

Buzzards Bay



National Estuary
Program

Buzzards Bay Shellfish Bed Closure Trends 1985- 2021,
Interim Analysis for the 2022 State of the Bay Report

Prepared by
Joseph E. Costa
Buzzards Bay National Estuary Program
Massachusetts Office of Coastal Zone Management
81-B County Rd Suite E, Mattapoisett, MA 02739

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Introduction

For nearly thirty years, the Buzzards Bay National Estuary Program, with the assistance of, and information from the Massachusetts Division of Marine Fisheries (DMF), has followed the classification, status, and changes in acreage of designated shellfish growing areas in Buzzards Bay (Fig. 1) as a metric for tracking the bacteria pollution, and the effectiveness of management actions taken by the state and municipalities. The origins of this effort began with a report on the history of shellfish bed closures in Buzzards Bay prepared by Frank Germano in 1992¹. Subsequently, the Buzzards Bay Coalition continued to receive information from DMF to estimate annual shellfish bed closures due to pollution. These closure statistics were reported in newsletters, and later, in the Coalition's State of the Bay reports and on the NEP's website.

The Massachusetts Division of Marine Fisheries (DMF) manages shellfish resources and protects public health through implementation of the Shellfish Sanitary Survey program. Through this program, all waters of the Commonwealth are subdivided into management units called designated shellfish growing areas (DSGA). This report summarizes the classification and closure status of these DSGAs for Buzzards Bay for 1985, and from 1990 to 2021 for use in the Buzzards Bay Coalition's 2022 *State of the Bay* report. The data is summarized by acres closed on July 1, linear feet of coastline closed on July 1, and annual acre-days closed. Closure statistics are also summarized by causes of closures. This analysis would not have been possible without the help and information provided by many past and present DMF shellfish area biologists and other DMF staff.

The analysis includes closures through the end of 2021. In 2020 and 2021, DMF applied more stringent rules that were issued by the U.S. Food and Drug Administration (FDA) National Shellfish Sanitation Program (NSSP) in 2019 and articulated in the 2019 [Guide for the Control of Molluscan Shellfish](#). These new guidelines required pollution source assessments of mooring areas that resulted in new or expanded mandatory closures around marinas and mooring fields. The effect of these rules are articulated in an [August 2020 DMF memorandum](#) that notes, "These new regs require defining all mooring areas in state waters and classifying them as Conditionally Approved, Restricted, Conditionally Restricted or Prohibited; they may not be classified as Approved. In addition, a dilution analysis will be required to determine if a particular mooring area needs to be CLOSED to SHELLFISHING while boats are present. An actual or assumed occupancy rate must be applied, along with an assumed discharge rate." These rules were applied, even though Buzzards Bay has an approved U.S. Environmental Protection Agency (EPA) no-discharge area. Besides impacts of the closures, the rules may indirectly affect any shellfish aquaculture growers and wild harvesters that export shellfish products to the European Union, because of rules there that preclude the import of shellfish from an area that is subject to any closures. The Town of Falmouth, in a fall 2021 posting, characterized the changes as "sweeping closures extensions ... brought forth by an agreement of the [FDA] and the [DMF]. These new changes are not local Town closures, they are DMF closures with which Falmouth recreational and commercial shellfish permit holders must comply." The effect of these rules was negligible in embayments that were already closed in their entirety during the summer boating season, like West Falmouth Harbor. However, portions of other embayments that were open year-round, but which were also designated mooring areas, became closed generally between May 1 and October 31. In those embayments, this resulted in an appreciable increase in annual acre-days and total acres closed on July 1. Notable areas affected included a large portion of Mattapoissett Harbor, Quisset Harbor (Falmouth), portions of Nasketucket Bay (Fairhaven), Onset Bay (Wareham), Sippican Harbor (Marion), and Apponagansett Bay (Dartmouth).

¹ Germano, F. 1992. History of Shellfish Beds Closures in Buzzards Bay: 1900 to 1992. Buzzards Bay National Estuary Program Technical Report.

Methods

DMF has adopted the FDA Growing Area Classifications system (Table 1) in their implementation of their Shellfish Sanitary Survey program. One category not included in Table 1 is the class "management closure." A management closure can be enacted for several reasons, but it is often the result of failing to complete or update a sanitary survey for the growing area. Little River in the Town of Dartmouth and Wild Harbor River in Falmouth are two DSGAs where a sanitary survey has not been completed in more than thirty years. Both estuaries are sparsely populated near shore, have little to no public access, purportedly few shellfish resources, and neither the state nor the towns have sought a sanitary survey for the areas. Although areas like these were often called "management closures" until 2012, today they are officially classified as "prohibited."

Fig. 1 shows the 68 major DSGAs defined by DMF for Buzzards Bay, circa 2018, which were evaluated in this report. The analysis includes 144 additional DSGA subareas (unlabeled segments in Fig. 1), many of which are too small to be seen at the scale. The area of all DSGAs evaluated totaled 179,322 acres. The magenta shaded polygons in Fig. 1, are within the NEP's jurisdictional boundaries, but were excluded from the calculation of closed areas in previous *State of the Bay* reports. Consequently, some summary tables and figures in this report exclude these areas to provide data consistent with the 2022 *State of the Bay* report. Some of the excluded DSGAs were closed the study period, including Cockeast Pond (100 acres) and Richmond Pond (62 acres) in Westport, Hadley Harbor in Gosnold (129 acres), and a few upper estuary areas including Horseshoe Pond in Wareham. DSGAs excluded from the *State of the Bay* reports, but were open for the entirety of the study period include Quicks Hole (586 acres) and Robinsons Hole (254 acres). The Cape Cod Canal was also excluded from the state of the Bay analysis. The west half of the canal (BB45.2, 354 acres) had been open to shellfishing for most of the entire study period, except the West End of the Canal which is a mandatory closure due to the Massachusetts Maritime Academy wastewater outfall (BB45.1, 68 acres). In 2019, these Canal DSGAs were merged by DMF, and the entirety of the Cape Cod Canal was closed to shellfishing. Figures and tables specify whether they include only state of the bay report DSGAs. The area of Buzzards Bay DSGAs excluding the magenta shaded polygons in Fig. 1, and used in the *State of the Bay* report, totals 177,707 acres.

The Buzzards Bay National Estuary Program (NEP) undertook a historical analysis based upon classifications of DSGA sub-areas as reported in historical Geographic Information System (GIS) datasets, reports prepared by DMF, and available archived correspondence from DMF to Buzzards Bay municipalities. These data and information were combined to create new GIS coverages representing boundaries and conditions on July 1 of each year, including the DSGA opening and closing dates of each DSGA where applicable. The opening and closing dates have changed in many estuaries, mostly extending the duration of seasonal closure, so these annual data are essential for the calculation of acre-days closed, both in the bay as a whole and for the town statistics.

For the calculation of coastline closed on July 1, consideration was given to the fineness of details incorporated in the DSGA boundaries, and the data was modified in two ways before calculation. Certain estuaries were clipped to finely defined marsh boundaries, which sometimes included ditches and narrow channels. These features, while having negligible effects on acreage closed, can appreciably add to coastline lengths closed. In addition, certain DSGA boundaries continue well into freshwater portions of rivers (particularly the Acushnet, Westport, Weweantic, and Sippican Rivers). While these river areas are narrow and add little to calculations of the total area of DSGAs closed in a municipality, they do add appreciably to the "marine" coastline of the municipalities.

To overcome both these biases to the calculation of coastline lengths affected by shellfish bed closes, the

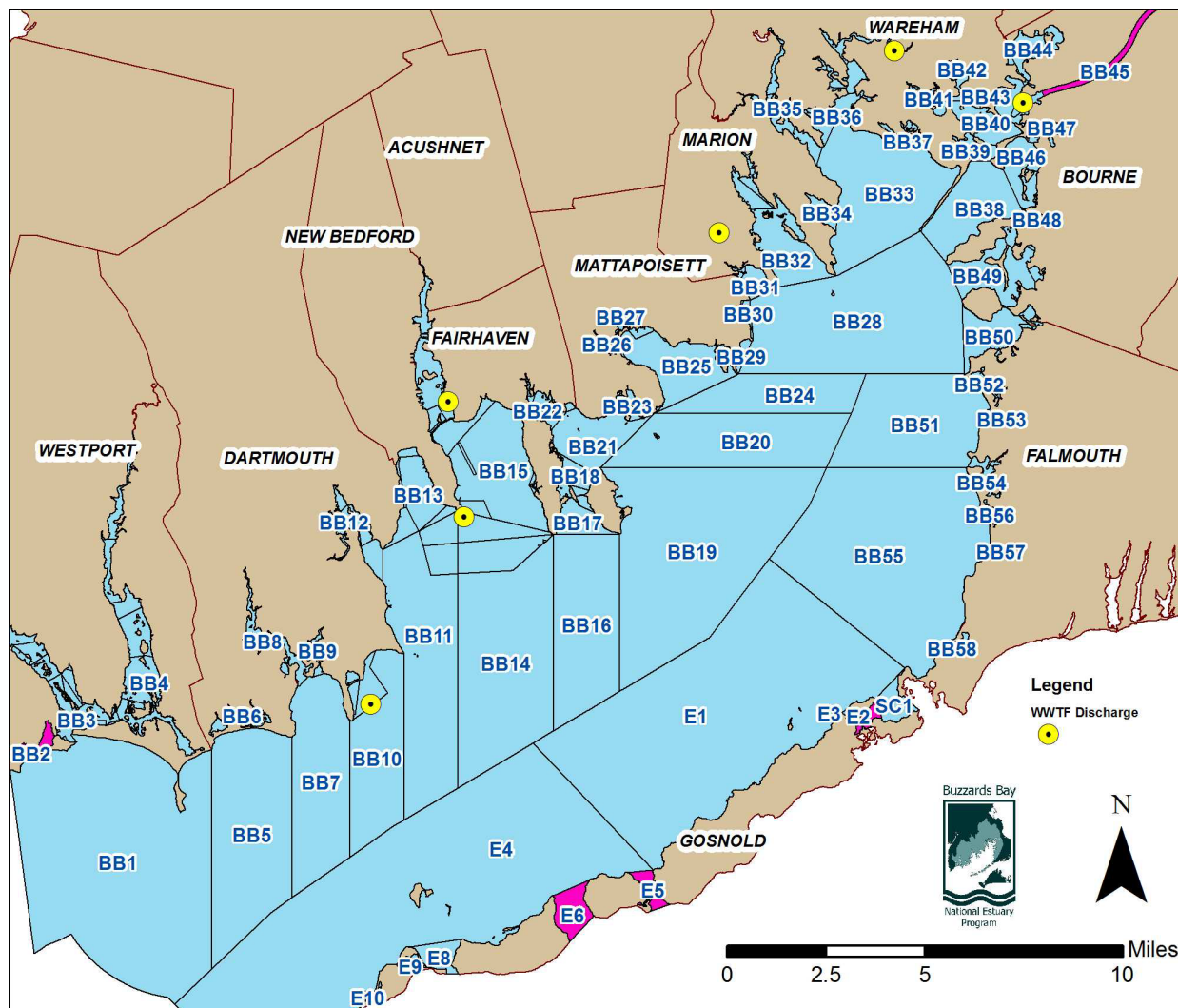


Fig. 1 DSGAs defined by DMF for Buzzards Bay.

boundary of DSGA coastlines were adjusted in two ways. First, the ESRI software ArcGIS function "Integrate" was applied to all coastlines forcing an average spacing of 10 m between digital points defining the DSGA and coastline polygons. Second, the freshwater portions of rivers, and certain salt marsh network drainage systems (on Sconticut Neck in Fairhaven) were clipped from the marine coastline. While the integrate processing did affect total coastline length, it had little effect on the calculation of percent of the coastline closed on July 1. In contrast, clipping off the freshwater portions of rivers, and the saltmarsh drainage networks on Sconticut Neck, changed the percent of the coastline closed on July 1 in those affected municipalities (Westport, New Bedford, Fairhaven, Marion, and Wareham). For example, without the additional processing of the coastline, Wareham had 54% of the coast closed to shellfishing on July 1, 2021, but this value was reduced to 49% of the coast closed after processing. For the other towns with river segments, the percent of the coast closed was 1-3 percent less after processing, and in other municipalities the change was less than 1% to nil.

Table 1. Summary of FDA Growing Area Classifications ²

Classification	Requirements	Permitted Use
Approved	Is not contaminated by fecal matter, pathogenic organisms, poisonous or deleterious substances, marine biotoxins, or indicator bacteria concentrations exceeding National Shellfish Sanitation Program (NSSP) Approved area bacteriological standards.	Direct harvest permitted at all times except when events such as emergencies or marine biotoxin episodes occur. Shellfish are considered safe as ready-to-eat food.
Conditionally Approved	Meets requirements for Approved classification during certain conditions.	Direct harvest permitted only when requirements for Approved classification are met. If the area meets Restricted classification requirements when closed, Authority must indicate whether harvested shellstock will be relayed or depurated.
Restricted	Sanitary survey indicates that the area is moderately polluted, but shellfish taken from it can be made safe by relaying, depuration, or low acid canned food processing.	Harvesters may take shellstock only by special license or permit, under Authority supervision. Harvested shellfish must be subjected to low acid food processing OR must complete decontamination in a relay area or depuration facility before they can be sold to consumers. Shellstock samples must meet established criteria to ensure decontamination was effective. Depurated shellstock must meet Restricted classification bacteriological standards for depuration.
Conditionally Restricted	Meets the requirements for Restricted classification during certain conditions.	Shellstock may be harvested under Restricted conditions only when Restricted classification requirements are met. Authority must indicate whether harvested shellstock are to be relayed or depurated.
Prohibited	A current sanitary survey has not been completed to support another classification, or Authority determines that shellfish may be so contaminated that they cannot be made safe and wholesome for human consumption by relay, depuration, or low acid food processing. A Prohibited zone must be established adjacent to every point source discharge of public health significance, including every sewage treatment plant discharge.	Shellfish cannot be taken except for depletion or when gathering seed for aquaculture, under Authority supervision.

Table 2. Classification of the primary cause of closure used in this study

² From https://www.accessdata.fda.gov/ORAU/ShellfishGrowingAreas/SGA_03_summary.htm (last accessed March 21, 2018).

- wastewater point source (closures around outfalls),
- closure at mouth of freshwater stream or brook, marsh discharge, or small closure around an individual stormwater pipe,
- marina, boat ramp, or boat density related closures,
- rainfall conditional (excludes areas that are both seasonal closures and rain conditional in balance of year),
- management decision (closure because of lack of sampling and local disinterest; until 2012 many explicitly listed as a management closure, subsequently as prohibited),
- seasonal closure various (dominant source not specified in DMF surveys, and not fitting into the above categories)
- year-round closure various (dominant source not specified in DMF surveys)

This report quantifies the DSGA closures in Buzzards Bay annually from 1990 to 2021, with 1985 added as a pre-NEP base conditions reference year. The author classified closures by a subjective assignment of primary cause inferred from DMF reports as defined in Table 2. Table 2 includes the cause "management decision" to characterize estuaries like Little River Dartmouth, and Wild Harbor River Falmouth, where there has been no effort to conduct a sanitary survey for decades. The analysis in this report focuses on closures relating to chronically elevated concentrations of indicator bacteria (fecal coliforms), and excludes temporary rain conditional closures, toxic algal bloom closures, closures for the placement of contaminated shellfish for depuration, closures due to episodic pollutant discharges like oil spills, and extreme weather events (rainfalls greater than four inches) that may close the entire bay to shellfishing. A more detailed summary of the methodology will be contained in a forthcoming NEP report.

Fig. 2 shows areas of Buzzards Bay never closed (green) or closed to shellfishing (red) sometime between 1985 and 2021 because of chronic bacteria pollution, including seasonal, rainfall conditional, and various year-round closures. Closures due to algal blooms, spills, and relay and seed stock closures were ignored in this report. Table 3 shows major DSGA areas classified as approved open throughout the study period based on chronic bacteria pollution (excludes extreme weather, spills, harmful algal blooms, seeding and depuration closures). Only certain subareas of other DSGAs have closures.

