

SHELLFISHING AREAS

Draft – April 2017

1. OVERVIEW

Shellfishing for oysters and quahogs in Narragansett Bay is an important economic and recreational activity, and it is highly dependent on favorable water quality. Rapid population growth, especially in Providence and Fall River, during industrialization in the late nineteenth and twentieth centuries brought water pollution that led to areas being closed to shellfishing to protect human health from the consumption of polluted shellfish. Combined sewer overflows funneled untreated wastewater from those urban cores to the Bay during heavy rainfall events, a problem that has recently been reduced with significant investments in infrastructure. Today, some key stressors that result in prohibited areas for shellfishing include urban stormwater runoff and pathogen loading from failing wastewater treatment systems in proximity to the Bay.

We used the number of acres open to shellfish harvesting as a proxy to indicate improvements or declines in water quality for public health over the last two decades. Shellfishing areas are classified as approved, conditionally approved, or prohibited. Conditionally approved areas are authorized based upon water quality testing and bacterial criteria for fecal coliform. In 2015, a total of 76 percent of the Bay was open for shellfishing—63 percent fully approved and 13 percent conditionally approved. Areas where shellfishing was prohibited accounted for 24 percent of the Bay. In the Upper Estuary, acreage of conditionally approved areas began increasing in 2000, and prohibited acreage declined at the same rate, suggesting water quality improvements. The most marked change occurred in the period from 2010 to 2015, when more than 1,000 acres in the Upper Estuary were upgraded from prohibited to conditionally approved.

2. INTRODUCTION

State agencies in Massachusetts and Rhode Island administer shellfish management programs that assess water quality conditions and regulate shellfish harvesting for commercial and recreational purposes throughout Narragansett Bay. Both states classify shellfishing areas based on water quality levels of fecal coliform bacteria, harmful algal blooms, and other management factors. These classifications are designed to protect public health and ensure the safe consumption of shellfish. Approved waters are areas where harvesting is allowed on a regular basis, conditionally approved waters allow shellfish harvest on an intermittent basis, and in prohibited waters shellfish harvest for human consumption is not allowed at any time (CRC 2014).

The importance of water quality for shellfishing in the Narragansett Bay was recognized over a century ago, when water pollution was a primary cause of the collapse of a vibrant oyster industry. At its height in the early 1900s, the local oyster industry employed over a thousand people and had an annual harvest of 1.4 million bushels (Schuman 2015). Total acreage leased to private growers peaked in 1912 at 20,846 acres, which represented 17 percent of the estuarine waters of Narragansett Bay. Oyster landings in Rhode Island collapsed by the 1950s (Oviatt et al. 2003).

In 1910, an investigation into contamination in oyster beds found traces of sewage and fecal coliform bacteria in many upper Bay oyster beds, primarily driven by the 400 percent increase in human population in coastal areas from 1850 to 1900 (Vadeboncoeur et al. 2010). As a result of a nationwide typhoid epidemic, caused in part by the consumption of polluted shellfish, the National Shellfish

Sanitation Program was established in 1925. This national program created standards for shellfish intended for consumption and required states to sample all shellfish waters and to close areas that did not meet standards. In 1926, Massachusetts closed the waters of the Taunton River and the northern portion of Mount Hope Bay. Between 1937 and 1985, thousands of bushels of quahogs and oysters were relayed or transported from the Taunton River to various towns in Rhode Island and Massachusetts for depuration or cleansing before harvest for human consumption.

Shea (1946) outlined Rhode Island's early water classifications for shellfish areas. Waters suitable for the cultivation of market shellfish were primarily in the West and East Passage, Sakonnet River, lower Mount Hope Bay, Palmer River, Barrington River, Kickemuit River and parts of Bristol Harbor and Greenwich Bay. Areas that were suitable for culture of seed oysters were identified in Mount Hope Bay and the lower Providence River. And waters in the upper Providence River, north of Field's Point, were defined as grossly polluted and causing nuisance.

In Narragansett Bay, Massachusetts regulates the portions of Mount Hope Bay and the Palmer River that lie within its state boundary ([MADMF 2013](#)). The Massachusetts Department of Fish and Game's Division of Marine Fisheries (MADMF) and the Massachusetts Department of Environmental Protection (MassDEP) have responsibility for shellfish management. In Rhode Island, the Office of Water Resources in the Department of Environmental Management (RIDEM) determines shellfish harvest restrictions for the remaining and largest percentage (95 percent) of the waters in Narragansett Bay ([RIDEM 2015](#)). All approved and conditionally approved areas are sampled for fecal coliform and harmful algal blooms 6 to 12 times per year. There are more than 110 fixed stations in the approved growing areas, with nearly 2,000 samples collected annually by the two states.

