] These various circumstances make participation and expenditures for recreational beach use difficult to measure. Therefore, it should be noted that estimates provided in this section only capture a small portion of the economic impact of beach use within the NBW.

It is also important to note that the data for RI and MA come from their respective state agencies and that these sources may use different data collection or methodology. As a result, there is some margin of error when comparing data from the two states. For more comprehensive information on methodology used throughout this report, please reference the "Methodology" section.

Current Status & Trends

Today, beach use and its associated leisure activities comprise key recreational activities in the NBW (Figure 3). Monitored marine beaches are the most popular attraction, with all 37 of the marine beaches— public and private—located on the shores of the Narragansett Bay. In 2015 at three marine beaches in the NBW there were nearly 2.5 million beach attendees, an increase of 56% compared to 2010. Visiting beaches and swimming in both salt and freshwater are the three most popular water-based activities in the area; according to a survey conducted by the State of RI in 2002, participants spent an average of 32 days visiting beaches, 26 days freshwater swimming, and 21 days saltwater swimming per year.[9] In RI alone, this amounts to more than 20 million beach visits and over 15 million salt water swimming days per year.[10]

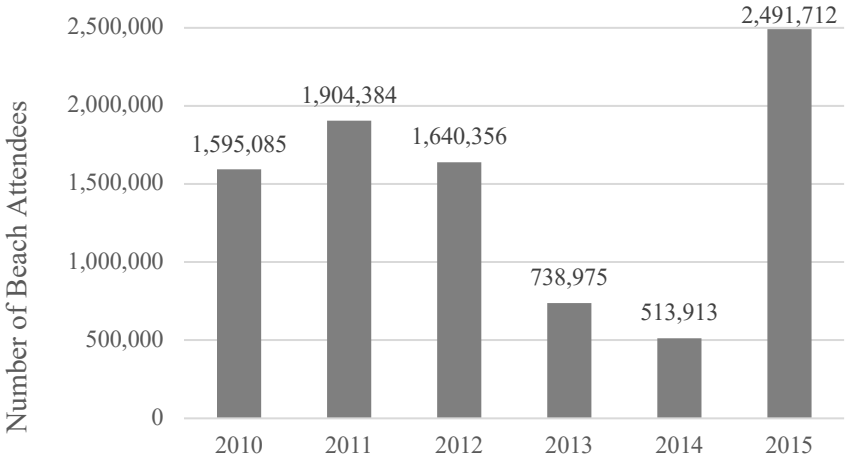

Figure 3: Recreational Beach Use at Three Marine Beaches in the NBW (2010-2015)[ii]
Source: Tom Rosa, Personal Communication, RIDEM

[i] Note: Sources that provide data on beaches in the NBW from which this number is derived includes the U.S. EPA, RI Parks and Recreation, RIDOH, RIGIS, and Mass GIS portals.

[ii] Attendance rate data were available for three marine beaches in the NBW: Scarborough, Fort Adams, and Goddard State Park. From 2013-2014, data was unable to be collected at Goddard Park, which could explain for the sudden drop in attendance.

Employment, Wages and Revenues

Recreational beach use is an activity that brings significant economic value to the NBW. Data for visitation, revenue, and employment at public, state, and town-operated marine beaches in the RI portion of the watershed suggest that beaches attract many visitors and generate considerable revenue (Table 1). While comprehensive data of beach use and revenue do not exist, data for seven beaches in eastern and southern RI show that over three million individuals visited these beaches during the summer of 2015. An additional three beaches in western RI brought in over $2 million (in 2016 dollars) in beach revenue.

Table 1: Attendance Rates, Revenue, and Employment for Seven RI Marine Beaches in the NBW over a 100-Day Season (2015) ($2016)

	Attendance (1000s)	Revenue ($1000s)*	Employment
Bristol	n/a	$253	45
City Park/Oakland	35	n/a	16
Conimicut	20	n/a	16
Eastons	n/a	$847	60
Fort Adams/Goddard/Scarborough	2,492	n/a	n/a
Narragansett	742	n/a	140
Sachuest/Third	n/a	$1,419	95
Total	3,289	$2,519	372

* Revenue for the 2015 fiscal year; includes parking and seasonal pass sales

Sources: Personal Communications[11]

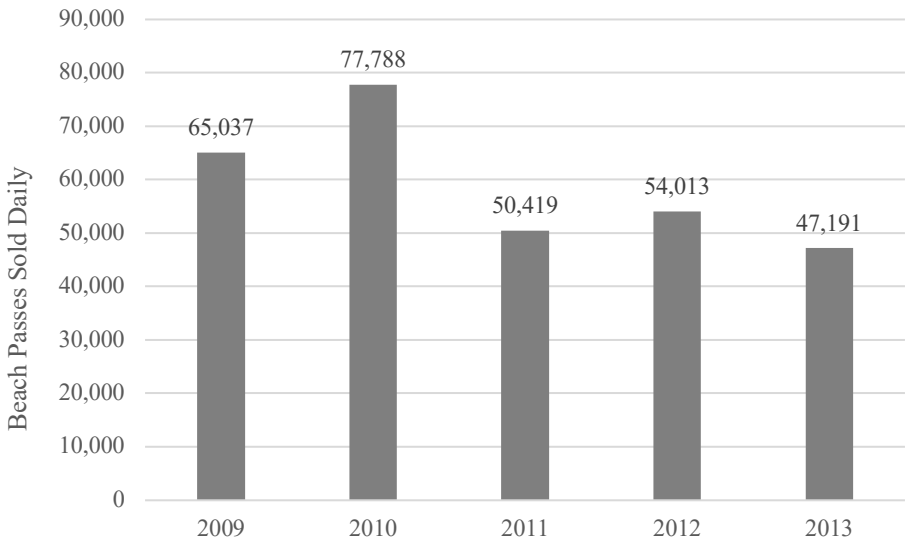

Figure 4: Beach Passes Sold Daily at Scarborough North and South Beaches in NBW (2009-2013)

Source: WPRI, 2014

Daily passes at Scarborough North and Scarborough South beaches in Narragansett, RI also illustrate the popularity of NBW beaches (Figure 4).[12] The number of daily beach passes sold is impressive, but unfortunately sales have decreased since 2010. The downward trend could possibly be due to an increase in RI beach fees for daily and seasonal passes in 2011. However, during the 2016 season, RI beach fees were reduced by close to 50%, marking the first reduction in recent history. This price reduction will hopefully increase beach attendance, bringing in more revenue to the area.

Furthermore, a 2017 study, *The Economic Impact of Rhode Island State Parks*, includes visitation and revenue data for several Rhode Island beaches. Four of the seven beaches in the study fall within NBW boundaries – in 2016, these four beaches had nearly 600,000 visitors (approximately 245,000 at Roger Wheeler, 53,000 at Salty Brine, 192,500 at Scarborough North, and 107,500 at Scarborough South) and $51.3 million in spending (approximately $18.7 million at Roger Wheeler, $3.6 million at Salty Brine, $19.3 million at Scarborough North, an $9.6 million at Scarborough South). Additionally, of the beaches in the study (including those outside of NBW boundaries), in-state visitors spent an average of $40 per beach visit, while out-of-state visitors spent considerably more at almost $200, with out-of-state visitors making up nearly 47% of all visitors.[13] These figures, although provided for only four beaches within the watershed, highlight their vast economic contribution to the watershed and their importance for drawing in tourists to the region.

Water quality and beach closures in the NBW

Monitoring water quality in the NBW is important for the safety of beach use. Beaches with high water quality attract people to the region to both reside and to visit, bringing in significant economic value to RI and MA. The marine beaches in the watershed are regularly monitored for water quality through funding provided by the U.S. EPA (Table 2). If bacteria levels exceed safety thresholds, beaches are closed by the health department until waters are safe for swimming.

Table 2: Monitored Marine Beaches in the NBW

RI	RI	RI	MA
Atlantic Beach Club	Fort Adams State Park	Peabody's Beach	Cedar Cove
Barrington Town Beach	Goddard Memorial Park	Plum Beach Club	Coles River Club
Bonnet Shores Beach Club	Gooseberry Beach	Sachuest Beach	Leeside
Bristol Town Beach	Grinells Beach	Sandy Point Beach	Pierce Beach
Camp Grosvenor	Hazards Beach	Saunderstown Yacht	Sandy Beach
Camp St. Dorothy	King Park Swim Area	Scarborough North	Swansea Town Beach
City Park Beach	Mackerel Cove Beach	Scarborough South	
Conimicut Point Beach	Narragansett Town Beach	Spouting Rock Assoc.	
Dunes Club	North Kingstown Town Beach	Third Beach	
Easton's Beach	Oakland Beach	Warren Town Beach	
Fogland Beach			

Source: NBEP, 2017

To combat closures, RI and MA communities have taken steps to reduce bacteria flow into waters, including the construction of the combined sewer overflow tunnel in 2009 in RI. Largely due to these

efforts and investments, the number of saltwater beach closure days has declined (Figure 5). The five-year average after building the sewer overflow tunnel (2010-2014) is 46% lower compared to the prior five-year period (2005-2009). [14]

Despite significant improvements to beach and water quality in the watershed, some monitored marine beaches are still a concern, particularly those in the upper region of the Bay; of the NBW beach closure days, 63% occurred in Warwick beaches.[15] Continued efforts to reduce water contaminants and beach closures will be critical for the economy and health of beach users.[16]

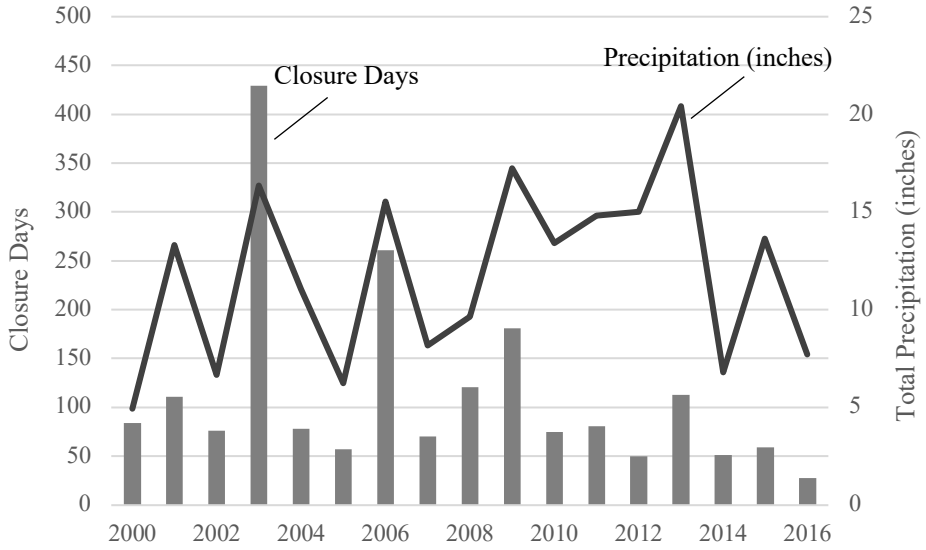

Figure 5: Saltwater Beach Closure Days and Precipitation in the NBW, 2000-2016
Sources: MADPH, 2001-2016; RIDOH, 2017

Future Threats and Opportunities

Land use | Sea level | Marine beaches | Water quality for recreation

As discussed above, water quality and its relation to human safety has long been a concern for beaches in the NBW. Currently, the most pressing threat to beaches is still beach closure due to poor water quality. Fecal bacteria measurements serve as a common indicator for water quality at beaches, and beaches with excessive fecal bacteria levels are closed due to the fact that they can cause serious illness in humans. Currently, out of the 37 beaches in the NBW, 14 are considered "high concern" (averaging more than 1.5 closures per year), while the other 23 are "low concern" (averaging less than 1.5 closures per year).[17] Fecal bacteria is carried into the water by rainfall, and originates from poor septic systems, overflow of sewers, poorly functioning cesspools, animal waste, and numerous other sources.[18] Due to increased urbanization (more impervious cover, cesspools, and septic systems, etc.) and increased rainfall from climate change, the level of fecal bacteria and prevalence of beach closures may increase in the future. This effect may be exacerbated by the warmer water temperatures from climate change, which promote bacterial growth, all of which may lead to increased beach closures unless the issue is properly managed. Furthermore, another pressing issue threatening the

future of marine beaches in the NBW is sea level resulting from climate change. With an expected sea level rise of 9.8 feet by 2100, the submersion of many of these beaches seems to be a looming issue for the future.[19]

Overall, the quality of water at marine beaches faces threats from increased urbanization and the impacts of climate change, which may lead to increased beach closures in coming years. Additionally, aside from the quality of the water, the beaches themselves are threatened by submersion from sea level rise. Efforts to control water quality moving forward are essential to the health of NBW and the important economic contribution that they have in the area.

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[2] Source: RIDEM, 2002.
[3] Source: Watershed Counts, 2014.
[4] Source: Rodericks, 2013.
[5] Sources: RIDOH, 2017; RIparks.com

[6] Sources: MA DPH, 2001-2016; RI DOH, 2017.
[7] Source: Allard, 2004.
[8] Source: Watershed Counts, 2014.
[9] Source: RIDEM, 2002.
[10] Source: Mazzotta et al., 2012.
[11] Sources: Personal Communications with Rosa, T.; Burke, W.; Cronin, W.; Reis, E.; Rooney, M.; and Wright, S.
[12] Source: WPRI, 2014.
[13] Source: Sproul, 2017.
[14] Sources: MA DPH, 2001-2016; RI DOH, 2017.
[15] Sources: RIDOH, 2017; Parris & McCormick, 2016; MA DPH, 2016.
[16] Source: Watershed Counts, 2014.
[17] Source: NBEP "Marine Beaches," 2017.
[18] Source: NBEP "Water Quality for Recreation," 2017.
[19] Source: NBEP "Sea Level," 2017

Appendix

Table A1: Beaches in the RI and MA portion of the NBW

Beach	State	Town	Beach	State	Town
Atlantic Beach Club	RI	Middletown	Holiday Acres Campground	RI	Glocester
Barrington Town Beach	RI	Barrington	Hope Pond Beach	RI	Scituate
Beachmont/Hayes Field	RI	Cranston	Irons Homestead	RI	North Scituate
Blue Beach	RI	N. Kingstown	Jamestown Shores Beach	RI	Jamestown
Bonnet Shores	RI	Narragansett	Jamestown Town Beach	RI	Jamestown
Branton	MA	Somerset	Kent County YMCA	RI	Warwick
Briar Point Beach Area	RI	Coventry	Kings Beach	RI	Newport
Bristol Town	RI	Bristol	Lincoln Woods State Park	RI	Lincoln
Camp Aldergate	RI	N. Scituate	Little Pond Beach	RI	Warwick
Camp Cookie	RI	Chepachet	Mackerel Cove Beach	RI	Jamestown
Camp Massasoit	RI	Johnston	Marion Irons Beach	RI	Glocester
Camp Meehan	RI	N. Providence	Mother of Hope Day Camp	RI	Chepachet
Camp Shepard	RI	Smithfield	Narragansett Town Beach	RI	Narragansett
Camp St. Dorothy	RI	Bristol	Ninigret Park	RI	Charlestown
Camp Watmough	RI	Glocester	North Kingstown Town Beach	RI	N. Kingstown
Cedar Cove	MA	Swansea	Oakland Beach Park	RI	Warwick
City Park Beach	RI	Warwick	Peabody's Beach	RI	Middletown
Colt State Park	RI	Bristol	Pierce	MA	Somerset
Colwells Campground	RI	Coventry	Roger Wheeler State Beach	RI	Narragansett
Conimicut Pt. Beach	RI	Warwick	Rose Nulman Memorial Park	RI	Narragansett
DiFonzo Recreation Area	RI	Glocester	Sachuest	RI	Newport
Dunes Club	RI	Narragansett	Salty Brine Beach	RI	Narragansett
Echo Lake Campground	RI	Burrillville	Sandy Beach	MA	Swansea
Easton's Beach	RI	Newport	Sandy Point Beach	RI	Portsmouth
Elm Street Pier	RI	Newport	Saunderstown Yacht Club	RI	Saunderstown
Episcopal Conference Center	RI	Pascoag	Scarborough State Beach	RI	Narragansett
Fogland Beach	RI	Tiverton	Slack Pond	RI	Smithfield
Fort Adams	RI	Newport	Spring Grove Beach	RI	Glocester
Georgiaville Beach	RI	Smithfield	Spring Lake Beach	RI	Burrillville
Glocester Country Club	RI	Glocester	Teddy's Beach	RI	Portsmouth
Goddard Memorial State Park	RI	Warwick	Third Beach	RI	Middletown
Gooseberry	RI	Newport	Town Beach	MA	Swansea
Gorton's Pond Beach	RI	Warwick	Town Walkway	MA	Somerset
Governor Notte Park	RI	N. Providence	Vanzandt Pier Beach	RI	Newport
Greenlake Beach	RI	Smithfield	Warren Town Beach	RI	Warren
Grinnells Beach	RI	Tiverton	Westwood YMCA	RI	Coventry
Harmony Hill School	RI	Glocester	World War II Memorial Park	RI	Woonsocket
Hazards	RI	Newport			

Source: MassGIS, RIGIS, USEPA, RIDOH

The Narragansett Bay Watershed Economy Project was conceived and partially supported by the Coastal Institute at the University of Rhode Island under the leadership of Dr. Emi Uchida. In addition, this project was supported, in part, under Assistance Agreement No. SE - 00A00252 awarded by the U.S. Environmental Protection Agency (EPA) to Mass Audubon. Additional project partners include the URI Graduate School of Oceanography, the URI Coastal Resources Center, the Natural Capital Project at Stanford University, and the George Perkins Marsh Institute at Clark University. The views expressed in this project are solely those of the authors. It has not been formally reviewed by EPA. Additional information is available at www.nbweconomy.org.

NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Commercial Fishing Overview

Due to the plentiful and healthy coastline of the Narragansett Bay watershed (NBW), commercial fishing is a flourishing industry—one that is directly dependent on the Bay. Commercial fishing provides considerable economic value and supports many jobs in the watershed region, not only for those directly involved in the commercial fishing industry, but also for those indirectly involved as well; restaurants and distributors that purchase finfish, shellfish, and crustacea for culinary uses or resale rely on commercial fishing, as do companies that use commercially caught fish for industrial purposes, such as bait or animal food production. In addition, households that buy fish for nourishment are dependent upon commercial fishermen.

In the U.S. over the last decade, the commercial fishing industry has been relatively steady in volume (weight), although landings have fluctuated over the years. Annual landings ranged from a low of 8.0 million pounds of shellfish and fish in 2009 to a high of 9.9 million pounds in 2011, with the remainder of years between 2006 and 2015 fluctuating between these values. Between 2006 and 2015, annual landings increased 2% in volume and 30% in value.[1] On the other hand, despite fluctuations in volume, the increase in landing value has increased relatively steadily. With the exception of 2003, value has increased every year from 2006 to 2015, from $4.0 million in 2006 to $5.2 million in 2015. Between 2006 and 2015, despite only a 2% change in landing volume, there was an 11% increase in value. Data from two of the three major ports in the NBW, Point Judith and Narragansett, indicates that while landing volume decreased only 3% from 2006 to 2015, landing value decreased 34%.[2]

The total economic value of commercial fish landings at NBW ports in 2015 amounted to nearly $65 million (in 2016 dollars).[3] In the same year, there were 155 commercial fishing establishments in the watershed, which employed over 700 individuals with $85 million (in 2016 dollars) in annual wages.[4]

History

Commercial fishing has existed in the NBW for hundreds of years, with origins dating back to colonial trade in the 17th century. Due to variations in coastal geomorphology and ecosystems of the region, many types of gear, species, and vessels have been used over the course of history.[5]

The first commercial fishermen used uncomplicated gear, such as hook, line, and floating traps. In 1867, beach seining—the use of a large vertical fishing net—became popular for seasonal fishing groups living on the beach.[6] In the late 1800s, pound and heart traps were widespread, followed by bottom trawls in the mid-1900s. As methods became more advanced and efficient, fishing moved from inshore to offshore resulting in greater landings.[7]

Over the past century, not only has fishing technology changed, but the abundancy of species found within the NBW has as well. Considerable declines in fish stocks have occurred due to changes in the environment, including changing water temperatures, predation, fishing pressures, and pollution. Since 1898, fish yields have decreased by 81%. In the late 1800s, alewife, shad, smelt, and menhaden were abundant and no longer are today. Changes in wild shellfish include the disappearance of soft-shell clam, oyster, and scallop, which were replaced by quahog.[8]

Despite the changing availability of fish types, the commercial fishing industry has experienced success in the NBW throughout history and is still a prominent industry today; in RI alone, there are more than 1,500 vessels that are commercially declared.[9]

Data Sources and Limitations

Estimates of establishments, employees, wages, and landings are provided for the economic impact of commercial fishing within the NBW. These data are derived from the Bureau of Labor Statistics (BLS), the National Ocean Economics Program (NOEP), and the National Marine Fisheries Service (NMFS). The BLS reported on the total number of commercial fishing establishments, employees, and wages for the counties within the NBW. NOEP reported on total landings in weight and value for commercial fishing in all principle ports in the NBW. NMFS reported data for specific species of fish landed.

The economic impact of recreational fishing is estimated for the NBW based on several assumptions and limitations. To estimate the commercial fishing activity within the NBW using published data at the county level, county figures were adjusted by the share of the land area in the watershed, assuming data is consistent in watershed and non-watershed areas (please refer to the "Geography" section of this report for a map of the NBW). Middlesex county is excluded, as less than 1% of it resides within the NBW. In addition, numbers are rounded to the nearest full number for establishments and employees.

To estimate the commercial fishing activity within the NBW using ports data, only the ports located within the NBW (Narragansett and North Kingstown) and Point Judith are included, all of which are in RI. While Point Judith is not within the watershed boundaries, it is included because it is an important landing port for fish caught in the Bay. There are no commercial fishing ports in the Massachusetts portion of the NBW due to the lack of marine coastline in the MA portion of the NBW (most of Massachusetts's coastline falls along Cape Cod). Data for Point Judith and Narragansett both date back to at least 2006, while North Kingstown landing data is available for 2011 onward.

It should be noted that all finfish, shellfish, and crustacea data are largely dependent upon a voluntary system of self-reporting by fishermen and buyers. These data are therefore susceptible to bias and inaccuracy and may underestimate the level of commercial fishing activity in the NBW. Additionally, the NMFS does not provide data for fish categories separated by port. Therefore, some landings captured could have been caught outside the NBW.

For additional information on methodology used in this report, please refer to the "Methodology" section.

Current Status and Trends

Commercial fishing remains a prominent industry in the NBW today despite historical fluctuations. Based on previously stated assumptions, in 2015 there were 155 commercial fishing establishments in the watershed (Table 1). These establishments employed over 700 individuals with $85 million (in 2016 dollars) in annual wages.

Table 1: Commercial Fishing Establishments, Employees, and Wages in the NBW (2015) (in 2016 dollars) [i]

County	Establishments	Employees	Wages ($1000s)
	Rhode Island		
Bristol	2	0*	0*
Kent	1	0*	0*
Newport	9	14	$611
Providence	N/A**	N/A**	N/A**
Washington	1	9	$795
	Massachusetts		
Bristol	138	692	$83,305
Norfolk	0	0	0
Plymouth	4	7	$414
Worcester	N/A	N/A	N/A
Total	**155**	**722**	**$85,125**

Source: BLS

Note: These figures are from the 1411 NAICS code ("Fishing")

*indicates the BLS had 0 recorded for these values, despite there being establishments

**indicates that commercial fishing was not present in the BLS report for this county

As a complement to the BLS data, the NOEP reports landings data for commercial fishing ports within the NBW. Data include total landings weight and value (Table 2).

For landing weight in 2016, the Point Judith, North Kingstown, and Newport ports were the 18th, 34rd, and 75th top ranked commercial fishing ports in the U.S. out of 131 ports (Table 2). Combined, these three NBW ports total over 77 million pounds. This would make them 13th top ranked commercial

[i] Scaled by ratio of NBW area to county land area: Bristol RI (100%), Kent RI (74.44%), Newport RI (82%), Providence RI (95.57%), Washington RI (16.47%), Bristol MA (71.93%), Norfolk MA (19%), Plymouth MA (36.45%).

fishing port in landing weight pounds in the U.S. Both the Point Judith and North Kingstown ports made considerable gains in the ranking from 2015, with Point Judith rising six spots and North Kingstown gaining nine, while Newport fell 11 spots. Point Judith has, by far, the most productive landing, with 53.4 million pounds of shellfish and fish in 2016, compared to 17.6 in North Kingstown and 6.6 in Newport.[10]

Concerning landing value, the Point Judith, North Kingstown, and Newport ports were the 15th, 74th, and 92nd most economically valuable commercial fishing ports in the U.S. out of 131 ports. Combined, these three NBW ports total over $78 million (this would make them the 10th most valuable commercial fishing port in the U.S. for annual fish landings). Compared to 2015, Point Judith rose nine spots, North Kingstown one spot, and Newport seven spots. Again, Point Judith had the most productive landing, with a value of $55.7 million, compared with $13.7 in North Kingstown and $8.9 in Newport. [11]

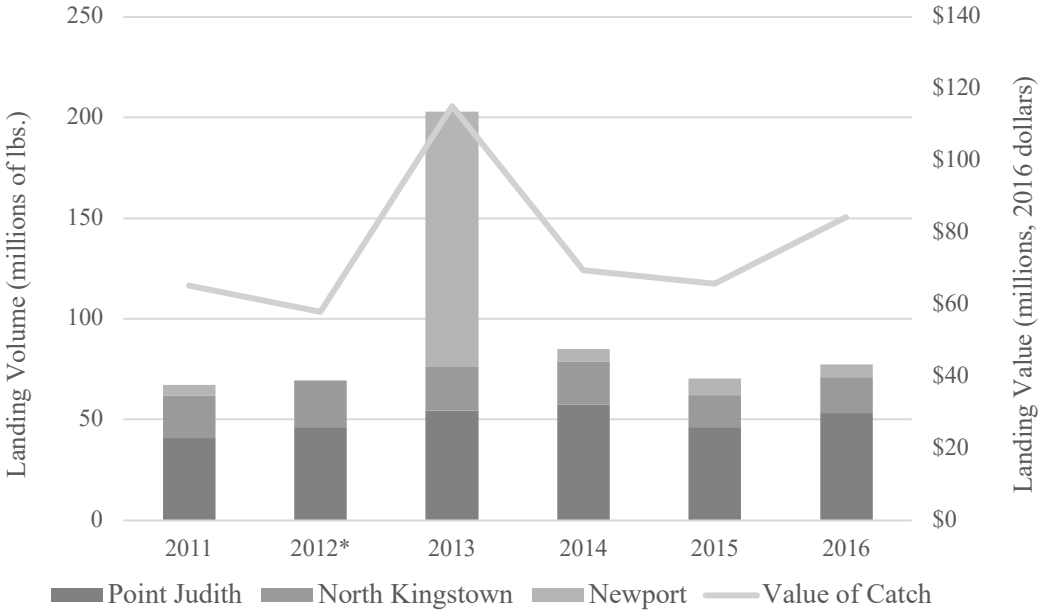
Table 2: Commercial Fishing Ports Rankings by Landing Weight and Value, NBW (2016) (2016 dollars)

Port	Weight (lbs.) (1000s)	Rank	Landed Value (millions)	Rank
Point Judith, RI	53,400	18	$55,700	15
North Kingstown, RI	17,600	38	$13,700	74
Newport, RI	6,600	75	$8,000	92

Source: NOEP, 2016

Data for landings history are also available for NBW ports, which can be used to investigate trends over time. During the last few years, landings have fluctuated in both weight and value (Figure 1).

At the Point Judith port, landing volume (weight) has increased, although not consistently, in the past decade. During this same time, despite an increase of 16% in landing weight from 2006 to 2016, there was almost no change in landing value. Conversely, the Newport port volume decreased 56% during this time, and value fell 68%. There was, however, an unusually productive year in 2013, where landing weight was nearly 20 times what it was in 2016, and value was over seven times what it was in 2016. Comparing this to national rates, commercial landing volume increased 2% from 2006 to 2015, while value increased 11%. During this same time, for Point Judith and Narragansett, landing volume decreased 3% from 2006 to 2012, but landing value decreased 34%.[12]



*no landing data for Newport in 2012

Figure 1: Commercial Fishery Landings, Narragansett Bay Watershed Ports, 2011-2016 (in 2016 dollars)

Source: NOEP, 2011-2016

Note: Graph starts in 2011 because that is when data became available for all three ports – data was not available for previous years in North Kingstown. 2012 is missing because there is no Newport data reported for this year.