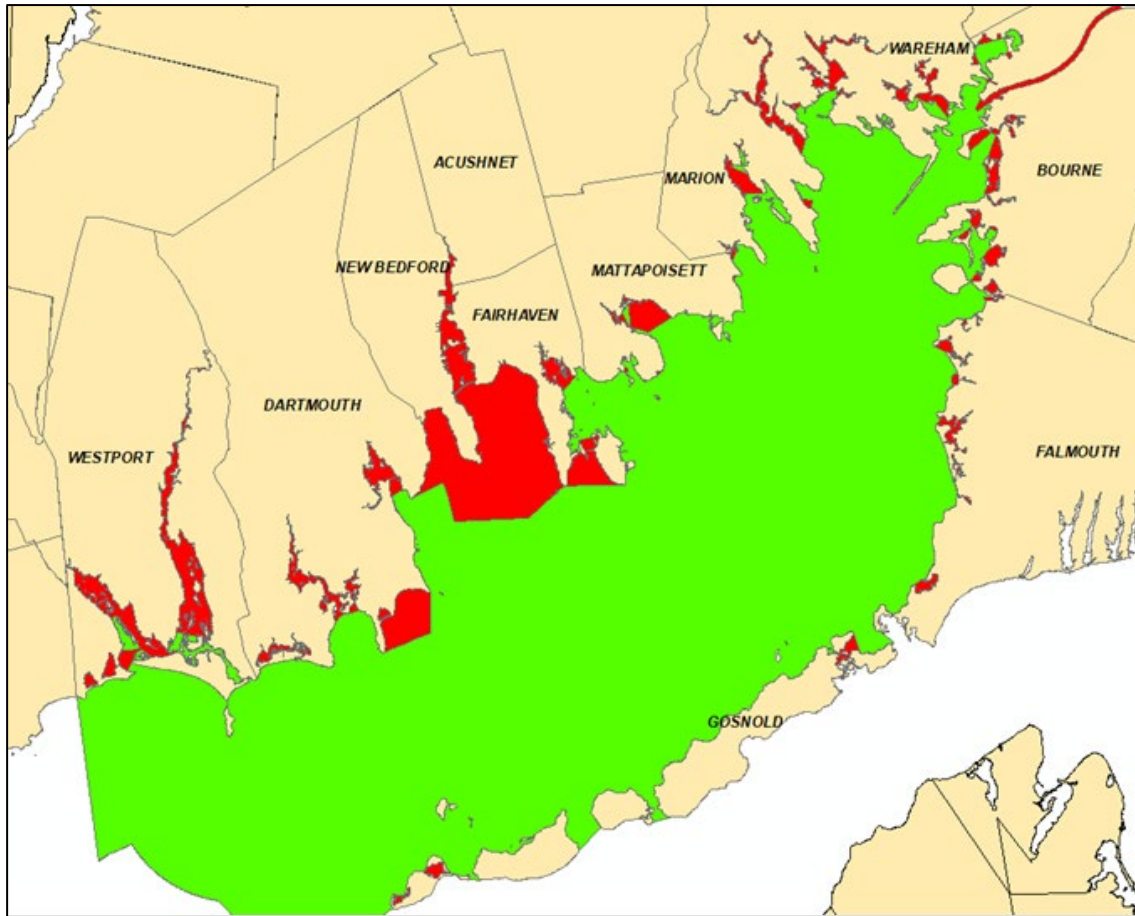


Fig. 2 Areas never closed shellfishing (green), and areas closed due to bacteria pollution sometime between 1985 and 2021 (red).

Table 3. Major DSGA Area classified as approved open in their entirety.

Major DSGA	DSGA Name	Area (acres)	
BB1	Westport South Coastal		17,086
BB16	Fairhaven South Coastal		4,811
BB19	West Island East Coastal		11,676
BB20	Fairhaven East Coastal		4,693
BB24	Mattapoissett South Coastal		2,598
BB28	North Buzzards Bay		9,303
BB29	Point Connett		141
BB33	Stony Point Dike		5,018
BB37	Little Harbor Bourne Cove		162
BB38	Stony Point Dike East		2,025
BB39	Widow Cove		259
BB5	Little Beach Coastal		6,536
BB7	Dartmouth Center Coastal		4,544
E1	Naushon West Coastal		19,898
E3	Northwest Gutter		39
E4	Gosnold West Coastal		25,689
E5	Robinsons Hole		254
E6	Quicks Hole		586
E8	Cuttyhunk Harbor		408
SC1	Woods Hole West Coastal		417

Results

Unaffected areas

There are 179,323 acres of DSGAs in Buzzards Bay defined in this study. Some DSGAs in their entirety have never been classified as chronically bacterially impaired (Fig. 2), except for short-term closures due to extreme rainfalls (typically over 4 inches), pollution spills, or extreme storms. These major DSGAs are principally those in central Buzzards Bay and a few sparsely developed coastal areas (Table 3). These areas may have been closed for other reasons in the past, including oil spills (all of Buzzards Bay was closed in 2003 due to the *Bouchard 120* oil spill, for example), or because of harmful algal blooms causing paralytic shellfish poisoning. Areas closed due to the relay of contaminated shellfish into clean areas for the purpose of depositions were similarly ignored.

Baywide Closure Trends

Fig. 3 shows the history of DSGA classifications in Buzzards Bay for the study period as of July 1 in each year, as compiled by the NEP. Conditional areas classified as both rainfall and seasonal were included only in the seasonal total. DSGA acres closed on July 1 and annual acre-days closed have declined between the early 1990s and 2017 (Fig. 3, Fig. 4a,b and Table 4). The declines during this period, particularly during the 1990s and early 2000s, were largely due to declines in year-round closures in New Bedford, and enactment of rainfall closures (principally in Westport and Wareham; see town summaries below). The declines were largely the result of the conversion of year-round closures (prohibited areas) into summer seasonal or rainfall conditional closures. When including rainfall conditional closures, the area affected by bacteria pollution has largely remained constant (Fig. 3), but the conversion of permanent closed to seasonal or rainfall conditional management designations resulted in important benefits to commercial and recreation shellfish harvesters. These reclassifications, mostly because of improved water quality, meant that large areas of the bay and lengths of the coast that were never available for shellfish harvesting became available for either portions of the year, or available year-round except for three days after certain volume rainfalls (Fig. 4c).

During the study period, the minimum acreage closed on July 1 was 8,846 acres (in 2009), and the maximum acreage closed was 13,768 acres (in 1995). These areas represent 4.9% and 7.7% of the entire surface of Buzzards Bay, respectively. However, most recreational shellfisherman do not use boats, and most of Buzzards Bay is too deep, of the wrong bottom types, or does not support the shellfish species most desired. An alternative metric of the impact of shellfish bed closures is the length of shoreline closed to shellfishing (Fig. 4d). By this metric, 1985 represented the lowest percent of the coast closed to shellfishing on July 1 (34%), and 2021 the greatest percent of the coast closed on July 1 (50%). The trends for municipalities varied more widely as described below.

The causes of the July 1 closures, as subjectively assigned for each DSGA in this study per Table 2, are shown in Fig. 5, both as a cumulative total (Fig. 5 top) and individually (Fig. 5 bottom). Historically, mandatory closures around wastewater facilities were the dominant cause of shellfish bed closures in Buzzards Bay (Fig. 6), accounting from 77% of July 1 closures in 1985, dropping to 34% 2021 (Fig. 7), based on classifications available through February 2021.

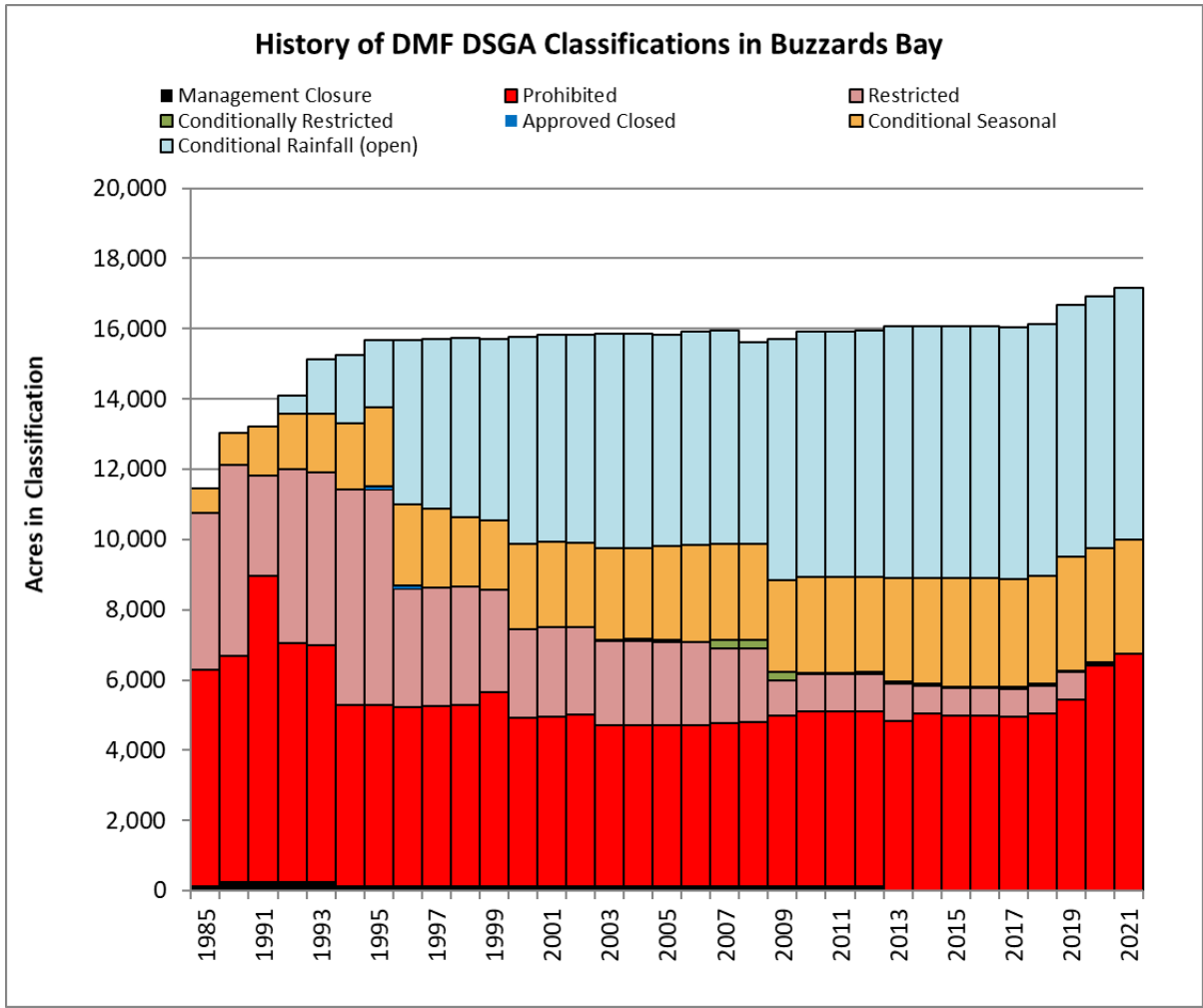


Fig. 3 History of DSGA classifications in Buzzards Bay.

The 2019 change in FDA rules for mooring areas, enacted principally in the summer of 2021, resulted in the pronounced July 1 increase in annual acre-days closed that year. Fig. 5 shows a 927-acre increase in the closure from boating related closures (as designated in this analysis), but this is somewhat of an underestimate because certain existing "seasonal" classified DSGAs were expanded to accommodate mooring areas, so some of the mooring expansions are reflected in the change in the seasonal closure category, which also expanded 958 acres between 2020 and 2021.

The single greatest cause for the reduction in shellfish bed closures during the 1990s and early 2000s can be attributed to reductions in the prohibited areas closed year-round near sewage treatment facility discharges and combined sewer overflow discharges (Fig. 6; Combined Sewer Overflows (CSO) are found only in New Bedford). Most of the declines resulted from water quality improvements from wastewater facility upgrades, elimination of CSO dry weather discharges, and the elimination of some CSO outfalls. Some wastewater facilities mandatory closures in Dartmouth and Wareham also changed, and there was a new expansion around the Dartmouth sewage discharge near Mishaum Point in 2020. The 2019 FDA rules may result in additional changes in mandatory closures around wastewater facility discharges, but these new dilution studies around wastewater facilities have not yet been completed.

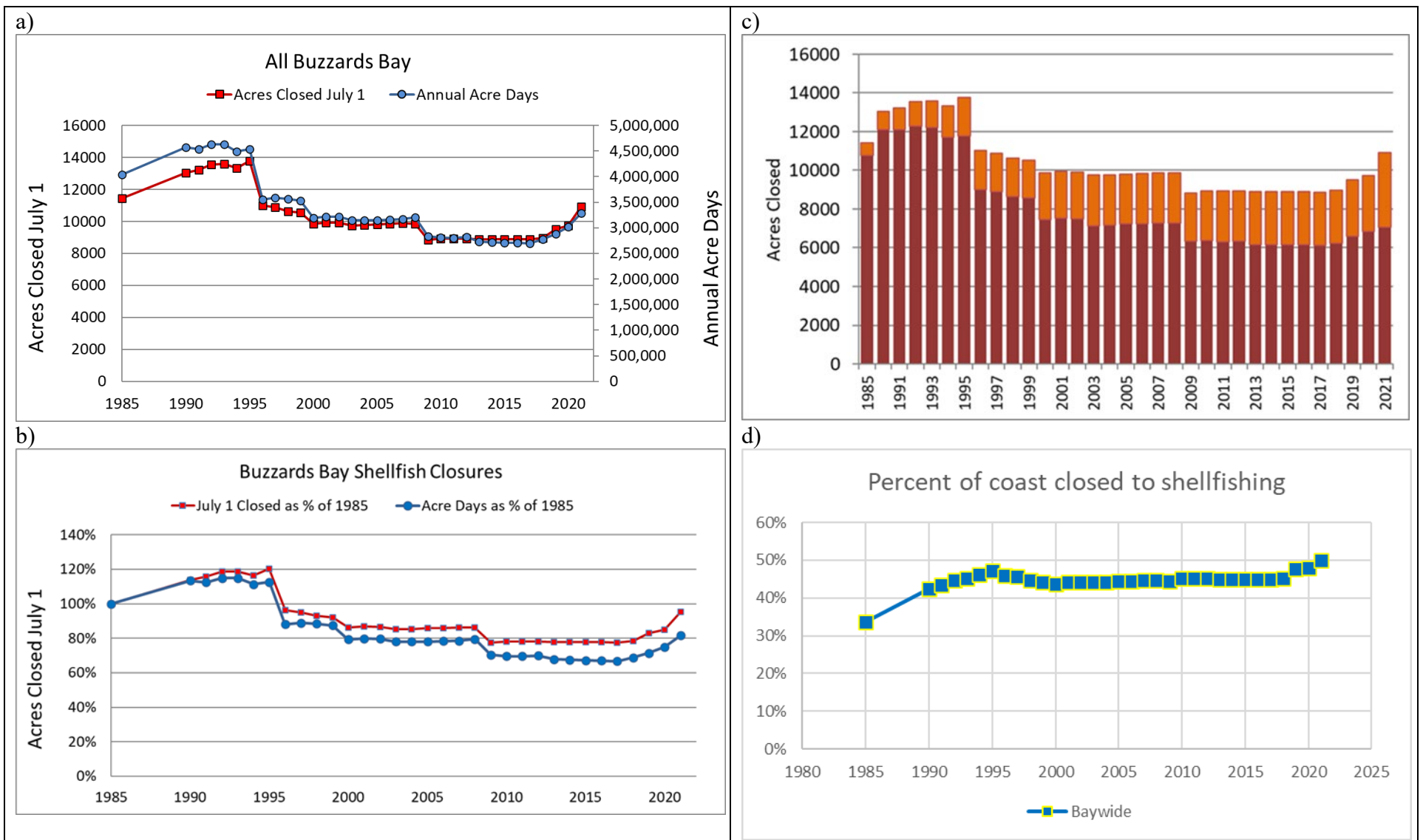


Fig. 4 a) Acres closed in Buzzards Bay on July 1 of each year (blue circles) and annual acre-days closed (red squares), b) The same data as a percentage of 1985 conditions, c) July 1 closures broken down by seasonal closures (typically summertime only) and year-round closures, and d) Percent of Buzzards Bay's coastline closed to shellfishing.

Table 4. Summary statistics of July 1 closed acres and annual acre-days for each study year.