Estuarine waters for shellfish harvesting are designated by the states pursuant to the Federal Clean Water Act. Class SA waters are designated for shellfishing for direct human consumption; they may be approved or conditionally approved. Class SB waters are suitable for shellfish harvest with depuration, meaning the shellfish must be kept in tanks of clean seawater to expel contaminants before being sold for consumption (RIDEM 2014, [MassDEP 2012](#)). The maximum level of fecal coliform bacteria allowed in Class SA waters is a geometric mean of 14 organisms per 100 mL, and the maximum for Class SB waters is 88 organisms per 100 mL (MassDEP 2012). Shellfish classifications are also based on sanitary surveys and shoreline surveys conducted by the state shellfish programs.

This report focuses on the areas of Narragansett Bay that are classified as approved, conditionally approved, and prohibited. It examines the present status of shellfishing areas and identifies trends from 1995 to 2015.

3. METHODS

The Narragansett Bay Estuary Program coordinated bi-state meetings with representatives from the Massachusetts Division of Marine Fisheries and the Rhode Island Department of Environmental Management to examine various approaches for using shellfishing areas as an indicator of public health and water quality. Through these discussions, it was determined that shellfish growing areas (area and percent change) can be measured consistently between the two states to track changes of improvements or declines in water quality in the Bay, as the state data are consistent in purpose and the classification systems are comparable. For this analysis, the Estuary Program defined three shellfish classification categories derived from the Massachusetts and Rhode Island shellfish growing areas classification systems:

- **Approved:** growing areas where shellfish harvesting is allowed for direct human consumption all year round (some exceptions may apply)
- **Conditionally Approved:** growing areas where shellfish harvesting is allowed for direct human consumption with some restrictions depending on each state's shellfish program criteria
- **Prohibited:** waters where shellfish harvesting is not allowed for direct human consumption;

The prohibited category includes small portions of the Bay in Rhode Island that are classified as unassessed or are prohibited for other reasons not related to water quality; in addition, it includes shellfish waters in Southwest Coastal Ponds that are closed for the purpose of habitat conservation. In Massachusetts and Rhode Island, shellfish growing areas used for shellfish transplanting are considered prohibited for this indicator as the harvest of shellfishing is not suitable for direct human consumption.

Data on Massachusetts shellfishing areas covered the period from 2005 through 2015, and the Rhode Island data covered 1995 through 2015. Following direction from the Massachusetts Division of Marine Fisheries, the Estuary Program updated the most current Massachusetts shellfishing growing areas to reflect annual changes and status in Mount Hope Bay, which had closed to shellfishing from the 1980s to 2009. Because only slight changes occurred from one year to the next, we analyzed the data for five-year intervals to identify changes in acreage of shellfish growing areas. We conducted analyses for the entire Narragansett Bay and for five regions within the Bay: the Upper Estuary including Mount Hope Bay; West Passage; East Passage; Sakonnet River; and the Mouth of the Bay.

We measured:

- total area (acres) and the percentage of the area classified as approved, conditionally approved, and prohibited for each 5-year interval from 1995 to 2015 in Narragansett Bay and within each Bay region,
- total change in area for each 5-year interval between 1995 and 2015 by category in Narragansett Bay and within each Bay region, and
- percentage change in area for each 5-year interval between 1995 and 2015 by category in Narragansett Bay and within each Bay region.

Data from Rhode Island and Massachusetts were reconciled to obtain a seamless shellfish growing area dataset at different time steps. Data provided as paper and digital maps were converted into GIS using heads-up digitizing and geo-referencing to a common coordinate system. In additions, an array of geospatial tools were used to compute the intersection between seamless Shellfish Growing Areas for each time step and the Bay regions which cross-tabulates the area and percent of each shellfish growing category by Bay region.

It is important to note that while every effort was made to ensure accuracy in digitizing paper and digital maps, the data are imperfect and it is estimated that any changes of one percent or less between years were likely attributable to digitization error and therefore they were not interpreted as actual changes. Other limitations and sources of error for the analysis are derived from the data sources. One the most significant inherent errors from the secondary sources is the inconsistency of coastlines boundaries from year to year. The Estuary Program did not attempt to reconcile the unmatched coastline boundaries across years of the state data.