Table 3: Landing Weight and Value of Point Judith, Narragansett, and North Kingstown Ports, 2006-2016 (2016 dollars)

	Point Judith		Newport		North Kingstown	
Year	**Weight (lbs.) (1000s)**	**Value ($1000s)**	**Weight (lbs.) (1000s)**	**Value ($1000s)**	**Weight (lbs.) (1000s)**	**Value ($1000s)**
2016	53,400	$55,700	6,600	$8,000	17,600	$13,700
2015	46,200	$45,954	8,300	$7,460	16,100	$11,041
2014	57,300	$51,130	6,400	$6,899	21,300	$11,362
2013	54,600	$48,162	126,800	$56,825	21,700	$10,004
2012	46,400	$44,591	--	--	23,000	$13,293
2011	40,800	$43,069	5,600	$8,015	21,000	$14,000
2010	35,600	$35,496	7,500	$7,606	--	--
2009	39,900	$36,288	7,600	$7,840	--	--
2008	37,600	$41,163	6,700	$7,251	--	--
2007	37,600	$42,551	8,700	$14,377	--	--
2006	46,000	$55,762	10,300	$24,783	--	--

Source: NOEP, 2006-2016

Certain species of fish account for higher landing value than others. This is especially true within the NBW. The species of fish that accounted for much of landing values at NBW ports in 2015 were longfin squid, American lobster, and sea scallop. Although less valuable than shellfish and crustacea, the most valuable finfish species landed were summer flounder, scup, and goosefish (Table 4).[13]

Table 4: Highest Value Shellfish, Crustacea, and Finfish Species Landed in the NBW (2015) (in 2016 dollars)

Species Name	Value ($1000s)
Longfin Squid	$19,123.3
American Lobster	$12,514.0
Sea Scallop	$7,993.6
Summer Flounder	$6,190.9
Scup	$4,337.0
Goosefish	$2,767.6

Source: NMFS, 2015

Given the highly variable nature of production of commercial fishing landings, it is difficult to establish trends over the past ten years. Despite this fluctuation, commercial fishing has a considerable economic impact: in 2016, the annual value of catches was over $77 million for these three ports combined, and in all of the NBW, commercial fishing establishments in 2015 employed over 700 people with wages over $85 million.[14]

Future Threats and Opportunities

Temperature | Estuarine fish communities | Water quality for aquatic life

Currently, the commercial fishing industry faces numerous threats and stressors, including overfishing, water pollution, and destruction of habitat, but perhaps the most pressing threats will arise from the effects of climate change. Climate change is expected to impact the Northeast Atlantic at a greater rate than the global average: the Narragansett Bay water temperature increased by 2.5 to 3° F from 1960 to 2012, while water temperature is projected to increase 3.6 to 5.4° F increase within the next century.[15] Many fish are already surviving at the upper limits of their temperature tolerance, and a further increase in temperature could lead to species migrating further north where temperature is comparable to that of the modern-day NBW. This could lead to less cool-cold water species, such as winter flounder and American lobster in the NBW, and an increase in the population of warmer water fish, such as scup, summer flounder, butterfish, and black sea bass, residing in the NBW. This shift in species present in the NBW presents a change in direction of the commercial fishing industry and what types of fish they harvest.

Furthermore, increasing water temperatures, aside from the direct impact they have on fish species diversity in NBW, will also affect many other aspects of marine life that impact fish populations. For example, this increase in water temperature will affect habitats that are critical to marine life, such as

seagrass. Seagrass is stressed by higher temperatures, leading to alterations in its reproduction patterns. A decline in seagrass would mean a decline in critical habitat, breeding ground, and nurseries for scallops, striped bass, flounder, and other species.[16] Additionally, issues such as nutrient loading, stormwater runoff, and wastewater runoff may increase in coming years due to increased precipitation as a result of climate change, as well as increased impervious cover from urbanization. This may cause issues such as increased prevalence of algal blooms and decreased levels of dissolved oxygen, which both negatively impact the health of fish populations.[17]

Overall, a culmination of issues, such as the effects of urbanization and climate change, will impact the future of commercial fishing in the NBW. These issues pose threats to the health and status of current fish species, but also opportunities to harvest new species that previously were not prevalent in the area. Efforts to control water quality and to mitigate and adapt to the effects of climate change are important steps to ensure the future of the commercial fishing industry and its economic impact in the watershed.

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[1] Source: NMFS U.S. Commercial Landings, 2015.
[2] Source: NMFS U.S. Rhode Island Landings, n.d.
[3] Source: NOEP, n.d.
[4] Source: BLS, 2015.
[5] Source: Hall-Arber et al., n.d.
[6] Source: Hall-Arber et al., n.d.
[7] Source: Oviatt et al., 2003.
[8] Source: Oviatt et al., 2003.
[9] Source: McGrath, 2016.
[10] Source: NOEP, n.d.
[11] Source: NOEP, n.d.
[12] Source: NMFS U.S. Rhode Island Landings, n.d.
[13] Source: NMFS, n.d.
[14] Source: NOEP, n.d.
[15] Source: NBEP "Temperature," 2017.
[16] Source: NBEP "Sea Grass," 2017.
[17] Source: NBEP "Water Quality for Aquatic Life," 2017.

Appendix

Table A1: Establishments, Employees, and Wages in RI and MA NBW Counties (2015)

County	Establishments	Employees	Wages ($1000s)
Bristol (MA)	192	962	$114,246
Bristol (RI)	2	0*	0*
Kent (RI)	2	0*	0*
Newport (RI)	11	18	$735
Norfolk (MA)	1	0*	0*
Plymouth (MA)	12	20	$1,121
Providence (RI)	N/A**	N/A**	N/A**
Washington (RI)	11	57	$4,759
Worcester (MA)	N/A**	N/A**	N/A**

Source: BLS, 2015

Note: *indicates the BLS had 0 recorded for these values, despite there being establishments
**indicates that commercial fishing was not present in the BLS report for this county

Table A2: Top Commercial Fishing Ports in the United States (2015) (in 2009 dollars)

Rank	Port	Weight	Port	Landed Value
1	Dutch Harbor-Unalaska, AK	787,400,000	New Bedford, MA	$321,900,000
2	Kodiak, AK	513,900,000	Dutch Harbor-Unalaska, AK	$218,200,000
3	Aleutian Islands (Other), AK	467,400,000	Kodiak, AK	$137,500,000
4	Intracoastal City, LA	427,500,000	Aleutian Islands (Other), AK	$111,300,000
5	Empire-Venice, LA	379,200,000	Empire-Venice, LA	$110,900,000
6	Reedville, VA	350,000,000	Honolulu, HI	$96,800,000
7	Pascagoula-Moss Point, MS	294,800,000	Alaska Penninsula (Other), AK	$90,300,000
8	Alaska Penninsula (Other), AK	268,000,000	Bristol Bay (Other), AK	$90,100,000
9	Naknek-King Salmon, AK	175,500,000	Cape May-Wildwood, NJ	$71,600,000
10	Cordova, AK	162,000,000	Key West, FL	$71,200,000
11	New Bedford, MA	123,800,000	Naknek-King Salmon, AK	$68,500,000
12	Seward, AK	94,400,000	Westport, WA	$65,000,000
13	Astoria, OR	91,500,000	Cordova, AK	$64,500,000

14	Sitka, AK	87,400,000	Stonington, ME	$63,800,000
15	Ketchikan, AK	84,300,000	Sitka, AK	$59,400,000
16	Westport, WA	83,500,000	Seward, AK	$59,300,000
17	Cape May-Wildwood, NJ	77,200,000	Hampton Roads Area, VA	$56,400,000
18	Bristol Bay (Other), AK	69,600,000	Brownsville-Port Isabel, TX	$55,100,000
19	Petersburg, AK	69,600,000	Pascagoula-Moss Point, MS	$53,900,000
20	Gloucester, MA	67,700,000	Point Judith, RI	$46,200,000
21	Newport, OR	65,000,000	Dulac-Chauvin, LA	$45,400,000
22	Portland, ME	62,400,000	Gloucester, MA	$44,400,000
23	Kenai, AK	49,600,000	Galveston, TX	$42,400,000
24	Point Judith, RI	46,200,000	Vinalhaven, ME	$39,700,000
25	Moss Landing, CA	45,100,000	Ketchikan, AK	$39,600,000
26	Port Hueneme-Oxnard-Ventura, CA	43,500,000	Petersburg, AK	$39,300,000
27	Honolulu, HI	32,299,999	Astoria, OR	$38,200,000
28	Rockland, ME	31,000,000	Bayou La Batre, AL	$37,200,000
29	Dulac-Chauvin, LA	30,500,000	Portland, ME	$34,600,000
30	Monterey, CA	28,400,000	Shelton, WA	$34,200,000
31	Grand Isle, LA	25,900,000	Reedville, VA	$33,100,000
32	Atlantic City, NJ	25,900,000	Newport, OR	$32,900,000
33	Brownsville-Port Isabel, TX	24,700,000	Intracoastal City, LA	$32,800,000
34	Point Pleasant, NJ	24,400,000	Grand Isle, LA	$32,600,000
35	Provincetown-Chatham, MA	21,200,000	Kenai, AK	$32,500,000
36	Coos Bay-Charleston, OR	20,600,000	Palacios, TX	$31,200,000
37	Bayou La Batre, AL	20,200,000	Provincetown-Chatham, MA	$30,600,000
38	Stonington, ME	19,100,000	Point Pleasant, NJ	$28,200,000
39	Wanchese-Stumpy Point, NC	18,200,000	Port Arthur, TX	$26,900,000
40	Key West, FL	17,300,000	Wanchese-Stumpy Point, NC	$26,600,000
41	Juneau, AK	16,700,000	Delacroix-Yscloskey, LA	$26,300,000
42	Galveston, TX	16,399,999	Long Beach-Barnegat, NJ	$25,400,000
43	North Kingstown, RI	16,100,000	Bellingham, WA	$25,400,000
44	Golden Meadow-Leeville, LA	16,000,000	Tampa Bay-St. Petersburg, FL	$24,700,000
45	Palacios, TX	15,400,000	Seattle, WA	$24,500,000
46	Los Angeles, CA	14,700,000	Golden Meadow-Leeville, LA	$23,800,000
47	Ilwaco-Chinook, WA	14,600,000	Juneau, AK	$22,500,000
48	Boston, MA	14,000,000	Friendship, ME	$21,800,000
49	Tampa Bay-St. Petersburg, FL	13,600,000	Coos Bay-Charleston, OR	$21,500,000
50	Port Arthur, TX	13,600,000	Beals Island, ME	$20,700,000
51	Delacroix-Yscloskey, LA	13,500,000	Port Hueneme-Oxnard-Ventura, CA	$20,700,000
52	Bellingham, WA	13,300,000	Anacortes-La Conner, WA	$20,600,000
53	Montauk, NY	11,600,000	Beaufort-Morehead City, NC	$20,300,000
54	Hampton Roads Area, VA	11,500,000	Atlantic City, NJ	$19,600,000
55	Princeton, CA	10,700,000	Homer, AK	$18,100,000
56	Anchorage, AK	10,400,000	Rockland, ME	$17,800,000
57	Brookings, OR	9,800,000	Fairhaven, MA	$17,800,000

58	Vinalhaven, ME	9,700,000	Olympia, WA	$17,200,000
59	Shelton, WA	9,600,000	Newington, NH	$17,100,000
60	Gulfport-Biloxi, MS	9,300,000	Fort Myers, FL	$16,800,000
61	Beaufort-Morehead City, NC	8,600,000	Spruce Head, ME	$16,500,000
62	Eureka, CA	8,400,000	Boston, MA	$16,200,000
63	Accomac, VA	8,300,000	Montauk, NY	$15,900,000
64	Newport, RI	8,300,000	Gulfport-Biloxi, MS	$15,000,000
65	Fort Myers, FL	7,300,000	Ilwaco-Chinook, WA	$14,500,000
66	Crescent City, CA	7,000,000	Jonesport, ME	$14,100,000
67	Homer, AK	6,700,000	Santa Barbara, CA	$13,900,000
68	Engelhard-Swanquarter, NC	6,600,000	Engelhard-Swanquarter, NC	$13,600,000
69	Columbia, NC	6,500,000	Accomac, VA	$13,000,000
70	Fort Bragg, CA	6,500,000	Yakutat, AK	$12,200,000
71	Morgan City-Berwick, LA	6,400,000	Mayport, FL	$12,100,000
72	Seattle, WA	6,400,000	Columbia, NC	$11,400,000
73	Long Beach-Barnegat, NJ	6,300,000	Swans Island, ME	$11,200,000
74	Santa Barbara, CA	6,200,000	Milbridge, ME	$11,200,000
75	New London, CT	6,100,000	North Kingstown, RI	$11,100,000
76	Beals Island, ME	6,000,000	Southwest Harbor, ME	$11,000,000
77	Slidell-Covington, LA	5,900,000	Bass Harbor, ME	$10,800,000
78	Portsmouth, NH	5,900,000	Port Clyde, ME	$10,800,000
79	Anacortes-La Conner, WA	5,900,000	Wrangell, AK	$10,700,000
80	Fairhaven, MA	5,800,000	Fort Bragg, CA	$10,600,000
81	Jonesport, ME	5,800,000	Slidell-Covington, LA	$10,600,000
82	Mayport, FL	5,700,000	Owls Head, ME	$10,100,000
83	Neah Bay, WA	5,600,000	Panama City, FL	$9,800,000
84	Port St. Joe, FL	5,400,000	Oriental-Vandemere, NC	$9,700,000
85	San Francisco Area, CA	5,200,000	Willapa Bay, WA	$9,700,000
86	Wrangell, AK	5,200,000	Naples, FL	$9,200,000
87	Friendship, ME	5,200,000	San Francisco Area, CA	$9,200,000
88	Upper Southeast (Other), AK	5,200,000	Apalachicola, FL	$9,100,000
89	Belford, NJ	4,900,000	Anchorage, AK	$9,100,000
90	Belhaven-Washington, NC	4,700,000	Neah Bay, WA	$8,900,000
91	Cameron, LA	4,400,000	Darien-Bellville, GA	$8,700,000
92	Yakutat, AK	4,400,000	Brookings, OR	$8,600,000
93	Spruce Head, ME	4,400,000	Blaine, WA	$8,500,000
94	Hampton Bay-Shinnicock, NY	4,099,999	Los Angeles, CA	$8,400,000
95	Ocean City, MD	4,099,999	Belhaven-Washington, NC	$8,300,000
96	Cape Canaveral, FL	4,000,000	Monterey, CA	$8,000,000
97	Oriental-Vandemere, NC	4,000,000	Morro Bay, CA	$7,800,000
98	Morro Bay, CA	3,600,000	Moss Landing, CA	$7,600,000
99	Panama City, FL	3,600,000	Newport, RI	$7,500,000
100	Bon Secour-Gulf Shores, AL	3,200,000	Cape Canaveral, FL	$7,400,000

Source: NOEP, 2015

Table A3: Commercial Fishery Landings, Narragansett Bay Watershed Ports 2006-2015 (in 2016 dollars)

Year	Weight (lbs.) (1000s)	Value ($1000s)
2006	56,300	$80,693
2007	46,300	$57,032
2008	44,300	$48,503
2009	47,500	$44,209
2010	43,100	$43,182
2011	67,400	$65,203
2012	69,400	$57,991
2013	203,100	$115,203
2014	85,000	$69,518
2015	70,600	$64,573

Source: NOEP, 2006-2015

The Narragansett Bay Watershed Economy Project was conceived and partially supported by the Coastal Institute at the University of Rhode Island under the leadership of Dr. Emi Uchida. In addition, this project was supported, in part, under Assistance Agreement No. SE - 00A00252 awarded by the U.S. Environmental Protection Agency (EPA) to Mass Audubon. Additional project partners include the URI Graduate School of Oceanography, the URI Coastal Resources Center, the Natural Capital Project at Stanford University, and the George Perkins Marsh Institute at Clark University. The views expressed in this project are solely those of the authors. It has not been formally reviewed by EPA. Additional information is available at www.nbweconomy.org.

NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Defense Overview

The defense sector is one of the key economic drivers of the Narragansett Bay watershed (NBW), especially in Newport and Quonset, Rhode Island (RI). This sector is the center of basic and applied research and development projects in marine-related technology, including submarines, underwater sound equipment, systems, and technical engineering services. The sector provides some of the highest paying jobs in RI, employing tens of thousands of highly skilled individuals in the labor force.

The Naval Station Newport hosts the Naval Undersea Warfare Center Division Newport (NUWC Division Newport) along with approximately 50 Navy, Marine Corps, Coast Guard, and U.S. Army Reserve tenant commands and activities.[1] At the core of the sector is the NUWC Division Newport, which is the U.S. Navy's principal research, development, test, and evaluation center for undersea weapons systems and other systems related to undersea battlespace (Figure 1). This federal military defense infrastructure is integrated with the private defense industry through contracts from the Department of Defense (DoD), ranging from ship building and repair, search detection, navigation, aeronautical and nautical system, instrument manufacturing to scientific research in general.

In 2013, the defense sector directly supported nearly 17,500 military and civilian workers and added $1.1 billion in earnings to the economy. The direct contribution to RI's Gross Domestic Product was estimated at $2.3 billion (in 2016 dollars).[2] While both public and private industries have contributed to the watershed economy through significant employment and wages, recent growth is attributable to the private defense industry.

History

Newport has been the center of the U.S. Navy's undersea technology since the U.S. Naval Torpedo Station was founded on Goat Island in 1871.[3] Situated in a geographically important location for times of warfare, it has military ties dating back to 1703, when it was used as a military fort.[4] As a result of the American Civil War, submarine and other technologies were introduced as a new radical concept in conducting naval warfare. During the first three decades of existence, the torpedo station found itself in a race to build new physical facilities fast enough to keep up with the expanding torpedo

program requirements. A factory was built in 1907 to build steam torpedoes for the U.S. Navy, which became (and remains) a major employer in Newport.

Figure 1: Naval undersea Warfare Center Division (NUWC), Newport, RI
Source: NUWC, Division Newport

This factory designed, researched, tested, and produced underwater weaponry through World War I and II (WWI and WWII), creating additional facilities on several islands. The Navy's presence expanded throughout WWI and WWII; in the 1940s, the U.S. Naval Operating Base had headquarters in Newport, including extensive naval facilities on both sides of Narragansett Bay. The Naval Torpedo Station was the first major contributor to the development and production of new high-energy explosives for the U.S. Navy. Since its establishment, it also became a training center for both officers and enlisted individuals who were instructed in a wide range of technical subjects including torpedoes, diving, mines, gun-control systems, torpedo boat and submarine operations, and countermining. By WWII, the Goat Island facility complex became an industrial activity primarily dedicated to the production of artillery, where personnel worked around the clock to manufacture torpedoes during the war.

Shortly after the U.S. entered WWII, the U.S. military expanded its base in Quonset and Davisville, RI.[5] In 1941, the U.S. Navy built the Quonset Point Naval Air Station, which served as the major northeastern naval base during the war and subsequent years. During WWII, Quonset was involved in the development of a naval night fighter aircraft. The Navy also established the Construction Battalion Center in Davisville on a site that was previously home to the thriving 370-acre Romano Farm and Vineyards. Davisville became the birthplace of the "Seabees," a portion of service people in the U.S. Navy tasked with building bases, creating roadways and airstrips, and numerous other construction projects during conflicts. During its heyday, Quonset's workforce, combined with that of the adjacent Davisville Construction Battalion Center, was the largest in the State of RI.

After WWII, Quonset Point saw a depletion in ships on the base. It became a Naval Air Rework Facility, where it specialized in reciprocating engines, and repaired and manufactured naval aircrafts. Like other WWII-era military installations across the country, Quonset Point fell victim to military budget cuts during the Nixon years and the Quonset base was decommissioned in 1974. The land and

buildings were offered to the State of RI and North Kingstown for civilian use. By the 1980s, Davisville's facilities were also stripped back to a skeleton crew— many of its buildings were sealed and the facilities faced operational closure in 1994. Following their closures, the land at Quonset and Davisville was managed and developed by various state entities until the Quonset Development Corporation (QDC) was created by the RI General Assembly in 2005. The QDC created Quonset Business Park, which is now home to almost 200 companies and employs more than 10,000 people in full- and part-time jobs across a variety of industries (for more information, refer to the section on "Ports and Transportation").

In contrast to Quonset, the defense sector reorganized and revived in Newport. A series of reorganizations of the naval undersea research and technology centers within the U.S. Navy led to the establishment of the NUWC Division Newport in 1992. Two NAVSEA Warfare Centers—the Naval Surface Warfare Center and the NUWC—were officially established as part of an overall Department of the Navy consolidation of research, development, test and evaluation, engineering, and fleet support activities. The station had once declined due to lack of demand for undersea weaponry after the Cold War, but it has regained its scale after the 9/11 attack in 2001. Since 2001, the sector has been growing and has become a key engine in naval technology in the US. In 2003, the Naval Surface Warfare Center and the NUWC began operating as an integrated entity, shifting from a site-centric model to a national business model. Today, Newport remains an integral site of naval training, research, and development. In addition to NUWC, the prestigious Naval War College, the Naval Education and Training Center, and other navy command schools makes this sector a leading employer in the watershed economy.

Data Sources

Almost all activities in the defense sector in the watershed lie solely in the RI portion of the NBW. We therefore report data only on RI's federal military defense infrastructure and the private defense industry (private contractors through the DoD).

Publicly available data for employment and outputs in the defense sector is limited. Therefore, this chapter relies heavily on a recent economic impact study of the RI's defense sector by Tebaldi (2014) and data provided by NUWC. NUWC employs two-thirds of all employees in the military defense infrastructure in RI.

Telbadi (2014) uses data partially available publicly and others available through exclusive contracts from the U.S. Office of Personnel Management, U.S. Coast Guard, RI National Guard, Defense Manpower Data Center, Federal Procurement Data System, RI Department of Labor and Training, U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, and NUWC Division Newport. Salve Regina University (2017) includes a few updated statistics. These data do not include U.S. Army National Guard's military base in Bridgewater, MA. Finally, Wyld (1997) describes the history of the Navy in Newport, RI from the 1800s to the present.

Current Trends

Overview of the defense sector in the watershed

The defense sector is one of the key economic drivers of the NBW, with almost all activities located in the RI portion of the watershed around Newport and Quonset, RI. The sector's core is the "military defense infrastructure," which is integrated with the "private defense sector" through contracts from the DoD. Combined, it undertakes basic and applied research and projects in marine-related technology, including submarines, underwater sound equipment, systems, and technical engineering services.

The defense sector contributes significantly to the watershed economy (Table 1). In 2013, the defense sector supported 17,497 jobs (or 15,760 full-time equivalents), of which 40% is in the private defense industry and 60% in military defense infrastructure.[6] This is nearly 3% of total employment in RI. The total direct earnings were $1.1 billion dollars. The direct contribution to the state's GDP was estimated at $2.3 billion (2016 dollars).

Table 1: The Direct Impact of the Defense Sector (2016 dollars)

	Employment	Earnings ($1000)	Output ($1000)
Military defense infrastructure	11,106	$680,964	$1,325,864
Private defense industry	6.391	$476,455	$976,288
Total defense sector	17,497	$1,157,419	$2,302,152

Source: Telbadi, 2014

The defense sector also supports nearly 4% of the RI's GDP. In 2013, the sector added $1.3 billion to the state's GDP. Roughly 42% was from the private defense industry and 58% from military defense infrastructure, roughly the same ratio as employment.

It is important to note that this federal military defense infrastructure is integrated with the private defense industry through contracts from the DoD, including ship building and repair, search detection, navigation, aeronautical and nautical system, and instrument manufacturing as well as scientific research. In 2013, the DoD engaged in 4,768 transactions with more than 200 private defense contractors in RI, awarding a total of $736 million in contracts (2016 dollars). The largest contracts included underwater sound equipment, aircraft accessories and components, systems and other professional engineering services. Since 2013, the proportion of employment has shifted slightly from federal military defense to the private defense industry.[7]

The defense sector is the highest paying sector in RI, with a large portion of the civilians classified in science, technology, engineering, and math (STEM) disciplines. In 2013, the average wage for civilian employees working for NUWC Division Newport was $114,256; the average for all civilian

employees for DoD was $97,381; and the average wage for all RI private defense workers was $74,550 (2016 dollars). These average wages are considerably higher than other sectors, for instance, manufacturing ($52,788) and leisure and hospitality ($19,050) (2016 dollars).[8]

Military defense infrastructure

The military defense infrastructure includes NUWC Division Newport along with 50 Navy, Marine Corps, Coast Guard, and U.S. Army Reserve tenant commands and activities at Naval Station Newport. Among these, the NUWC Division Newport employs two-thirds of the defense civilians in the military defense infrastructure; it is the U.S. Navy's principal research, development, test and evaluation center for undersea weapons systems and other systems associated with undersea battlespace. Its major focus is in applied research and system development for submarines, autonomous underwater systems, undersea offensive and defensive weapon systems, and countermeasures associated with undersea warfare. It provides research, development, test and evaluation, engineering and fleet support.

Over time, employment at NUWC Newport Division has increased steadily in RI (Figure 3). The workforce in this sector tends to be highly educated with the majority in STEM fields. In 2016, roughly one-third of those employees had advanced degrees and more than two-thirds were classified as engineers or scientists. The Naval Station Newport also hosts more than 30 Naval Educational Programs (e.g., the Naval War College), which train and develop Navy's midshipman candidates, senior enlisted personnel, officer candidates, and senior officers. The number of Navy students is estimated to be 9,600 to 15,000 annually (Telbadi, 2014).

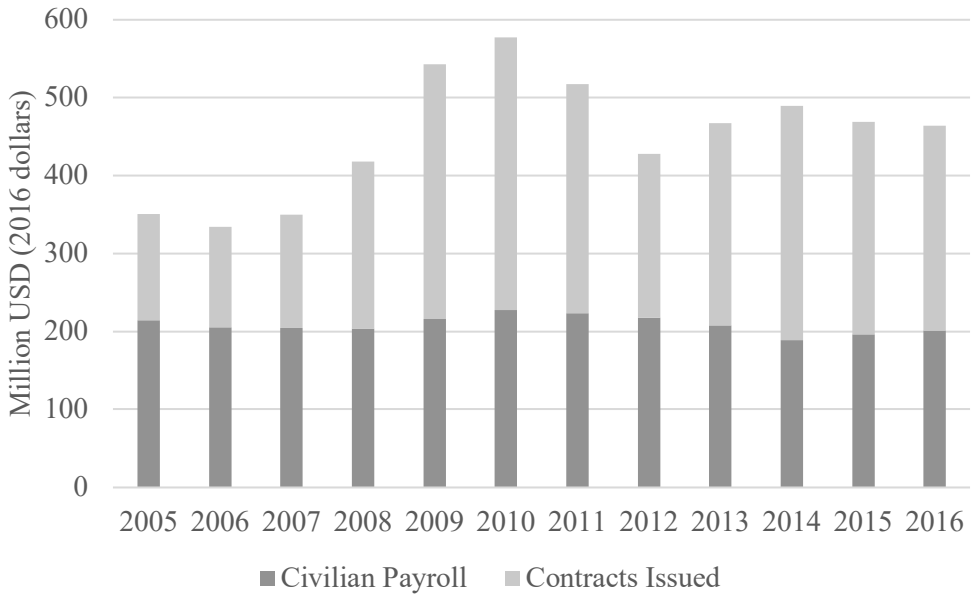

Figure 2: Civilian Payroll and Contracts in RI Issued at the Naval Undersea Warfare Center (Division Newport, RI) from 2005 to 2016 (2016 dollars, million)
Source: NUWC Economic Impact on Southern New England, 2005-2016

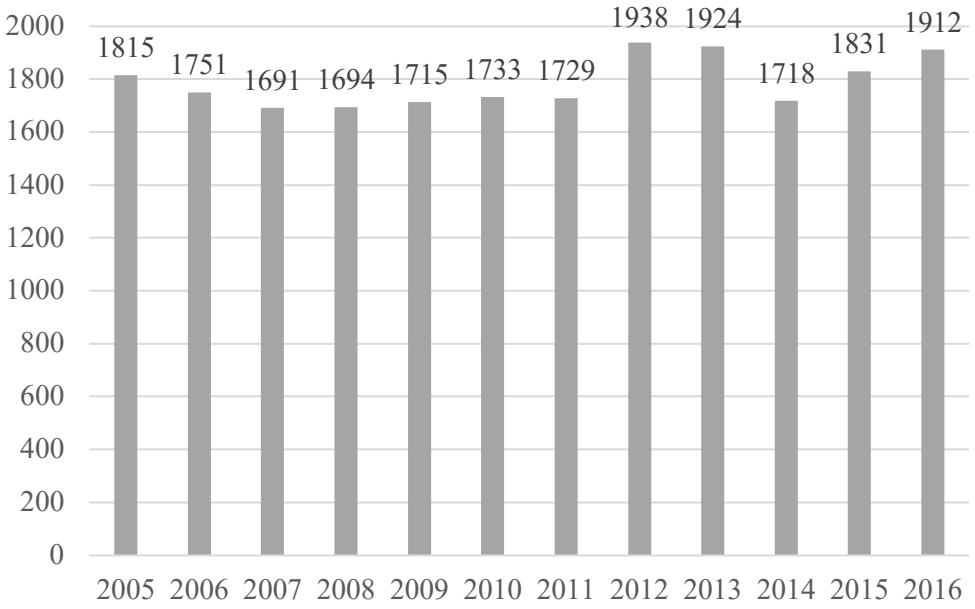

Figure 3: Civilian Employees Based in RI Employed by the Naval Undersea Warfare Center (Division Newport, RI) from 2005 to 2016

Source: NUWC Economic Impact on Southern New England, 2005-2016

Private defense industry

The military defense industry is complemented by research and development performed by the private defense industry, which is based on contracts awarded by the DoD. Funded programs, especially private contracts, have been increasing in the past decade (Figure 2). Between 2005 and 2016, private contracts in RI have increased by nearly twofold from $136 million to $262 million, peaking in 2010 at $350 million (in 2016 dollars). In 2013, the DoD awarded a total of $713 million in contracts, of which nearly 85% was through the Department of the Navy. The remaining 15% was awarded by the Defense Logistics Agency, Department of the Army, Department of the Air Force, and directly by the DoD. In 2013, more than 200 private defense contractors in RI were awarded contracts from the DoD.