Year	July 1 Closed acres	Percent of 1985	Annual Acre-days	Percent of 1985
1985	11440	100%	4033496	100%
1990	13027	114%	4572102	113%
1991	13228	116%	4534722	112%
1992	13564	119%	4634743	115%
1993	13588	119%	4630994	115%
1994	13319	116%	4487999	111%
1995	13768	120%	4541245	113%
1996	11011	96%	3552149	88%
1997	10874	95%	3585592	89%
1998	10638	93%	3563688	88%
1999	10538	92%	3527339	87%
2000	9859	86%	3198525	79%
2001	9932	87%	3220732	80%
2002	9909	87%	3214160	80%
2003	9754	85%	3147722	78%
2004	9757	85%	3146025	78%
2005	9811	86%	3147373	78%
2006	9832	86%	3162858	78%
2007	9867	86%	3165459	78%
2008	9866	86%	3204323	79%
2009	8846	77%	2839685	70%
2010	8926	78%	2808442	70%
2011	8926	78%	2805225	70%
2012	8939	78%	2818318	70%
2013	8893	78%	2733865	68%
2014	8893	78%	2721699	67%
2015	8893	78%	2706617	67%
2016	8893	78%	2702187	67%
2017	8879	78%	2690424	67%
2018	8970	78%	2773558	69%
2019	9504	83%	2880643	71%
2020	9727	85%	3020942	75%
2021	10913	95%	3289451	82%

The second most important driver in closure reductions during the 1990s and 2000s were the conversion of non-wastewater facility related year-round and seasonal closures to rainfall conditional closures (Fig. 5, bottom). These changes largely occurred in Westport, New Bedford, Fairhaven, and Wareham. The enactment of these rainfall conditional closures was one of the most important strategies implemented by the MA Division of Marine Resources to make shellfish stock more available to residents. Rainfall conditional classification areas, allow for the taking of shellfish except after a rainfall exceeds a specific threshold (most often between 0.2 or 0.3 inches). If the rainfall condition is exceeded, the shellfish beds are closed typically for two or three days. Rainfall conditional closures are enacted only where it is the desire of a town to implement such a program, and only where justified by water quality data taken in time series after did size rainfall events. Only five towns implement rainfall conditional areas (Westport, Dartmouth, New Bedford, Fairhaven, and Wareham; see Fig. 8, top), but these programs markedly decreased summer acreage closed and annual acre-days closed in those municipalities. There have been no new rainfall conditional areas adopted since 2013 (Fig. 8, bottom).

Embayment and Town-wide Trends

Shellfish bed closure trends within individual towns and embayments may differ profoundly from baywide trends. Changes at a municipal and embayment level can be seen clearly in the bay wide maps for selected years in Fig. 9 through Fig. 16. This variability in the trends of July 1 closings, annual acre-days, and primary causes of closures is seen in selected embayments in Fig. 17 through Fig. 27. Fig. 28 shows the change in July 1 acres closed in each municipality, and Fig. 29 shows the change in length of coastline closed as a percentage of the towns coast.

Discussion

Between 1900 and 1970, Buzzards Bay shellfish bed closures were mostly around New Bedford because of the numerous municipal wastewater outfalls there, and near a few other municipal wastewater outfalls. In the 1980s, new FDA rules required annual monitoring and a more rigorous sanitary survey programs for state water. In that decade, the shellfish sanitary monitoring program was transferred from the Department of Environmental Quality Engineering (DEQE; renamed Department of Protection in 1989), to the Massachusetts Division of Marine Fisheries. The new monitoring data led to new closures around Buzzards Bay in the 1980s. At the time, many residents around estuaries with no past shellfish bed closures often assumed the new closures were due to distant sources like the New Bedford outfall, rather than local diffuse pollution sources like failed septic systems, boats, or runoff from new development. These shellfish bed closures around Buzzards Bay during the late 1980s were a driving force in the establishment of the NEP (formerly the Buzzards Bay Project). The recognition of local non-point source pollution of bacteria through stormwater networks, overland runoff, and boat waste, as well as the need to better manage shellfish resources became important priorities in the 1991 *Buzzards Bay Comprehensive Conservation and Management Plan* (CCMP).

During the 1990s, because certain embayments were closed to shellfishing due to boat "mast counts" and occupancy on certain large boats with waste flushed from macerator grinder heads (toilets) on board, the CCMP focused on establishing EPA designated boat no discharge areas first in certain Buzzards Bay municipalities (Wareham in 1992, Westport in 1994), then baywide 2000.

The increase in shellfish bed closures between 1985 and 1993 was not only due to new water quality data, but also due to the failure of DEQE and DMF to complete certain sanitary surveys in a timely way. In the early 1990s, the NEP provided grants to DMF to work with town shellfish constables to complete these surveys. As noted above, from principally 1993 to 2001, wastewater facility improvements and elimination or reduction of CSO discharges resulted in dramatic declines in closures for New Bedford and Fairhaven, and to a lesser degree in Dartmouth, and these changes largely account for the bay-wide declines in Fig. 4

during that period. The enactment of rainfall conditional closures in New Bedford, Westport, Fairhaven, and Dartmouth were important to increasing availability of shellfish resources in those communities between 1996 and 2009. Between 2009 and 2018, bay wide shellfish bed closures were largely unchanged, with improvement in some areas offset with declines in water quality or changes in DSGA boundaries elsewhere. In 2018 and 2019, some water quality degradation, and redefinition of management areas led to new closures. Most of the dramatic increase in closures in 2020 and 2021 relate to the imposition of 2019 FDA guidelines for managing shellfish resource areas. These closures were not based on water quality data, but a more conservative assumption about the potential risk of pollution discharges from boats, even where there is a boat waste no discharge designation in place.

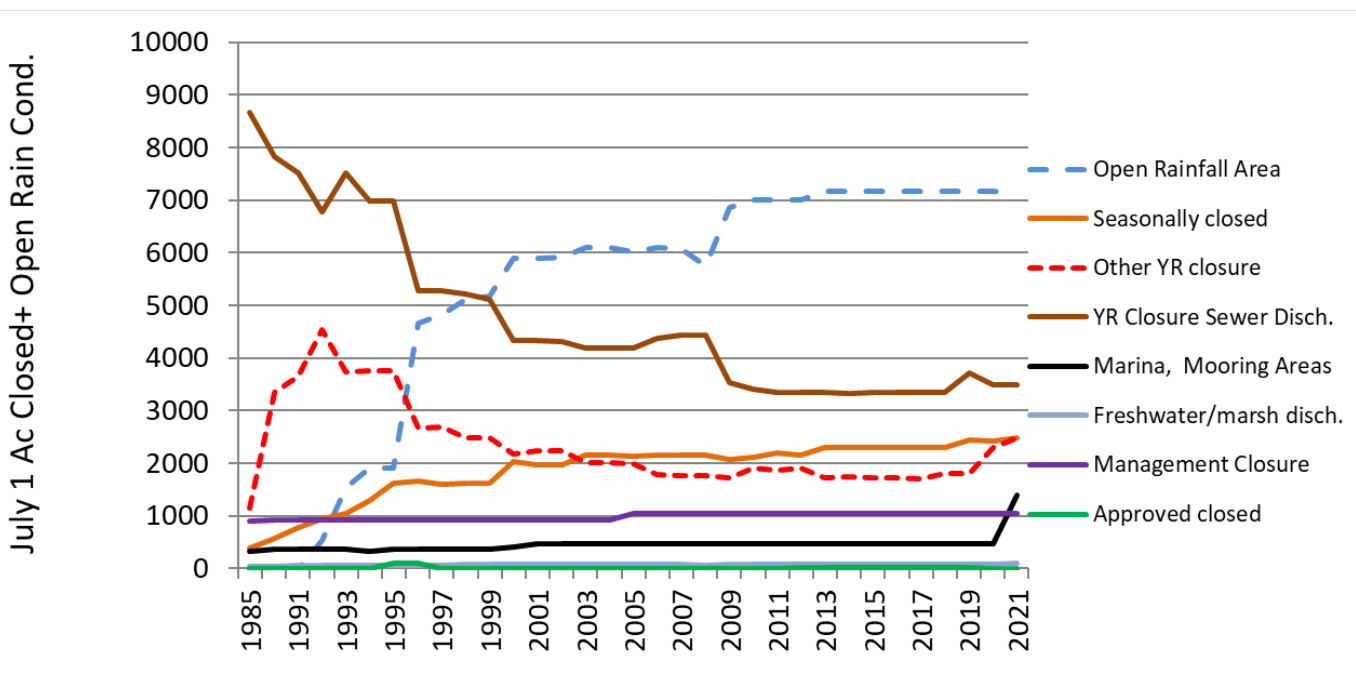
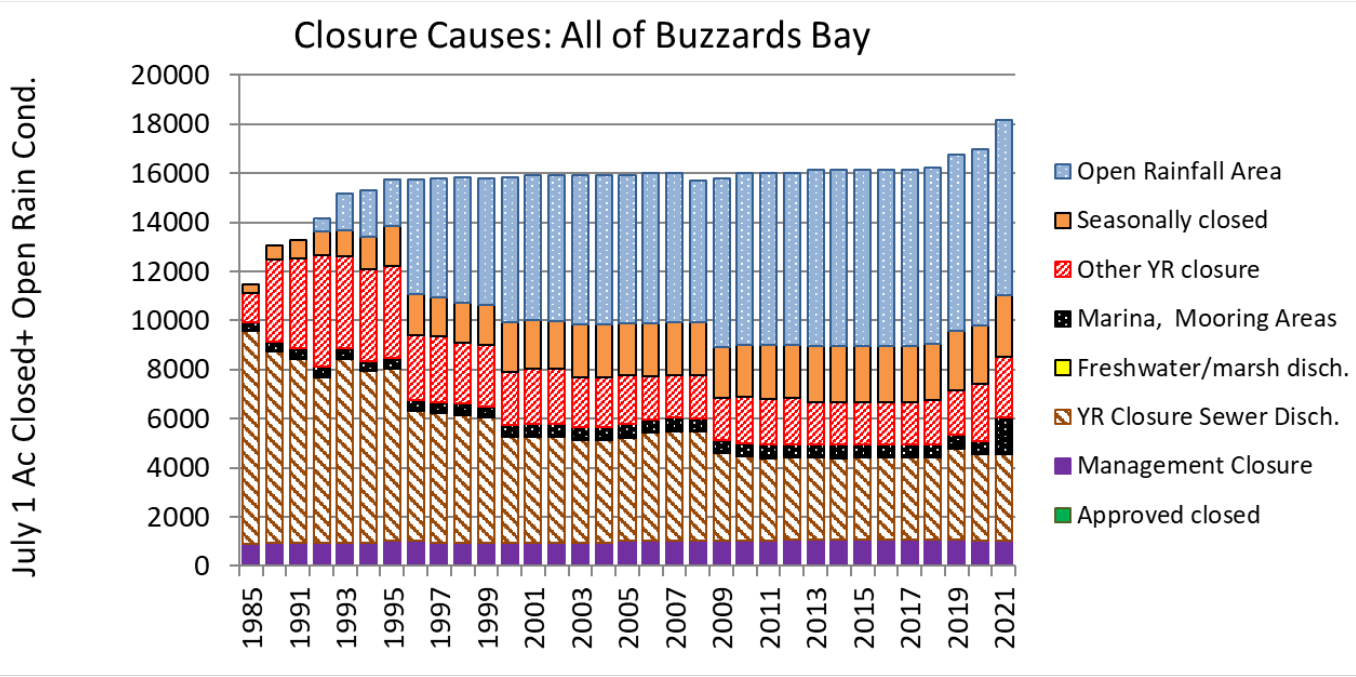


Fig. 5 Acres closed in Buzzards Bay on July 1 of each year as subjectively characterized by cause.

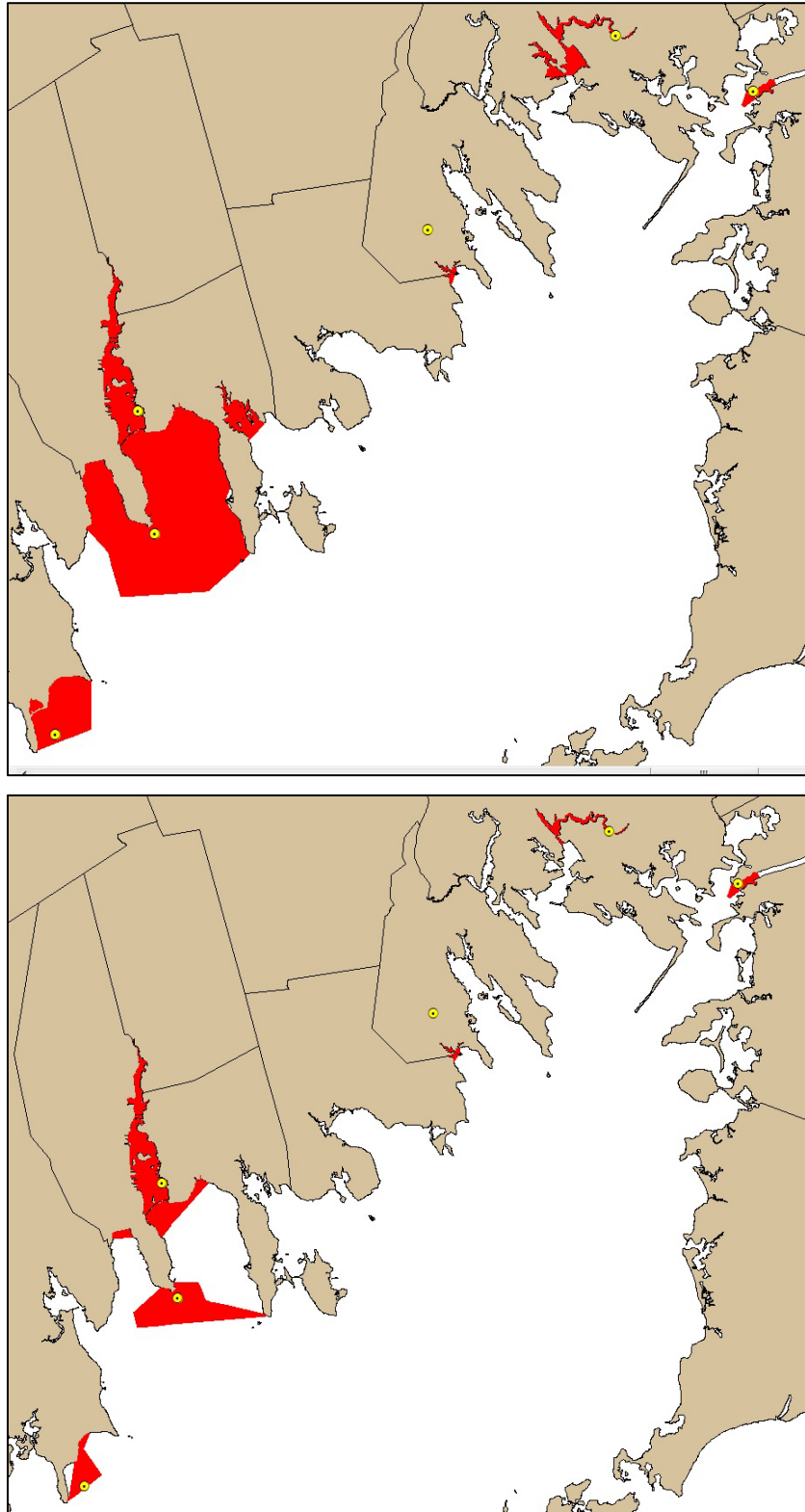


Fig. 6 Top: maximum extent of wastewater discharge related closures in Buzzards Bay for any period (including a temporary misattribution in Little Bay, Fairhaven). Bottom: 2018 wastewater discharge related closures in Buzzards Bay.

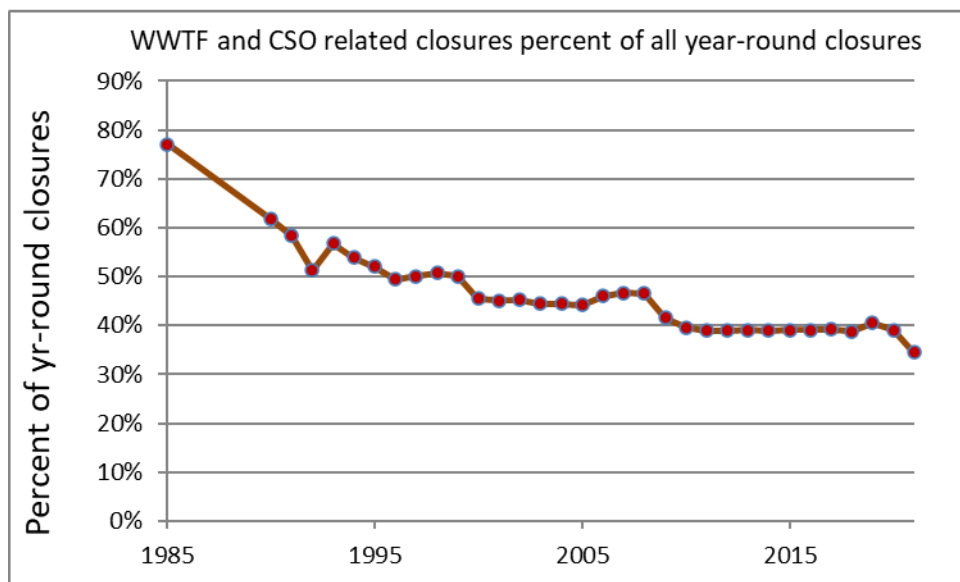
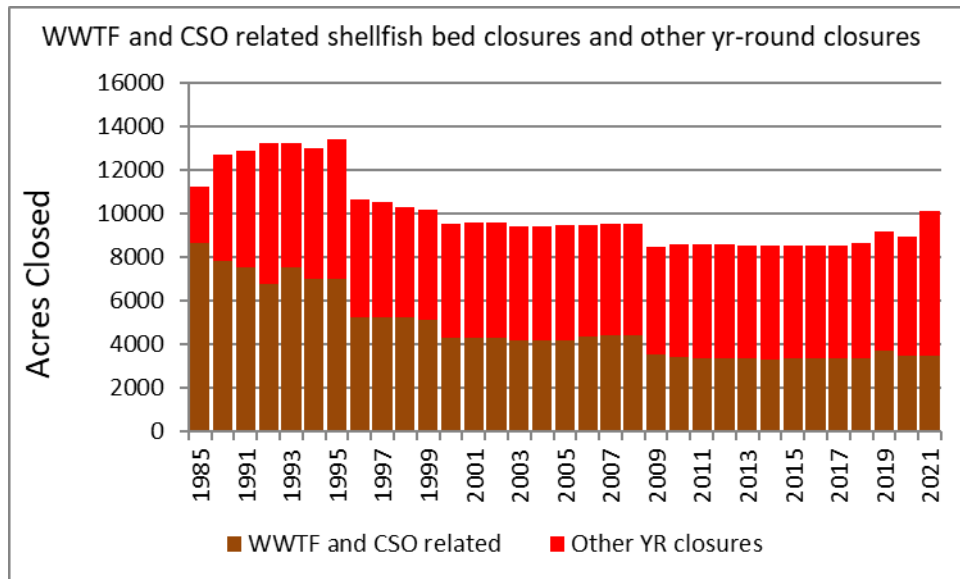


Fig. 7 Top: July 1 closures related to wastewater facility discharges compared to other year-round sources. Bottom: the percent contribution of wastewater facility discharges as a percentage of year sources.