4. STATUS AND TRENDS

Status

In 2015, approximately 63 percent of the Bay’s waters were classified as approved shellfish growing areas, and 13 percent were conditionally approved. In 24 percent of the Bay, shellfish harvesting for direct human consumption was prohibited (Table 1; Figure 1).

Table 1. Area (acres) and percentage of shellfish growing areas in Narragansett Bay by category in 2015.

Shellfish Growing Areas	Total Acreage	Percent of Narragansett Bay
Approved	79,253	63
Conditionally Approved	16,297	13
Prohibited	30,542	24
<i>Narragansett Bay</i>	<i>126,092</i>	

It should be noted that 35 percent of the approved area of Narragansett Bay was located in deeper waters, south of Aquidneck Island and north of the line between Point Judith and Sakonnet Point, where little shellfishing occurs.

Of the five Bay regions, the Upper Estuary had by far the lowest percentage (6 percent) and acreage (2,249 acres) of approved shellfish growing area (Table 2; Figure 1). The other regions had 68 to 95 percent of their area classified as approved. Conditionally approved areas accounted for 44 percent of the Upper Estuary in contrast to the other regions, which had 1 percent or less of their area classified as conditionally approved. Half of the Upper Estuary and 31 percent of the East Passage were classified as prohibited (Table 2; Figure 1).

Table 2. Area (acres) and percentage of shellfish growing areas by category in Bay regions in 2015.

Bay Region	Acreage¹	Approved		Conditionally Approved		Prohibited	
		Acreage	Percent	Acreage	Percent	Acreage	Percent
Upper Estuary	35,803	2,249	6	15,755	44	17,799	50
West Passage	25,364	22,760	90	387	1	2,217	9
East Passage	20,519	14,029	68	105	0.5	6,385	31
Sakonnet River	13,090	12,429	95	0	0	661	5
Mouth of the Bay	31,052	27,784	90	0	0	3,268	10

¹ Due to inconsistencies between data sources, the total of the regional acreages listed here does not equal the total Bay acreage in Table 1 (0.2 percent error).