DoD contracts support the development of new defense technologies and products. These include underwater sound equipment, systems engineering services, and aircraft accessories and components. Major private contractors in 2013 included Systems Engineering Associates Corporation, L-3 Communications Holdings, McLaughlin Research Group, and SAIC Inc.[9] RI also receives contracts from defense companies outside RI, such as General Dynamics Electric Boat. In 2013, General Dynamics employed 2,522 workers at its Quonset Point facility in RI, which fabricates Virginia Class submarines.

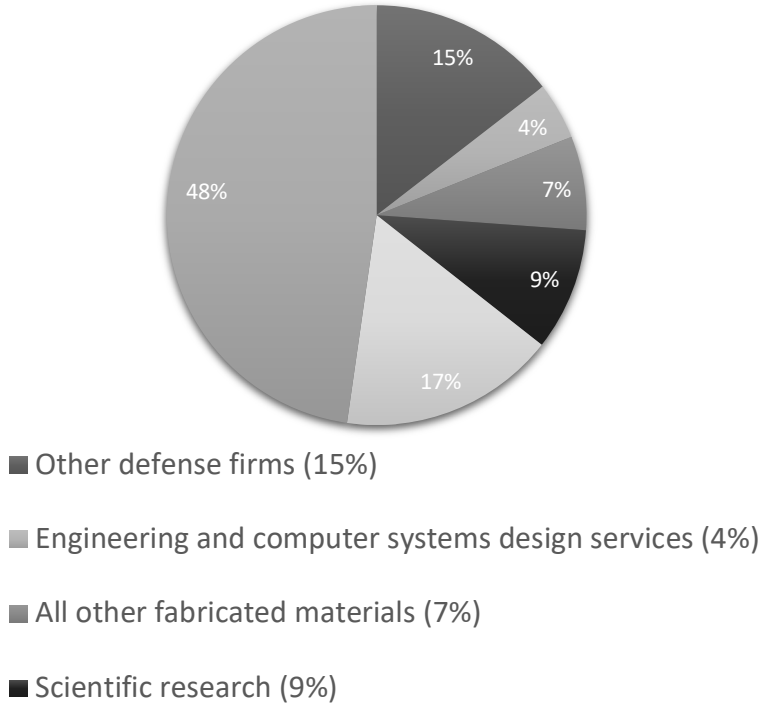

Figure 4: Employment in Private Defense Industry in RI, 2013
Source: Adapted from Telbadi, 2014

These DoD contracts support a significant labor force across several sectors in the watershed's economy (Figure 4). In 2013, the private defense industry in RI employed 6,391 workers. Ship building and repair, the largest private defense sector, employed 3,051 workers, accounting for nearly 50% of private defense employment in the state.[10] The second largest defense industry is search detection, navigation, guidance, aeronautical and nautical system, and instrument manufacturing, with over 1,000 workers. Other sectors include scientific research, engineering and computer systems design services, and fabricated metal.

Future Threats and Opportunities

Sea level rise

The main threat to the defense sector in the NBW is sea level rise that will occur in coming years due to climate change. NOAA predicts that sea level rise along the Northeast Atlantic will be higher than the global average and will rise by an estimated 9.8 feet by 2100 (intermediate-high scenario).[11] A study of 18 coastal Naval installations in the U.S. found that flooding will likely increase tenfold in these bases by 2050, and by 2070 nine of the 18 bases could experience up to 520 floods per year. The study also found that eight of the 18 bases may lose up to 50% of their land due to these floods by the year 2100.[12] Much like the bases in this study, given that the U.S. Naval War College in Newport as well as numerous defense industry buildings are along the coast, they are extremely vulnerable to a rise in sea-level. As seen from the STORMTOOLS projection, even just a one-foot

rise in sea level would impact the area surrounding the Naval War College (Figure 5) and would also impact the Coast Guard station on Block Island (Figure 6). As with other industries, such as Ports and Marine Transportation, adjustments will need to be made to accommodate these changes. While sea level rise may negatively impact current infrastructure in the defense sector, it also provides the opportunity to build new infrastructure along the future coastline that will arise due to climate change.

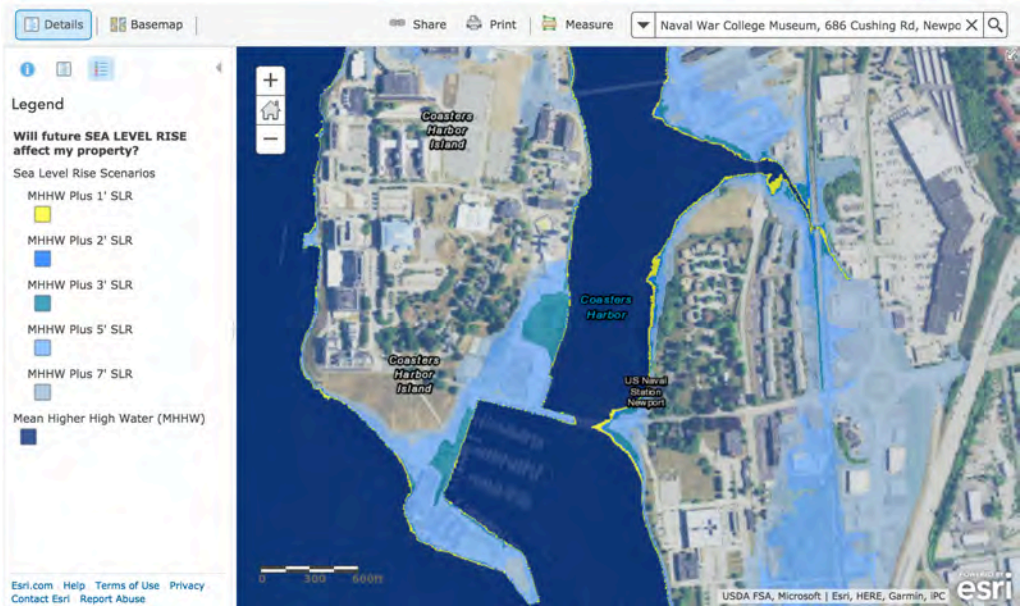

Figure 5: Sea Level Rise and Its Impact on the Naval War College, Newport, RI

Note: The rise in sea level is based on an increase in sea level rise (SLR) from the mean higher high-water point (MHHW)

Source: STORMTOOLS

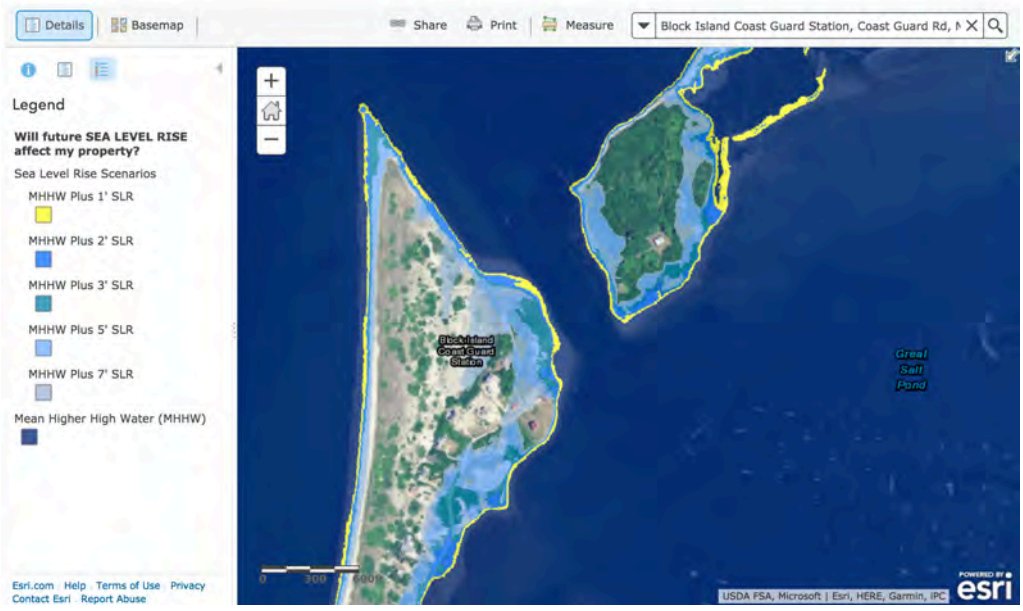

Figure 6: Sea Level Rise and its Impact on the Coast Guard Station on Block Island

Note: The rise in sea level is based on an increase in sea level rise (SLR) from the mean higher high-water point (MHHW)

Source: STORMTOOLS

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Salve Regina University (SRU). (2017). *NUWC Economic Impact Study 2017*.

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[1] Source: CNIC, n.d.
[2] Source: Tebaldi, 2014.
[3] Source: U.S. Navy, n.d.
[4] Source: Wyld, 1997.
[5] Source: QDC, 2014.
[6] Source: Tebaldi, 2014. The Military Defense Infrastructure includes civilian employees operating under the umbrella of the DoD, Coast Guard Personnel, RI National Guard personnel, and the

active-duty military in the Army, Navy, Marine Corps, and Air Force. The Private Defense Industry is comprised of defense contractors in NAICS sectors defined in Tebaldi, 2014, p.3.

[7] Source: Personal communication, Tebaldi, 2017.

[8] Source: Tebaldi, 2014.

[9] Source: Tebaldi, 2014.

[10] Source: RI Department of Labor and Training, reported in Telbadi, 2014.

[11] Source: NBEP "Sea Level," 2017.

[12] Source: Spanger-Siegfried *et al.*, 2016.

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NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Forestry Overview

Forests and open space play vital roles in almost every facet of our daily lives, both in rural and urban areas. They are much more than places to visit for recreational purposes: forests provide a variety of valuable goods and services for our economy. For example, forest products are used to build and furnish houses, produce paper, and are present in the food we eat. The forest products industry accounts for nearly 5% of U.S. manufacturing output (GDP). This amounts to over $200 billion in products annually, employing almost 900,000 workers in 2016.[1]

In addition to generating a monetary contribution and supporting jobs, forests provide a multitude of ecological benefits that include carbon sequestration, air pollution removal, carbon storage, and water filtration, among others. A 2010 study illustrated that in the study year alone, trees and forests in the U.S. removed over 17 million metric tons of air pollution. This amounted to human health effects valued at nearly $7 billion.[2]

The significance of forests is also apparent in the Narragansett Bay watershed (NBW): in 2015, the 611,000 acres of forest helped employ over 5,000 individuals.[3] This report estimates that in 2013, all forest-based sales generated in the Rhode Island (RI) portion of the NBW reached a total of $698 million (in 2016 dollars). In addition, the forest product and recreational sectors accounted for over 3,000 jobs. This report also estimates that in 2006 in the Massachusetts (MA) portion of the NBW, the forest-based sector employed over 2,000 individuals. In total, this accounted for over $170 million in employee wages (in 2016 dollars).

History

Forest lands in the NBW have faced many changes over the years, due to both human action and natural forces. These changes include urban development, human manipulation, aging, and other natural processes such as windstorms, snowstorms, and floods, all of which impact forest development.[4] Due to these effects, the cover and health of forests in the watershed has fluctuated throughout history.

Beginning in the early 17th century when European settlers such as Roger Williams began to colonize RI and MA, forest still covered much of the watershed. In RI, 90% of land in the state was forested in 1630 (Figure 1). These large areas of forest were drastically reduced beginning in 1767, decreasing to less than 25% by 1887.[5] The rapid reduction of forested land was mainly due to the peak of agriculture when farmers deforested land at staggering rates to make room for crops.[6]

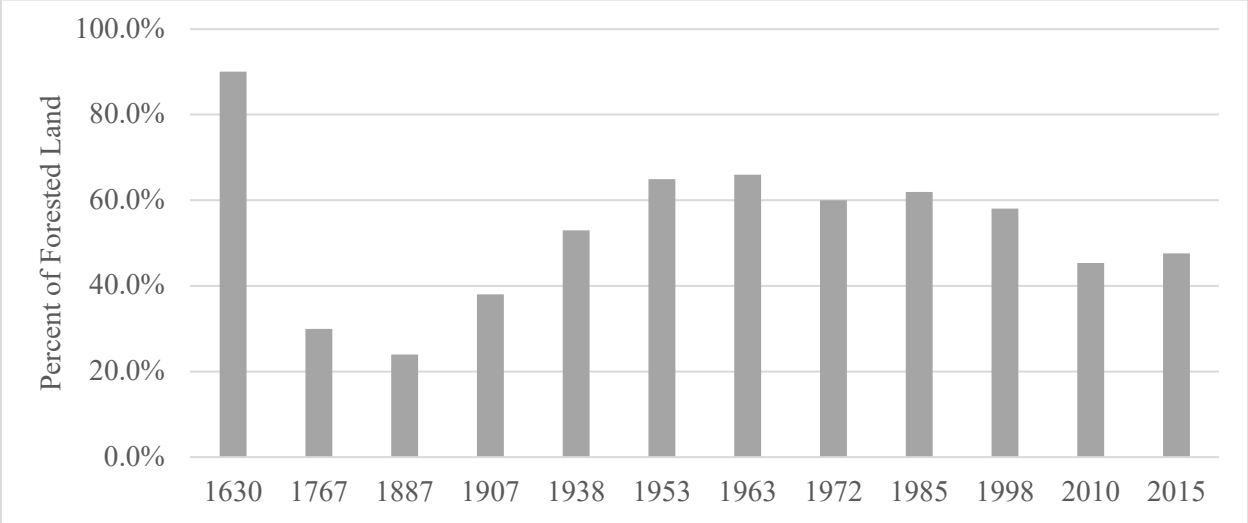

Figure 1: Percent of Forested Land in Rhode Island: 1630, 1767, and 1887-1998[7]

Source: RIDEM, 2002; NBEP, 2017

Note: The decline in coverage between 1630 and 1767 was due to European settlement, as colonists collected wood for fire and cleared land for agriculture (previously, the Native American tribes were nomadic and did not stay in one location and clear extensively for settlement). The Industrial Revolution marked a pivotal shift in forest coverage in the state—as migration shifted towards cities, agriculture was abandoned and forests began to grow on vacant farms.[8]

Major deforestation occurred later in MA than in RI, with the peak of clearing occurring between 1830 and 1885. During this time, 70% of forested land in in MA was cleared for harvesting forest products and agricultural pursuits including pastures, cropland, and orchards.[9]

Between the late 1800s and the mid-1900s, agriculture in the NBW began to decline as the Industrial Revolution took hold and populations shifted away from farms and into cities to work in factories. This led to a rise in the growth of urban-industrial population centers and an increase in abandoned farms, allowing forests to make a comeback in the 20th century.[10]

Although a revival occurred for forests in the NBW, it was short-lived. Since 1952, the area of forest land in RI has decreased by 15%, from an estimated 434,000 acres to an estimated 367,000 acres in 2015. This remaining forest coverage in 2015 accounts for approximately 55% of total land area in the state.[11] During the same period in MA, forest land has decreased less dramatically at 9%, from an estimated 3.3 million acres of forest cover to an estimated 3.0 million acres. This 2015 forest cover

accounts for approximately 61% of total land area in the whole state, including the non-NBW portion.[12] A large amount of this forestland is privately owned (Figure 2).[13]

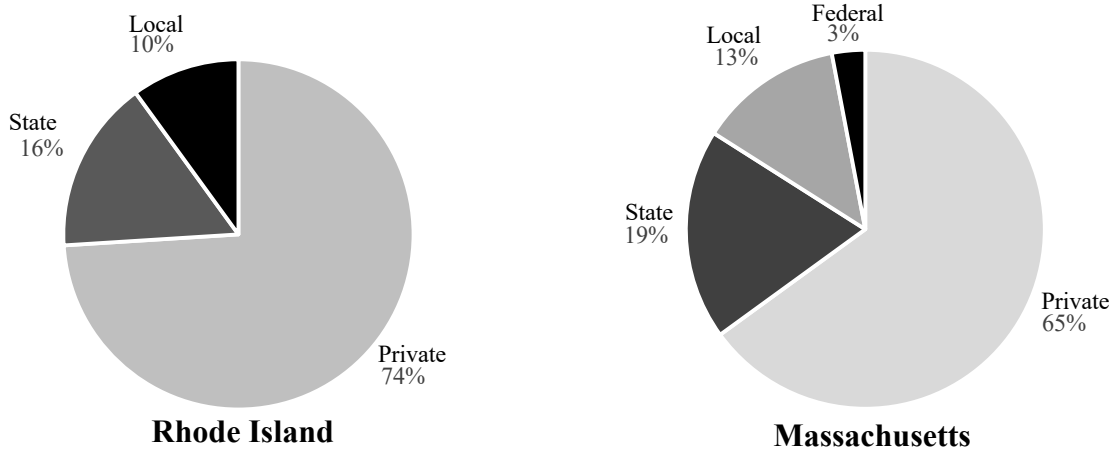

Figure 2: Forest Ownership of Rhode Island and Massachusetts, 2013
Sources: USDA Forests of Rhode Island, 2013; USDA Forests of Massachusetts, 2013

Despite major historic losses in forest coverage for both states, forest area has been increasing in the past few years. For example, from 2010 to 2015, there was a 5.1% increase in total forestland, increasing from 352,000 to 369,800 acres in RI.[14] In MA from 2010 to 2015, the improvement is smaller with a less than 0.3% increase in forestland, from 3,014,600 to 3,024,900 acres; similarly, it is estimated that 38,000 acres of forest and wetlands were lost between 2005 and 2013, accounting for a loss of 1.2%.[15] [16] The exact cause of this increase is not identified in reports, but cites the economic recession and potential unidentified factors as the cause of the increase, although this trend may be reversing. In addition to marginal forest coverage increases, timberland—forestland that produces commercial crops of timber— has seen an increase in the last five years. In RI, timberland area has increased nearly 5% and MA has witnessed a 1% increase.[17]

Although there have been recent positive improvements to forested land in RI and MA, forests have become more fragmented.[18] Fragmented forestland is a growing concern in the watershed due to its potential impact on local water cycles, reduction of wildlife habitat, isolation and loss of species and gene pools, and fostering the invasion of exotic plant species.[19] In response, public agencies and non-profit organizations have begun to purchase forested land in RI and MA to prevent this fragmentation. Since 1952, the acreage owned by state and local municipalities has increased by 14% in RI.[20] In MA, there are 943,000 acres of forest permanently protected from development in the state.[21]

Data Sources and Limitations

Estimates of forest land value, sales, employment, and wages are provided for the economic impact of forests within the NBW. These data are derived from local studies and national studies at the state level, including the United States Department of Agriculture Forest Service state reports, the Economic Importance of Rhode Island's Forest Based Economy, and an Assessment of the Forest Resources of Massachusetts.

Unfortunately, attaching a monetary value to the numerous benefits generated by forests can be a challenge. Many residents within the NBW only recognize financial gains from their forest lands when they sell their property.[22] Despite this difficulty, this report still estimates the monetary value of forests given available information. To estimate the forest-based economic impact within the NBW, this report uses published data at the state level. State figures were adjusted by the share of land area within the watershed: for RI, this is 62.5% and for MA, 12.6%. For example, the USDA estimate of 367,000 acres of forest in RI translates to 230,000 acres of forest (62.5% of total forest coverage in the state) in the RI portion of the watershed (for a map of the NBW, please reference the "Geography" section).

For additional information on the methodology used in this report, please refer to the "Methodology" section.

Current Status & Trends

Today, individuals across the country enjoy the benefits of forests, including recreational and environmental services. These include water filtration, carbon sequestration, air filtration, as well as recreational benefits, such as aesthetic values and benefits for hikers, rock climbers, wildlife watchers, horseback riders, leaf peepers, hunters, and fishermen. A 2010 study showed that in that year alone, trees and forests in the U.S. removed over 17 million metric tons of air pollution. This amounted to human health effects valued at nearly $7 billion, including the estimated avoidance of more than 850 incidences of human mortality and 670,000 incidences of acute respiratory symptoms.[23]

Forests also provide high economic values for many individual firms and industries. For instance, forests supply firewood and timber products for industries such as logging, shipbuilding, lobster traps, and real estate. In addition, forests provide non-timber products that have economic values for some people, including witch hazel, maple syrup, mushrooms, berries, and floral greenery.

The significance of forests in the U.S. is also apparent in the NBW, where it provides many important benefits to residents of and visitors to the region. The forest industry generates value through the sale of products and by providing jobs to NBW residents. The State of Rhode Island conducted a study in 2013 to estimate the direct overall value of RI's forest-based economy and found that all forest-based sales generated in the RI portion of the NBW reached a total of $698 million (in 2016 dollars; Table 1). In addition, the forest product and recreational sectors accounted for over 3,000 jobs.

Table 1: Estimated Value of Forest-Based Manufacturing and Recreation for Sales and Employment in RI Portion of the NBW, 2013 (in 2016 dollars)

	Sales ($1000s)	Jobs
Forestry & Logging	$1,286	63
Wood Products Manufacturing	$104,168	413
Furniture and Related Product Manufacturing	$131,174	813
Paper Manufacturing	$201,263	750
Wood Energy	$15,433	16
Christmas Trees and Maple Syrup	$3,215	25
Total Forest Products	$456,538	2,080
Forest Recreation Sales	$241,129	938
Total	**$697,667**	**3,018**

Source: North East State Foresters Association, 2015

In 2006, MA conducted a similar original study and estimated the overall value of the forest-based economy in the state.[24] Based on previously stated assumptions, this report estimated that in 2006 in the MA portion of the NBW, the forest-based sector employed over 2,000 individuals (Table 2). In total, this accounted for over $170 million in employee wages (in 2016 dollars).

Table 2: Estimated Value of Forest-Based Establishments, Employment, and Wages in MA Portion of the NBW, 2006 (in 2016 dollars)

Licensed Foresters	Licensed Harvesters	Employees	Wages ($1000s)
22	64	2,117	$170,106

Source: de la Cretaz, et al., 2010

Beyond these extractive benefits, forests also provide non-extractive benefits. These include providing a steady and dependable supply of clean air and water through purification, regulating climate, and offsetting human carbon dioxide emissions. Forest ecosystems are the largest terrestrial carbon sinks on earth— on average, one acre of forest can store approximately 85 tons of carbon.[25] Many of the water supply reservoirs in the NBW are surrounded by forests due to their important role of filtering out pollutants and maintaining water quality.[26] Attaching a monetary value to this type of benefit generated by forests is an extremely difficult challenge, and one that is not addressed in this phase of the project.

Table 3: Forested Land in the Narragansett Bay Watershed, 2015

	Acres (1000s)
Rhode Island	230
Massachusetts	382
Total	612

Sources: Forests of Massachusetts, 2015; Forests of Rhode Island, 2015

Forests are an extremely vital and valuable part of the NBW. Not only do they generate revenue in the region and provide employment and wages for residents, but forested ecosystems contribute to the quantity and quality of available water, and impact the health of surrounding ecosystems. For example, forests act as a sponge by capturing and storing water when it is abundant and releasing it during dry periods. Without forests and the various provided benefits, agricultural production, quality of life, and human health would be jeopardized.[27]

Future Threats and Opportunities

Land use | Temperature | Precipitation

Land use within the NBW varies greatly with respect to population density: in more densely populated areas, like the Providence River Estuary, up to 85% of land is urbanized, while less developed areas can be up to 70% forest. Even though there is substantial forest coverage in certain places in the NBW, this remaining forest land has been under threat over the past decades, especially from human development. From 2001 to 2011, the amount of forest land in the NBW decreased by 4.3% from 443,800 to 424,642 acres, while the amount of urban land increased by 8.5% from 350,369 to 379,804 acres.[28] Furthermore, climate change can impact tree species composition and coverage: trees that are under the most pressure include the Eastern hemlock, red maple, and eastern white pine (this will also impact industries reliant on these specific species, such as timber harvesting and maple syrup collection).

Aside from human expansion, the effects of climate change will also shape the future of forests in the NBW. Air temperature in the area has been slowly increasing over the past few decades, but this increase is expected to accelerate in years to come; if global carbon emissions continue to follow a trajectory similar to that in recent decades, the climate in the NBW will be similar to that of modern-day Georgia or South Carolina, with a likely seven-degree increase in average summer temperature to an estimated 77° F.[29] Accompanying this change in temperature is a change in precipitation patterns. The overall amount of precipitation is expected to increase in RI and MA: since the 1980s, the two states have averaged 40 inches of rainfall per year— this is expected to increase by up to three inches by 2100.[30]

Both the temperature increase and change in precipitation can have impacts on the forest ecosystems in the NBW. These changes in forest composition will alter everything from the type of wood harvested for furniture and houses to the amount of carbon they sequester to the types of animals they shelter. The impact will vary from tree species to tree species depending on their adaptability, but the USDA predicts major losses in Eastern hemlock, red maple, and eastern white pine, as well as an increase in prevalence of blackgum, flowering dogwood, sassafras, American basswood, Eastern cottonwood, pignut hickory, and white oak. Other species will experience minor changes in population or none at all.[31] Additionally, the trees that are decreasing in population will be moving

further north and further west due to increases in temperature and changes in precipitation in their current habitat.[32]

Overall, it is difficult to qualify the potential threats or benefits that may arise from the new composition of forests. However, this forest coverage will continue to be threatened by a growing population and increased human development of open space and forest land.