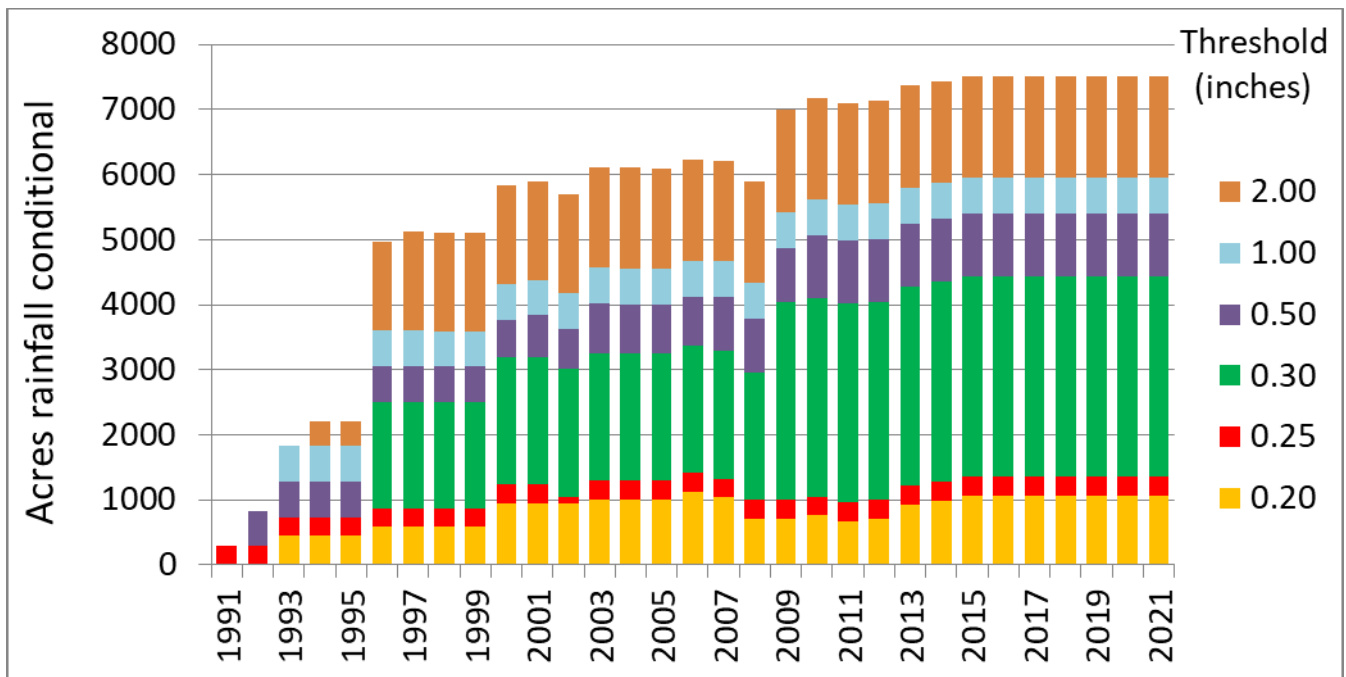
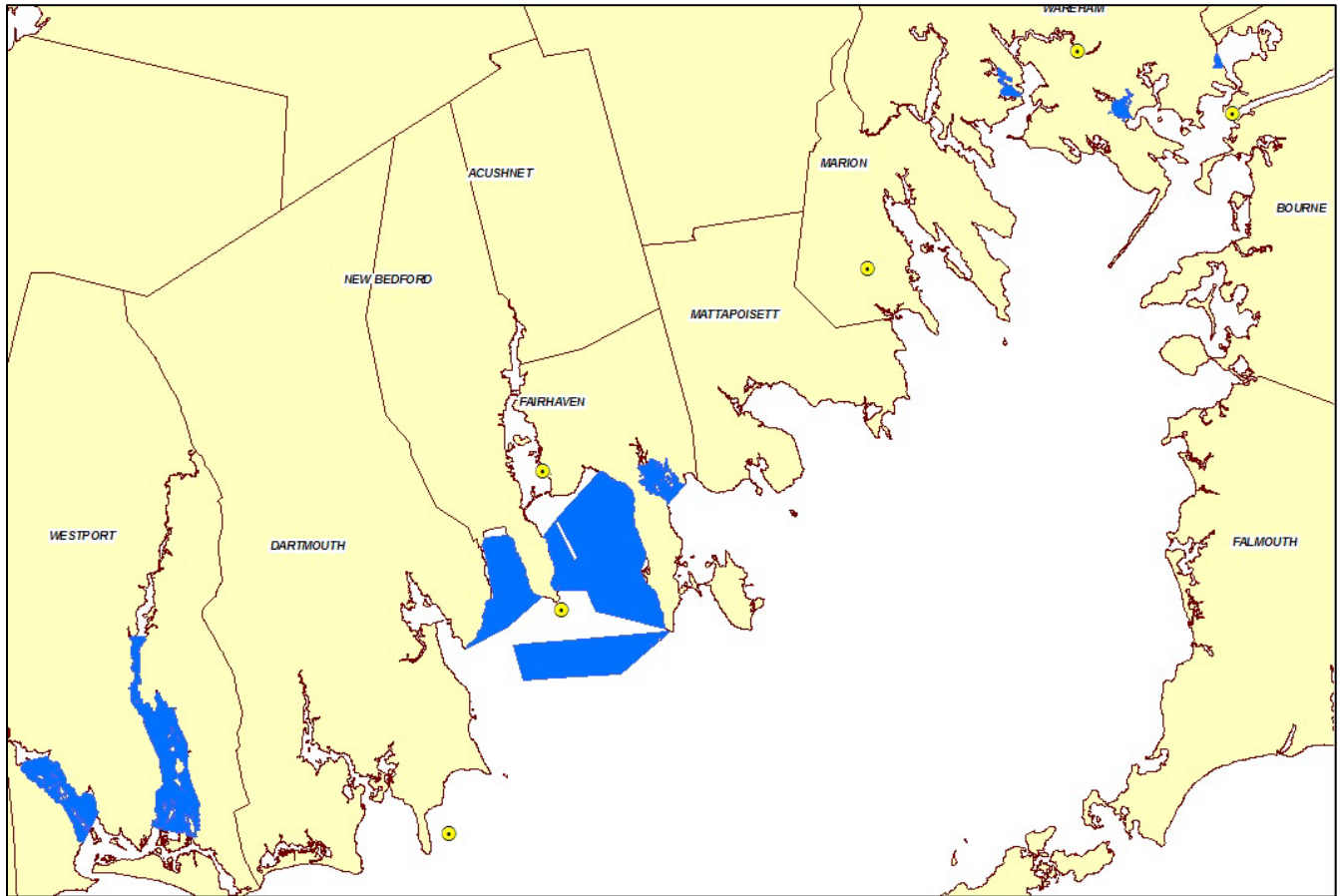


Fig. 8 Top: The maximum extent of areas classified with a rainfall conditional classification at any time during the study period. Bottom: Acres as rainfall conditional by threshold.

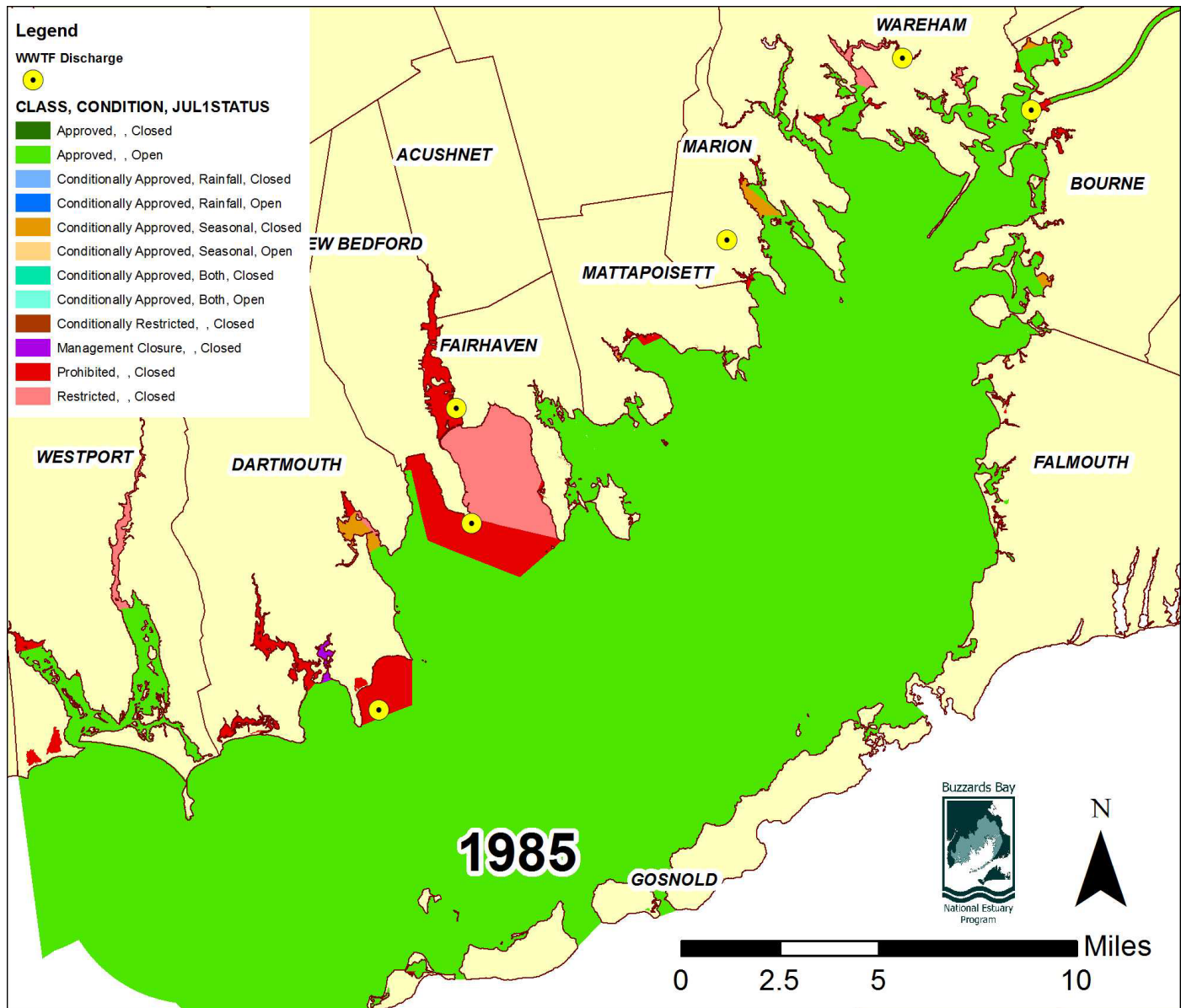


Fig. 9 Shellfish bed classifications and closures on July 1, 1985. Management closures, prohibited, and restricted areas are closed year-round.

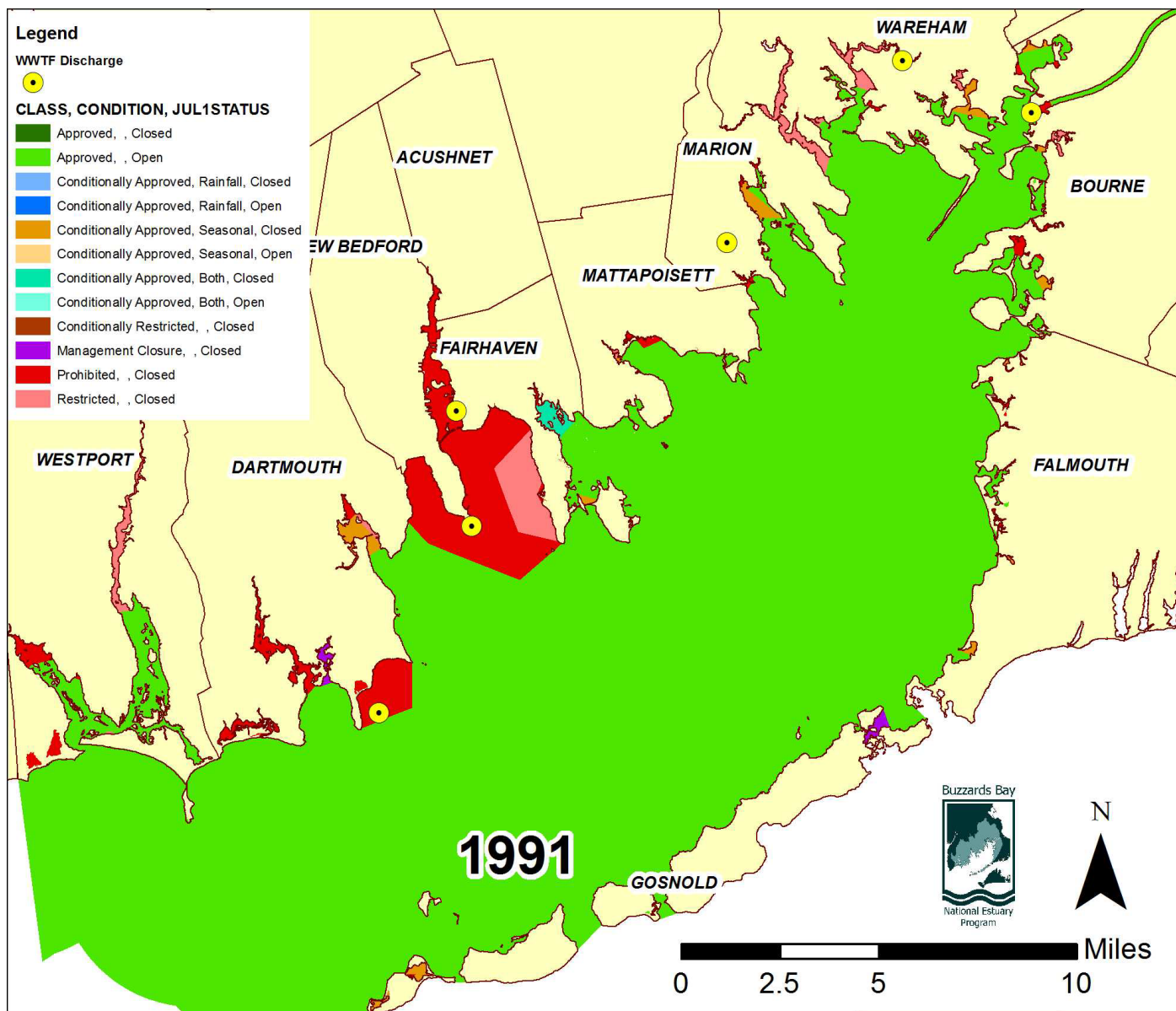


Fig. 10 Shellfish bed classifications and closures on July 1, 1991. Management closures, prohibited, and restricted areas are closed year-round.