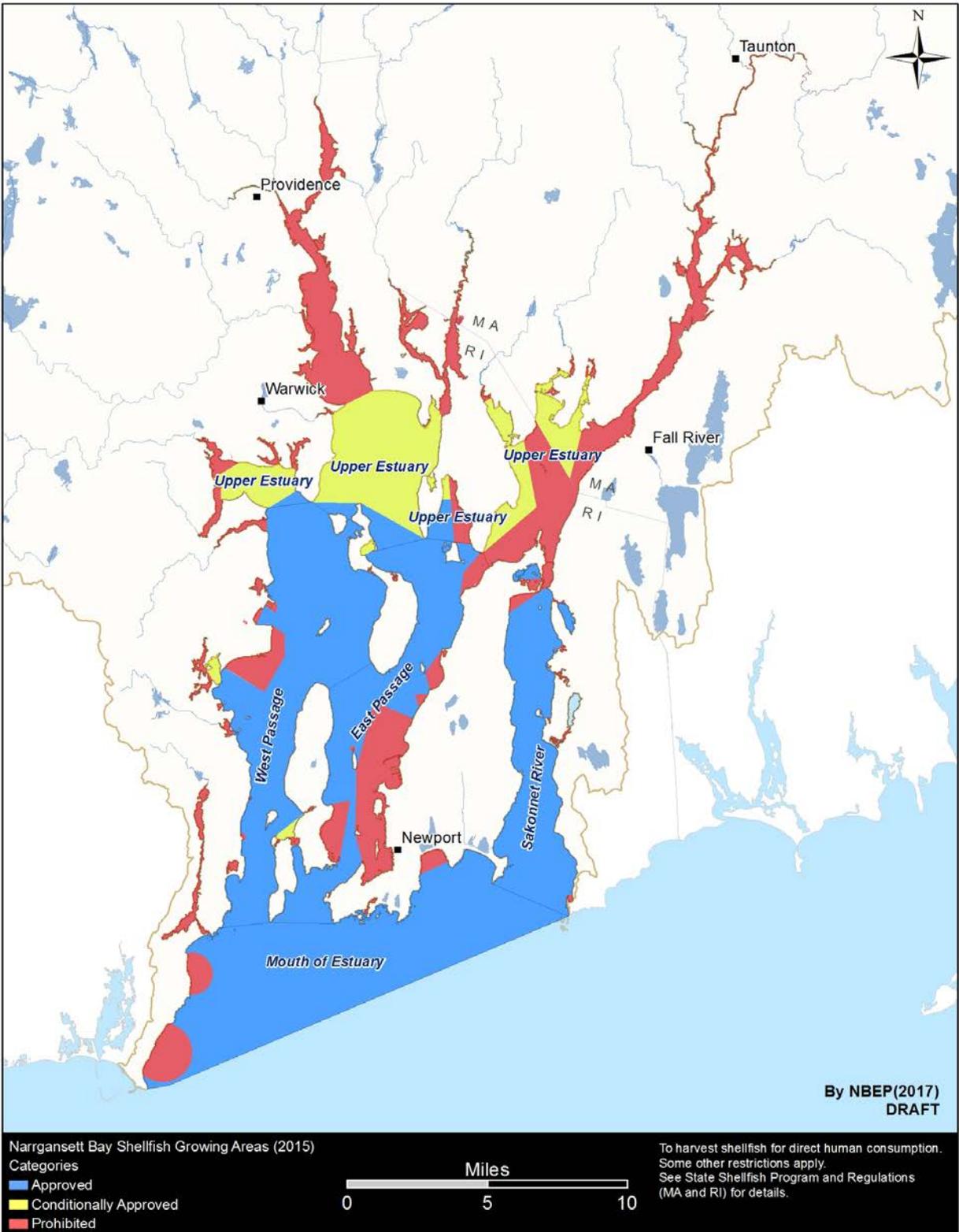


Figure 1. Shellfish growing areas in Narragansett Bay by category in 2015.

Trends

We calculated the acreages and percentages of the three categories of shellfishing growing areas in Narragansett Bay at five-year intervals between 1995 and 2015 (Table 3). The percentage of the Bay classified as approved and conditionally approved appears to have slightly changed when calculating acreage and percent change across the Bay. However, more apparent changes are shown in the Bay regions (Table 4).

Table 3. Area (acres) and percentage of shellfish growing areas by category in Narragansett Bay at 5-year intervals from 1995 to 2015.

Category	Approved		Conditionally Approved		Prohibited	
	Acreage	Percent	Acreage	Percent	Acreage	Percent
1995	82,386	66	14,807	12	27,903	22
2000	80,856	65	14,322	11	29,938	24
2005	79,753	63	14,612	12	31,667	25
2010	79,180	63	15,175	12	31,578	25
2015	79,253	63	16,297	13	30,542	24