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[28] Source: NBEP "Land Use", 2017
[29] Source: NBEP "Temperature", 2017
[30] Source: NBEP "Precipitation", 2017
[31] Sources: URI, RIDEM, RIAES, USDA, n.d.
[32] Source: Fei, et al., 2017

Appendix:

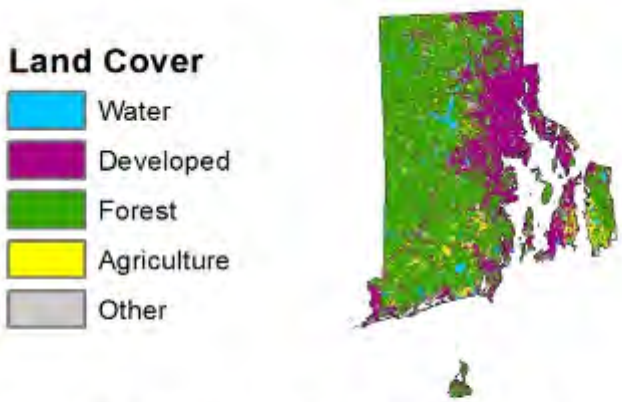

Figure A1: Forest and Other Land Cover of Rhode Island, 2011
Sources: USDA Forests of Rhode Island, 2015; National Land Cover Database (Jin et al. 2013)

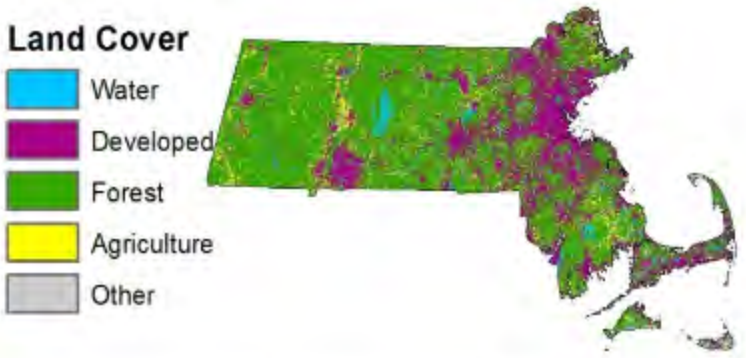

Figure A2: Forest and Other Land Cover of Massachusetts, 2011
Sources: USDA Forests of Massachusetts, 2015; National Land Cover Database (Jin et al. 2013)

Figure 6.—Private ( ) and public ( ) forest ownership

Figure A3: Forest Ownership of Rhode Island

Source: USDA Forests of Rhode Island, 2013 (Hewes et al. 2014)

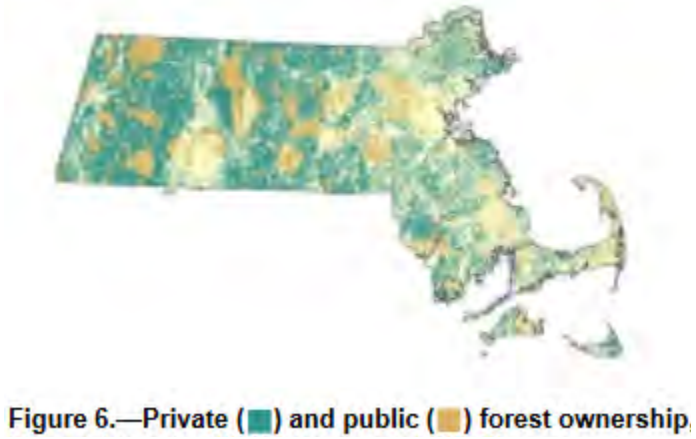

Figure 6.—Private ( ) and public ( ) forest ownership

Figure A4: Forest Ownership of Massachusetts

Source: USDA Forests of Massachusetts, 2013 (Hewes et al. 2013)

Table A1: Value of Forested Land in Rhode Island and Massachusetts, 2015 ($1994)

	Acres (1000s)	Value ($1000s)*
Rhode Island	370	$45,214
Massachusetts	3,025	$369,655
Total	3,395	$414,869

Note: *Based on the Costanza et al., 1997 estimate of $122.2 per acre of forest

Sources: Forests of Massachusetts, 2015; Forests of Rhode Island, 2015

Table A2: Estimated Value of Forest-Based Manufacturing and Recreation for Sales and Employment in Rhode Island, 2013

	Sales ($1000s)	Jobs
Forestry & Logging	$2,000	100
Wood Products Manufacturing	$162,000	660
Furniture and Related Product Manufacturing	$204,000	1,300
Paper Manufacturing	$313,000	1,200
Wood Energy	$24,000	25
Christmas Trees and Maple Syrup	$5,000	40
Total Forest Products	$710,000	3,325
Forest Recreation Sales	$375,000	1,500
Total	**$1,085,000**	**4,825**

Source: North East State Foresters Association, 2015

Table A3: Estimated Value of Forest-Based Establishments, Employment, and Wages in Massachusetts, 2006

Licensed Foresters	Licensed Harvesters	Employees	Wages ($1000s)
174	504	16,800	$1,130,000

Source: de la Cretaz, et al., 2010

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NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Hunting Overview

Hunting for big game, small game, migratory birds, and other animals is a popular recreational activity within the Narragansett Bay watershed (NBW). In fact, hunters in the NBW are more plentiful than hunters in other small states such as Delaware or Hawaii.[1] Residents and visitors hunt on private land, leased land, and in parks or public lands managed by Rhode Island (RI) or Massachusetts (MA). Game including deer, hare, and waterfowl are the most popular hunted animals, but turkey and pheasant are also commonly hunted. In RI, small game hunting is the most popular, while in MA big game hunting is the most popular type of hunting.[2]

More than 26,000 hunters were active within the NBW in 2011, a 21% increase from 2001.[3] These hunters took nearly 560,000 trips over more than 530,000 days in one year. Nearly $32 million (in 2016 dollars) was spent on hunting related expenditures, such as food, lodging, transportation, and equipment.[4]

History

Hunting has been an important aspect of the NBW since pre-colonial times when native tribes hunted for sustenance. Over time, hunting has transitioned from a task necessary for survival to a recreational activity. As the popularity of recreational hunting continued to increase in the watershed, laws were created and branches of government were established to enforce the laws. In 1739, MA was the first state in the nation to appoint game wardens for hunting law enforcement to preserve and increase deer populations.[5] Likewise, in RI, the Commissioners of Birds was created in 1899 to enforce hunting laws.[6]

Since 1978 in RI, the Division of Law Enforcement in the Department of Environmental Management (RIDEM) has enforced environmental laws related to hunting.[7] The state also mandates training in safe hunting practices for those applying for a hunting license for the first time.[8] As time has progressed, hunting has not only become a recreational activity, but also a means to control populations of certain animals in the NBW such as deer and coyotes.

Today, hunting takes place on various lands within the NBW. In RI, there are over 11,000 acres of private lands enrolled in the RIDEM co-op deer hunting program. In the 2015-2016 deer season,

almost 600 permits were issued to hunt on these lands. There are also more than 48,000 acres of state land in 27 wildlife management areas available to RI deer hunters.[9] In MA, the Land Protection Program provides areas for recreational hunting. In 2015, this program protected over 2,000 acres of wildlife lands and, in total, has protected more than 200,000 acres. All protected lands are open to the public for hunting, fishing, and other passive recreation.[10]

Data Sources and Limitations

Estimates of participation rates and expenditures are provided for the economic impact of hunting within the NBW. These data are derived from the U.S. Fish and Wildlife Service (USFWS) 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. The USFWS survey focuses on those at least 16 years old, and this report only focuses on hunting that occurs within RI and MA state borders, disregarding out-of-state hunting by RI and MA residents.

To estimate the recreational hunting activity within the NBW using published data at the state level, state figures were adjusted by the share of the state's population in the watershed in 2010 (for a map of the NBW and its population, please reference the "Geography" section of this report). This equates to 88.8% of the state population in RI and 15% in MA. This approach assumes that participation rates for hunting are the same in both watershed and non-watershed areas. For example, the USFWS estimate of 20,000 recreational hunters in RI translates into around 17,800 hunters in the RI portion of the watershed.

Additional information on methodology used in this report can be found in the "Methodology" section.

Current Status and Trends

Today, many individuals participate in recreational hunting in the NBW. Based on previously stated assumptions, in 2011 there were over 26,000 hunters in the watershed (Table 1). On average, each hunter spent on average 20 days hunting in a year. In total, these hunters took nearly 560,000 trips and spent more than 530,000 days hunting.[11]

Table 1: Estimated Recreational Hunting in the NBW (2011)

	Number of Hunters (1000s)	Number of Trips (1000s)	Number of Hunting Days (1000s)	Average Number of Hunting Days
RI	17.8	423.6	372.1	21
MA	8.4	134.7	159.3	19
Watershed	26.2	558.3	531.4	20.3

Note: Scaled by ratio of state population in the watershed: RI = 88.8%, MA = 15%
Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

According to the survey, a large portion of the hunters are state residents (Table 2). Within the watershed, there are over 21,000 individuals who hunt in their own state, which represents 81% of the hunters in the watershed. The remaining 19% are out-of-state tourists, who bring in economic value to the region.[i]

Table 2: Estimated Residential Recreational Hunting in the NBW (2011)

	Number of Hunters (1000s)	Number of Trips (1000s)	Number of Hunting Days (1000s)	Average Number of Hunting Days
RI	13.3	241.5	220.2	17
MA	7.8	131.4	156.2	20
Watershed	21.1	372.9	376.4	17.8

Note: Scaled by ratio of state population in the watershed: RI = 88.8%, MA = 15%
Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

According to the survey, the majority of hunters in the NBW are white, middle-aged men from urban areas (Table 3).[12]

Table 3: Characteristics of Residential Hunters in the NBW (2011)

	RI	MA
From urban area	76%*	73%*
Males	86%	88%
Between ages 45-64	50%*	66%*
White	100%	95%
4 years or more of college	24%*	36%*
Percent of days hunting on private land	78%*	58%*
Average number of days hunting per year	17	20

*Based on a sample size of 10-29
Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

Overall, hunting is a recreational activity that brings considerable economic value to the NBW. In total in 2011, more than 26,000 hunters spent nearly $32 million (in 2016 dollars) within the NBW, helping boost the economies in RI and MA (Table 4). Hunters pay for guides, access, membership dues, land, guns, ammunition, licenses, permits, auxiliary equipment, and specialized clothing. Hunters may also travel far enough to areas where lodging and food become necessary. Hunters within the NBW spent nearly $32 million (in 2016 dollars) on related expenditures (e.g., food, lodging, transportation, and equipment). It is important to note that there are both long- and short-term impacts of this expenditure; for example, a short-term impact would be purchasing ammunition, guns, or accommodations, while long-term impacts may include membership dues, licenses, and permits.

[i] We do not know the number of non-residents who are RI or MA residents hunting across state lines, but still within the watershed.

Table 4: Estimated Expenditures of Hunters in the NBW (in 2016 dollars)

	Expenditures ($1000s)	Trip Related Expenses ($1000s)	Equipment/Other Spending ($1000s)	Average per Participant
RI	$17,490	$4,404	$13,086	$983
MA	$14,117	$2,734	$11,383	$1,681
Watershed	$31,607	$7,138	$24,469	$1,294

Note: Scaled by ratio of state population in the watershed: RI = 88.8%, MA = 15%
Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

Future Threats and Opportunities

Land use | Open space

Hunting relies heavily on the availability of healthy habitats for game animals, mainly forests and open space. Increasing populations and urban sprawl are placing stress on these resources. Not only is population rising in the NBW, but settlement patterns are changing; urban areas are no longer the hotspot for population growth—instead, populations are expanding outward and settling in previously less-developed areas. As a result, people are developing open space and forests land. For example, from 2001 to 2011, the amount of forest coverage in the NBW decreased by 4.3%, while the amount of urban land increased by 8.5%.[13] Open space faces the same threat—in the NBW, 15% of total land coverage is protected open space, but 17% of open space in the NBW is not protected, making it vulnerable to human development. There is, however, the opportunity to preserve this open space and therefore protect the benefits it provides, such as hunting. Mass EOEAA found that initiatives spearheaded by private and state organizations led to the permanent preservation of nearly 110,000 acres of open space land in MA from 1999-2005.[14] These efforts indicate the success of initiatives in protecting open space areas.

Furthermore, the effects of climate change will have an impact on species distribution and populations in the NBW. For example, two popular hunting species, the wild turkey and the white-tailed deer, are susceptible to the effects of climate change. The habitat distribution of the wild turkey will shift increasingly northward, with the Audubon Society predicting that the bird will lose 80% of its wintertime range by the year 2080, reducing populations available for hunting (Figure 1).[15] The white-tailed deer, on the other hand, will become more susceptible to diseases that will thrive in warmer temperatures.[16] This will be coupled with an increase in deer populations due to decreased mortality rates during winters and increased reproduction rates.[17]

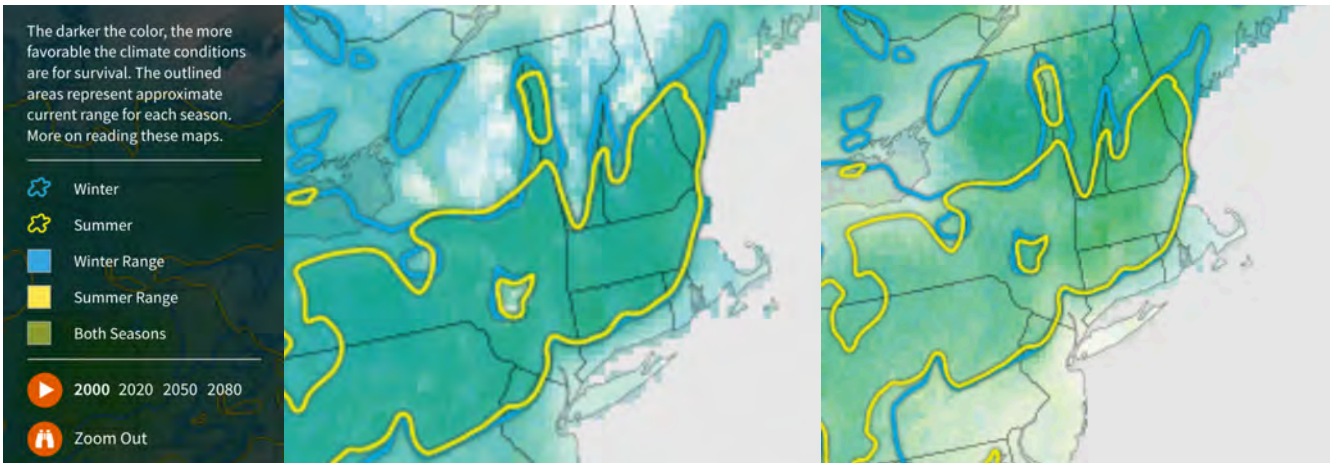

Figure 1: Habitat Changes of Wild Turkey Due to Climate Change (Left: 2000, Right: 2080)

Note: Darker areas indicate more conducive habitats for wild turkey populations. As seen from above, the winter and summer boundaries in RI will stay the same but will be less hospitable areas for wild turkey habitats.

Source: Audubon Society, n.d.

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[9] Source: RIDEM Division of Fish and Wildlife "White Tailed Deer," 2016.
[10] Source: MA DFG "Massachusetts Wildlife," 2015.
[11] Source: USFWS et al. (2011 RI and MA surveys), 2013.
[12] Sources: USFWS et al. (2011 RI and MA surveys), 2013.
[13] Source: NBEP "Land Use," 2017.
[14] Source: NBEP "Open Space," 2017.
[15] Source: Audubon Society, n.d.
[16] Source: Penn State, 2015.
[17] Source: Wisconsin Department of Natural Resources, 2013.

Appendix

Table A1: Recreational Hunting in MA & RI (2011)

	Number of Hunters (1000s)	Number of Trips (1000s)	Number of Hunting Days (1000s)	Average Number of Hunting Days
RI	20	477	419	21
MA	56	898	1,062	19
Total	76	1,375	1,481	

Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation

The Narragansett Bay Watershed Economy Project was conceived and partially supported by the Coastal Institute at the University of Rhode Island under the leadership of Dr. Emi Uchida. In addition, this project was supported, in part, under Assistance Agreement No. SE - 00A00252 awarded by the U.S. Environmental Protection Agency (EPA) to Mass Audubon. Additional project partners include the URI Graduate School of Oceanography, the URI Coastal Resources Center, the Natural Capital Project at Stanford University, and the George Perkins Marsh Institute at Clark University. The views expressed in this project are solely those of the authors. It has not been formally reviewed by EPA. Additional information is available at www.nbweconomy.org.

NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Ports & Maritime Trade Overview

Since colonial times, the Narragansett Bay watershed (NBW) has provided Rhode Island (RI) and Massachusetts (MA) with strategic outlets for maritime trade and transport (for a map of the NBW, please refer to the "Geography" section). Although the purpose of these ports has evolved over the past four centuries, they have remained a pivotal element of the local economy and culture and have exerted a profound influence on the history of the area. These ports have seen a shift from the trade of agricultural products between colonies, to marking RI's involvement in the slave trade, to housing a naval stronghold, and finally, to boasting one of the top automobile import ports in the country. Although their purpose has adapted to the needs of NBW economies, they continue to be a source of jobs, economic stimulation, and pride for both RI and MA.

History

The NBW is home to a rich history of maritime trade and activity that spans over 400 years and a variety of export/import products. The NBW's maritime trade is rooted in Newport, RI, which, due to its strategic location and natural deep-water harbor along the coast, was one of the first and most vital ports in the development of maritime activity in the area. Maritime trade in colonial Newport dates back to the early 1600s, and originally focused on the exchange of agricultural goods with neighboring colonies. By the 1700s, trade expanded outward from the colonies to European powers such as France, Spain, and the Dutch. Manufactured products, such as spermaceti candles, rum, and twine, made in RI and neighboring cities across the border, such as New Bedford and Nantucket, took the place of agricultural goods (Figure 1).[1] This manufacturing and exportation of rum marks RI's involvement in the "triangle trade" (the trade of molasses, rum, and slaves between West Africa, the West Indies, and RI) and, subsequently, RI's involvement in the slave trade. In addition to the triangle trade, Newport brought in tens of thousands of individuals over a hundred-year period to serve as slaves, making it one of the top slave ports in the colonies—the port at Newport brought in over 30,000 slaves between 1751-1775.[2] This trade continued even after it was outlawed by the RI General Assembly in the 1770s and 1780s. It eventually declined by the start of the 19th century but ramped up again with exports generated by Brown & Sharpe, Nicholson File, US Rubber Company and American Screw Company, all leaders in their respective fields.

Figure 1: The Port of Newport (ca. 1730)
Source: University of Massachusetts

Around this time, Newport's port activity peaked, and Providence usurped Newport as the hub of maritime trade. The once-booming maritime trade industry slowly faded, and by the 19th century, was overshadowed by alternative industries, such as coastal tourism, including steamboats stopping through coastal ports. The decline in trade, however, was coupled with the establishment of the U.S. Navy's presence in Newport, RI. In the late 19th century, the Navy established the Naval War College and the Naval Training Station—previously, Newport experienced heavy activity during the American Revolution and the Civil War due to its strategic positioning. The Navy maintained a strong presence in Newport until 1973. At this time, the active fleet was removed and activities at Port of Davisville, Quonset were suspended. This was part of a larger trend of the U.S. government closing naval bases in 33 states because they were considered excess capacity after the Vietnam War ended (for more information, refer to the "Defense" section).

In 1973, seizing this opportunity, the State of RI purchased lands at Quonset and the Port of Davisville from the U.S. Navy for $10 million. Over the span of five decades, the RI government has continuously invested in the expansion and renovation of the Quonset Business Park and the Port of Davisville. This park now includes rail access, an airport, and an access road, making it the only port in the state with all four forms of access. In addition, it is the port with the most import vessel arrivals in the state (Figure 2).[3]

Figure 2: The Port of Davisville
Source: Quonset Development Council (QDC)

Methodology and Data Sources

This report will focus on the two major ports in the NBW: ProvPort (privately owned) and the Port at Davisville. Information in this section relies on publicly available information prepared for the state, including the RI Coastal Resources Management Council's (CRMC) "Ocean Special Area Management Plan" for the Narragansett Bay for 2010, and a 2014 economic analysis conducted by ProvPort regarding their impact on the state between 1994 and 2014. Additional information on the Port of Davisville was sourced from the Quonset Development Council (QDC), a quasi-government agency responsible for managing the port. Information regarding recent port activities was sourced from the Providence Journal, the leading local news reporter in the state. Historical information regarding the NBW and its connection to the slave trade was sourced from public news sources (RI NPR) and Clark-Pujara (2009). Both sources pulled heavily from primary source historical documents to account RI's involvement in the slave trade. Additionally, data for RI maritime trade were also obtained from a 2018 report *The Economic Impact of Rhode Island's Marine Trades Sector* (Sproul and Michaud).

For information on the methodologies that were used in this report, please refer to the "Methodology" section.

Current Status and Trends

The Port of Davisville has experienced substantial growth since its purchase in 1973. Currently, the Port of Davisville, the only public port in the state, is home to approximately 200 companies and employs over 11,000 individuals. The success of the Port of Davisville benefits the local and state economies, marking a resurgence of maritime trade and related activities throughout the NBW. The Port of Davisville is one of the top ten automobile importers in the country and brought in over 227,000 cars by port in 2015 alone, which marked a 27% (48,800 cars) increase from 2014 and the

sixth consecutive year of increased auto imports.[4] [5] An additional 42,000 arrived by rail and truck to the Quonset Business Park, bringing the total to over 269,000 cars imported to Quonset in 2015.[6] The Port of Davisville is also capable of importing and managing a variety of projects. For example, it imports and stores wind turbine materials, seafood products, sub-ocean pipeline materials, and other large project cargo and specialty items.

Aside from its successful port, Quonset Business Park is home to leading submarine manufacturer Electric Boat. The company, like the Port of Davisville, has experienced a resurgence in recent years. Electric Boat was founded in 1974 with a little over 100 employees. Despite almost collapsing in the late 1990's due to a lack of funding, support from the U.S. Navy has allowed Electric Boat to thrive. Today, the company employs over 3,700 individuals and is expected to continue growing until the 2020s. In addition to Electric Boat and submarine manufacturing, the ship and boat building and repair industry are successful in the NBW. Currently, there are 61 companies in the watershed involved in boat/ship building and repair, generating over 350 jobs and approximately $20 million in wages.[7] The boating and submarine industries provide opportunities for growth over the next few decades, both in Quonset and across the NBW. Additionally, the Port of Davisville is likely to grow in coming years. In early 2016, RI Governor Gina Raimondo announced a $90 million plan to update Pier 2 at the port, allowing it to expand and increase its capabilities and import capacity. Out of its 3,212 acres, 1,347 are still developable.[8]

Comparable to the Port of Davisville, ports in the Greater Providence Area, such as ProvPort, have also experienced growth in recent years. Founded in 1994, ProvPort is a privately owned and managed company and is the largest port in the Greater Providence Area. ProvPort's leading export is used automobiles, and it is the main hub of petroleum imports for RI and parts of MA and Connecticut, which is used for both gasoline and as heating oil.[9] ProvPort is also a major importer of cement, road salt, specialty chemicals, and large project cargo, such as parts for wind turbine projects. During its two decades of operations from 1994 to 2004, ProvPort has directly generated 975 jobs in RI, along with $122.3 million in economic output in the state and almost $18 million in state and local taxes (Figure 3).[10] A majority of these jobs, almost 833, are located in the City of Providence, which also had a $117.9 million share of ProvPort's output from 1994-2004. These figures only reflect the direct impact of ProvPort. There are also indirect and induced effects—more information on these impacts can be found in 4Ward Planning's Economic Impact Analysis of ProvPort. 4Ward Planning's modeling predicts an increase in employment (direct effect) of over 5,500 throughout the state, accompanied by an estimated output of approximately $2.3 billion from 2014-2010.

In 2016, voters in RI approved Question 5 for RI Port Infrastructure Bonds. This measure approved $50 million for infrastructure modernization in Davisville and $20 million for the expansion of ProvPort.[11]

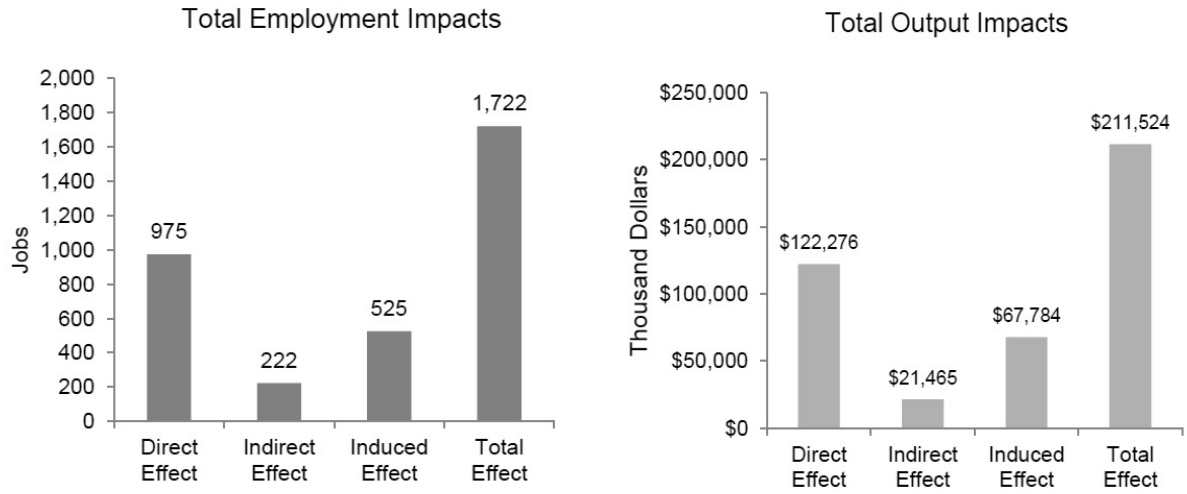

Figure 3: Economic Impact of ProvPort
The impact of ProvPort on employment and economic output for the years of 1994-2014
Source: 4Ward Planning, 2015

Unlike ProvPort and Davisville, the ports in Newport and Galilee are not focused on maritime trade. Instead, the Port of Newport, making a transition from its historical roots, now primarily receives small and large cruise ships for tourism purposes. In Galilee, the focus is on seafood and seafood processing. Galilee's outputs, such as Point Judith calamari, are well known to those in South County and across the state.

Overall, the growth of these ports in the NBW marks the growth and revitalization of the marine trade sector in the watershed. Aside from direct employment and benefits, the presence and growth of these ports has spurred economic development through both direct and indirect impacts. Although the definition of marine trade and its subsequent impacts on the economy vary, they represent and illustrate a positive trend for the NBW. For example, in 2012 the RI Department of Labor classified over 300 companies and 5,000 employees being related to "marine trade," while broader definitions estimate that over 650 companies and almost 7,000 employees are related to the marine industry.[12] Furthermore, Sproul and Michaud (2018) estimate that the marine trade sector in RI makes up 4.7%, or 1,712, of the firms in the state's economy. These firms employed over 13,000 people and generated $2.65 billion in annual gross sales and $2.64 billion in value added to the state's economy. The two largest subsectors are marine services and supply, which accounts for 431 firms with over 2,700 jobs and $583.6 million in gross annual sales, and marines, docks, and yacht clubs, which has 269 firms, over 2,700 jobs, and gross annual sales of $367.4 million.[13] Marine trade is a wide-encompassing industry, and despite the wide range of estimates, it is clear the ports and maritime trade industry has a positive impact on economies within the NBW (and one that will continue to grow over the coming decades).

Future Opportunities and Threats

Sea level rise

As the earth's climate warms, so do its oceans and waterbodies. This increase in water temperature causes the water to expand and icecaps to melt, leading to sea level rise across the globe (8.2 feet by 2100). Due to a culmination of effects, this impact will be greater in the Northeast Atlantic, with a rise in sea level predicted to be 9.8 feet by 2100. Although this sea level rise has been occurring over the past century, this growth rate is expected to increase dramatically in coming decades. For example, from 1930 to 2015, Newport has experienced an average of one inch of sea level rise per decade, and in Providence the rate was 0.9 inches per decade from 1938-2015. NOAA projects a maximum sea level rise of one foot from current levels by 2035 and two feet by 2050 in Newport.[14] Given the reliance of ports and maritime trade on coastal areas, any rise in sea level could potentially threaten the location of current ports, while giving way to the development of new ports in areas that previously did not have coastal access.