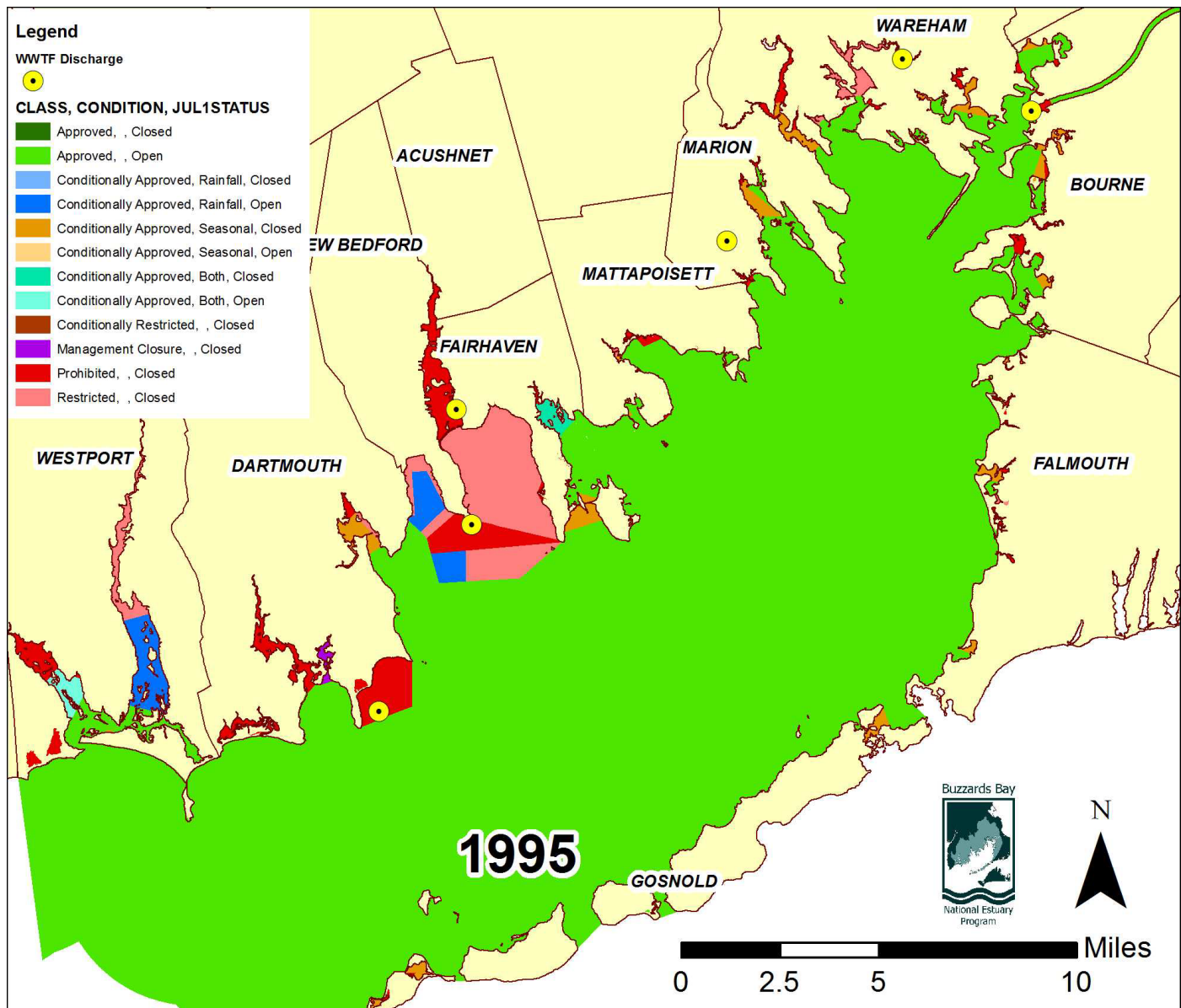


Fig. 11 Shellfish bed classifications and closures on July 1, 1995. Management closures, prohibited, and restricted areas are closed year-round.

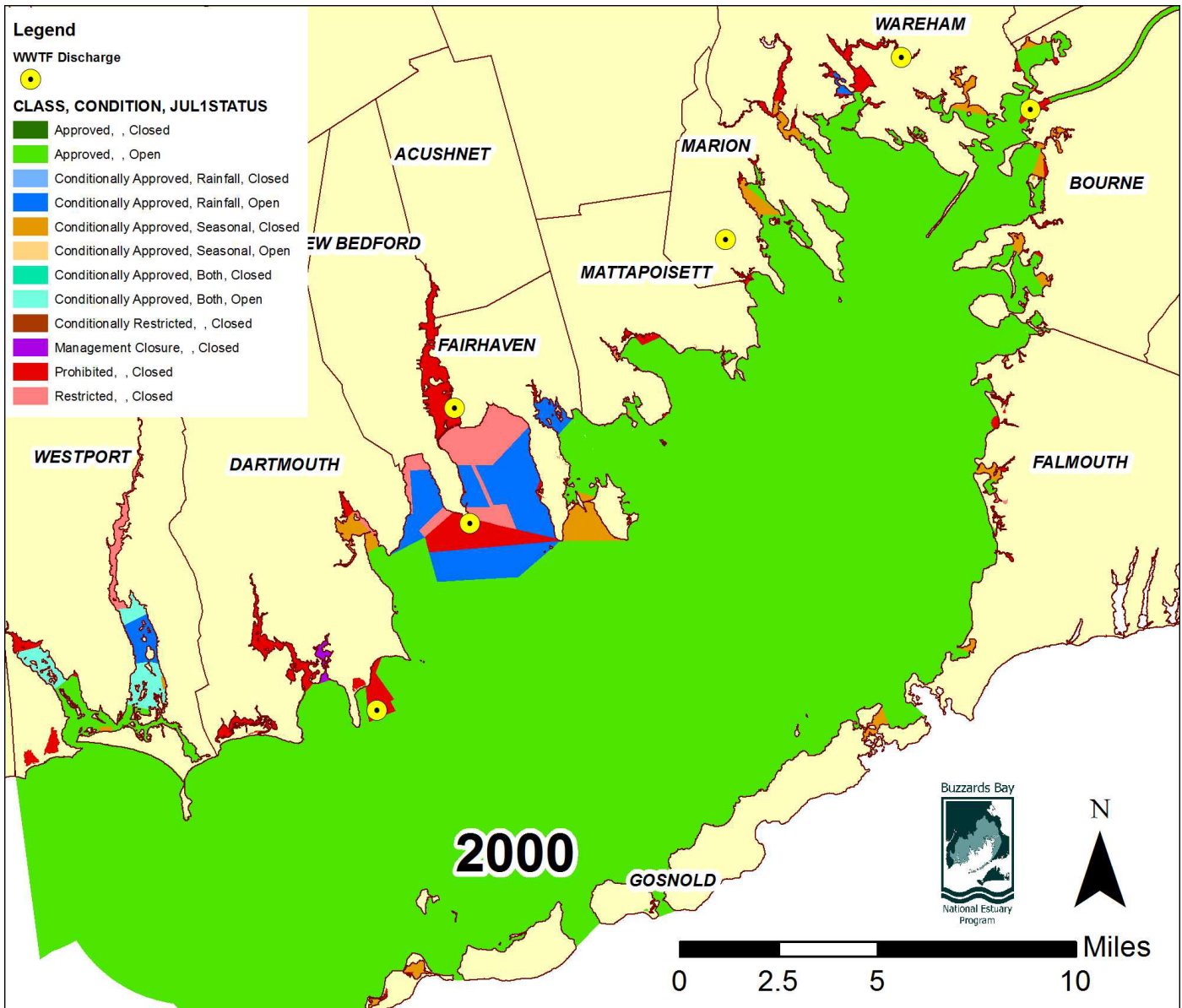


Fig. 12 Shellfish bed classifications and closures on July 1, 2000. Management closures, prohibited, and restricted areas are closed year-round.

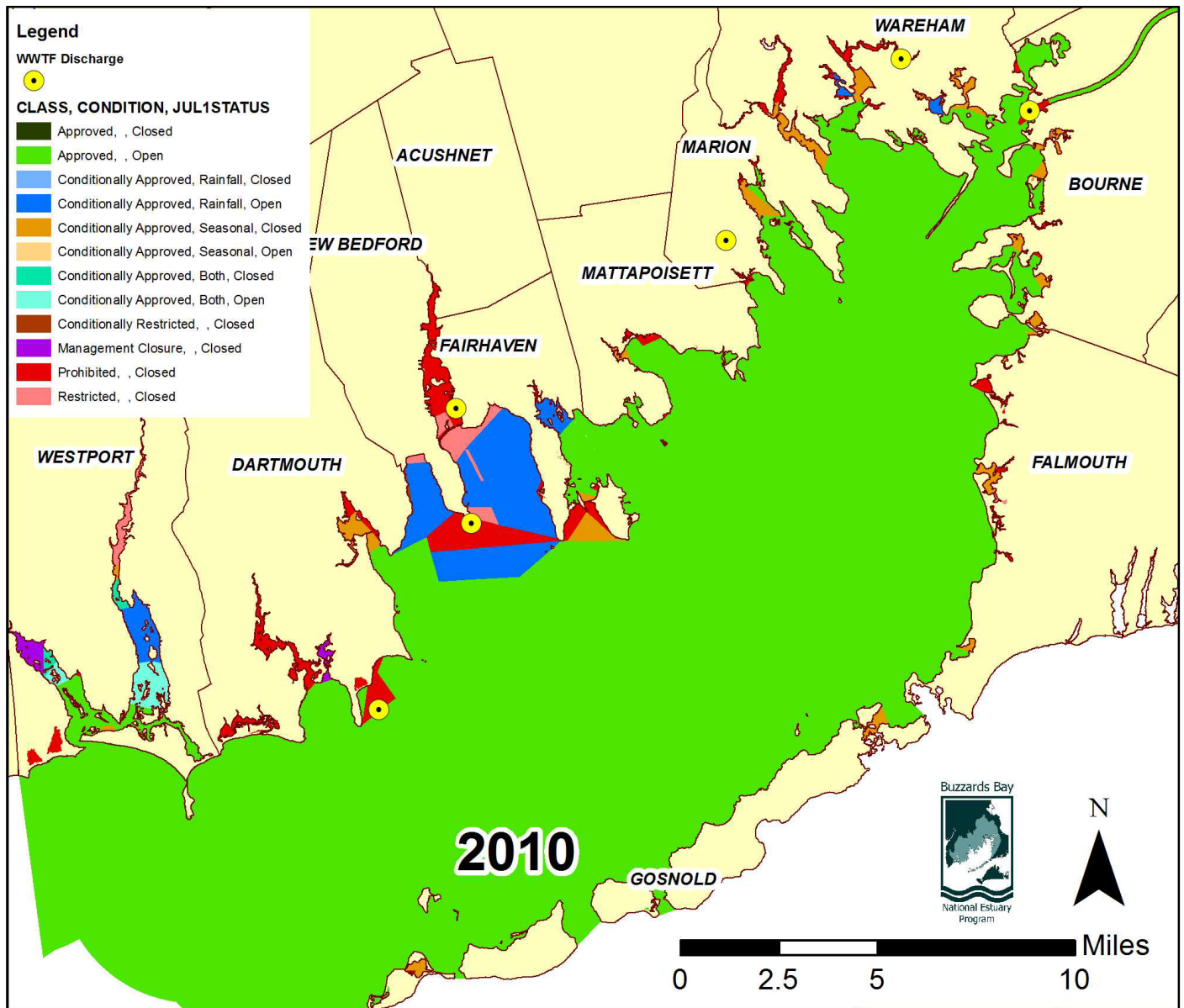


Fig. 13 Shellfish bed classifications and closures on July 1, 2010. Management closures, prohibited, and restricted areas are closed year-round.

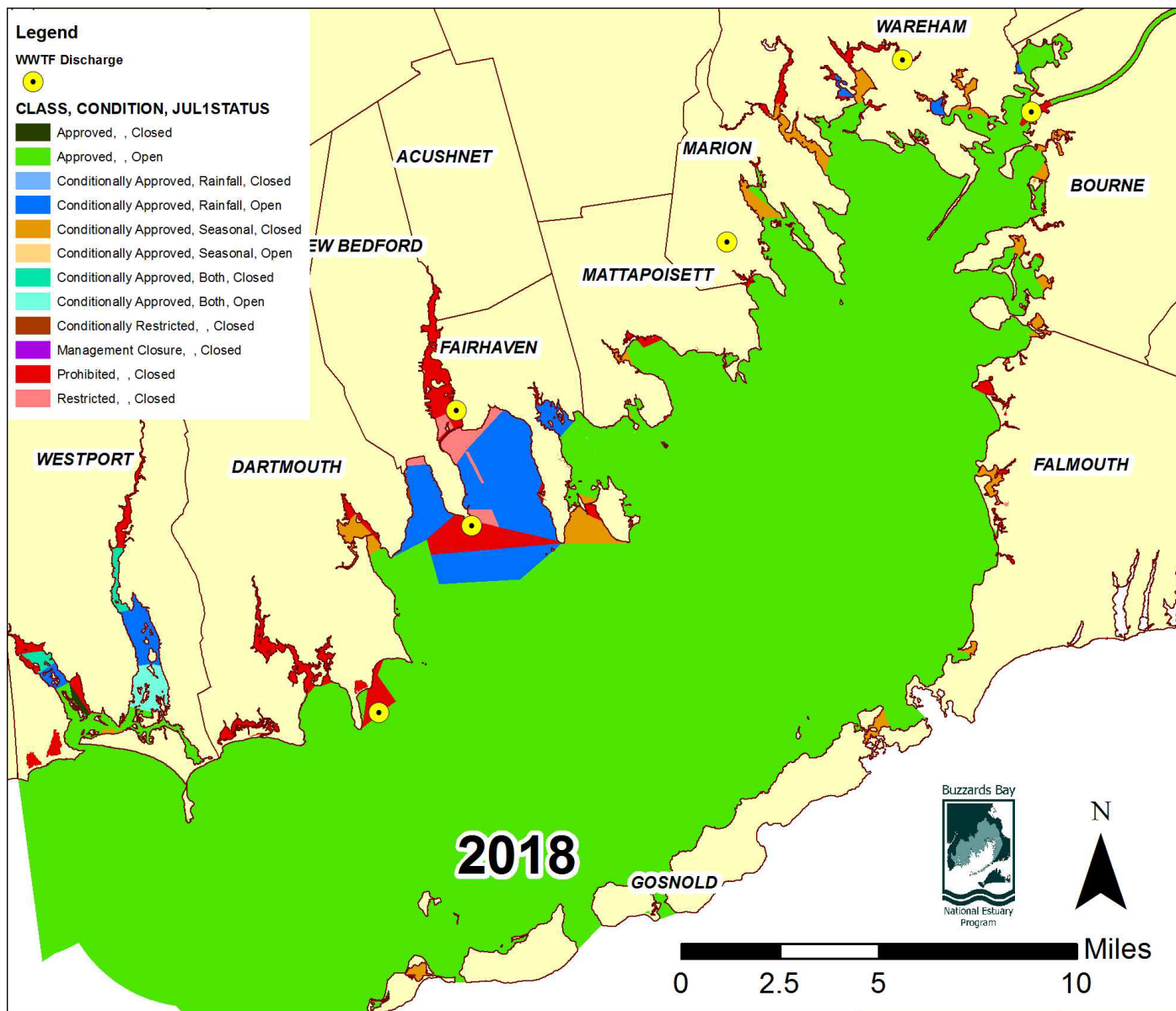


Fig. 14 Shellfish bed classifications and closures on July 1, 2018. Management closures, prohibited, and restricted areas are closed year-round.