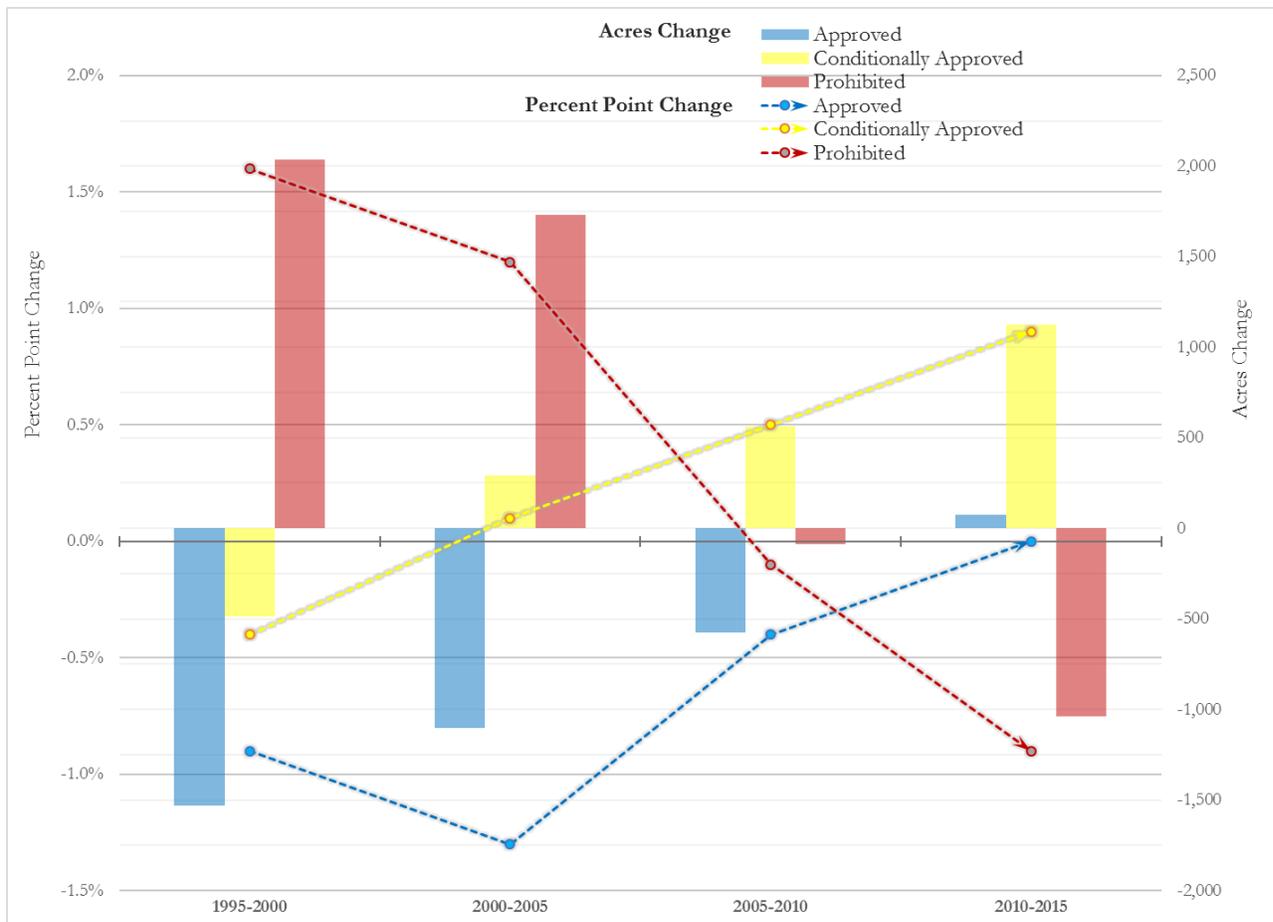


Figure 2. Changes in shellfish growing areas by category in Narragansett Bay at 5-year intervals. Bars represent change in acres. Dotted lines/points are percent change.

We also calculated the amount of change in area by category for the five Bay regions at five-year intervals from 1995 to 2015 (Table 4). Results for the entire Narragansett Bay are summarized in Figure 2. Of note, the Upper Estuary had an increase of approximately 1,100 acres in conditionally approved areas from 2010 to 2015, while prohibited areas decreased by approximately the same amount (Table 4; Figure 3).

Table 4. Changes in shellfish growing areas by category in Narragansett Bay regions at 5-year intervals.

<i>Bay Regions</i>	<i>Area (acres) Change by Category of Shellfish Growing Area</i>			
	<i>5-year Interval</i>	<i>Approved</i>	<i>Conditionally Approved</i>	<i>Prohibited</i>
<i>Upper Estuary</i>				
	1995–2000	0.0	-488	518
	2000–2005	32	264	281
	2005–2010	-2	623	-650
	2010–2015	24	1099	-1095
<i>West Passage</i>				
	1995–2000	0.0	2	0
	2000–2005	-238	23	322
	2005–2010	-238.	-61	429
	2010–2015	-116	-2	-16
<i>East Passage</i>				
	1995–2000	-1530	0	1517
	2000–2005	162	9	-53
	2005–2010	-0.3	0	0
	2010–2015	162	0	-164
<i>Sakonnet River</i>				
	1995–2000	0.0	0	0
	2000–2005	0.0	-5	47
	2005–2010	-301	0	99
	2010–2015	-3	-25	27
<i>Mouth of the Bay</i>				
	1995–2000	0.0	0	0
	2000–2005	-1058.7	0	1132
	2005–2010	-32.3	0	32
	2010–2015	3.2	0	0

5. DISCUSSION

The most notable changes in shellfishing areas in Narragansett Bay occurred in the Upper Estuary over the last decade. Acreage of conditionally approved growing areas began to increase in 2000 and continued this trend through 2015, while prohibited areas declined at the same rate from 2005 through 2015 (Table 4; Figure 3). These changes in the Upper Estuary suggest an improvement in water quality conditions. Ninety-seven percent of the 16,297 acres of conditionally approved areas in the entire Narragansett Bay occurred in the Upper Estuary (Table 2).