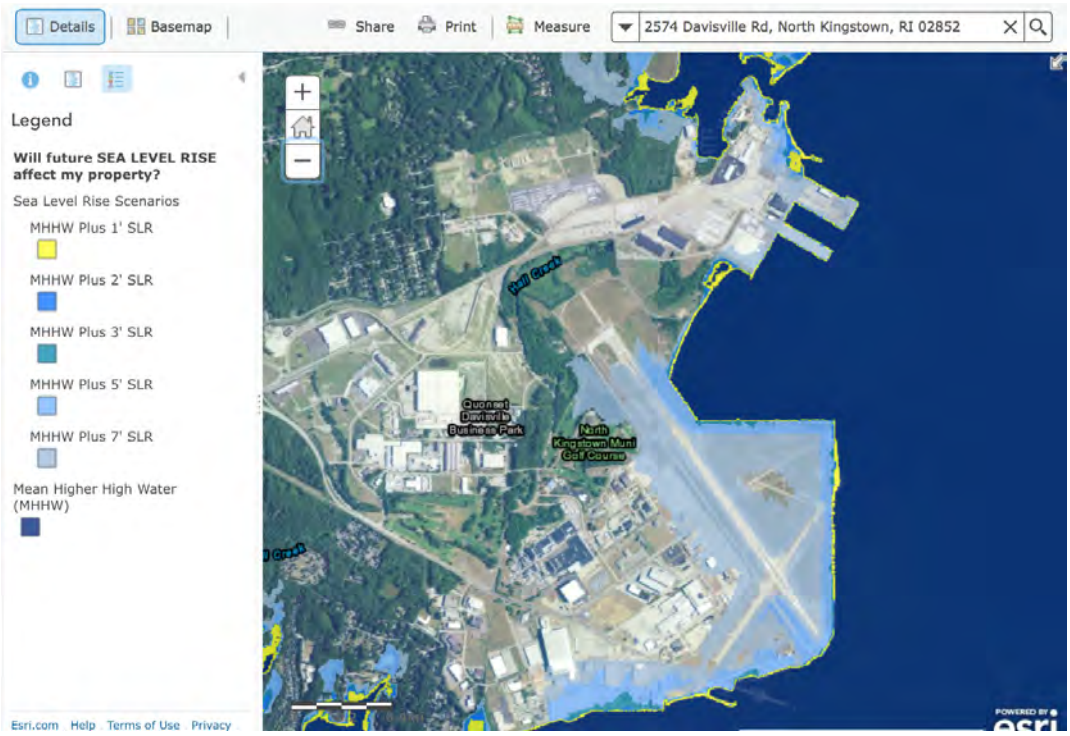

Figure 4: Sea Level Rise and its Impact on the Port of Davisville, Quonset, RI

Note: The rise in sea level is based on an increase in sea level rise (SLR) from the mean higher high-water point (MHHW)

Source: STORMTOOLS, n.d.

Both the Port of Davisville and ProvPort are vulnerable to future sea level rise. Using STORMTOOLS, a predictive software from URI and the RI CRMC, basic projections for the impact of sea level rise were made for the Port of Davisville and ProvPort. The Port of Davisville, one of the most productive ports in the state, will experience partial submersion under seal level rise predictions of just one foot (Figure 4) with the most significant impact occurring at a rise of seven feet (this is

still well below the 2100 NOAA prediction of 9.8 feet). Additionally, ProvPort, although not directly on the coast like the Port of Davisville, would still potentially be vulnerable to sea level rise through an increase in water level in the Providence River, a tidal river leading to the NBW (Figure 5). Adaptation to these changes is necessary for ensuring the future of ports and maritime trade in the NBW.

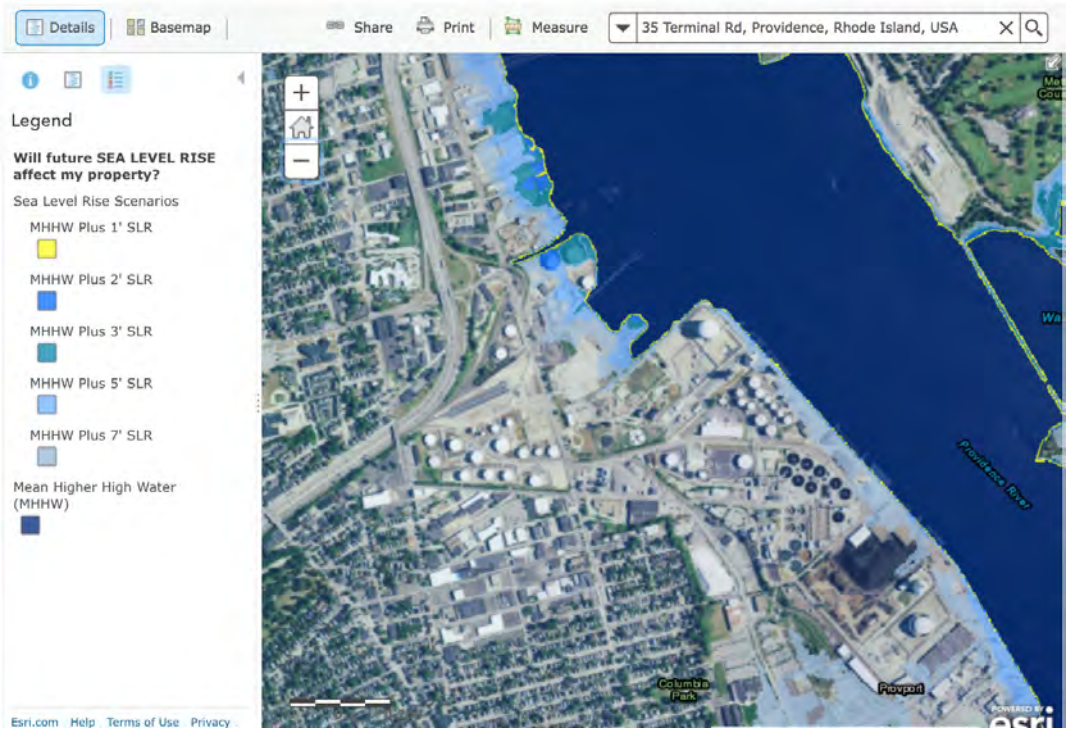

Figure 5: Sea Level Rise and its Impact on ProvPort, Providence, RI

Note: The rise in sea level is based on an increase in sea level rise (SLR) from the mean higher high-water point (MHHW)

Source: STORMTOOLS, n.d.

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[1] Source: RI CRMC, 2010.
[2] Source: Clark-Pujara, 2009.
[3] Source: QDC, n.d.
[4] Source: QDC, n.d.
[5] Source: Bramson, 2016.
[6] Source: Bramson, 2016.
[7] Source: RI Department of Labor and Training, 2017.
[8] Source: QDC, n.d.
[9] Source: EIA, 2017.
[10] Source: 4Ward Planning, 2015.
[11] Source: Ballotpedia, n.d..
[12] Source: Planning Decisions, 2014.
[13] Source: Sproul and Michaud, 2018.
[14] Source: NBEP "Sea Level," 2017.

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NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Recreational Boating Overview

Recreational boating draws many in-state and out-of-state visitors to the Narragansett Bay watershed (NBW). The allure of recreational boating in the NBW exists for both freshwater and saltwater. At these locations, tourists and residents can fish, swim, clam, or sightsee, among other activities. The popularity of boating in the NBW is due to the high-quality waters, magnificent shoreline, and bountiful freshwaters of the area (Figure 1). This activity takes place from marinas, yacht clubs, and public boat ramps, as well as docks and moorings at private residences. Additionally, the most popular activity for recreational boaters is fishing.

In total, in the NBW, 56,000 registered boaters took over 97,000 trips on the water. These recreational boaters spent over $201 million (in 2016 dollars) on boating-related expenditures. In addition, expenditures supported over $150 million in labor income and more than 2,700 year-round jobs.[1]

Figure 1: Recreational Boaters in East Greenwich, RI

Credit: Sean McMahon

History

Within the NBW, there is a total of more than 560 miles of shoreline. In addition, there are more than 2,600 ponds, lakes, and reservoirs, and over 5,400 rivers and streams.[2] Throughout history, these areas have been ideal locations for recreational boaters.

Beginning in the latter half of the 19th century, there was a rise of interest in leisure activities, which included boating for pleasure. The waters in the NBW became destination hotspots for recreational boaters, particularly the wealthy. Newport was an especially popular location for boaters and was thought of as a "sailing playground" for the rich and famous. Many of America's most influential businessmen built summer "cottages" in Newport, Rhode Island (RI) including the Vanderbilt family. With this influx of wealth, Newport Harbor became a major yachting destination and, in 1883, the New York Yacht Club held its first annual regatta in Newport. The "City-by-the-Sea" became more popular after 1930, when the most coveted sailing race in the world, America's Cup, was brought to Newport. America's Cup remained in Newport until 1983. Despite losing the Cup races, recreational boating remains a popular activity in the NBW.[3]

Today, recreational boating remains a very popular activity that many natives and visitors alike participate in. However, instead of being an activity for only the wealthy, more people are able to partake in recreational boating. In 2014, 36% of the U.S. adult population, over 87 million, participated in recreational boating at least once during the year.[4] Recreational boating is especially popular in the North Atlantic region;[1] in 2013, there was one boat for every 38 persons[5] and, in 2012, boaters from New York to Maine spent $2 billion on trips, boat visits, and other recreational boating activities.[6]

Data Sources and Limitations

Estimates of participation rates and expenditures are provided for the economic impact of recreational boating within the NBW. These data are derived from national, regional, and local surveys and studies, including the Northeast Recreational Boater Survey, National Marine Manufacturers Association, and Planning Decisions, Inc. Unfortunately, there exists no available and complete list of numbers of marinas, slips, and moorings within the watershed.

The Northeast Recreational Boater Survey included volumes on RI and Massachusetts (MA). The survey measured boating trips, visits of registered boaters, and expenditures within the two states for 2012. The National Marine Manufacturers Association (NMMA) provided information on boat registrations and boater characteristics within MA and RI in 2013. A more detailed view on the recreational boating sector was generated by Planning Decisions, Inc. in 2014 for the RI Marine Trades Association. In this report, analysts looked at the cluster of enterprises that comprise the

[1] Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island.

marine trades industry associated with boating in RI. It included expenditures, jobs and wages supported, and revenue generated via recreational boaters.

To estimate the recreational boating activity within the NBW using published data at the state level, state figures were adjusted by the share of the state's population in the watershed in 2010. This equates to 88.8% of the state population in RI and 15% in MA (for maps of the area and population of the NBW, please reference the "Geography" section). This approach assumes that registrations and participation rates for recreational boating are the same in both watershed and non-watershed areas. For example, the NMMA estimate of over 39,000 boat registrations in the state translates into around more than 35,000 boat registrations in the RI portion of the watershed.

For additional information on the methodology used in this report, please reference the "Methodology" section.

Current Status and Trends

The popularity of recreational boating in the Northeast holds true throughout the entire NBW (Figure 2). Boater density is particularly high within the Narragansett Bay, demonstrating the intensity of recreational boating within the NBW.[7] RI and MA suggest that use-density is particularly high within the Narragansett Bay for fishing (Figure 3). Relaxing, wildlife viewing, and swimming are also activities recreational boaters partake in.

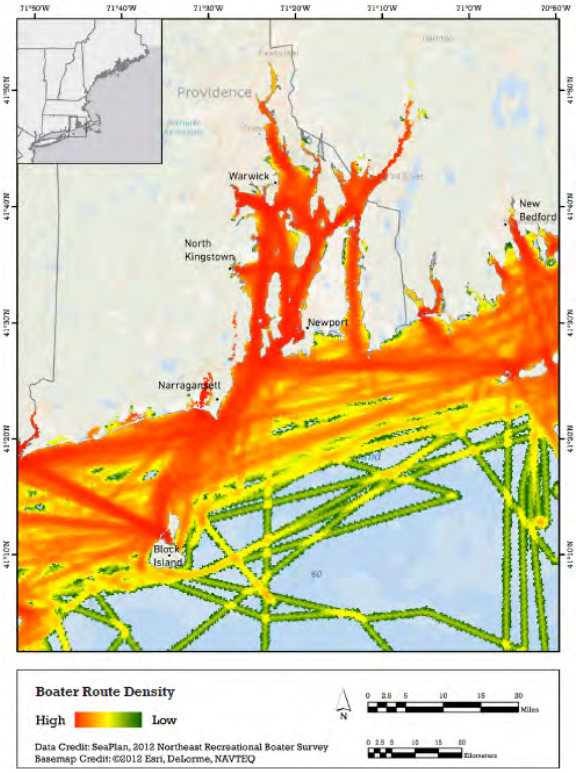

Figure 2: Recreational Boater Route Density in RI and MA (2012)

Source: Starbuck & Lipsky, 2013

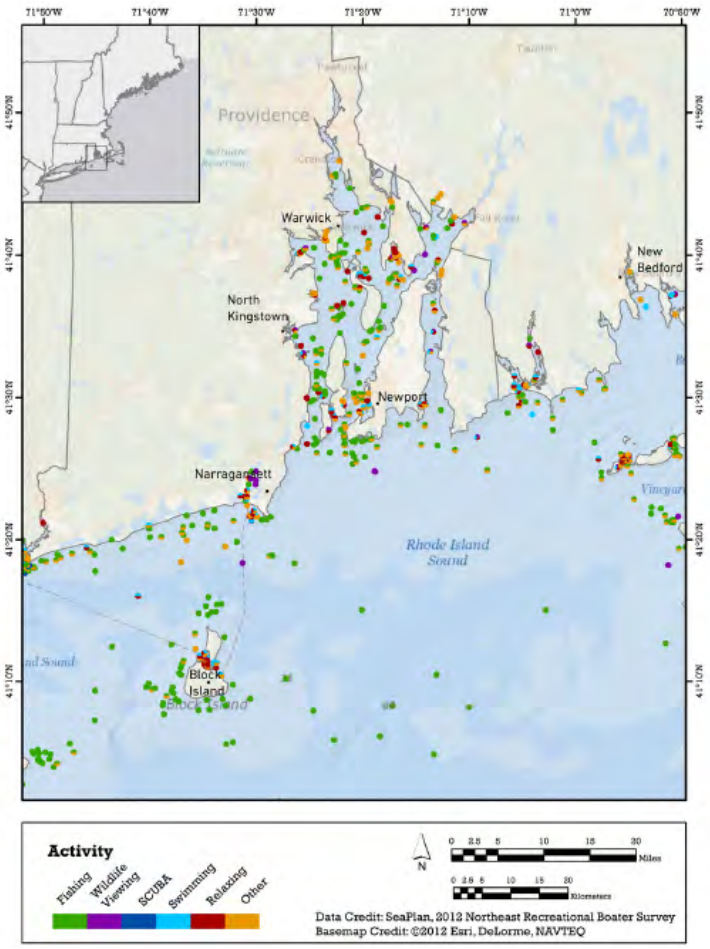

Figure 3: Recreational Boater Activity Points in RI and MA (2012)
Source: Starbuck & Lipsky, 2013

The number of registrations for recreational boaters in the NBW further illustrates the demand for recreational boating in the watershed (Table 1). In 2013, there were close to 56,000 boat registrations in NBW, with 63% in RI and 37% in MA. During 2012, there were over 97,000 trips taken in the NBW by these registered boaters (Table 1). In addition, close to 62,000 boat visits occurred, where recreational boaters spent time visiting their boats but not taking them out on the water. [8]

Table 1: Estimated Recreational Boating Registrations, Trips, and Boat Visits in the NBW

	Number of Registrations[1]	Number of Trips[2] (1000s)	Number of Boat Visits[2] (1000s)
RI	35,167	57.7	40
MA	20,650	39.4	21.9
Watershed	55,817	97.1	61.9

[1] Data is from 2013 (NMMA) [2] Data is from 2012 (Starbuck & Lipsky)
Sources: Starbuck & Lipsky, 2013; NMMA, 2014

In terms of the demographics of recreational boaters, the activity is primarily taken up by those in the middle class.[9] This means that boating can be enjoyed by a large population, making it a recreational activity with the opportunity for growth.

Expenditures of boaters indicate that recreational boating contributes critically to the watershed economy (Figure 4), including making big purchases such as motorboats or sailboats, or smaller purchases, like paying for repairs, gas, and boating equipment. Boaters may also travel far enough to areas where lodging and food become necessary. Recreational boaters in the two states spent more than $650 million (in 2016 dollars), with $510 million of the expenditures occurring in MA and $140 million occurring in RI (Table 2). [10] It is important to note that these expenditure figures include both short- and long-term expenditure. Short term expenditures (such as gas) are those that are repeated consistently over time whereas long-term expenditures (such as the purchase of a new boat) occur less often. When looking at expenditures per capita, recreational boaters in RI spent $134 per person, which is the highest in the region by nearly 30%. Per capita spending in MA was also above the regional average at $79.

Figure 4: Annual Average Boater Expenditures per Capita in Northeast Region (2012) (in 2016 dollars)

Source: Starbuck & Lipsky, 2013

It is also possible to identify the home port of the boaters, and RI again stands out with nearly 20% of expenditures in the state coming from nonresident boaters (Figure 5). This is well above the regional average of 6% and the MA average of 4%, highlighting the importance of recreational boating as part of the tourism industry in RI.[11]

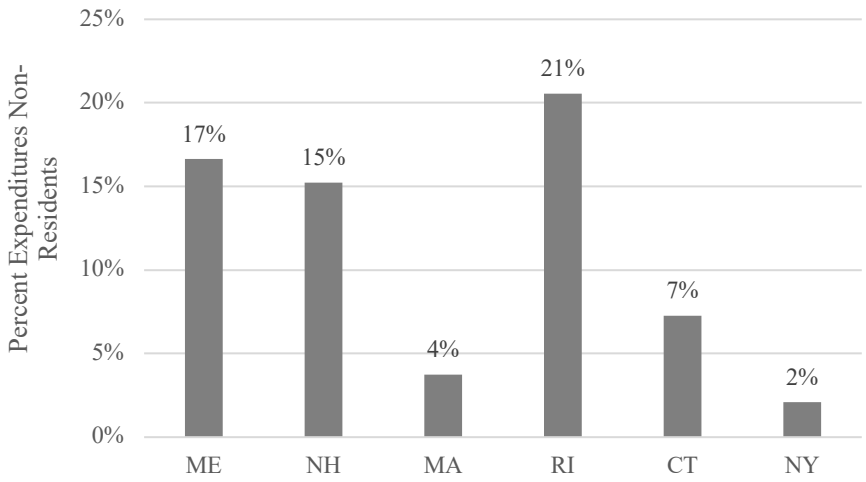

Figure 5: Percentage Share of Non-Resident Boater Expenditures in Northeast Region (2012)

Source: Starbuck & Lipsky, 2013

A significant number of year-round jobs are also supported by the spending of recreational boaters within the NBW. Using previously stated assumptions, in 2012 in the NBW, recreational boaters spent over $201 million (in 2016 dollars) that supported over $150 million in labor income and more than 2,700 year-round jobs (Table 2).[12]

Table 2: Expenditures and Impacts of Recreational Boaters in the NBW (2012) (in 2016 dollars)

	Expenditures ($1000s)	Total Impact ($1000s)	Year-Round Jobs Supported	Labor Income Supported ($1000s)
RI	$124,662	$216,793	1,783	$92,131
MA	$76,643	$135,276	975	$58,633
Watershed	$201,305	$352,069	2,758	$150,764

Source: Starbuck & Lipsky, 2013

As a complement to the national and regional surveys, a more detailed view on the recreational boating sector was generated at the state level for RI. Analysts looked at manufacturers, service providers, professional services, construction, and transportation enterprises associated with boating. Based on previously stated assumptions, in the NBW in 2012, these associated enterprises, in addition to sole proprietors and out-of-state boaters, spent over $1 billion in the state. These expenditures supported over 6,300 jobs with a payroll of more than $291 million.[13]

Overall, recreational boating is an activity that brings considerable economic value to the NBW. In 2012, 56,000 registered boaters took over 97,000 trips in the NBW. Recreational boating not only brings value to those participating in the activity, but it also spurs significant economic

activity for businesses in the area that serve and support recreational boaters. Over $201 million (in 2016 dollars) in expenditures by these boaters supported more than 2,700 year-round jobs and $150 million in wage income. The continual growth related to recreational boating is a good sign for the future economy of the NBW.

Future Threats and Opportunities

Sea level | Estuarine fishing communities | Freshwater fishing communities | Water clarity | Shellfishing | Water quality for recreation |

Recreational boating in the NBW is sensitive to changes in fresh, salt, and estuarine waters. Because recreational boaters engage in the activity for a variety of reasons, such as fishing, swimming, shellfishing, and sightseeing, impacts on all of these activities may also impact recreational boating. The effects of climate change will affect multiple aspects of these activities, from fish habitats to the recreational status/safety of waterbodies in the state. For example, sea level rise will potentially impact marinas and ports that currently support recreational fishing boats. Within the next century, average sea level is expected to rise to current high tide levels. This sea level rise will place increasing stress on the marina industry, requiring existing marinas to adapt to these changes through measures such as installing floating docks.[14]

Additionally, aside from impacts on infrastructure, the water itself will be affected by climate change. Water clarity, which provides aesthetic benefits and may determine what areas boaters choose to visit, is under threat from increased water temperatures and growing populations in the NBW, which leads to increased stormwater, wastewater, and nutrient runoff. Not only can these decrease the clarity of the water, but can also increase algal bloom occurrences, fecal bacteria levels, and other problematic indicators that determine water quality.[15] [16] Currently, 85% of estuarine waters, 80% of lakes and ponds, and 40% of freshwater streams and rivers studied are considered acceptable for recreational use, which includes boating. This percentage is under threat from increased fecal pathogens from wastewater runoff from increased human development, as well as increases in stormwater and nutrient runoff, as discussed above.[17]

Furthermore, estuarine fish populations are also under threat from climate change. The prevalence of cool-cold water species, such as winter flounder and American lobster, is decreasing due to increasing water temperatures. Meanwhile, warmer water species populations, such as summer flounder and butterfish, are increasing. This shift in species provides a threat to fishing for current species in the area, but an opportunity to harvest new species in the future.[18] The same shift is seen in freshwater fish communities, where species like brook trout are declining due to warming waters and the impacts of human development.[19]

Overall, the future of recreational boating in the NBW will be impacted by a number of anthropogenic and climate change related issues that affect water clarity and quality. There will also be an impact on fish species, such may drive recreational boaters to visit or abstain from visiting certain areas.

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[19] Source: NBEP "Freshwater Fish Communities," 2017.

Appendix

Table A1: Recreational Boating Registrations, Trips, and Boat Visits in MA & RI

	Number of Registrations[1]	Number of Trips[2] (1000s)	Number of Boat Visits[2] (1000s)
RI	39,602	65	45
MA	137,668	262.6	146
Total	177,270	327.6	191

[1] Data is from 2013 (NMMA) [2] Data is from 2012 (Starbuck & Lipsky)
Sources: Starbuck & Lipsky, 2013; NMMA, 2014

Table A2: Annual Boat Expenditures in the Northeast (in 2012 dollars)

	Expenditures ($millions)	Population	Per Capita
ME	$125.10	1.3	$96
NH	$42.70	1.3	$33
MA	$488.30	6.5	$75
RI	$134.30	1.05	$128
CT	$334.10	3.59	$93
NY	$840.40	19.6	$43
Total	$1,964.90	33.34	$59

Source: Starbuck & Lipsky, 2013

Table A3: Percentage Share of Non-Resident Boater Expenditures in Northeast Region (2012)

	ME	NH	MA	RI	CT	NY
Total	125.1	42.7	488.3	134.3	334.1	840.5
Own State	104.3	36.2	470.1	106.7	309.8	822.95
Share Own	83%	85%	96%	79%	93%	98%
Share Other	17%	15%	4%	21%	7%	2%

Source: Starbuck & Lipsky, 2013

Table A4: Expenditures and Impacts of Recreational Boaters in MA & RI (2012) (in 2016 dollars)

	Expenditures ($1000s)	Labor Income Supported ($1000s)	Per Capita Spending	Year-Round Jobs Supported	Total Impact ($1000s)
RI	$140,385.3	$103,751.7	$134	2,008	$244,137.0
MA	$510,953.9	$390,887.9	$79	6,498	$901,841.8
Total	$651,339.2	$494,639.6		8,506	$1,145,978.8

Source: Starbuck & Lipsky, 2013

Table A5: Economic Impacts of Marine Trades in RI (in 2012 dollars)

	Spending	Jobs	Wages	Tax & Fee Revenue
Direct	1,538,703,870	7,100	327,717,000	-
Total	2,582,182,348	14,700	598,487,000	117,940,000

Source: Planning Decisions, Inc., 2014

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NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Recreational Fishing Overview

Recreational fishing is an economic powerhouse for Rhode Island (RI), Massachusetts (MA), and other coastal states in the U.S. In the Narragansett Bay watershed (NBW), fishing is a popular recreational activity that attracts residents and visitors to the area. Recreational fishing takes place in both saltwater and freshwater, including on the Bay coastline and in some of the 2,600 ponds, lakes, and reservoirs, and 5,400 rivers and streams in the watershed. Anglers catch fish from the shoreline, bridges, piers, and various types of boats. Many different types of fish are targets for recreational fishing including striped bass, flatfish (flounder, halibut), and bluefish in saltwater, and black bass and trout in freshwater.

More than 221,000 recreational anglers within the NBW spent over two million days fishing in watershed waters in 2011. These anglers spent nearly $147 million (in 2016 dollars) on expenditures, generating more than $86 million in salaries and wages, and supporting over 2,000 jobs.[1]

History

Ideal waters for recreational fishing within the NBW are part of what make the region a popular summer destination. Recreational fishing has deep historical roots in the area, playing an important role in the watershed for centuries. Types of recreational anglers include weekenders, vacationing families on charter boats, and individuals fishing with droplines from piers dotting the shoreline.[2]

As the popularity of recreational fishing expanded in the watershed, laws were created and government branches were established to enforce fishing laws. In MA, the earliest fishing laws date back to 1627, when the Colony of New Plymouth created a law that declared fishing to be free. The first Water Bailiff was employed in 1670 and in 1948 a Chief Coastal Warden and Chief Conservation Officer were hired to enforce fishery laws and ensure recreational fishing remained a sustainable activity.[3] In RI, Game Wardens were established in 1940, eventually becoming the Environmental Police in 1998. Environmental Officers enforce RI laws and regulations governing the recreational fishing, helping to support a healthy industry in the state.[4]

Today, recreational fishing takes place on freshwater and saltwater throughout the NBW. These locations include the Bay, more than 2,600 ponds, lakes, and reservoirs, and over 5,400 rivers and

streams. Anglers target many different species of fish, and catch from areas such as the shoreline, bridges, piers, and various types of boats.

Data Sources and Limitations

Estimates of participation rates and expenditures of recreational fishing and their economic impact on the NBW economy are provided in the following section. These data are derived from National Survey of Fishing, Hunting, and Wildlife-Associated Recreation conducted by the U.S. Fish and Wildlife Service (USFWS) in 2011.[i] This report only focuses on recreational fishing that occurs within RI and MA state borders, disregarding out-of-state fishing by RI and MA residents. Additional data are obtained from the American Sportfishing Association (ASA), which provides estimates of anglers' participation and economic impact, focusing on recreational anglers at least 16 years old.

To estimate the recreational fishing activity within the NBW using published data at the state level, different approaches were taken. For RI, state figures were adjusted by the share of the state's population in the watershed in 2010. This equates to 88.8% of the state population in RI (for maps of the area and population of the NBW, please see the "Geography" section of this report). This approach assumes that participation rates for recreational fishing are the same in both watershed and non-watershed areas. For example, the USFWS estimate of 42,000 freshwater anglers for the state translates into over 37,000 freshwater anglers in the RI portion of the watershed.

In MA, given that so little of the state has direct access to saltwater in the NBW, a different approach was taken. For saltwater angling, only watershed cities and towns with direct access to Narragansett Bay are included: Fall River, Somerset, and Swansea. Their combined population represents 1.9% of the state's population. Reported watershed figures are state numbers adjusted by the share of the state's population in the NBW adjacent towns. Therefore, the USFWS estimate of 323,000 saltwater anglers translates into 6,000 saltwater anglers in the MA portion of the watershed who participated in saltwater recreational fishing. For freshwater angling in MA, the same approach as mentioned above for RI is used. This amounts to 15% of MA's population in the watershed.

Based on these assumptions, the economic impact of recreational fishing is estimated for the NBW for both sources. For additional information on the methodologies used in this report, please reference the "Methodology" section.

Current Status and Trends

Today, recreational fishing draws both in-state and out-of-state visitors to the NBW. Based on previously mentioned assumptions, in 2011, nearly 222,000 anglers were estimated to have participated in recreational fishing in the watershed (Table 1). Of these anglers, 37% fished in freshwater. In total, freshwater anglers took over one million trips and spent over one million days

[i] The USFWS survey focuses on individuals that are at least 16 years old.

fishing in the lakes and rivers within the watershed. The remaining 63% of anglers fished in saltwater, taking over one million fishing trips and spending over one million days on the water.[5]

Table 1: Estimated Recreational Fishing Participation in the NBW (2011)

	Number of Anglers (1000s)	Number of Trips (1000s)	Number of Fishing Days (1000s)	Average Number of Fishing Days
		Freshwater		
RI	37.3	617.2	656.2	18
MA	44.1	559.8	674.9	15
Watershed	81.4	1,177	1,331.1	16.4
		Saltwater		
RI	134.1	986.6	1,269.8	9
MA	6.1	78,185	76.9	13
Watershed	140.2	1,064.8	1,346.8	9.6
		Combined		
Watershed Total	221.6	2,241.7	2,677.9	

Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

In the survey, anglers are identified by their residences. This allows us to determine the proportion of recreational anglers in the NBW that are tourists bringing economic value to the region. Within the watershed, there are over 124,000 individuals who recreationally fish in their own state (Table 2). More than half of the total anglers fishing in the watershed are residents, and there are more residential freshwater anglers than saltwater anglers.