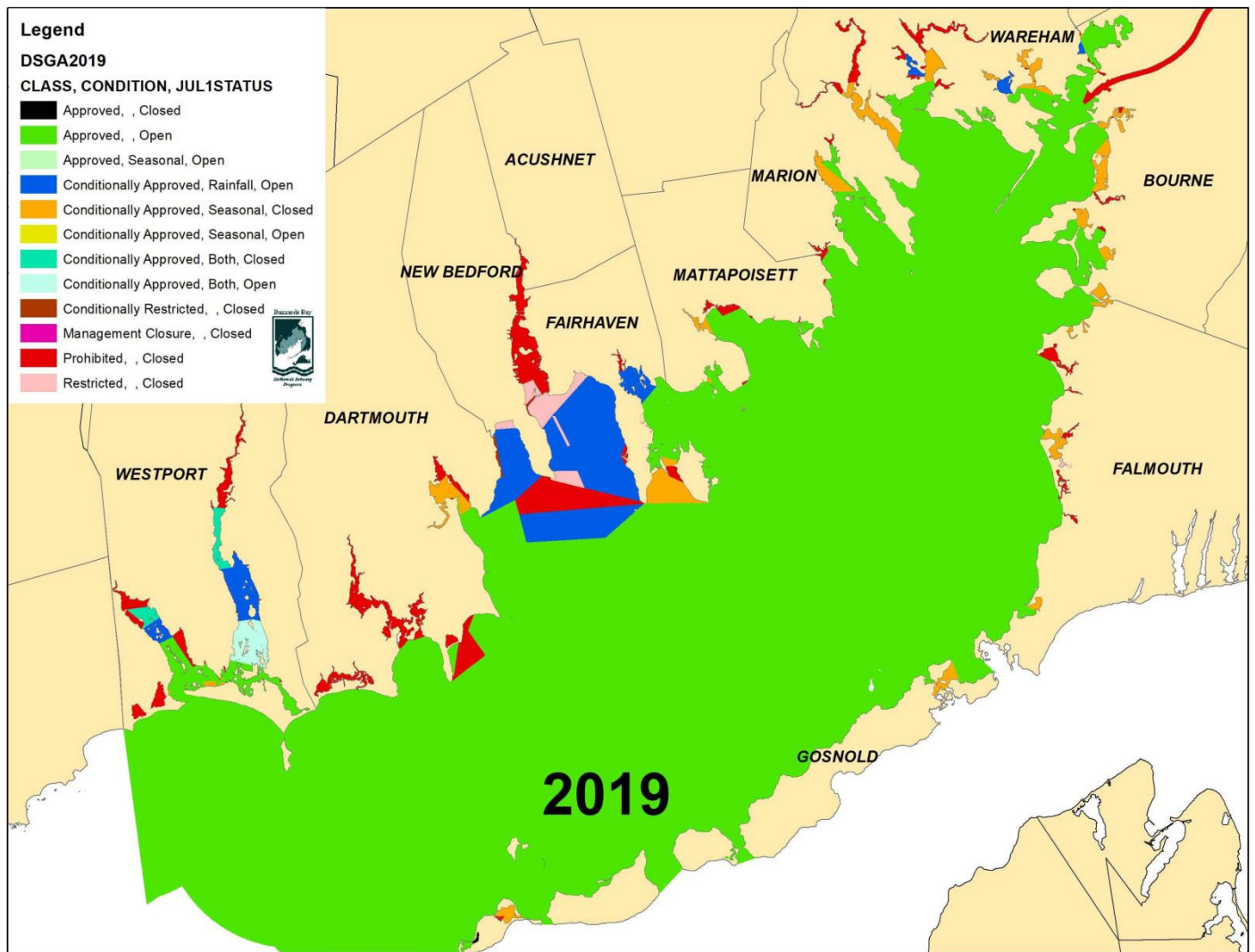


Fig. 15 Shellfish bed classifications and closures on July 1, 2019. Management closures, prohibited, and restricted areas are closed year-round.

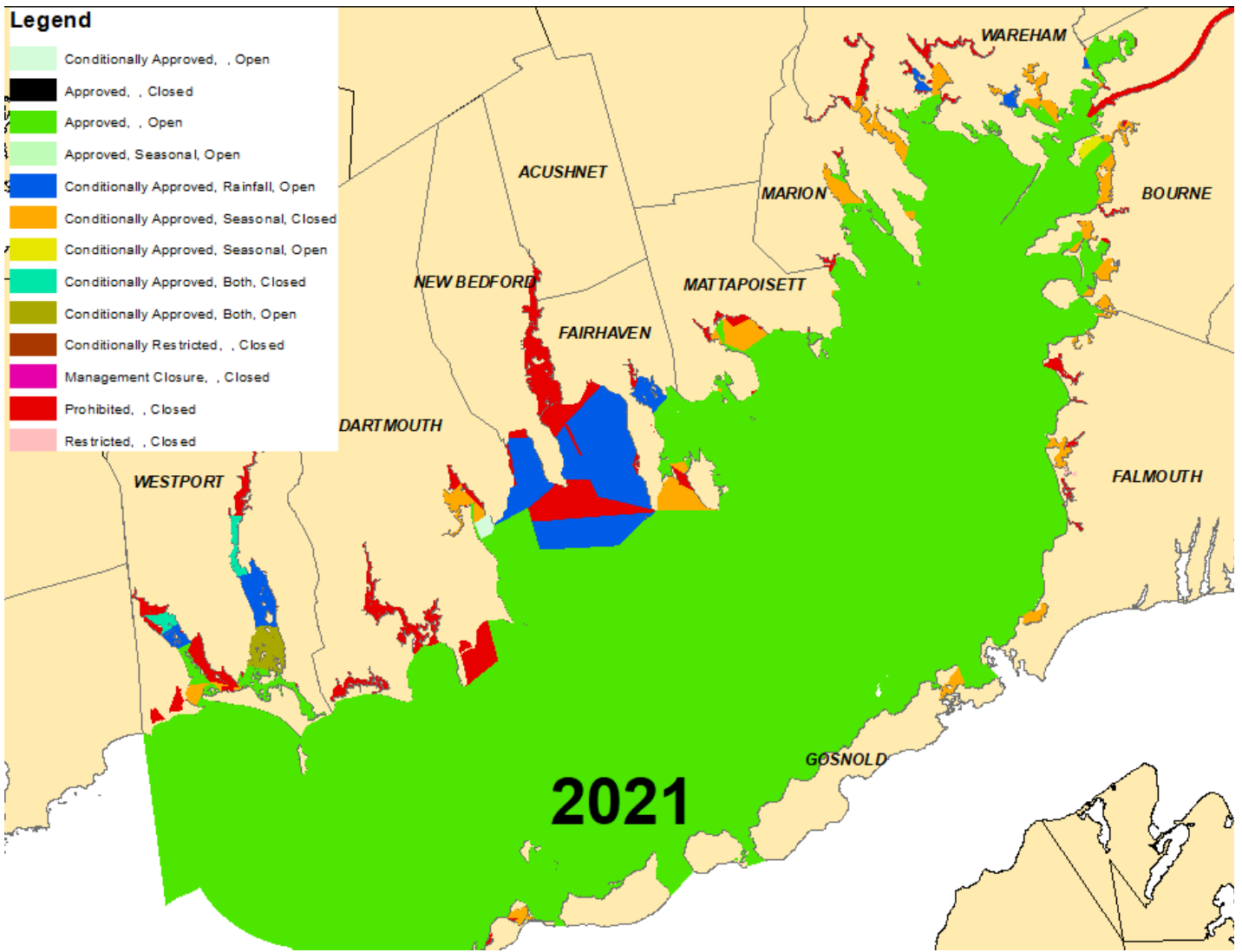
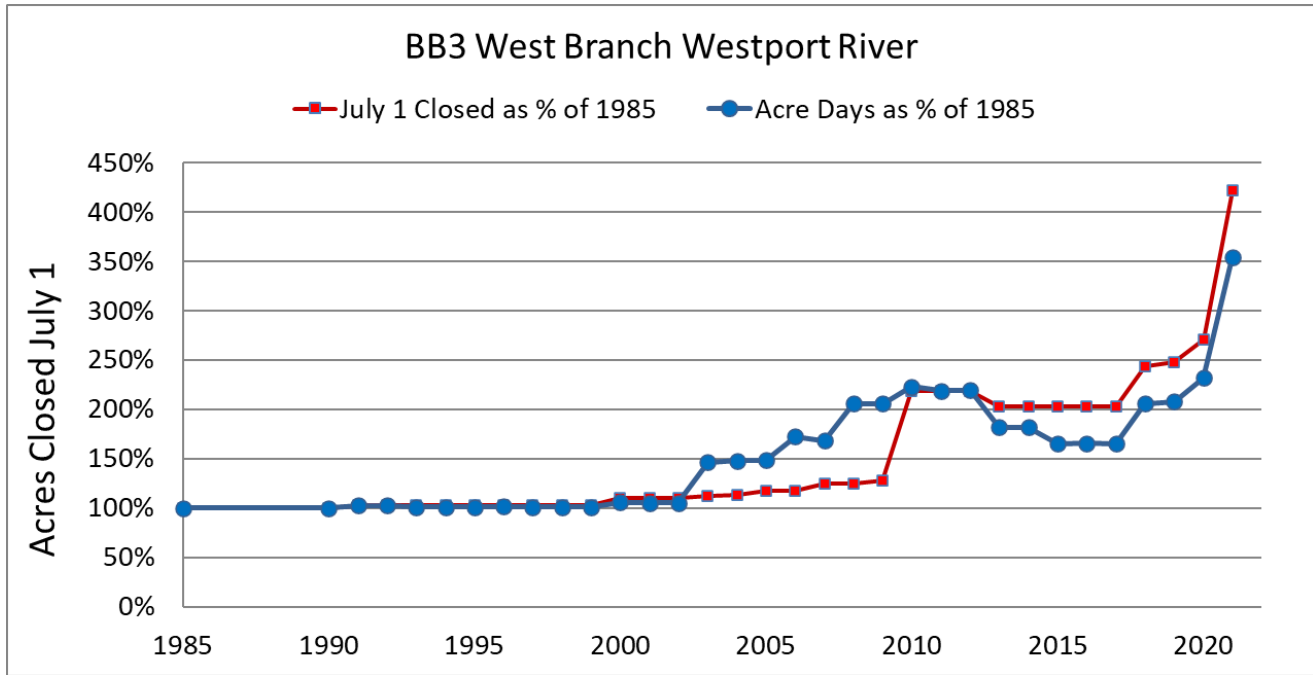


Fig. 16 Shellfish bed classifications and closures on July 1, 2021. Management closures, prohibited, and restricted areas are closed year-round.



BB3: West Branch Westport River

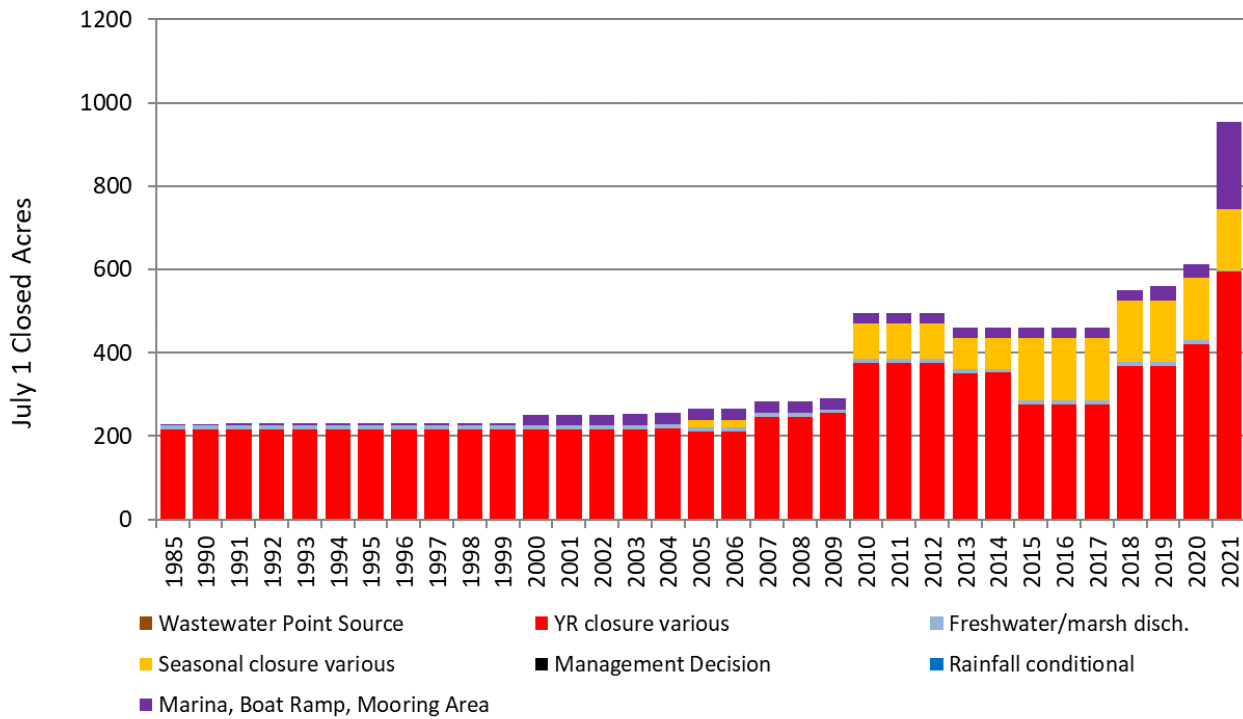
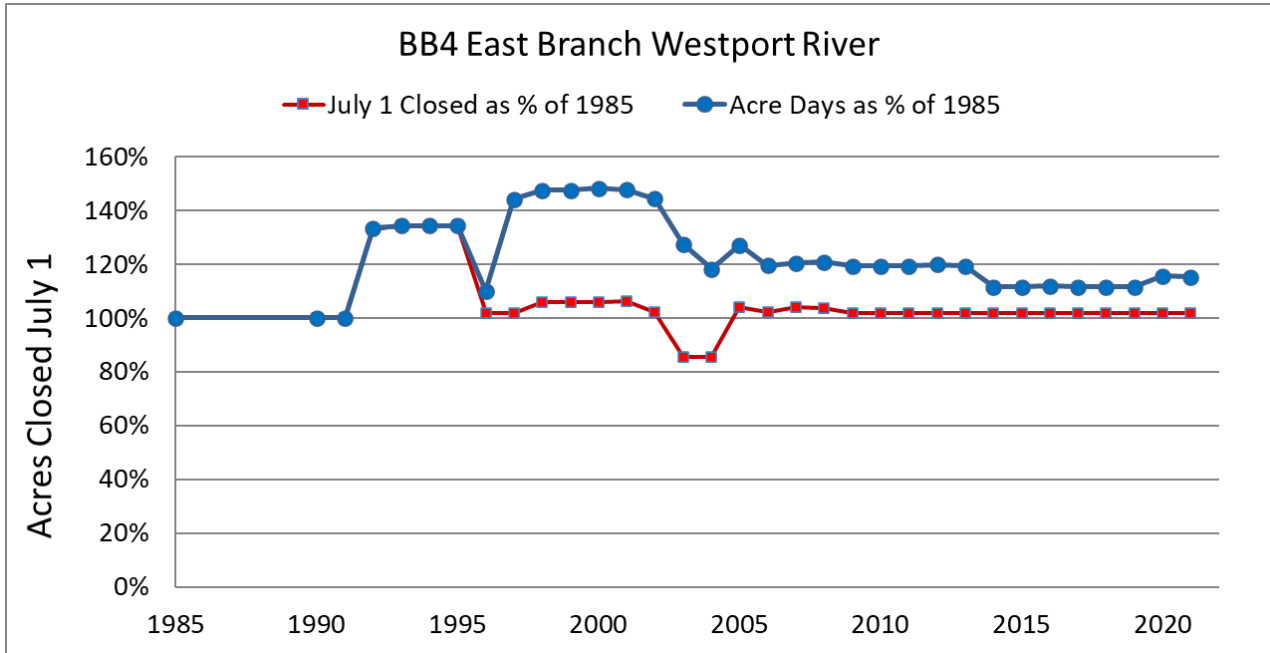