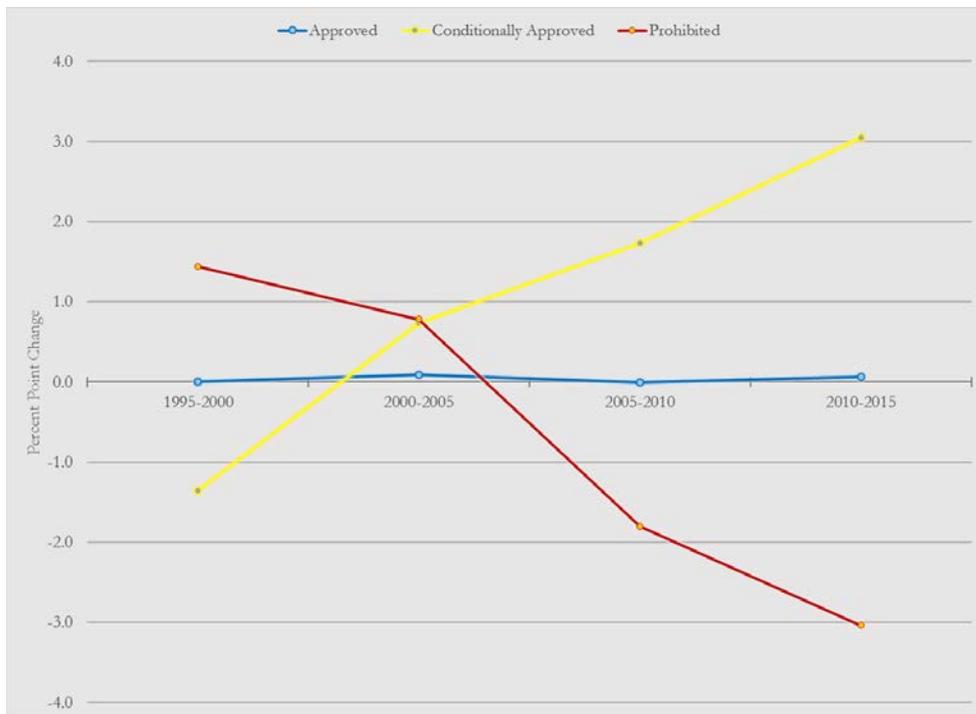


Figure 3. Percent change of acreage in the Upper Estuary of Narragansett Bay.

While the shift from prohibited areas to conditional areas indicated improvement, the Upper Estuary still had a very limited area—only 6 percent—that was fully approved without conditions (Table 2). The Upper Estuary’s approved areas were primarily limited to waters at the northern portions of Prudence Island (Figure 1). Of the 30,542 acres that were prohibited in Narragansett Bay, almost 60 percent (17,799 acres) were in the Upper Estuary, where water quality impairments were likely due to loadings from Providence, Fall River, and surrounding urban areas (Figure 1). It is important to note that prohibited areas include waters with a restricted classification by MADMF, at the mouth of the Taunton River. An upgrade from prohibited to restricted classification indicates water quality improvements (MADMF 2013), but still is in the classification of not suitable for harvesting shellfish for human consumption. Shellfish in these areas may be allowed for removal to grow out in approved areas.

Improvements in water quality in the Upper Estuary, including the Providence River estuary and Mount Hope Bay, are most likely due to upgrades in the wastewater treatment plant facilities. Tunnels installed by the Narragansett Bay Commission and the City of Fall River have significantly reduced combined sewer overflows. In recent years, RIDEM’s Office of Water Resources has conducted targeted post-storm monitoring in the upper Bay to evaluate water quality improvements resulting from the completion of two phases of the Narragansett Bay Commission’s combined sewer overflow abatement project. An agreement between RIDEM and the United States Food and Drug Administration allows the state to re-open the upper Bay’s conditionally approved areas to shellfish harvesting as soon as post-storm monitoring data demonstrate that it is safe to do so. RIDEM is examining whether the lower portion of the Providence River may be reopened as a conditionally approved area. Before that can happen, shellfish management plans must be developed to ensure the long-term viability of the shellfish stock.

The Massachusetts Division of Marine Fisheries conducted a dye study in the Fall River plant outfall in 2013 and the Somerset plant in 2014 that identified that most of the effluent from Fall River followed the channel into Rhode Island's waters while the Somerset plant, which has considerably less volume, showed less effect on the surrounding waters (MADMF 2015).