One significant difference between the two states is the share of anglers that are not state residents. In RI, only 41% of the anglers in the state's water are residents, whereas in MA, residents represent 67% of saltwater anglers (Table 2). Those fishing in RI are far more likely to be non-residents, implying that recreational fishing provides RI's economy with more tourist spending. This is not surprising given the differing amount of coastal areas within the NBW for each state (much of MA's coastline is located outside of the NBW, along Cape Cod).[ii]

Data are also available that allow us to identify characteristics of fishermen (Table 3). Most recreational anglers are from urban areas, are male, and are white. In addition, many anglers are between the ages of 45 and 64, and earn well above average incomes, which may be a reflection of higher than average education levels.[6]

[ii] Unfortunately, the number of non-residents who are RI or MA residents recreationally fishing across state lines, buts still within the watershed, is not known.

Table 2: Estimated Residential Recreational Fishing Participation in the NBW (2011)

	Number of Anglers (1000s)	Number of Trips (1000s)	Number of Fishing Days (1000s)	Average Number of Fishing Days
		Freshwater		
RI	30.2	582.5	612.7	20
MA	34.8	516.7	631.7	18
Watershed	65.0	1,099.2	1,244.4	19.1
		Saltwater		
RI	55.1	640.2	867.6	16
MA	4.1	69.8	67.5	16
Watershed	59.2	710.1	935.0	15.8
		Combined		
Watershed Total	124.2	1,809.3	2,179.4	

Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

Table 3: Characteristics of Residential Anglers in RI and MA (2011)

	RI	MA
From urban area	85%	89%
Males	73%	78%
Between ages 45-64	44%	32%
White	95%	92%
Those with incomes > $75,000	43%	52%
4 years or more of college	44%	49%

Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

Expenditures of recreational anglers (Table 4) indicate that recreational fishing contributes critically to the watershed economy. Recreational fishing necessitates spending by anglers for guides, licenses, access fees, fuel, ice, bait, boating costs, fishing equipment, auxiliary equipment, and specialized clothing. Anglers may also travel far enough to areas where lodging and food become necessary.

Recreational anglers in the NBW spent over $136 million (in 2016 dollars) on related expenditures (e.g., food, lodging, transportation, and equipment; Table 4). It is important to note that these expenditures are comprised of both long- and short-term expenses—short-term expenditures are those that are typically made repeatedly and have an oft-recurring economic impact (such as buying bait or food) while long-term expenditures are made less often, and therefore are reflect more infrequently in the data (such as purchasing new fishing equipment). RI residents accounted for 83% of total recreational fishing expenditures, and MA residents accounted for the remaining 17%.

As a complement to the USFWS data, a survey by the American Sportfishing Association (ASA) provides additional insight into the economic impact of the recreational fishing industry in the NBW (Table 5). During 2011, more than 221,000 recreational anglers in the NBW spent nearly $158 million (in 2016 dollars) on retail sales, generating more than $86 million in salaries and wages. These expenditures supported over 2,200 jobs.[7]

Table 4: Estimated Expenditures of Anglers in the NBW (2011) (in 2016 dollars)

	Expenditures ($1000s)	Average per Participant
	Freshwater	
RI	$16,157.1	433
MA	$17,083.2	387
Watershed	$33,240.3	409
	Saltwater	
RI	$97,012.8	723
MA	$5,796.0	950
Watershed	$102,808.8	736
	Combined	
Total	$136,049.1	556

Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

Table 5: Estimated Economic Impact of Recreational Anglers in the NBW (2011) (in 2016 dollars) ($1000s)

	Anglers (1000s)	Number Fishing Days (1000s)	Retail Sales	Salaries & Wages	Jobs	Federal Tax Revenues	State & Local Tax Revenues
				Freshwater			
RI	37.3	656.0	$23,964.5	$11,818.3	313	$2,809.1	$2,638.5
MA	44.1	674.9	$23,596.9	$13,960.2	319	$3,393.2	$2,867.6
Watershed	81.4	1,330.9	$47,561.4	$25,778.5	632	$6,202.3	$5,506.1
				Saltwater			
RI	134.2	1,270.1	$103,698.2	$56,308.5	1,483	$13,280.4	$12,026.6
MA	6.1	76.9	$6,517.3	$4,184.3	93	$990.6	$755.8
Watershed	140.3	1,347	$110,215.5	$60,492.8	1,576	$14,271.0	$12,782.4
				Combined			
Total	221.7	2,677.9	$157,776.9	$86,271.3	2,208	$20,473.3	$18,288.5

Source: Southwick Associates, 2013

To arrive at a total economic impact estimate for recreational fishing within the NBW, results from both sources are considered (Table 6). In total, over 221,000 recreational anglers spent over two million days fishing in the watershed in 2011. These anglers spent nearly $147 million (in 2016 dollars) on expenditures, generating more than $86 million in salaries and wages, and supporting over 2,200 jobs.

Table 6: Total Estimated Economic Impact of Recreational Anglers in the NBW (in 2016 dollars)

	Anglers (1000s)	Number of Fishing Days (1000s)	Expenditures ($1000s)	Salaries & Wages ($1000s)	Jobs
Total Watershed	221.7	2,677.9	$146,913	$86,271.3	2,208

Source: Southwick Associates, 2011; 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

Regardless of the study, recreational fishing is an activity that brings significant economic value to the NBW, and this impact is often overlooked. Recreational fishing in the watershed is not only of value to anglers who benefit from the enjoyment of the recreational experience, but it spurs significant economic activity in areas and businesses that serve and support the fishing public.[8]

Anglers travel to fishing sites, pay license fees, buy or rent boats, buy fishing gear and equipment, eat in restaurants, and rent or own lodging when they embark on recreational fishing excursions.[9] These expenditures help to boost the economies of both RI and MA. In addition, the topography of the Narragansett Bay and the coastline of RI and MA allow for a dominating recreational fishing presence, and demand will most likely grow in coming years.[10]

Future Threats and Opportunities

Sea level | Water clarity | Estuarine fish communities | Freshwater fish communities | Water quality for aquatic life | Water quality for recreation

Currently, 85% of estuarine waters studied in the NBW are deemed "acceptable" for recreational use, which includes boating and fishing, while 80% of lakes and ponds and 40% of freshwater streams and rivers are deemed the same. This acceptability of use is determined by fecal coliform levels, which are used as an indicator for water quality for recreational use: fecal pathogens in water can cause illness in humans and can occur due to increased urbanization (more impervious surfaces, overflow of sewers and wastewater, stormwater runoff, etc.).[11] This issue may be exacerbated by increased precipitation and warmer water from climate change, which increase the amount of water carried to waterbodies and facilitate bacterial growth.[12] [13] Increasing urbanization and climate change threaten to increase fecal bacteria in waterbodies, thereby threatening their potential for recreational use, such as fishing.

Furthermore, recreational fishing will be impacted by potential changes in fish population. The same factors mentioned above, such as climate change and urbanization, will also impact aquatic life, causing issues like nutrient loads, harmful algal blooms, and reducing water clarity and the amount of dissolved oxygen in the water.[14] These problems pose serious risk to the health of fish communities. Additionally, warming water temperatures from climate change will impact the type of species available for recreational fishing: in both freshwater and estuarine water, there has been a decrease in

the population of cool-cold water fish, like brook trout and winter flounder, and an increase in warmer water fish, such as summer flounder and butterfish.[15] [16]

Finally, the infrastructure for fishing itself is under threat from sea level rise. By 2100, sea level in the northeast could rise by nearly 10 feet.[17] Coastal areas used for fishing, such as piers, may be submerged by rising sea levels. Docks used for housing boats for recreational fishing may also be negatively impacted by the rise. However, as stated in the "Ports and Maritime Trade" section, a change in shoreline provides an opportunity for the development of new infrastructure along the new coast.

Overall, recreational fishing is susceptible to changes in water quality, which will affect both the status of waters deemed acceptable for recreational activity as well as the status of fish themselves. Infrastructure for fishing may also be impacted, but changes in the coast may provide new opportunities for fishing areas and warmer waters will also provide the opportunity for fishing of warm-water species not previously present in the area. Adaptation to these coming changes will be imperative for the continued success of recreational fishing in the NBW.

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[6] Source: USFWS et al., 2013.
[7] Source: Southwick Associates, 2013.
[8] Source: Colt et al., 2000.
[9] Source: Georgianna, 2000.
[10] Source: Hall-Arber et al., 2001.
[11] Source: NBEP "Water Quality for Recreation," 2017.
[12] Source: NBEP "Precipitation," 2017.
[13] Source: NBEP "Temperature," 2017.
[14] Source: NBEP "Water Quality for Aquatic Life," 2017.
[15] Source: NBEP "Estuarine Fishing Communities," 2017.
[16] Source: NBEP "Freshwater Fishing Communities," 2017.
[17] Source: NBEP "Sea Level," 2017.

Appendix

Table A1: Recreational Fishing Participation in MA & RI (2011)

	Number of Anglers (1000s)	Number of Trips (1000s)	Number of Fishing Days (1000s)	Average Number of Fishing Days
RI	175	1,800	2,080	12
MA	532	7,850	8,367	16
Total	707	9,650	10,447	

Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation

Table A2: Angler Participation of Sportfishing in MA & RI

	Total Anglers	Non-Resident Anglers	Total Fishing Days	Non-Resident Fishing Days	Freshwater Anglers	Freshwater Fishing Days	Saltwater Anglers	Saltwater Fishing Days
RI	174,882	96,061	2,079,990	500,635	41,983	738,755	151,138	1,430,260
MA	531,707	154,583	8,367,439	778,903	294,264	4,499,001	323,077	4,048,841

Source: Southwick Associates, 2013.

Table A3: Economic Impact of Recreational Anglers in MA & RI ($2011)

	Retail Sales	Salaries & Wages	Jobs	Federal Tax Revenues	State & Local Tax Revenues
RI Freshwater	$25,085,633	$12,371,219	353	$2,940,532	$2,761,925
MA Freshwater	$146,228,713	$86,510,958	2,127	$21,027,310	$17,769,876
RI Saltwater	$108,549,235	$58,942,571	1,670	$13,901,720	$12,589,140
MA Saltwater	$318,845,787	$204,708,079	4,883	$48,461,966	$36,975,236

Source: Southwick Associates, 2013.

The Narragansett Bay Watershed Economy Project was conceived and partially supported by the Coastal Institute at the University of Rhode Island under the leadership of Dr. Emi Uchida. In addition, this project was supported, in part, under Assistance Agreement No. SE - 00A00252 awarded by the U.S. Environmental Protection Agency (EPA) to Mass Audubon. Additional project partners include the URI Graduate School of Oceanography, the URI Coastal Resources Center, the Natural Capital Project at Stanford University, and the George Perkins Marsh Institute at Clark University. The views expressed in this project are solely those of the authors. It has not been formally reviewed by EPA. Additional information is available at www.nbweconomy.org.

NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Research and Education Overview

The Narragansett Bay and its watershed are home to cutting-edge research in natural and social sciences, technology and engineering, and, more recently, interdisciplinary approaches dealing with complex societal problems. The Narragansett Bay watershed (NBW) is home to the largest estuary in New England and has been deemed an estuary of national significance by the National Estuary Program under the Clean Water Act.[1] Population growth, urbanization and suburbanization, and climate change have created pressure on the watershed, resulting in societal challenges that are representative of other regions in the U.S. and which have driven research into these complex topics.

Over the years, the NBW has attracted direct grants from federal and state agencies as well as private foundations. Research encompasses a wide-range of grand challenges in American society, including terrestrial and marine water quality issues, marine science and technology, land use change, and, more recently, sea level rise and the effects of climate change. Due to this unique culmination of factors, scientists have attracted millions of dollars each year for research projects and educational opportunities in NBW, sponsored by numerous government agencies and nonprofit organizations. The University of Rhode Island's Graduate School of Oceanography, for instance, attracts more than $25 million yearly, which supports over 300 research projects, a portion of which focus on research within the NBW. Academic research institutions within the watershed that are active in research activities related to the watershed include Brown University, Providence College, Rhode Island College (RIC), Roger Williams University, Salve Regina University and the University of Rhode Island (URI). Research institutions located outside the watershed also use the NBW as research base, for instance, Clark University, Eastern Connecticut State University, MIT Sea Grant, University of Connecticut, University of Massachusetts, and Worcester Polytechnic Institute.

The NBW is also home to U.S. Environmental Protection Agency's (EPA) Atlantic Ecology Division (AED) and the National Oceanic and Atmospheric Agency's Northeast Fisheries Science Center (NEFSC) Narragansett Laboratory. The AED, one of the EPA's National Health and Environmental Effects Research Laboratories, studies environmental changes in coastal areas, such as sea level rise, and how these changes impact not only the ecosystem but also the surrounding communities. It also works to understand how these risks can be managed and mitigated.[2] The NEFSC, located at URI's

Narragansett Bay Campus, conducts research on the fish stocks, ecology and conservation of protected species, fisheries management and sustainable coastal management.[3]

History

The NBW hosts several institutions that actively engage in scientific research involving the watershed. URI, founded in 1892, has a long history of involvement in research in the NBW and has become a hub of research activity over the years. Capitalizing its unique position at the interface of the Narragansett Bay and Rhode Island (RI) Sound, URI founded the Graduate School of Oceanography (GSO) on the Narragansett Bay in 1961 and has established a global reputation for excellence in marine research, teaching, and outreach. Owing to its unique and cutting-edge facilities and globally renown scientists, GSO attracts more than $25 million in yearly research support, with over 300 research projects investigating local to global phenomena, including research within the NBW. The Narragansett Bay is the home port for the National Science Foundation's 185-foot research ship, R/V *Endeavor*, which is operated by GSO and represents the flagship of myriad research vessels and shore-based facilities. URI also founded the Marine Science Research Facilities (MSRF) at its Bay Campus. The MSRF houses state-of-the-art laboratories for rearing and maintaining a variety of marine organisms and perform chemical, physical and molecular analysis of samples, which aids in a wide variety of marine research and education.[4] In addition to GSO, researchers in the College of the Environment and Life Sciences and the College of Engineering have led a number of externally funded research projects using NBW as their primary site. Many are interdisciplinary and interinstitutional collaboration involving scientists and engineers from URI, Brown University, and other academic institutions in New England.

URI has also attracted grants through the Sea Grant program since its inception in 1968.[5] The Sea Grant Program, funded by the Department of Commerce's National Oceanic and Atmospheric Association (NOAA), is involved with 33 colleges and universities in coastal and Great Lakes states across the country. This involvement primarily began in 1966, when Senator Claiborne Pell of RI, with the help of members of the URI administration and faculty, drafted the National Sea Grant College Act. The program focuses on education and research involving coastal/marine resources. The RI Sea Grant Program partners with the Coastal Resources Center at URI and with the law school at Roger Williams University. In 2015 alone, the RI Sea Grant generated over $2 million in federal funding for research in the state, matched with over $1 million from alternative sources. [6]

Furthermore, URI was selected as a university host for the North Atlantic Coast division of the Cooperative Ecosystem Studies Unit (CESU) in 1999. The network involves governmental organizations (mainly the Department of the Interior), non-profits, and colleges/universities, and works towards enhancing the understanding of environmental knowledge—"the North Atlantic Coast CESU is part of a national network of biogeographic programs being established to provide research, technical assistance and education to federal land management, environmental and research agencies."[7]

Aside from academic research, a number of non-profits and citizen-science groups have developed within the NBW to study and conserve the area, which also attracts federal, state, and private foundation grants. One of the most prominent organizations is Save The Bay, founded in 1970 with the purpose of conserving the Bay and engaging and educating the public on the benefits and importance of the watershed.[8] Save The Bay hosts a number of educational events for schools and organizations through its "Explore the Bay" program, ranging from after school programs to hands-on activities located along the coast.[9] Save The Bay also has hosted initiatives, such as its eelgrass and scallop restorations, to protect, monitor, and restore natural habitats in the NBW. These restoration efforts are a collaboration between Save The Bay, volunteer assistance, and funding from organizations such as NOAA's Restoration Program Partnership.[10] Another prominent organization related to the NBW is the Narragansett Bay Estuary Program (NBEP), funded by the U.S. EPA National Estuary Program. Founded in 1985, it operates with the purpose of understanding, protecting, and restoring the Narragansett Bay. NBEP partners with state (both RI and MA) and federal agencies, as well as nonprofit organizations such as Mass Audubon, The Nature Conservancy, and Save The Bay, to band together in protection of the estuary.[11] Additionally, citizen science groups such as URI's Watershed Watch are also active in the research and protection of the NBW. Partnering with the RI Department of Environmental Management (RIDEM) and non-profits like NBEP, Watershed Watch relies on volunteers to report weekly monitoring updates from water bodies all across the state. The organization monitors water quality in these areas to understand water quality patterns across time, to educate the public about water quality issues, and to ensure the health of water resources across the state.

Aside from academic and nonprofit institutions, the government also conducts research on the national and state levels within the NBW, both of which highlight the importance of long-term research projects in the watershed. For example, there is the NEFSC Narragansett Laboratory, under NOAA's control since 1970, which studies the impact of environmental changes on fish populations. A majority of research focuses on depleting fish stocks, sustainable fisheries management, and species conservation. The laboratory is also an important resource for NOAA in understanding how climate change impacts fish populations (specifically endangered species) and marine ecosystems. Furthermore, the Narragansett Laboratory is home to the Apex Predators Program (APP), an initiative focused on studying biological and ecological patterns of approximately 30 different shark species in the area. In order to successfully accomplish these initiatives, the facility works in conjunction with the EPA's AED, GSO, and the Woods Hole Oceanographic Institute.[12] [13] Additionally, the AED, also located in Narragansett, studies ecosystem services of coastal environments and how these services are impacted by environmental changes, such as a rise in sea level or other effects of climate change as well as human activity. The AED also focuses on coastal wetland assessments, estuary monitoring and management, and nutrient changes and their impact on surrounding ecosystems.[14] Additionally, another long-term governmental research project is the fixed-site water quality monitoring program headed by the RI Department of Environmental Management's (RIDEM) Office of Water Resources,

which has been operating since 2003. As of 2005, there are 13 locations across the state that collect information on water temperature, salinity, chlorophyll, and dissolved oxygen levels. The monitoring is a collaborative effort between RIDEM, GSO, the Narragansett Bay Commission, the Narragansett Bay National Estuarine Research Reserve, Roger Williams University, NBEP, and the URI Coastal Institute.[15]

Data

Data on grant awards on research based solely in the NBW is non-existent and difficult to construct. The lead institution that receives these grants is URI, which then works in collaboration with many other institutions within and outside the watershed. The reported statistics focus on nine federal agencies that frequently fund research that uses the Narragansett Bay and its watershed: The National Science Foundation, the U.S. Environmental Protection Agency, the U.S. Department of Commerce, the U.S. Department of the Interior, the U.S. Navy, the U.S. Air Force, the U.S. Army, and the National Aeronautic & Space Administration. However, the numbers need to be interpreted with caution since they include research that takes place outside NBW. On the other hand, data do not include grants made to Brown University, Clark University, or other research institutions that use NBW for place-based scientific research. Information in this section regarding grants and awards has been sourced from the URI's publications, including GSO.

Information about institutions and organizations was sourced from their self-published and publicly available material (Save The Bay, the Sea Grant Program, Ocean SAMP and specific project-based websites).

Information and data on research related to the defense sector, which are primarily funded through the Department of Defense, are reported in the section on the "Defense Sector."

Current Status and Trends

Research

Statistics from URI illustrate the magnitude of the research grants. In the recent years, URI has received grants from a variety of federal institutions, including the National Science Foundation (NSF), the U.S. Environmental Protection Agency, U.S. Department of the Interior, and the U.S. Department of Commerce, to finance research in the NBW. The National Science Foundation is a major grant contributor, along with the Department of Commerce, and U.S. Navy, with other institutions also making considerable contributions (Figure 1). As will be discussed below, a portion of this grant money funds research in the NBW, and spans a variety of subjects, ranging from understanding land use changes and their impact to the effects of climate change on the coastal environment.

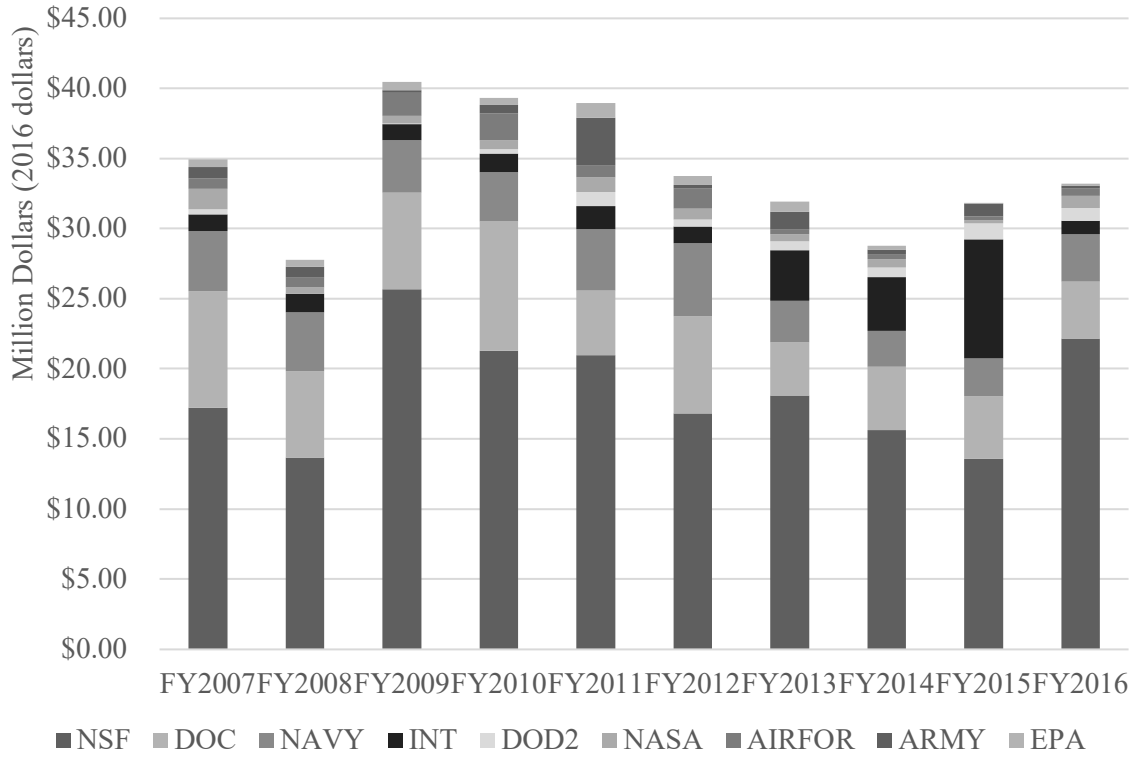

Figure 1: Grants awarded to URI through Division of Research and Economic Development, by agency, 2007 to 2016 (2016 million dollars)

Source: URI, Division of Research and Economic Development Annual Report FY2016.

Note: The acronyms stand for the following agencies:

NSF: National Science Foundation, **DOC**: U.S. Department of Commerce, **NAVY**: U.S. Navy, **INT**: U.S. Department of the Interior, **DOD2**: U.S. Department of Defense (Excludes Army, Navy, & Air Force), **NASA**: National Aeronautic & Space Administration, **AIRFOR**: U.S. Air Force, **ARMY**: U.S. Army, **EPA**: Environmental Protection Agency

In more recent years, the NBW has become home to interdisciplinary research that involves natural and social scientists, engineers, communication, and outreach specialists, generating scientific research that helps decision making by the stakeholders. One prominent example is of this is grants from NSF, specifically through the Established Program to Stimulate Competitive Research (EPSCoR), which funds interdisciplinary collaborative research projects within the NBW. In recent years, URI has received three Track-1 EPSCoR grants that focus on research related to the NBW—although URI is the main or co-recipient of these grants, they entail collaboration with multiple institutes of higher education, both inside and outside of RI. URI received its first Track-1 grant in 2006 along with Brown University. The grant provided $6.75 million to encourage research among all eleven higher education institutions in the state, part of which focused on marine life sciences.[16] In 2010, URI was once again awarded a Track-1 EPSCoR grant, with over $20 million awarded to encourage research in marine life science by partnering with nine colleges and universities in RI.[17] URI received its third Track-1 EPSCoR grant in 2017, with $19 million used to stimulate research with a focus on coastal ecology research and its relation to climate change. The grant also involves Brown University, Bryant University, Providence College, RISD, RIC, Roger Williams University,

and Salve Regina, all of which will collaborate to help establish the Rhode Island Consortium for Costal Ecology, Assessment, Innovation, and Modeling.[18] URI has also received two EPSCoR Track-2 grants, which focus on building collaborative research teams. In 2013, URI, along with the University of Delaware and the University of Vermont, received a $6 million Track-2 grant to focus on water research, forming the North East Water Resources Network (NEWRnet). The purpose of NEWRnet was to research how climate changes impact water quality, including scientific approaches including water sensors to monitor water quality and an economic approach to understand how individuals change their water use patterns when exposed to water quality education.[19] URI and RISD are also involved in a Track-2 grant received by the University of New Hampshire in 2015 for $6 million. The grant covers a four-year project studying the future of dams in New England, including the impacts of dam removal and the expansion of hydropower dams.[20]

Aside from major collaborative grants under EPSCoR, single institutions also receive grants for their research. For example, in 2010, Bryant University received a $534,000 NSF grant to study sediments in the NBW, the largest research grant ever received by the University. The focus of the project was studying sediment pollution and the impact of climate change on the ecosystem in the Narragansett Bay.[21] In 2012, Brown University received a $600,000 grant from the Rhode Island Research Alliance, with part of this grant dedicated to research on algae biomarkers, allowing for a better understanding the climate history of the Narragansett Bay; Brown University partnered with URI for this research.[22] Furthermore, in 2015, three faculty members at Brown University received funding under STAC, RI's matching program for EPSCoR, to research climate change its ecological impact on the Narragansett Bay.[23] These grants, funding a variety of initiatives in the NBW, illustrate the immense effort put forth and cutting-edge research that is being done by faculty, students, and organizations at the academic institutions across the watershed.

Aside from academia, other organizations also receive funding to study and research pressing issues the NBW. For example, in 2016, the Environmental Protection Agency issued a $4 million grant spread across different stakeholders in New England through its Southeast New England Program (SNEP).[24] The project includes programs that focus on improving water quality near Aquidneck Island and an initiative to develop models for estimating the value of ecosystem services in the NBW led by Mass Audubon in conjunction with URI's Coastal Resources Center and the Natural Capital Project.[25] [26]

Education and Outreach

Throughout the NBW, numerous organizations have invested in environmental education as it relates to Narragansett Bay, including academic institutions, government agencies, and nonprofit organizations. Notably, institutions of higher education provide environmental education opportunities specifically relating to the NBW for students of all ages. For example, at the university level, URI is a natural outlet for NBW-related education. There are numerous classes that provide hands-on experience relating to the Narragansett Bay, including marine field classes that allow for an

interactive learning experience in the Bay and aboard the R/V *Endeavor*.[27] Oceanography classes at Community College of Rhode Island encourage interactive learning by allowing students to collect their own data from Narragansett Bay.[28] These are just two tangible examples of how higher learning institutions in the NBW connect the Bay to classroom experiences – it is likely that there are numerous classes at colleges and universities across the state that provide direct or indirect opportunities for education and research related to the Bay.