Fig. 17 Closure history of DSGA BB3, West Branch of the Westport River



BB4: East Branch Westport River

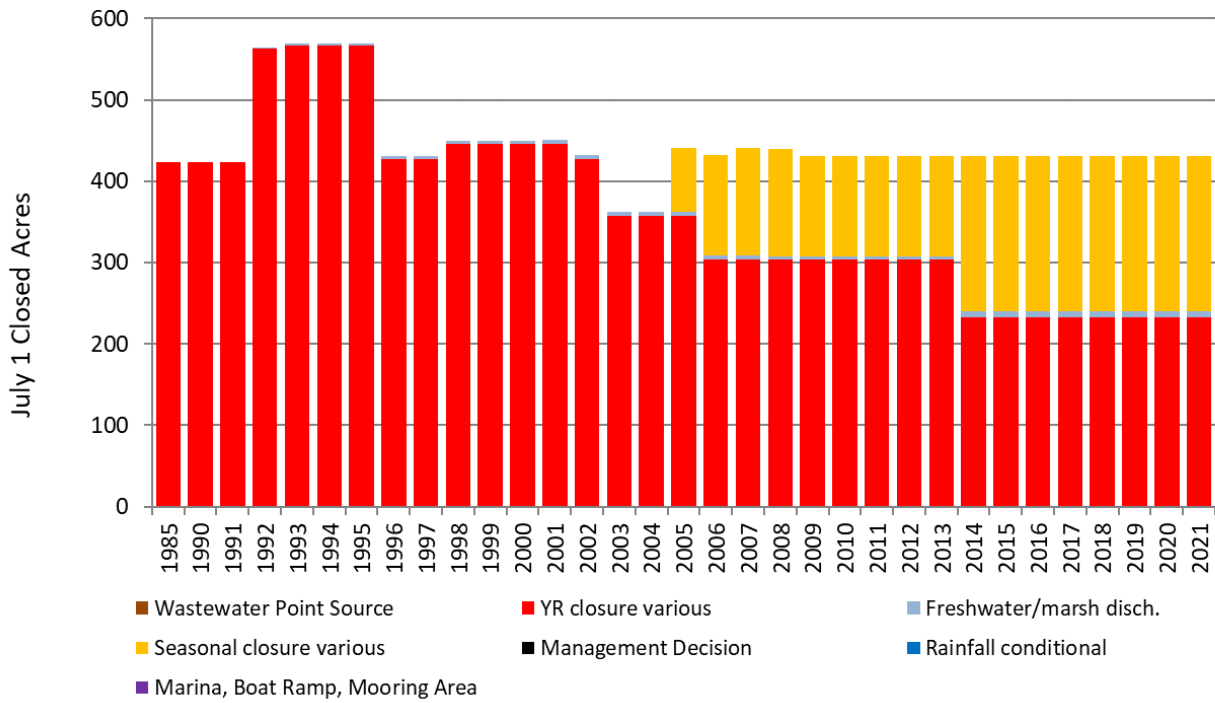
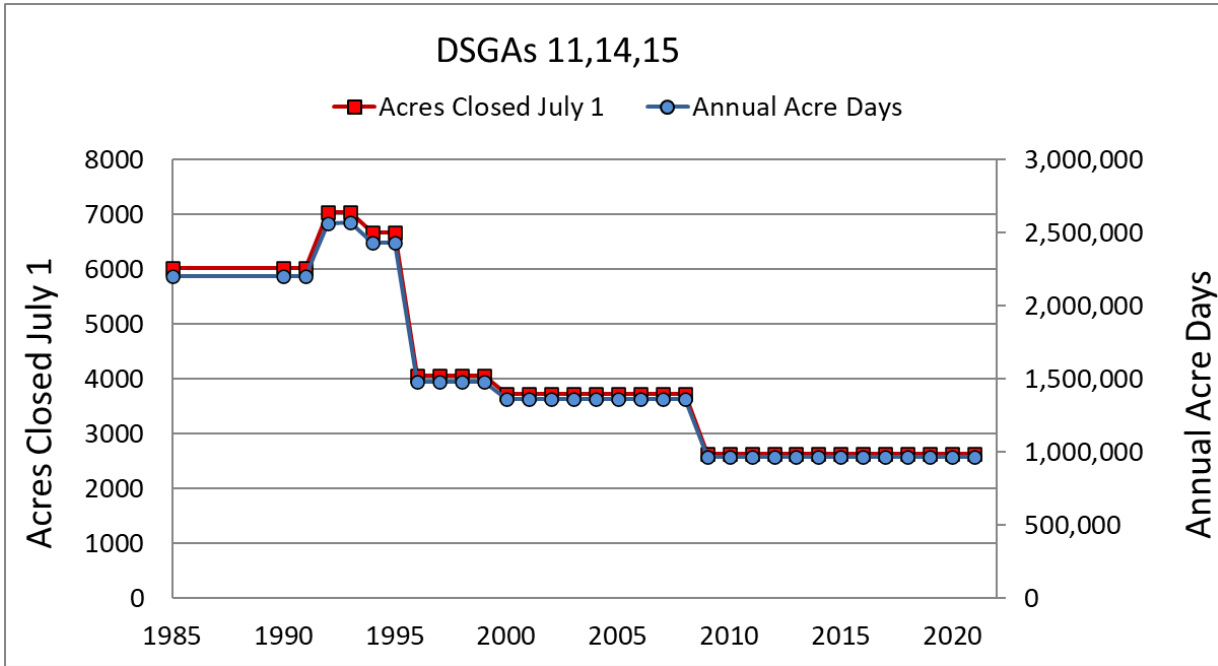


Fig. 18 Closure history of DSGA BB4, East Branch of the Westport River



DSGAs 11, 14, 15

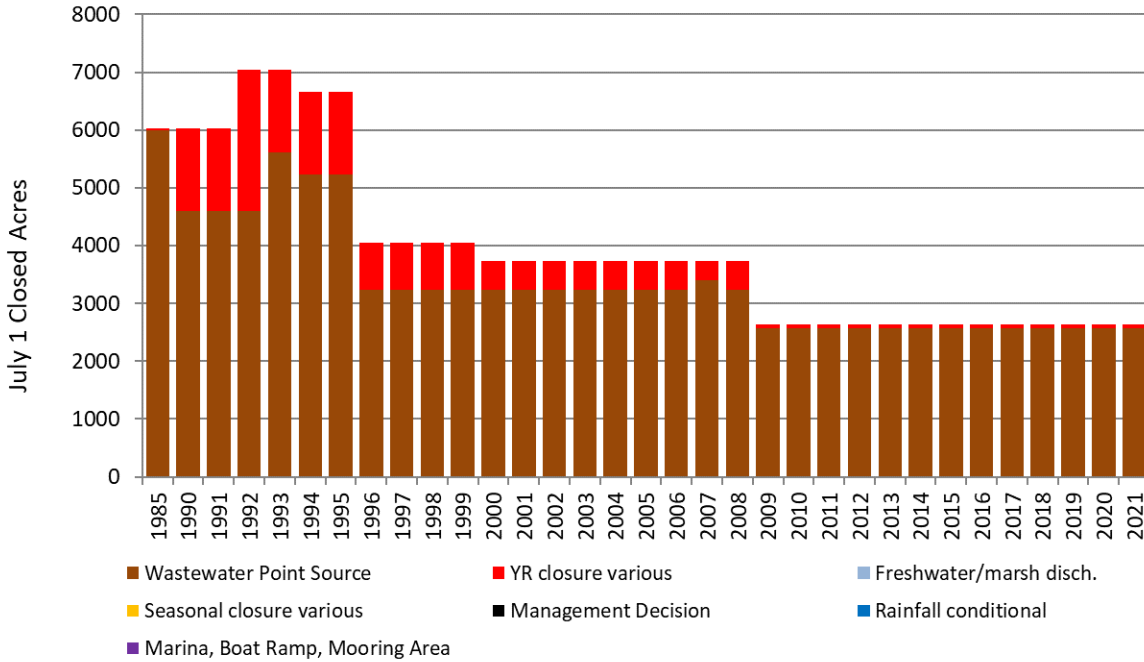
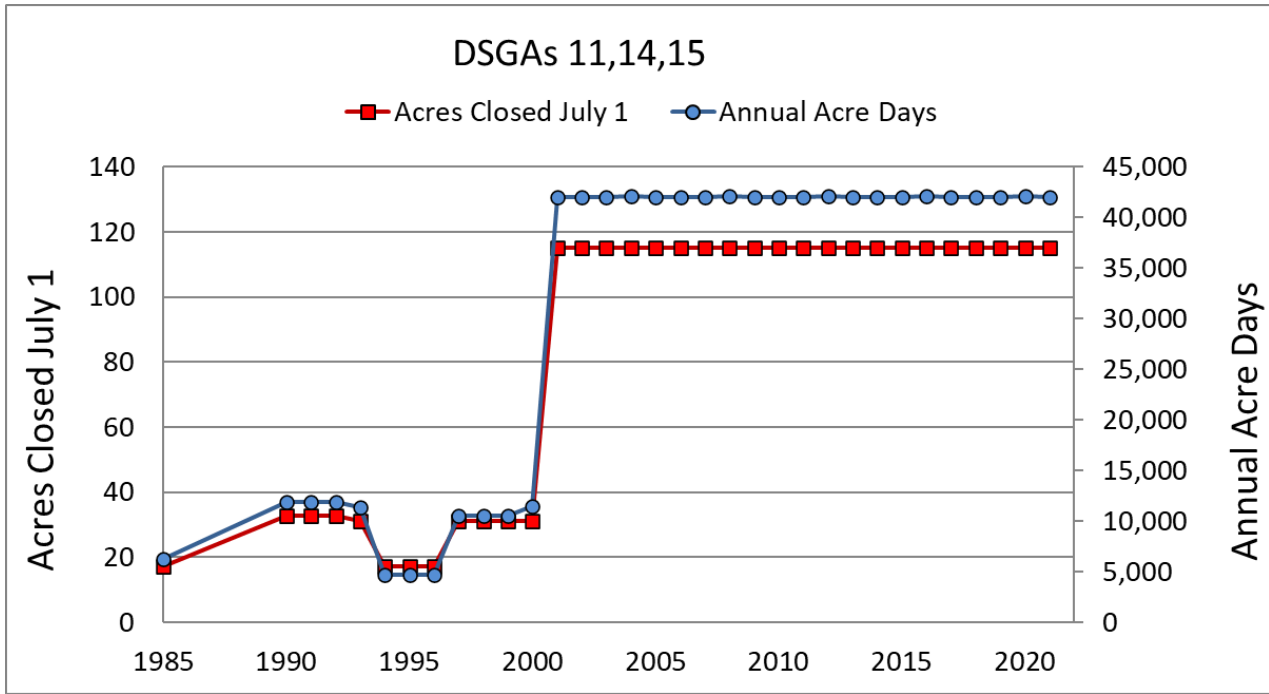


Fig. 19 July closures in DSGAs BB11, BB14, and BB15, Outer New Bedford Harbor areas, 1985-2018. Top: July 1 Acres closed versus acre-days; Bottom: closure by cause.



BB52: Wild Harbor Wild Harbor River

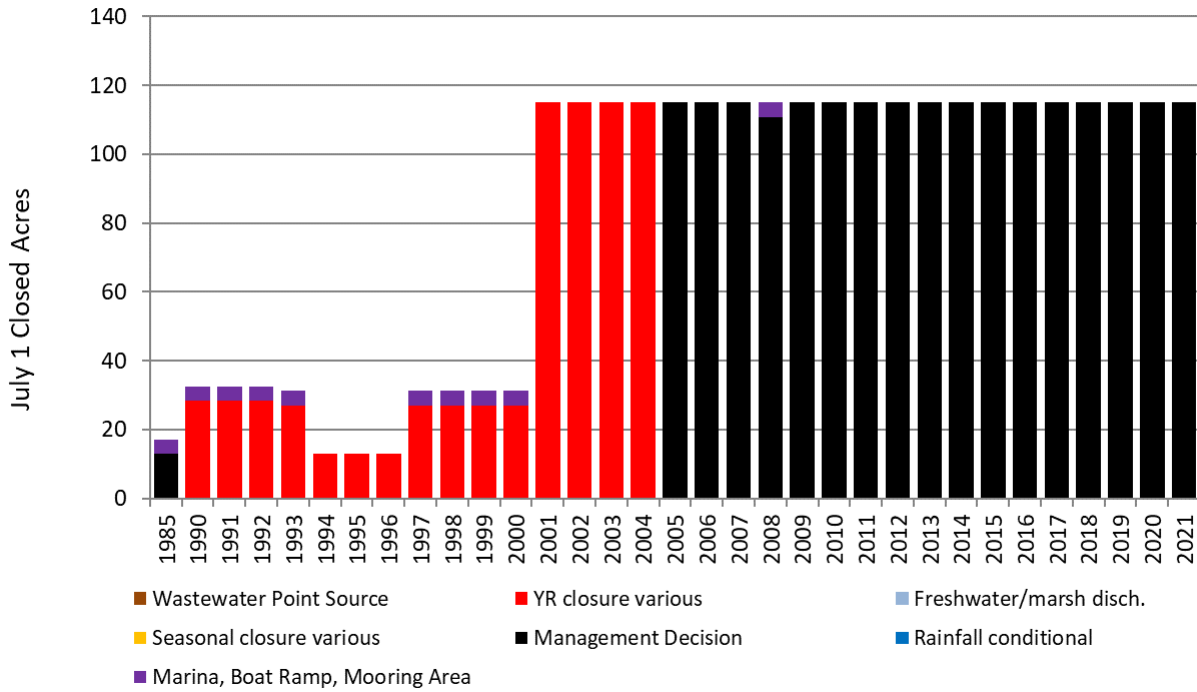
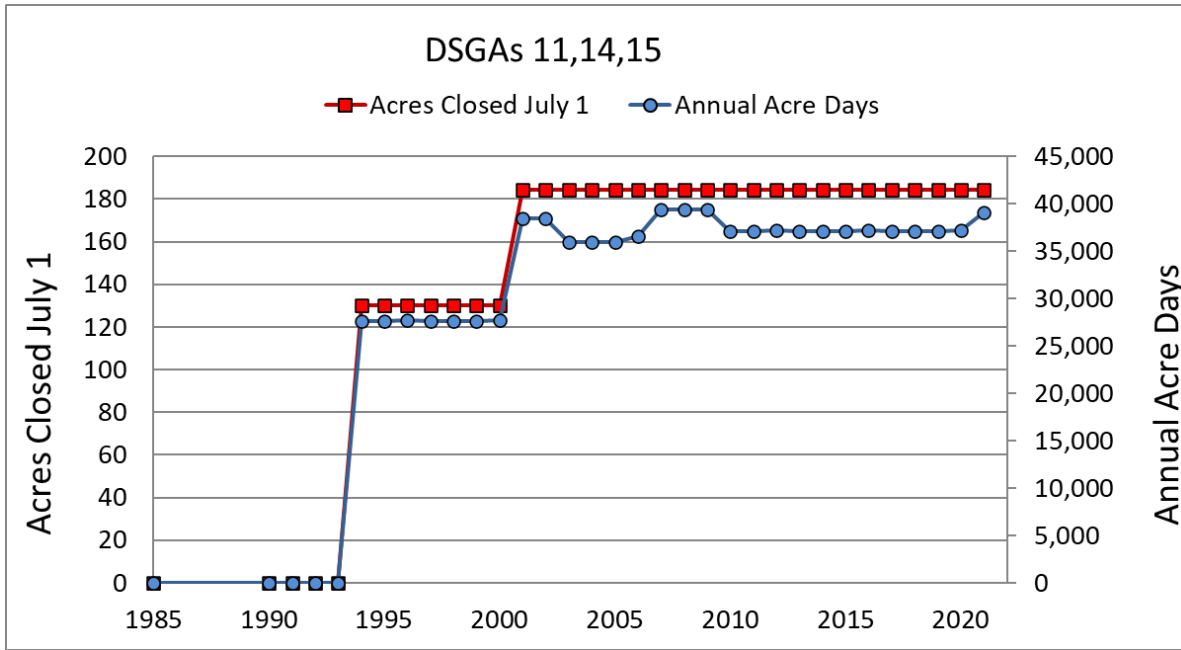


Fig. 20 Closure history of DSGA BB52 Wild Harbor Wild River.