While the majority of prohibited areas (17,799 acres) were located in the Upper Estuary, there were large prohibited areas in the other Bay regions, and these classifications were not related exclusively to water quality. The East Passage included 6,385 acres of prohibited areas, and much of that acreage was located in and around Newport Harbor (Table 2; Figure 1). In that area, shellfishing was prohibited for safety reasons because of the high concentration of commercial, industrial, and military activities. Similarly, a prohibited area was established in the West Passage for safety reasons around the Quonset Business Park (Figure 1). Other prohibited areas in the West Passage were based on water quality concerns, including smaller areas such as the Potowomut River in Greenwich Bay and Sheffield Cove in Jamestown. Water quality issues were the reason for the prohibited areas in the Sakonnet River, including the northern section near Tiverton and Portsmouth as well as in small coves and embayments. In the Mouth of the Bay, prohibited waters were located in the Narrow River, at two safety zones around sewer outfalls on the western shore, and at Easton's Beach in Newport.

Urban landscapes and combined sewer overflows are prime contributors of pathogen loadings to the Bay (see "Wastewater Infrastructure" chapter), but there are many sources to consider, including stormwater runoff, septic systems, and waterfowl, among others. In many instances, stormwater from rainfall triggers temporary closures. This varies by growing area and by criteria set forward by the state shellfish programs (RIDEM 2015, MADMF personal communication 2017). Within a suburban coastal embayment in nearby Buzzards Bay, investigators found significant loading of fecal coliform from storm drains and small streams during rain events (Weiskel et al. 1996). Others report that septic systems can be a source of pathogens to coastal waters (e.g., Lipp et al. 2001), although Weiskel and others (1996) found that the bacteria were substantially attenuated during transport to coastal waters via groundwater. As progress is made to address fecal coliform contamination from point sources and nonpoint sources, additional upgrades from prohibited to conditionally approved shellfish growing areas can be expected. While the oyster fishery appears to be returning and quahog landings have fluctuated historically (Oviatt et al. 2003), these industries are important to the Bay's economy (Schuman 2015), and opening prohibited areas or upgrading conditional areas to approved would be beneficial to the fishery.

6. DATA GAPS AND RESEARCH NEEDS

This indicator is primarily dependent on management actions, and other supporting data could potentially be used to gain a better understanding of water quality changes. Geographical data need to be gathered and reconciled for Massachusetts and Rhode Island on sources of pollution that affect the closing of shellfishing areas, such as stormwater infrastructure, septic systems, wastewater treatment plant outfalls, and combined sewer overflows. With the enhanced datasets, a comprehensive study or model could be conducted to investigate relationships among land use, potential sources, and receiving water bacterial concentrations, perhaps following an approach similar to that of Kelsey and others (2004).

Recent changes showing a decline of prohibited areas and an increase of conditionally approved areas in the Upper Estuary have been attributed to improvements at wastewater treatment plants and to combined sewer overflows abatement efforts. However, additional data analysis is needed to correlate

factors that trigger closure days of conditionally approved areas and water quality improvements such as reduced pathogen loadings from infrastructure.

Comparisons between the bacterial data collected by Massachusetts and Rhode Island for beach closures (see “Marine Beaches” chapter) and shellfish closures would provide a more complete analysis of the status of water quality impairments and trends in the Bay. In addition, research on the implications of climate change is needed as more precipitation and warming waters (see “Precipitation” and “Temperature” chapters) may trigger more closures of marine beaches and shellfishing areas.

In October 2016, a shellfish closure was triggered in Narragansett Bay by a harmful algal bloom of the phytoplankton *Pseudo-nitzschia* spp. Rhode Island DEM conducted an intensive program of phytoplankton sampling and shellfish meats collection. Approximately 150 samples were tested for domoic acid, the toxin produced by *Pseudo-nitzschia* cells that causes amnesic shellfish poisoning. A similar closure occurred in 2017. Rhode Island Sea Grant is funding research to understand this new and concerning phenomenon.

7. ACKNOWLEDGEMENTS

This chapter written by Eivy Monroy, Watershed and GIS Specialist with the Narragansett Bay Estuary Program, with assistance in data preparation and extensive GIS analyses provided by Stefan Bengtson, GIS Analyst Contractor with the Estuary Program and writing assistance by James Tobey, Coastal Resources Center, University of Rhode Island. In addition, we thank our partners at the Rhode Island Department of Environmental Management, Office of Water Resources, including Elizabeth Scott, Joe Migliore, Lucinda M. Hannus, Sue Kiernan, and at the Massachusetts Division of Marine Fisheries, including Greg Sawyer and Mike Hickey, who contributed to this chapter.