URI also provides internship opportunities for undergraduates across the state whose research focuses on the Narragansett Bay. The Summer Undergraduate Research Fellowship (SURF) program, supported by the Rhode Island Institutional Development Award's Network of Biomedical Research Excellence of the National Institutes of Health and NSF EPSCoR, provides students from URI, Brown University, RIC, RISD, PC, Bryant University, Roger Williams University, and Salve Regina University with summer internship opportunities for supervised independent research; although all research focuses on Narragansett Bay, it covers a wide variety of topics, ranging from the effect of water pollutants in the Bay on embryonic development to the effect of pH changes on microorganisms in the Bay. Over the past decade, SURF has supported the summer research of over 300 students from various majors.[29]

In addition to supporting university students, institutions like URI support educational programs that reach out to younger students and the general public. For example, URI is home to the Narragansett Bay Classroom, operated through the Office of Marine Programs. The Classroom offers both on-site and in-classroom interpretive programs for students from elementary to high school. Students can learn about a variety of NBW related topics ranging from aquaculture to marine wildlife.[30] URI also offers educational opportunities in the form of summer camps for K-12 students, such as the Ocean Science Exploration Camp, where students can get hands-on experience learning about the ecosystem of Narragansett Bay, or the Ocean Exploration: Naval Science and Technology Camp, which focuses on ocean exploration.[31]

Additionally, the Coastal Institute at URI offers interdisciplinary programs to the public with the goal of enhancing knowledge and community engagement relating to the NBW. For example, the Coastal Institute collaborates with the RI Sea Grant to publish *41° North*, a magazine focusing on RI coast, and supports several educational theatrical programs that educate viewers on the history and current state of the Narragansett Bay.[32] It also hosts Studio Blue, an art gallery and "multimedia costal and learning commons," in conjunction with GSO, Office of Marine Programs, and RI EPSCoR. Studio Blue is a venue that blends art and science and engages viewers on issues relating to the Bay's coastal ecosystem.[33] URI also frequently offers public lectures relating to the Narragansett Bay, such as a 2017 series supported the RI Sea Grant, titled "Warming Seas and the Ocean State," where researchers had a chance to share their work relating to climate change and the Narragansett Bay.[34]

Aside from academic institutions, nonprofit organizations within the NBW are also heavily involved in environmental education as it relates to the Bay. One prominent example of this is Save The Bay (STB), an organization focused on educating and engaging the public on matters relating to Narragansett Bay. STB runs numerous programs for children and adults alike, which both teach them about NBW related issues and provide hands-on experience in the classroom and in the field. The organization also encourages volunteer participation for several important ecological initiatives – it has hosted several successful projects over the past few decades, including its eelgrass and scallop restoration projects. In 2001, Save The Bay began an eelgrass restoration effort in the Bay (eelgrass is a critical marine habitat that declined by 90% due to disease, natural disasters, and human activity). This effort relied on the help of volunteers across the state to assist with eelgrass transplants and monitoring, and funding from the USDA's Natural Resource Council (NRC), NOAA, Restore America's Estuaries, and the RI Habitat Restoration Trust Fund.[35] Building off of this effort, Save The Bay has also led a successful restoration effort for bay scallops (which attach themselves to eelgrass), started in 2007. This initiative is supported by NOAA and Restore America's Estuaries.[36] These programs not only provide valuable ecological services but educate the public about the importance of these projects to the Bay ecosystem. Along with these restoration projects, the organization commonly holds beach clean-ups that volunteers of all ages can participate in. STB also offers volunteer and internship opportunities for adults in Providence, Newport, and Westerly. These opportunities focus on a diverse array of topics related to the Bay, from aquarium management and marine biology to coastal ecology and habitat restoration.[37] STB also reaches into the classroom by offering educational programs for students across RI, including both in-classroom programs and field trip opportunities. These classroom programs offer students hands-on opportunities to learn about the bay, ranging from lessons about shellfish, seals, eelgrass, and other wildlife to lessons on the impacts of climate change on the Bay.[38] [39]

Another nonprofit organization focused on community outreach and education is Clean Ocean Access, whose mission is to improve ocean health by reducing pollution, improving water quality, and protecting shorelines. From its inception in 2013 to 2017, the organization hosted 87 events that reached 4,265 students for 6,108 hours across RI. During this time, it conducted events for elementary, middle, and high schools; colleges and universities; and organizations such as the Boys and Girls Club, summer camps, and the Boy and Girl Scouts of America. It has worked with public and private schools in towns like Portsmouth, Middletown, and East Providence, as well as with students from CCRI, Salve Regina, and Roger Williams. Activities included hands-on water quality testing and monitoring, beach cleanups, learning about community engagement, and creating digital content to spread awareness about water quality.[40]

Aside from nonprofits, state organizations also offer educational programs relating to the NBW. For example, the RI Department of Environmental Management (DEM) has several initiatives for all ages through its Aquatic Resource Education Program, such as its hands-on ecology programs, tours and

in-class aquaculture lessons. It also provides training sessions for educators, including teachers and scout leaders, who may then share this knowledge with their students.[41]

Future Threats and Opportunities

Sea level rise

Given that a majority of research in the NBW uses infrastructure located on or near the coast, the Research and Education sector is susceptible to sea level rise that will impact these buildings. Sea level is predicted to rise by 9.8 feet in the Northeast Atlantic region by 2100, which is higher than the global average. This rise in sea level, due to glacial melting and expansion of warm water, will have a serious impact on coastal structures. URI developed a program—STORMTOOLS—for the RI CRMC which predicts the impacts of sea level rise on the state. The tool predicts that just a seven-foot rise in sea level will lead to the submersion of almost 4,000 buildings.[42] Given that sea level will rise by nearly 10 feet, this is a conservative estimate of the impact that sea level rise will have by 2100. Infrastructure near the coast, such as URI's Narragansett Bay Campus, may be highly vulnerable to these changes (Figure 2).

In terms of opportunities, the NBW itself, as a forefront of the impacts of climate change, will provide an opportune location for studying the impacts of climate change. From its effect of forest coverage and composition to its impact on marine fish species, the NBW provides a diverse backdrop for a multitude of research topics and how we can adapt to these issues going forward.

Figure 2: Sea Level Rise and Its Impact on URI's Narragansett Bay Campus

Note: The rise in sea level is based on an increase in sea level rise (SLR) from the mean higher high-water point (MHHW)
Source: STORMTOOLS

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[40] Source: Touhey et al., 2018.
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NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Tourism Overview

Tourism's contribution to the economy is becoming increasingly important in a globalizing world—in 2015, the United Nations reported 1.2 billion international travelers and over $1.26 trillion in tourism spending with 11% of tourists and 19% of spending coming from North America. In that same year, tourism accounted for 7% of the world's total exports, illustrating its vital contribution to the global economy.[1i]

The tourism industry in the Narragansett Bay watershed (NBW) has been shaped by historical forces, including social, economic, and technological changes. Modern tourism in the watershed began in the 18th century with a trickle of the wealthy elite spending their summers along the Bay; by the 19th century, when the Industrial Revolution had taken hold, tourism became accessible to a wider, middle-class population. While the face of tourism has continuously changed over the centuries in the NBW, the popularity of tourism has not. Tourists are visiting the NBW in larger numbers than ever, hailing from countries all across the world. These tourists have an enormous impact on the economy of the watershed, especially the southern portion of the Narragansett Bay. To illustrate this impact, in 2016, the two industries most closely related to tourism—the Arts, Entertainment, and Recreation and Accommodations and Food Services—employed more than 90,000 people in the watershed with wages totaling over $1.8 billion. From these figures, looking specifically at the direct impact of tourism, the number of jobs was approximately 37,500 with wages totaling nearly $1.8 billion. Tourism has established itself as an integral part of the NBW's economy and, given its growth in recent decades, remains a promising contributor to the region's economy. One of these sectors, the Arts, Entertainment, and Recreation, industry encompasses aspects of art and culture in the watershed, both of which play an important role in tourism and the watershed's rich history. For more detailed information on this topic, please see the "Arts and Culture" subsection towards the end of this chapter.

History

Long before the modern wave of tourism, Native American tribes, such as the Narragansett, recognized the benefits and beauty of the NBW—they summered on the shores of the Narragansett Bay with winter homes further inland.[2] It would take centuries for the rest of the world to recognize

[i] This is based on Travel and Tourism Satellite Account of the Bureau of Economic Analysis (BEA).

the beauty of the NBW the way the Narragansett did—modern tourism did not take hold until the 18th century with a trickle of wealthy Southern elites who escaped to the shores of the NBW for the summer. They came in sufficient number so that "[i]n the eight years from 1767 to 1775, indeed, the pioneer society column of the Newport Mercury listed some four hundred summer visitors."[3]

Heading into the 19th century, the numbers of tourists to the NBW remained small. More than 90% of the nation's 3.5 million people lived in rural areas, with seven of every eight workers employed in agriculture in 1810.[4] As a result, there were very few with either the means or time for travel or the knowledge of where to visit. In the decades leading to the Civil War, travel still remained slow (it took three days to travel from New York to Newport) and tourism was still restricted to a small, privileged group of individuals.[5] Changing settlement patterns, however, slowly gave rise to an increase in tourism, as people moved off farms and into cities. This trend was occurring especially quickly in the NBW—by 1860, 60% of the population in Rhode Island (RI) and Massachusetts (MA) resided in urban areas (much higher than the national average of 20%), a major shift from 93% of people residing in rural areas in the country only half a century earlier.[6]

After the Civil War, tourism experienced a sudden, major shift as the trickle of tourists grew into a swift current, forming the modern tourism industry. This growth was partially due to changes in demographics, although population growth had slowed despite the millions of immigrants who continued to arrive at Ellis Island. More of the growth came from changes in the size and structure of the economy as well as technological advances. In 1860, the U.S. economy was smaller than that of France or the UK, but by 1920, the U.S. economy was nearly 75% larger than the combined economies of France and the UK and three-fourths the size of *all* of Western Europe.[7] Along with this economic growth came a growing middle-class: there were more workers toiling in factories than on farms and income per person had more than doubled. With rising wages, a shortened work week to slightly more than 50 hours, and paid vacation, an increasing number of workers were able to afford the cost and time of leisure travel to destinations along the NBW (Figure 2).[8] The NBW also provided an escape from the illness and pollution of increasingly industrialized cities.[9]

Advances in travel efficiency also allowed for increased tourism in the area—not only did more people have means to travel, but travel was considerably faster; by 1930, tourists could travel from New York City to St. Louis in 24 hours—about the same time as it took to get from Boston to Newport a century earlier.[10]

It is important to note that while the above section focuses primarily on the southern portion of the Bay, the upper Bay also experienced successful bouts of tourism, but in a much different way. While tourism in the lower Bay focused on seasonal visits, tourists in the upper portion were primarily "day trippers," a subset of tourists that remains important in today's tourism industry. Destinations like Colonel SS Atwell's Clam Shack at Fields' Point in Providence were popular among upper Bay

tourists. Other favorites were the amusement parks and shore dinner halls at Rocky Point in Warwick and Crescent Park in Riverside.

Figure 1: Jamestown, RI, ca. 1890
The Thorndike Hotel, Gardner House, Riverside, Bay View Hotel, ferry boat "*Conanicut*" and the Bay Voyage Hotel.
Source: Jamestown, RI visitor website

By 1920, the importance of tourism to the area's economy was recognized by the state of RI—the government acknowledged the decline of manufacturing in the region and the rise of tourism and its growing contribution to the economy.[11] Thirty years later, this sentiment was reflected by the national government: in a report to the President of the United States on the strengths and weaknesses of New England (a region that had experienced decades of slow growth and decline), the committee came to much the same conclusion, stating, "the vacation business has excellent prospects for expansion nationally and especially in New England with its historic significance, scenic beauty, temperate summer climate, excellent hunting, fishing, and winter sports facilities."[12]

This recognition, however, occurred as the population of the area experienced declines in population growth; between 1940 and 1980, the population of MA and RI grew at less than half of the U.S. rate as people left the region or chose not to enter it.[13] By the early 1950s, the return of the America's Cup and the Jazz and Folk Festivals were bringing some tourists to Newport. At this time, much of colonial Newport's housing stock was still in place—in part because Newport had never fully recovered from its occupation in the Revolutionary War as it "missed" the Industrial Revolution upstate, and in part because of early preservation actions that had saved the Great Friends Meeting House, Touro Synagogue, Old Colony House, Redwood Library, and Gilded Age "summer cottages" along Bellevue Avenue. In the upper Bay, meanwhile, the amusement parks, beaches, and shore dinner halls were closing. By the early 1980s, Newport had lost the America's Cup and the *Wall Street Journal* wrote that "to many New Englanders [RI was] little more than a smudge on the fast lane to Cape Cod."[14]

Luckily, this downward trend in tourism did not continue—the entire New England region benefitted from the "Massachusetts Miracle," a period of intense economic growth in MA during the 1980s. Decades of decline were reversed and tourism reinstated itself as a major industry. By 1981, tourism generated 5% of the state's GDP, two years later RI held the first Governor's Conference on Tourism, and by 2014-2015 tourists were spending upwards of $25 billion in MA and RI, where it was supporting over 210,00 jobs.

Methodology and Data Limitations

Quantifying the tourism sector in the watershed is difficult because the industry transects multiple areas of the economy, including the travel, housing, retail, and restaurant industries, among others. This also means that there is no single NAICS industry code associated with the tourism, making analysis more difficult than it is with other economic sectors. For example, with aquaculture, there is a NAICS industrial code (1125) with measures of economic size such as employment, wages, and sales for just this industry, which makes an economic analysis of aquaculture more clear-cut.
The tourism industry is an umbrella industry that encompasses the eating & drinking industry (312120), the real estate and rental and leasing industry (53), the retail trade industry (44-45), and the bed and breakfast industry (721191), for example. Due to this large scope, analysis of the tourism sector as a whole can be difficult and accurate estimates of its impact hard to capture. Given these difficulties, there are two approaches used in this report to examine the impact of tourism on the NBW. The first "producer" approach examines the industries that are most related to tourism, including their employment level, wages, and GDP. This approach has three methods: 1) using National Ocean Economic Program (NOEP) Tourism and Recreation data, 2) using Bureau of Labor Statistics for two industries closely related to tourism, and 3) examining seasonality of taxes for two industries closely related to tourism. The second "consumer" approach examines tourism rates and the tourists' levels of expenditure. Additional information on methodology can be found in the "Methodology" section of this report.

Producer approach (industry contribution)

The first method utilizes NOEP data from its estimation of the "Ocean Economy." NOEP's Ocean Economy data include all industries related to ocean/marine activity, including living resources, minerals, ship and boat building, tourism and recreation, and transportation. For each industry, NOEP has information on number of establishments, employment, wages, and GDP for each sector.[15] This report specifically examines the tourism and recreation data. Given the overlap between maps of coastal areas used by NOEP and the area of the NBW, the NOEP ocean economy estimates are used in this report as estimates for the RI portion of the NBW.[ii] There is, however, some margin of error in this approach. This is because NOEP data includes *all* coastal areas of RI, while this report only

[ii] The six sectors in the ocean economy are construction, living resources, minerals, ship and boat building, tourism and recreation, and marine transportation.

includes those that fall into the boundaries of the NBW. For example, the NOEP data for RI would include data for all of Washington County, while this report would only include scaled data for the portion of Washington County that falls in the NBW (for a map of the NBW, please see the "Geography" section). However, given the high level of overlap between the NBW and NOEP areas, NOEP data is used as a proxy. Additionally, as Bristol County is the only county in MA to lie along the coast, NOEP data is used just for this county to represent the MA portion of the NBW.

The second method uses Bureau of Labor Statistics (BLS) data for two industries that are closely related to tourism: Arts, Entertainment, and Recreation and Accommodations and Food. Data are broken down by county. As this method uses a different data source than the first method, it is not meant as a comparison to method one—it does, however, provide deeper insight into tourism's impact using alternative data.

The third method examines the seasonality of the data using RI tax records, which may be helpful given the cyclic nature of the tourism industry. For example, in New England, nearly two-thirds of business occurs in July and August; in MA, it was 60% and in RI it was 67%. In this report, we examine the seasonal pattern in RI based on existing state tax records. Monthly tax revenues are available for all communities in RI for two of tourism's main sectors—food and drinks and accommodations, and these are the taxes studied in this report.

Consumer approach (tourism rates and expenditures)

This approach utilizes specific estimates from the consulting firm Tourism Economics on the number of tourists and the level of their expenditures using the IMPLAN model. This model is designed to capture the linkages between industries—who buys what from whom—and the patterns of spending. By simulating the flow of money through this economic system, the model generates estimates of the jobs and wages created by those expenditures. This report examines the *direct* impact of tourism—for example, the waiters, crew members, and lifeguards. For more information on its *indirect* impacts—for example, the workers employed in industries supplying the restaurants, hotels, and shops with produce, clean linens, and locally produced merchandise—please reference Tourism Economics' 2015 report.

Current Status and Trends

Producer approach – method one (NOEP data)

In 2014, there were 2,156 establishments in the tourism and recreation industry employing 34,757 people (Table 1). Nearly one of every 13 jobs in the state is in this sector in the watershed. This is disproportional to the one of 33 share of wages that is in the watershed, possibly because watershed jobs are more likely to be seasonal and pay lower wages.

Table 1: NOEP Estimates of Recreation and Tourism in RI: 2014
(in 2016 dollars)

	Number of Establishments	Employees	Wages
Tourism & Recreation Sector	2,156	34,757	$687,123,024
State Economy	35,802	463,375	$23,152,721,807

Source: NOEP Ocean Economy

The only watershed county in MA with coastal access in the NBW is Bristol County, and the numbers are similar except for a larger share of activity in the Living Resources sector. This is due to the contributions of the state's fishing fleet and fish processing plants, including those in New Bedford.

From these NOEP data, the main difference between MA and RI is the relative sizes of the industries at the state level. One indicator of this difference is per capita figures for the two states. In 2014 in RI, 33 of every 1,000 people were employed in the tourism and recreation industry in the water sector. This is three times larger than the number in MA (ten for every 1,000), and even larger than the number in Bristol County, MA (five in every 1,000). Within RI, there is also a considerable range in the size of the industry across the state. Newport was at the high end with more than twice the state average (78 in 1,000), while Providence (22 in 1,000) was at the low end, although it is still twice as high as for MA (ten in 1,000). The story is similar when looking at wages, although the differentials are a bit larger.

Producer approach – method two (BLS data)

In the Arts, Entertainment, and Recreation industry in 2015, there were 930 establishments in the watershed, which represented 51% of the industry's employment in the watershed counties (Table 2). These establishments employed 15,000 people and paid wages of $1.85 billion (adjusting for inflation between 2015 and 2016). Of the watershed total, slightly more than half was in RI.

Table 2: Arts, Entertainment, & Recreation in RI &
Accommodations & Food Services in RI
(2016 dollars)

	Establishments	Employment	Wages (in 2016 dollars)
Arts, Entertainment, & Recreation	930	15,003	$436,391,956
Accommodations & Food Services	4,652	76,490	$1,416,163,370
Total	5,582	91,492	$1,852,555,326

Source: BLS

The Accommodation and Food Services industry is also heavily dependent on tourism. In 2015, there were 4,652 establishments in the watershed, again with RI accounting for more than 50% of both employment and wages. Those establishments employed 76,490 and paid wages of $1.4 billion (2016 dollars).

Taken together, in the watershed in 2015, there were 5,582 establishments generating over 91,000 jobs that paid wages of more than $1.8 billion in these two sectors.

Producer approach – method three (seasonal tax data)

Moving on to the tax-seasonality approach, the seasonal effect is defined as the above average tax revenues in the summer months, when it is assumed that tourism is at its peak. The seasonality is more pronounced in the water-dependent communities in the watershed. This is evident in the monthly indexes for the hotel tax in the watershed's 13 water-dependent communities and 16 non-water-dependent communities (Figure 2). In the water-dependent communities, in July (month seven), tax revenues from the hotel tax are five times above the January level, while in the remainder of the state the multiple is 3.25. A similar but less pronounced seasonal effect exists in the meal and beverages tax.

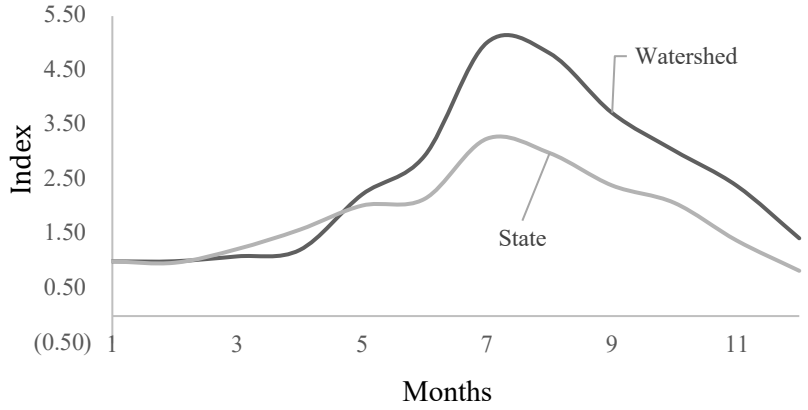

Figure 2: Seasonality of Hotel Tax Revenue: 2015
Source: RI Department of Revenue, 2015, 2016

To quantify this seasonality effect, the base amount (or level of comparison) for the taxes was set as the average for the months from November-March (months with comparatively lower tourism rates). In 2015, the state raised more than $28.5 million in these two taxes—$3.6 million from the hotel tax and nearly $24.9 million from the meals and beverage taxes.[16] Under this scenario, if the year had no seasonal effect, the state would have raised slightly more than $23 million in these two taxes—$2.1 million from the hotel tax and nearly $21 million from the meals and beverage taxes. These figures can then be used to isolate the monetary impact of the seasonal effect, calculated by taking the

difference between the actual revenue in 2015 and the year-without-seasonal-effect prediction. Therefore, of total 2015 tax revenue of $28.5 million, more than $5.4 million came from the seasonal effect of summer months.

It is also possible to estimate sales given that these are tax revenues are from a 1% tax rate. Based on this rate and adjusting for inflation, a year without seasonal effect (no "summer") would generate $2.34 billion in industry revenue (Table 3). Actual sales are estimated nearly $2.89 billion, so the seasonal effect is $550 million.[17]

Table 3: Hotel and Meal & Beverages Tax Revenue in RI: 2015 (in 2016 dollars)

	State Taxes		Industry Revenues	
	Hotel	**Meal & Beverage**	**Hotel**	**Meal & Beverage**
Actual	$3,694,449	$25,176,806	$369,444,916	$2,517,680,570
Non-seasonal	$2,116,908	$21,254,207	$211,690,825	$2,125,420,682
Seasonal	$1,577,541	$3,922,599	$157,754,091	$392,259,887

Source: RI Department of Revenue, 2015, 2016

It is clear from these producer-side estimates that there may be a connection between increased summer month tax revenue and increased tourism during these months. Using NOEP's approach, the tourism and recreation industry in the watershed creates nearly 35,000 jobs and $687 million in wage income. Looking at state tax data on two industries shows that 19% of annual sales is from a seasonal effect. In 2015, in these industries, this represents $550 million. If one were to attribute this seasonal factor to other spending, the cumulative effect would be substantially larger.

Consumer approach

Data for this approach comes from consultants working for state agencies, including from a number of consulting firms working over a span of years using similar, but not identical terminology and methodology.[iii] The numbers here are an attempt to piece together the size of the industry in the watershed. This is done separately for the RI and MA sections of the watershed – this is because, due to the different data sources and data collection methods, the two states might not be comparable.

In 2015 there were 24.1 million tourists in RI. "Tourist" can refer to two types of individuals: "visitors" who traveled at least 50 miles or stayed overnight, and "travelers" who traveled less than 50 miles and did not stay overnight. In RI, there has been an increase in the share of long distance/overnight tourists. In 2009, 43% of the visitors were long-distance or overnight tourists, and

[iii] These firms include: Tourism Economics, IHS Consulting, Advantage Marketing, and the Donahue Institute

by 2013 the number had risen to 48%. There is no comparable number in 2015, but data indicate that nearly one-third of the tourists stayed overnight in RI (although it is not clear is if this is considered in the reports).[18]

In 2015, the expenditures of "visitors" alone was slightly more than $4 billion. Expenditures were also rising rapidly (Figure 3). Between 2010 and 2015, tourism spending increased 60% faster than the overall state economy.[19] In part, this rapid growth reflects the industry's recovery from the recession because it is an industry greatly affected by the overall state of the economy, and in part the industry's faster than average long-term growth.

Table 4: Impact of Travelers in RI Watershed: 2015 (2016 dollars)

	Employment	Wages (billions)
Direct Impact	30,464	$1.58
Total Impact	68,610	$2.89

Source: Tourism Economics, 2015

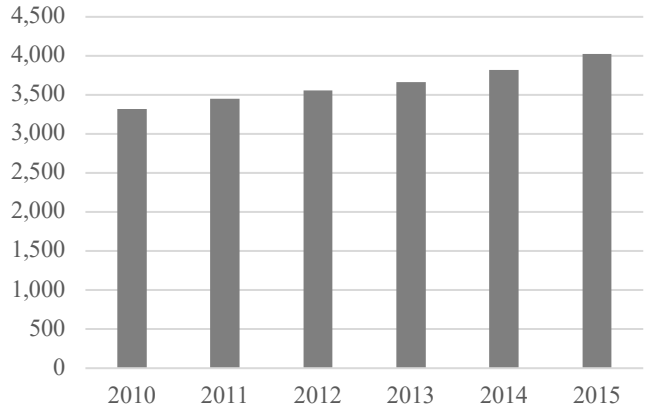

Figure 3: Visitor Spending in RI (millions)

Source: Tourism Economics, 2015

Note: Visitors defined as individuals who traveled 50+ miles or stayed over-night
Travelers defined as individuals who did not travel 50+ miles or stayed over-night

The largest share of spending in 2015 was the food and beverage sector. This sector accounted for 24% of total spending, followed by 21% in the recreation sector that includes gaming and marinas.[20] Growth in overnight and long-distance tourists is evident in a rising share of spending going to lodging and the declining share going to local transportation.

A direct impact of the $4 billion in spending by "visitors" is nearly 36,000 jobs—waiters, housekeepers, shop keepers, rental agents, and tour directors—that the spending supports (Table 5). These jobs account for nearly 6% of the state total, or about 50% of manufacturing employment in the state. These numbers make the industry the 5th largest employer in the state behind health care, retail, manufacturing, and professional, scientific, and technical services. There is also an above average growth in employment. Between 2010 and 2015, tourist industry employment increased 2.7% a year, more than twice the overall rate of employment growth in the state (Figure 4).[21]

Table 5: Direct Impact of Tourists in RI: 2015 (2016 dollars)

	Visitors	Travelers	Total
Employment	35,720	17,381	53,101
Income (Millions)	$1,065	$511	$1,576

Source: Tourism Economics, 2015
Note: Visitors defined as individuals who traveled 50+ miles or stayed over-night
Travelers defined as individuals who did not travel 50+ miles or stayed over-night

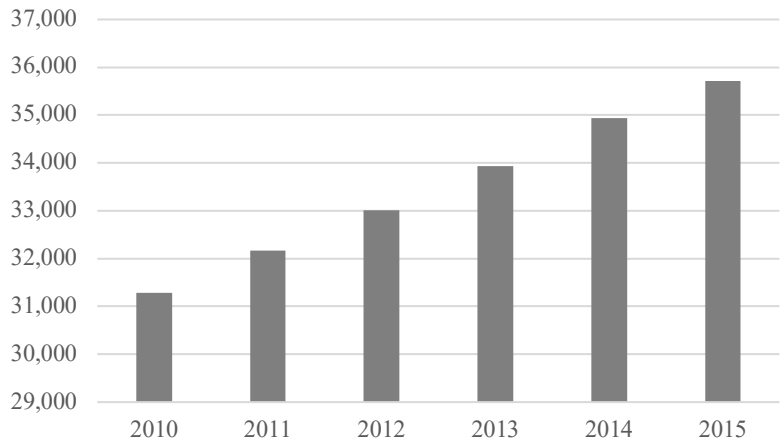

Figure 4: Direct Impact of Visitors on Employment in RI
(*Note:* Visitors defined as individuals who traveled 50+ miles or stayed over-night
Travelers defined as individuals who did not travel 50+ miles or stayed over-night
Source: Tourism Economics, 2015

The wages earned in these jobs in 2015 total just over $1 billion, which equals about 33% of the wages earned in manufacturing (Table 5). The additional industry sales and individual incomes increase taxes at all levels. The estimate is that the additional spending will generate nearly $500 million in state and local tax revenue. It is possible to estimate the impact of those day trippers who

travel less than 50 miles.[iv] In 2015 the employment supported by day trippers was about half of that supported by overnight tourists.[22] The total direct employment supported by tourists was 53,101, 20% more than manufacturing employment in the state. The total income generated by those jobs was nearly $1.6 billion.[23]

These previous figures are state totals. The 2015 report provides expenditures by county, which can then be translated into the RI portion of the NBW.[v] In 2015, expenditures in the watershed, once adjusted to 2016 dollars, were estimated to be 85% of the state total. There were also substantial differences in the level and intensity of the tourism spending across the state. Nearly half is evenly divided between Newport and Providence Counties, while spending is lowest in Bristol where only 1% of the tourism spending occurs (Table 6). The differences across the state are even more pronounced when looking at the spending per resident. Newport ($15,508) is the highest in the watershed while Bristol is the lowest ($784).

Table 6: Traveler Spending in the RI Portion of the Watershed: 2015 (2016 dollars)

	Spending (Millions)	Spending Per Resident
Bristol	$75.9	$784
Warwick	$1,024.6	$12,394
Newport	$1,285.4	$16,686
Providence	$1,288.8	$7,251
South County	$466.4	$6,171
Blackstone Valley	$549.6	$2,277
Balance of state	$339.9	$1,852
Watershed	$5,030.8	$4,843

Source: Tourism Economics, 2015

There are also significant variations within the state in terms of the type of spending. In Blackstone Valley, one-third of expenditures were in recreation, which includes gaming. Newport and South County, meanwhile, account for 82% of spending on seasonal homes, while Newport, where 8% of the state's people live, accounts for 38% of lodging expenditures and 30% of food and beverage expenditures.[24]

Tourism in MA is also a large industry. In 2014, tourist expenditures were $19.5 billion, with about 86% of that total from domestic travelers. In RI, international travelers represented less than 1% of the total, while in MA international travelers' spending was 14% of the total, and this was growing

[iv] Non-construction employment for the travel economy is assumed to be the impact of the day trippers. For example, the travel employment for retail was 3,544 and for all direct it was 5,410, so 1,866 is estimated to be the day trippers.

[v] Using the assumptions that the share of spending in a community in the watershed equals the share of the community's population in the watershed and that the structure of the impact remains unchanged (e.g., there is uniform spending throughout the county, both inside and outside of the watershed).

14% faster than domestic spending. In terms of economic impact, the $19.5 billion in tourist expenditures supported 212,200 jobs at which they earned $7.86 billion in wages.[25]

It is also possible to estimate the size of the industry in the MA part of the watershed because the 2014 MA study has data at the county level, although it is only for domestic tourism. Domestic tourist expenditures in 2014 in the four watershed counties is estimated to be $2.9 billion, which accounts for about 17% of state's domestic tourist expenditures.[vi] This is substantially below the share of the state's population (38%) because per capita tourist expenditures in the watershed counties was only 45% of the state total and because nearly 50% of the state's tourism spending is in Suffolk County. Within the watershed, expenditures in 2015, once adjusted for inflation, were just over $1 billion. These expenditures supported nearly 7,000 jobs and wages of $205 million.[26]

Table 7: Tourism in MA Watershed: (2014)
(in 2016 dollars)

	Bristol	Norfolk	Plymouth	Worcester	Watershed
Direct Impact					
Expenditures	$307.6	$104.5	$250.5	$352.9	$1,015.5
Employment	1,996.1	978.0	1,662.6	2,304.8	6,941.5
Wages	$60.8	$30.6	$48.0	$66.5	$205.9
Total Impact					
Employment	3,208.8	1,572.3	2,672.7	3,705.2	11,159.0
Wages	$116.1	$58.4	$91.6	$126.9	$393.0

Source: Research Department of the U.S Travel Association, 2015

The two studies were done by different consulting firms and they are not exactly comparable. They do, however, allow for an estimate of the combined impact of tourism. Looking at the direct impact of the tourist spending, the number of jobs directly related to tourist spending will be near 37,500 earning wages of nearly $1.8 billion. Looking at the total impact and including the indirect and induced effects, the tourism industry in the watershed generates nearly 80,000 jobs and wages of almost $3.3 billion.

It is not difficult to see the extent to which the tourism industry in the watershed is centered in RI. One indicator that may not be completely captured in the aggregate numbers would be the events held in Newport, which remains a primary tourist destination. Included on that list would be annual events such as the Black Ship Festival and the Newport Boat Show. There are also the Newport Mansions, a large slate of summer sailing events on the waters of the Bay, and the cruise ship visits that have become a regular feature in the waters off of Goat Island in the fall.

[vi] The MA figures are only for domestic travel that was 86% for state and is likely to be a higher percentage in watershed since international destinations such as Vineyard Nantucket, and Cape Cod are not in watershed. Also, the total expenditures estimates were based on the reported multipliers in the MA study that were applied to the direct spending figures in the report. To estimate the economic impact of the spending in the region, the same assumptions are made as in the RI analysis and the 2014 data is converted to 2015 dollars.

Here are a few of the numbers:

1. The Preservation Society of Newport County's mansions:[27] A 2013 study estimated that the mansions attract 650,000 visitors that spent an average of $118 a day in Newport. The annual direct spending of these individuals is nearly $78 million (in 2016 dollars). The total impact on the state, which includes the direct, indirect, and induced effects, was the creation of 1,949 jobs that pay wages of $42 million that supports 786 jobs with wages of $3.3 million (2016 dollars). This activity generates nearly $5.7 million in taxes for the state (2016 dollars).
2. The Volvo Ocean Race:[28] Newport was a stopover port for the Volvo Ocean Race in May of 2015. In the 13 days the race village at Fort Adams was open, the event attracted nearly 148,000 viewers—42% who were from out of state and 10% who were international visitors. Spectators spent $23.2 million, which had an impact of $49.1 million on the state's economy once the indirect effects were included (2016 dollars).
3. Cruise Ships: In 2017, 80 cruise ships including the Queen Mary II with the capacity of nearly 2,700 guests, were scheduled to dock in Newport. The cruise ship activity has been a growth sector. In 2016, 59,023 passengers visited Newport, more than double the number in 2000. The revenue from the head tax in 2016 was $354,138, which up nearly 125% from 2000 after an adjustment for inflation.[29]

Regardless of the metric used, the figures discussed above illustrate the enormous importance of the recreation and tourism industry in the watershed. Millions of tourists and day trippers come to the watershed annually, spending millions of dollars that stimulate the local economy. These tourists and their spending generate nearly 80,500 jobs that pay nearly $2.9 billion in wages in a single year. It is important to highlight that the tourism industry includes figures that may overlap with other sections in this report given that the major category in the tourism industry is "recreation and entertainment."[vii] This "recreation and entertainment" may include spending from categories such as recreational fishing, wildlife viewing, recreational boating, hunting, and beach use, all of which are sections in this report. As a result, these total tourism figures overlap with these other sectors. Please see these sections for further information and breakdown of data for their related industries.

Arts and Culture in the NBW

As detailed above, one consumer-side approach to measuring the impact of tourism in the watershed entails examining the Arts, Entertainment, and Recreation industry. Included in this industry are arts and culture, both of which are integral elements of the watershed's history and major contributors to the tourism sector. There are numerous galleries, events, artists, theaters, and organizations dedicated

[vii] The industry impact is broken down into: 1) agriculture, fishing, mining 2) construction and utilities 3) manufacturing 4) wholesale trade 5) air transport 6) other transport 7) retail trade 8) gasoline stations 9) communications 10) finance, insurance, and real estate 11) business services 12) education and health care 13) recreation and entertainment 14) lodging 15) food and beverage 16) personal services 17) government

to art and culture in both RI and MA, drawing in residents and tourists alike to the watershed. There are numerous benefits related to art and culture – some of which are not quantifiable or cannot be measured through their market value; this report focuses on the market value that can be measured. Recently, the Bureau of Economic Analysis (BEA) launched a new effort to capture economic data on the estimated overall impact of the "Arts and Culture Industries" at the state-wide level and data from these estimates are provided below for both RI and MA. As evidenced by the BEA data and examples below, it is clear that the arts and culture industries have immense economic and social contributions to the watershed.

According to the BEA, there were 17,902 individuals employed in the "Arts and Cultural Industries" in RI in 2015, 3.3% of the state's total employment. Additionally, there were wages of $1 billion, 3.4% of the total wages of the state. Of this number, slightly over 4,000 worked in the "core" art and cultural industries with a majority in educational services, performing arts companies, advertising, architectural services, and photography and photofinishing services. The total value added to the state's economy was nearly $1.9 billion (2016 dollars), ranking RI 42nd in the country for value added.[30] Using the proportional scaling methodology discussed in the above sections, this translates to 15,900 employees in the NBW portion of RI with $904 million in compensation. Additionally, in MA, there were 131,169 individuals employed in the "Arts and Cultural Industries" in 2015, 3.6% of total employment in the state. There was nearly $11.5 billion (2016 dollars) in compensation. In the "core" industries, there were over 37,000 employees with a majority in advertising, architectural services, education services, performing art companies, and promoters of performing arts and similar events. The total value added to the state's economy was approximately $21.3 billion (2016 dollars), ranking MA 9th in the country for value added.[31] This translates to approximately 19,400 individuals employed in the sector and $1.7 billion in wages in the NBW portion of MA.

Aside from these aggregate figures, there are numerous examples of events and organizations that illustrate the importance of art and culture in the watershed. One example is the music festivals of Newport, perhaps the most famous musical events in the state. A 2012 study of the Jazz and Folk Festivals estimated that there was over $5.3 million (2016 dollars) in direct spending related to the festivals, mostly comprised of spending on lodging and food and beverages, although it also includes expenditure relating to shopping, entertainment, and other expenses. Additionally, the report found that although nearly 90% of attendees traveled to Newport solely with the purpose of visiting the festival, half of these visitors traveled to additional destinations during their stay (21% visited other spots in Newport, 17% visited the Newport mansions, and 17% visited Providence and Warwick); this indicates that, in addition to festival-related spending, these visitors and tourists extended their expenditure to surrounding communities through activities such as dining and accommodations.[32] Another example of a vital cultural and artistic event is WaterFire in Providence, RI, which draws in residents and tourists alike to the attraction. Approximately one million individuals visit the event each year, and the WaterFire organization estimates that the event generates $114 million in economic output, $9 million in taxes, and supports nearly 1,300 jobs annually.[33]

The watershed also provides a culturally rich and diverse art scene, some of which is inspired directly by scenery of the Bay—Downtown Providence, for example, offers free monthly Gallery Nights, highlighting over 15 popular art venues and inviting visitors to explore the city's diverse communities.[34] Save The Bay has also used annual art auction nights to raise both awareness and funding for their ongoing conservation projects. Although the organization does not restrict submissions to these auctions solely to works that involve the Narragansett Bay, many pieces are often related to the natural features and resources of the area by default.[35] Some special exhibitions, however, such as the "Pathways 2017" gallery exhibit displayed at The Gilbert Stuart Museum in North Kingstown, RI, have focused specifically on the Narragansett Bay and artists who have utilized its scenic views and attractions as inspiration in their works. In the first half of the showcase spanning from mid to late summer, the museum's Rhode Island Masters series displayed oil and watercolor paintings of South County land and seascapes from 1865 through to the year following devastation caused by New England's infamous Hurricane of 1938. These pieces have enduring value not only as works of art, but they also serve as evidence chronicling the state's coastal history and heritage, as the paintings capture the picturesque views that both captivated the artists at the time of their creation and that continue to resonate today with both RI residents and tourists. The autumn portion of the gallery series featured current local art inspired by Rhode Island coastlines, providing space for emerging artists to display their work. According to museum records, about 3,500 of the 4,500 (~78%) total annual visits to the museum coincided with the "Pathways 2017" exhibition, with approximately 2,900 attendees during the first portion that included the Rhode Island Masters paintings.[36] [37]

Overall, the arts and culture sector, in addition to providing immeasurable and immense value to the watershed's heritage, brings in millions in revenue and employs thousands each year. Aside from their economic and historical importance, local arts and culture can also provide an invaluable service—they can facilitate public interest and potential funding for environmental protection, and they may indirectly contribute to maintaining the watershed's aesthetic resources' value for the region's economy over time.

Future Threats and Opportunities

Sea level | Water clarity | Marine beaches | Water quality for recreation

Tourism across the NBW will be sensitive to environmental changes in coming years, ranging from impacts of sea level rise to changes in water quality. Structurally speaking, a number of tourist destinations, such as hotels, landmarks, and beaches could potentially disappear with a rise in sea level. A 9.8-foot rise by 2100 is predicted for the Northeast coastal region. To put this into perspective, just a seven-foot rise in sea level, 3,918 buildings will be lost in the NBW.[38] Given that a number of tourist destinations in the NBW are located along the coast, such as the Newport Mansions, these destinations or their supporting infrastructures (such as hotels and restaurants) could be flooded or submerged when the sea level rises. Additionally, lighthouses, which serve as a tourism staple in the

NBW, are especially sensitive to rises in sea level. Several lighthouses along the coast have already needed to be relocated due to coastal erosion.[39]

Furthermore, the aesthetic value of waterbodies in the NBW is threatened by decreases in water quality. In the past, the Narragansett Bay has been characterized by its relatively clear water, but due to a number of anthropogenic factors, such as urbanization, this water clarity has been declining. Since the 1970s, major steps have been made in improving water clarity, but this is under threat due to increasing population and urbanization in the NBW. Given that water clarity is a human measure of water quality, if clarity declines, then individuals may perceive the water as being dirtier or less desirable for recreational activities.[40] Additionally, in the NBW, 85% of estuarine waters and 20% of freshwater rivers/streams were deemed acceptable for recreational use, such as boating and swimming. This approval is threatened by factors that are placing increasing stress the fecal pathogen load in waterbodies, including storm and wastewater runoff, sewer overflows, increasing impervious cover, and poor wastewater treatment systems, many of which occur due to increasing population and poor management.[41] For more specific information on recreational activity as it relates to marine beaches, please see the "Beaches" section.

Overall, sea level rise threatens a number of historical and cultural tourist sites in the NBW. Increasing stress placed on water quality threatens water-based tourism, such as boating, beach visitation, or fishing. There is the opportunity to manage these threats, such as preventing nutrient loads and runoff into waterbodies, which may help maintain these waterbodies for recreational and tourism purposes. Taking such actions will be imperative for ensuring the future the tourism sector and its important contribution to the economy of the NBW.

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NARRAGANSETT BAY WATERSHED ECONOMY

The ebb and flow of natural capital

Wildlife Viewing Overview

Wildlife viewing is an activity enjoyed by residents and visitors alike in the Narragansett Bay watershed (NBW). This recreational activity includes observing, photographing, and feeding wildlife in parks, nature preserves, wetlands, and other locations where wildlife is present. Wildlife viewing takes place both around the home and away from home, and many different types of wildlife are the focus of recreational wildlife viewing. Water fowl, birds of prey, and songbirds are the most popular animals to be observed, photographed, or fed, while land mammals, fish, insects, spiders, and reptiles are also popular (Figure 1).[1]

Recreational wildlife viewing has increased in popularity within Rhode Island (RI) and Massachusetts (MA) since 2001. More than 172,000 wildlife viewers within the NBW spent over two million days and $400 million (in 2016 dollars) on wildlife viewing related expenditures such as food, lodging, transportation, and equipment.[2] This activity has potential for future growth as it is an important part of ecotourism, a growing sector worldwide.[3] This is especially the case as the baby boomer generation grows older and has more free time to spend pursuing recreational activities, as wildlife viewing and birdwatching are popular outdoor activities for this demographic.[4]

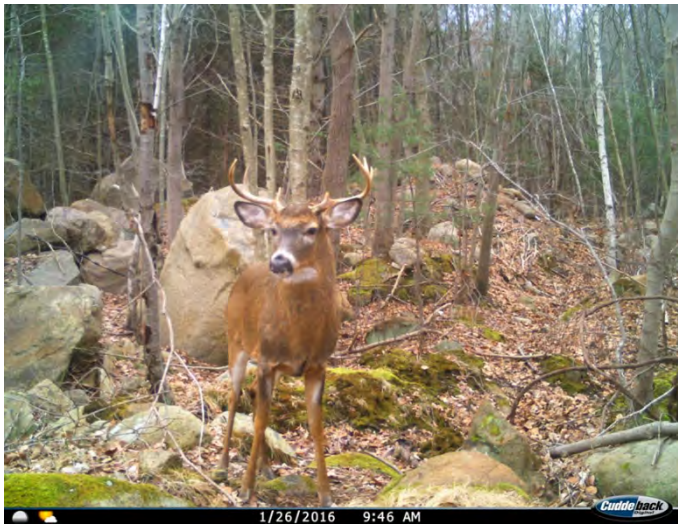

Figure 1: Deer Caught on Wildlife Camera, East Greenwich, RI
Source: Dawn and Joseph Giroux

History

Wildlife watching is a revered recreational activity, and public concern for protecting the wildlife we delight in has existed for over a century. In 1903, President Theodore Roosevelt established the first National Wildlife Refuge. This set in motion a promise to preserve America's wildlife heritage for future generations to enjoy. Individuals in the NBW were taking initiative even before this movement, forming the Audubon Society of RI in 1897 to protect birds, other wildlife, and their habitats. Less than two decades later, the first MA Audubon wildlife sanctuary opened in 1916 for bird protection.[5]

Since Roosevelt's time, many organizations have been formed that act in the name of wildlife protection. These organizations aim to preserve the wildlife that we appreciate viewing. For example, the National Wildlife Refuge System has grown to include more than 94 million acres on over 540 refuges throughout the U.S., the Mass Audubon protects over 36,000 acres, and the Audubon Society of RI maintains and manages over 9,000 acres.[6]

Data Sources and Limitations

Estimates of participation rates and expenditures plus the economic impact of wildlife viewing within the NBW are presented here. These data are derived from the U.S. Fish and Wildlife Service (USFWS) 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.[i] This report only focuses on wildlife viewing that occurs within RI and MA state borders, disregarding out-of-state wildlife viewing carried out by RI and MA residents. Data for RI were also obtained from a 2017 report by Tom Sproul, *The Economic Impact of Rhode Island State Parks.*

To estimate the recreational wildlife viewing activity within the NBW using published data at the state level, state figures were adjusted by the share of the state's population in the watershed in 2010. This equates to 88.8% of the state population in RI and 15% in MA (for maps of the area and population of the NBW, please reference the "Geography" section). This approach assumes that participation rates for wildlife viewing are the same in both watershed and non-watershed areas. For example, the USFWS estimate of 282,000 wildlife viewers in RI translates into nearly 73,000 wildlife viewers in the RI portion of the watershed.

For additional information on the methodologies used in this report, please reference the "Methodology" section.

Current Status and Trends

Today, wildlife viewing is a popular recreational activity in the NBW for a wide variety of individuals. Based on previously stated assumptions, in 2011 there were over 172,000 individuals who viewed wildlife away-from-home in the watershed (Table 1). These individuals took over one

[i] The USFWS survey focuses on those at least 16 years old.

million trips at least one mile from home for the primary purpose of observing, photographing, or feeding wildlife. They also spent almost nearly three million days viewing wildlife.[7]

Table 1: Estimated Away-from-Home Wildlife Viewing Participation in the NBW (2011)

	Number of Wildlife Viewers (1000s)	Number of Trips (1000s)	Number of Viewing Days (1000s)	Average Number of Viewing Days
RI	72.8	807	1,093	15
MA	99.3	677	1,582	16
Watershed	172.1	1,484	2,675	15.5

Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013
Note: Scaled by ratio of state population in the watershed: RI = 88.8%, MA = 15%

According to the survey, more than half of the wildlife viewers are tourists from out of state, bringing in economic value to the region through associated tourism spending (Table 2). Within the watershed, there are over 82,000 individuals in RI and MA who view wildlife away from home in their own state. These individuals take over one million trips and spend nearly two million days every year viewing wildlife. The residents who engage in wildlife viewing away from home represent 48% of all away-from-home wildlife viewers in the watershed, with the remaining 52% being out-of-state tourists.[ii]

Table 2: Estimated Residential Away-from-Home Wildlife Viewing Participation in the NBW (2011)

	Number of Wildlife Viewers (1000s)	Number of Trips (1000s)	Number of Viewing Days (1000s)	Average Number of Viewing Days
RI	31.1	592	724	23
MA	51.3	525	1,170	23
Watershed	82.4	1,117	1,894	23

Note: Scaled by ratio of state population in the watershed: RI = 88.8%, MA = 15%
Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

Although a substantial number, away-from-home wildlife viewing is a small component of the total wildlife viewing activities; much of the wildlife viewing is done within one mile of residents' homes (Table 3). In 2011 in the NBW, there were nearly six times the amount of residential around-the-home wildlife viewers than there were residential away-from-home wildlife viewers, with 82,400 away-from-home compared to 454,400 around-the-home. When comparing total NBW wildlife viewing participation—residents and tourists—around-the-home is still over twice as popular as away-from-home. In 2011, there were 172,100 away-from-home wildlife viewers in the NBW compared to 454,400 around-the-home wildlife viewers. Despite the large magnitude of around-the-

[ii] We do not know the number of non-residents who are RI or MA residents viewing wildlife across state lines, but still within the watershed.

home wildlife viewers, this report focuses on away-from-home wildlife viewers. This is because away-from-home viewers take trips for the specific purpose of viewing wildlife.

Table 3: Estimated Total Wildlife Viewing Participation in the NBW (2011)

	Number of Wildlife Viewers, Around-the-Home (1000s)	Number of Wildlife Viewers, Away-from-Home (1000s)
RI	230.9	72.8
MA	223.5	99.3
Watershed	454.4	172.1

Note: Scaled by ratio of state population in the watershed: RI = 88.8%, MA = 15%
Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

Data are also available that allow one to identify characteristics of those that are viewing wildlife recreationally (Table 4). The majority are from urban areas, are female, between the ages of 45 and 64, and are white. Many wildlife watchers are also earning well above average incomes, which is partly a reflection of higher than average education levels.[8]

Table 4: Characteristics of Residential Away-from-Home Wildlife Viewers in RI and MA (2011)

	RI	MA
From urban area	89%	86%
Females	55%	57%
Between ages 45-64	53%	54%
White	91%	96%
4 years or more of college	61%	66%
Annual income above $100,000	33%*	42%*
Average number of days of activity per year	23	23

*Based on a sample size of 10–29
Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

Wildlife viewing also contributes to the economy, although the impact is not as large as that of recreational fishing and hunting. Many participants contribute to the NBW economy by purchasing equipment to view, photograph, or feed wildlife, or traveling far enough to areas where lodging and food become necessary.

Furthermore, a study done by Tom Sproul for the University of Rhode Island found that in 2016 there were nearly 9.5 million visitors to Rhode Island state parks, beaches, bikeways, and campgrounds, many of which fall within the boundaries of the NBW. While all of these areas are potential wildlife viewing destinations, it is difficult to estimate the portion of economic output solely related to wildlife viewing with this data; rather, these figures provide an overview of the economic importance of wildlife viewing venues in the NBW. In 2016, out of the 9.5 million visitors, state parks had the highest number of visitors (6.8 million), followed by bikeways (1.4 million), beaches (1.2 million),

and then campgrounds (77,000). These visitors generated $38.8 million in state and local revenue and had a $312 million economic impact, which in turn supported over 3,700 jobs. A majority of spending was from bars and restaurants ($89.1 million), gas stations ($75.9 million), hotels and motels ($49.5 million), and grocery stores ($46.7 million). On average, out-of-state visitors spent considerably more per visit at $95 compared to in-state visitors, who spent almost $16. Although not all of this economic output or visitation can be attributed to wildlife viewing, it is likely an activity that many visitors partake in when they visit these venues.[9]

Overall, wildlife viewing is a recreational activity that brings immense economic value to the NBW. In total in 2011, more than 172,000 wildlife viewers spent over $397 million (2016 dollars) within the NBW on related expenditures (e.g., food, lodging, transportation, and equipment), helping boost the economy of the states within the watershed (Table 5). These expenditures included over $121 million (2016 dollars) of trip related expenses and $276 million (2016 dollars) spent on equipment. It is important to note that these expenditures can include both long- and short-term expenses—for example, long-term expenses would be purchasing equipment (a purchase that is made and then will last for an extended period of time), whereas short-term expenses would include activities like purchasing food and accommodations (these purchases are repeatedly/continually made over time).

Table 5: Estimated Expenditures of Wildlife Viewers in the NBW (2011) (in 2016 dollars)

	Expenditures ($1000s)	Trip Related Expenses ($1000s)	Equipment/Other Spending ($1000s)	Average per Participant
RI	$191,521	$75,393	$116,128	$440
MA	$206,215	$46,167	$160,048	$733
Watershed	$397,736	$121,560	$276,176	$592

Note: Scaled by ratio of state population in the watershed: RI = 88.8%, MA = 15%
Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

Future Threats and Opportunities

Land use | Open space | Salt Marshes | Temperature

The future of wildlife viewing relies on the preservation of open space, forests, salt marshes, and other natural habitats in the NBW. These environments are under threat from anthropogenic and natural stressors such as population growth, human developments, and climate change. Forests provide an especially important habitat for a number of wildlife viewing species, such as bird species and land mammals. Historically, population growth and increasing human settlements within in the NBW have been major drivers of deforestation—from 2001 to 2011, forest coverage in the area decreased by 4.3%, decreasing the amount of habitat for wildlife and wildlife viewing.[10] Forests are also under pressure from changes in temperature and precipitation patterns related to climate change. The National Oceanic and Atmospheric Administration (NOAA) expects the temperature in the

Northeast to rise by an average of 7° F by 2100.[11] Such a change could alter the flora and fauna in the NBW, posing both a threat for current species in the area as well as an opportunity for new species to migrate into the area due to new warmer temperatures (for more information on the impacts of climate change on forest, please see the "Forestry" section). However, efforts must be taken to maintain and conserve these lands. Mass Audubon estimates that between the years of 2005 to 2013, 13 acres of land were developed every day, leading to the loss of 38,000 acres of forest.[12]

Furthermore, an opportunity to preserve wildlife is increased protection for open space land. Like forests, open space land is vulnerable to human threat. Seventeen percent of open space lands in the NBW are not protected, leaving them open to development. Actions from state and private organizations, however, have proven successful in efforts to conserve open space. Mass EOEAA estimates that in MA alone, these organizations successfully championed the protection of almost 110,000 acres of conserved land between 1999-2005.[13]

Additionally, species distribution and boundaries may shift as air and water temperatures increase. For example, the habitat boundaries of colder water species, such as the harp seal, may move further north and the species may no longer inhabit the waters of the NBW. On the other hand, increasing water temperatures make the NBW increasingly hospitable to warmer water species, such as the manatee, providing a new opportunity for wildlife watching of previously unavailable species.[14] Habitat changes on land may also occur for species such as the leatherback turtle and the piping plover, who use coastal areas for nesting grounds, which will be susceptible to immersion under sea level rise.

Furthermore, salt marshes (another critical habitat for wildlife), such as Allin's Cove and the Galilee Salt Marsh, are under increasing stress from climate change. Sea level rise and increasing water temperatures threaten the health and future of salt marshes. It is estimated that 13-87% of salt marshes will be lost with just a one to five-foot rise in sea level, well below the 9.8-foot estimate from NOAA by the year 2100.[15] [16] Overall, proper actions to mitigate and address these changes are imperative to protect both wildlife and the economic impact of wildlife viewing in the NBW in the future.

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[1] Source: USFWS, 2013.
[2] Source: USFWS, 2013.
[3] Source: Wight, 1996.
[4] Source: Wilson, 2015.
[5] Sources: Audubon Society of RI, n.d.; Mass Audubon, n.d.; USFWS, 2006.
[6] Sources: Audubon Society of RI, n.d.; Mass Audubon, n.d.; USFWS, 2006.
[7] Source: USFWS, 2013.
[8] Sources: Audubon Society of RI, n.d.; Mass Audubon, n.d.; USFWS, 2006.
[9] Source: Sproul, 2017.
[10] Source: NBEP "Land Use," 2017.
[11] Source: NBEP "Temperature," 2017.
[12] Source: MassAudubon "Losing Ground," 2014.
[13] Source: NBEP "Open Space," 2017.
[14] Source: Heffener, et al., 2012.
[15] Source: NBEP "Salt Marshes," 2017.
[16] Source: NBEP "Sea Level," 2017.

Appendix

Table A1: Away-from-Home Wildlife Viewing Participation in MA & RI (2011)

	Number of Wildlife Viewers (1000s)	Number of Trips (1000s)	Number of Viewing Days (1000s)	Average Number of Viewing Days
RI	82	909	1,231	15
MA	662	4,514	10,546	16
Total	744	5,423	11,777	

Source: 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 2013

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