8. REFERENCES

Coastal Resources Center (CRC). 2014. Shellfish Management Plan. University of Rhode Island, Narragansett, RI, 372 pp.

Kelsey, H., D.E. Porter, G. Scott, M. Neet, and D. White. 2004. Using geographic information systems and regression analysis to evaluate relationships between land use and fecal coliform bacterial pollution. *J. Exp. Mar. Biol. Ecol.* 298:197–209.

Lipp, E.K., S.A. Farrah, and J.B. Rose. 2001. Assessment and impact of microbial fecal pollution and human enteric pathogens in a coastal community. *Marine Pollution Bulletin* 42:286–293.

Massachusetts Department of Environmental Protection (MADEP). 2012. Massachusetts Consolidated Assessment and Listing Methodology (CALM) Guidance Manual. Division of Watershed Management Watershed Planning Program. 48 pp.

Massachusetts Division of Marine Fisheries (MADMF). 2013. Designated Shellfish Growing Areas. <http://www.mass.gov/eea/agencies/dfg/dmf/programs-and-projects/designated-shellfish-growing-areas.html>. Last Accessed 17 March 2017.

Sawyer, G. 2015. A Sanitary Survey Report of the Taunton River in the Town of Somerset and the City of Fall River. Massachusetts Division of Marine Fisheries (MADMF). (available upon request to from MADMF)

Sawyer, G. 2017. A Sanitary Survey Report of the Taunton River in the Town of Somerset and the City of Fall River. Massachusetts Division of Marine Fisheries (MADMF). (available upon request to MADMF)

Nevers, M.B., and R.L. Whitman. 2005. Nowcast modeling of *Escherichia coli* concentrations at multiple urban beaches of southern Lake Michigan. *Water Res.* 39:5250–5260. [doi:10.1016/j.watres.2005.10.012](https://doi.org/10.1016/j.watres.2005.10.012)

Olyphant, G.A. 2005. Statistical basis for predicting the need for bacterially induced beach closures: emergence of a paradigm. *Water Res.* 39:4953–4960. [doi:10.1016/j.watres.2005.09.031](https://doi.org/10.1016/j.watres.2005.09.031)

Oviatt, C., S. Olsen, M. Andrews, J. Collie, T. Lynch, and K. Raposa. 2003. A century of fishing and fish fluctuations in Narragansett Bay. *Reviews in Fisheries Science* 11:221-242.

Rhode Island Department of Environmental Management (RIDEM). 2016. Notice of Polluted Shellfishing Grounds. <http://www.dem.ri.gov/maps/mapfile/shellfsh.pdf#page=32>

Rhode Island Department of Environmental Management (RIDEM). 2014. Consolidated Listing and Assessment Methodology. Rhode Island Department of Environmental Management, Office of Water Resources.

Rhode Island Department of Environmental Management (RIDEM). 2015. RI Shellfish Harvest Restrictions. ArcGIS online map, <http://ridemgis.maps.arcgis.com/apps/webappviewer/index.html?id=110a7a4aec914a3492117e9848fe67da>

Rhode Island Department of Environmental Management (RIDEM). 2006. Water Quality Regulations, Rule 8.B(2). <http://www.dem.ri.gov/pubs/regs/regs/water/h20q09a.pdf>

Shea, W.J. 1946. Report on Pollution of the Waters of the State. Rhode Island. Map 1 of Sanitary Classification of Tidal Waters – Present Condition. Rhode Island Department of Health, Division of Sanitary Engineering.

Schumann, S. 2015. Rhode Island's Shellfish Heritage: An Ecological History. University of Rhode Island. Narragansett, RI. 168 pp.

Vadeboncoeur, M.A., S.P. Hamburg, and D. Pryor. 2010. Modeled nitrogen loading to Narragansett Bay: 1850 to 2015. *Estuaries and Coasts* 33:1113–1127.

Weiskel, P.K., B.L. Howes, and G.R. Heufelder. 1996. Coliform contamination of a coastal embayment: sources and transport pathways. *Environ. Sci. Technol.* 30:1872–1881.