BB54: West Falmouth Harbor

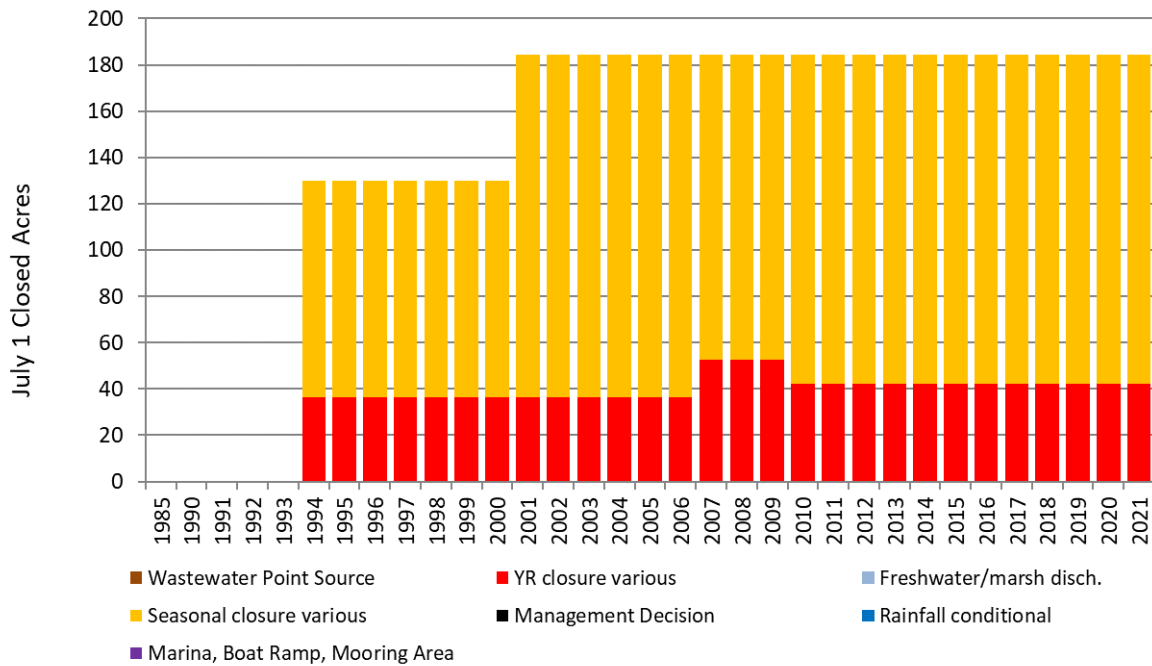
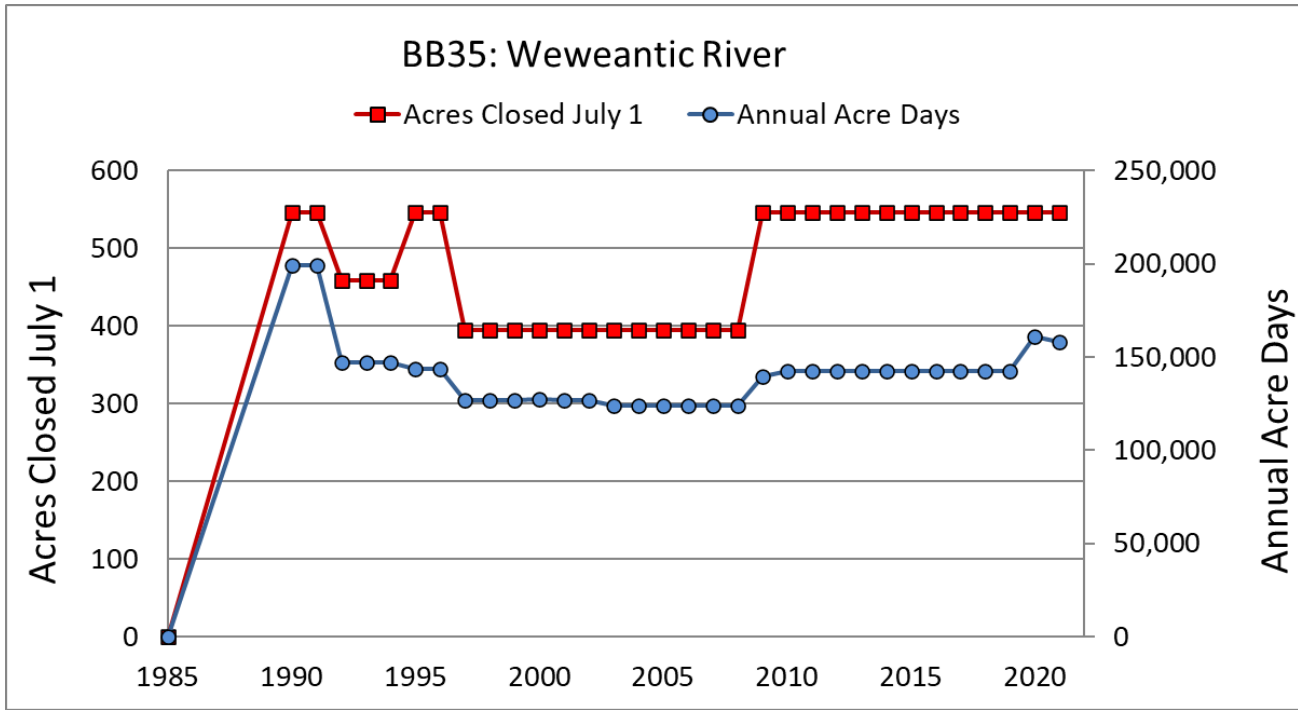


Fig. 21 Closure history of DSGA BB54, West Falmouth Harbor.



BB35: Weweantic River

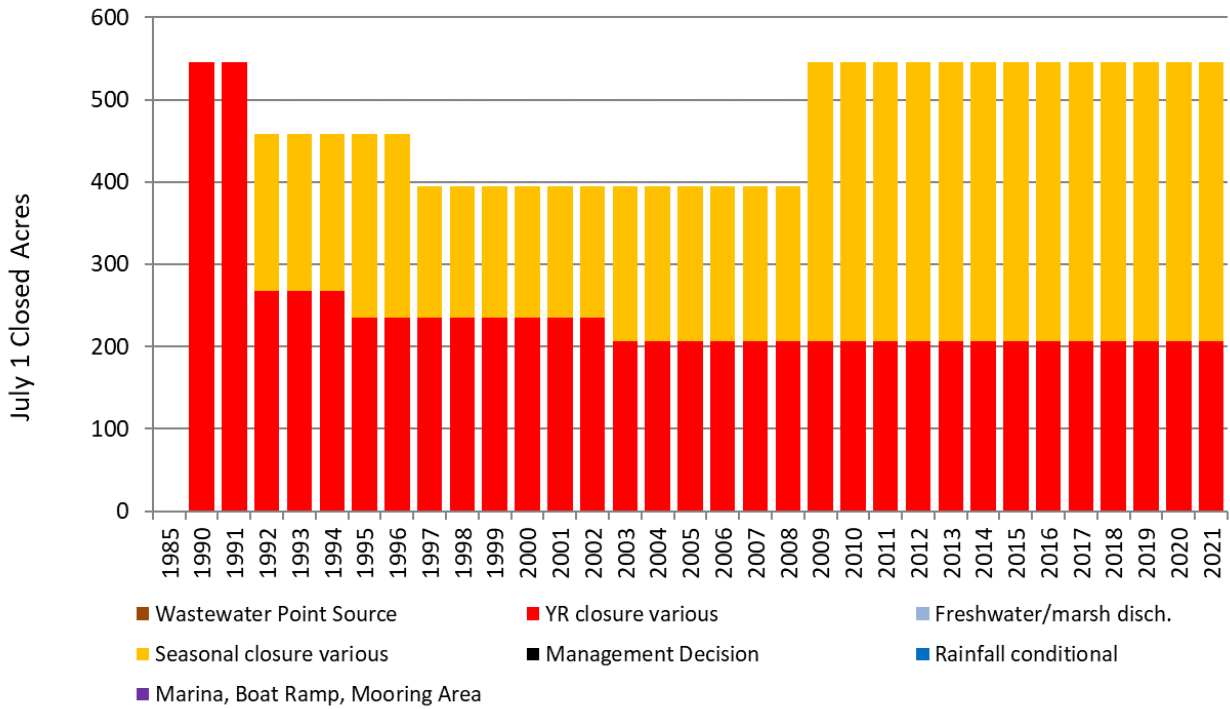
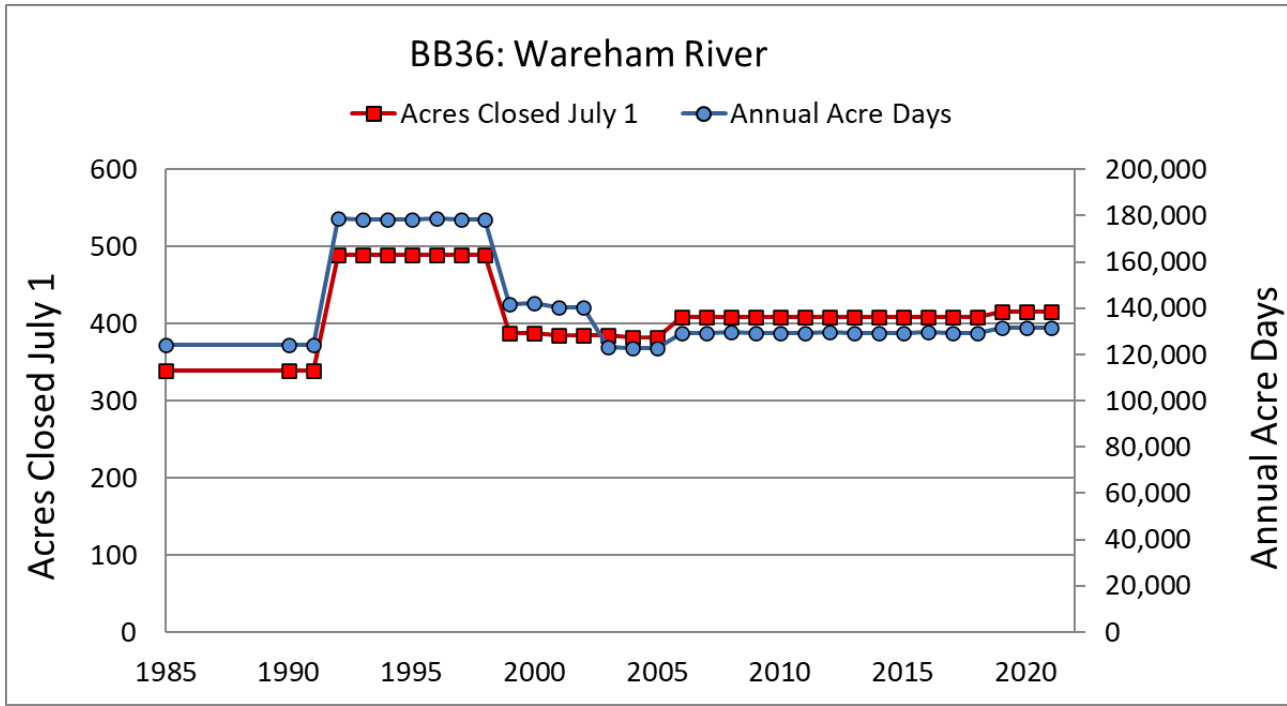


Fig. 22 Closure history of DSGA BB35, Weweantic River



BB36: Wareham River

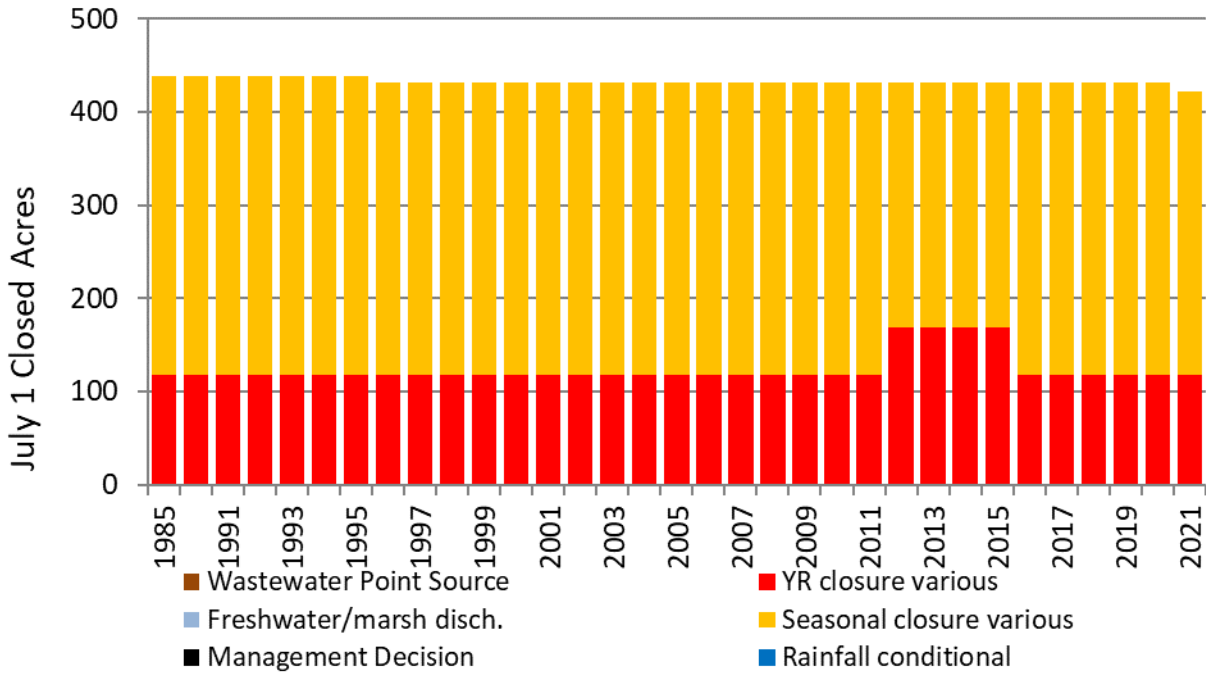
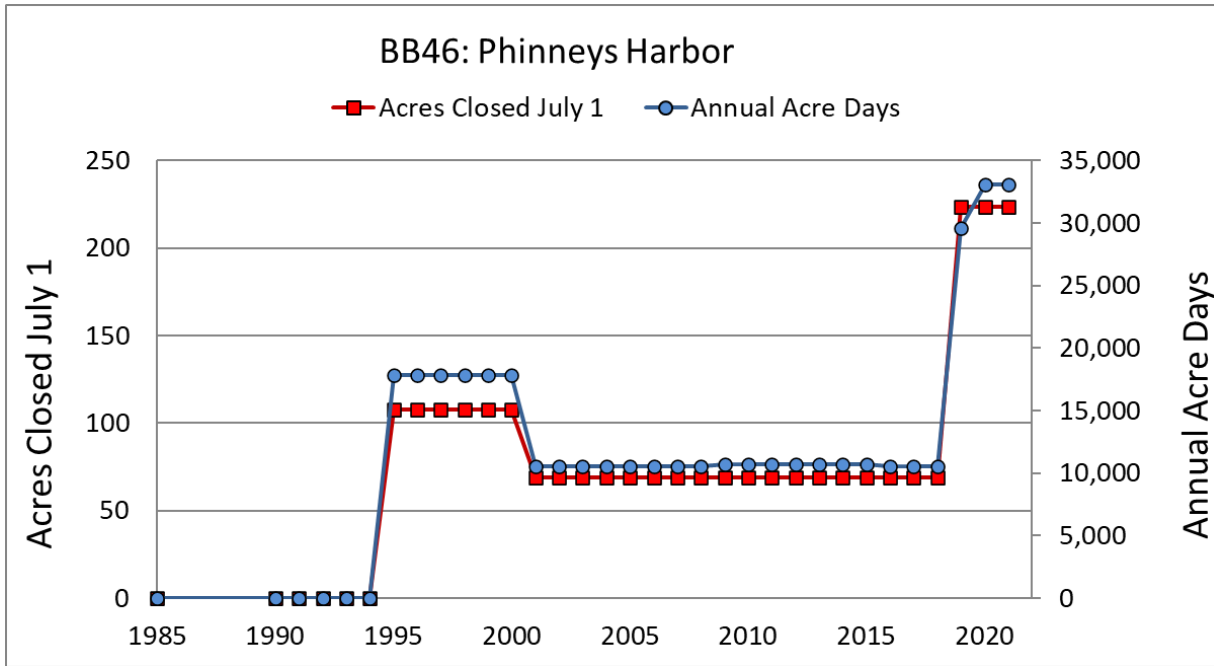


Fig. 23 Closure history of DSGA BB36, Wareham River



BB46: Phinneys Harbor

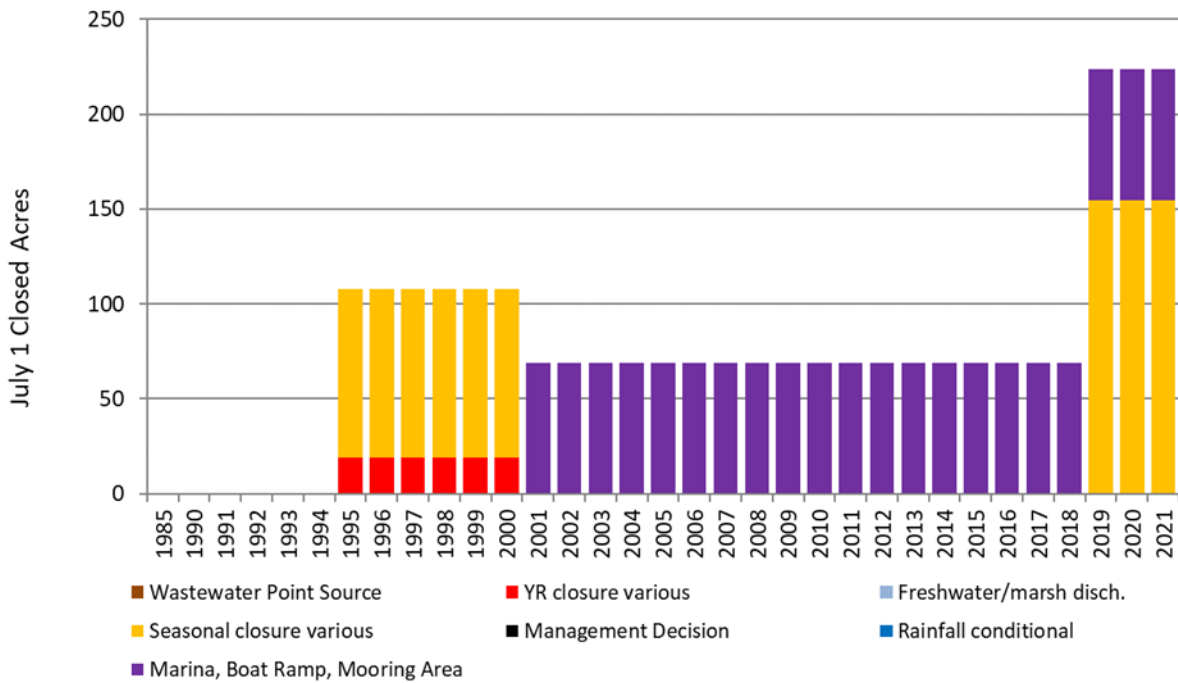
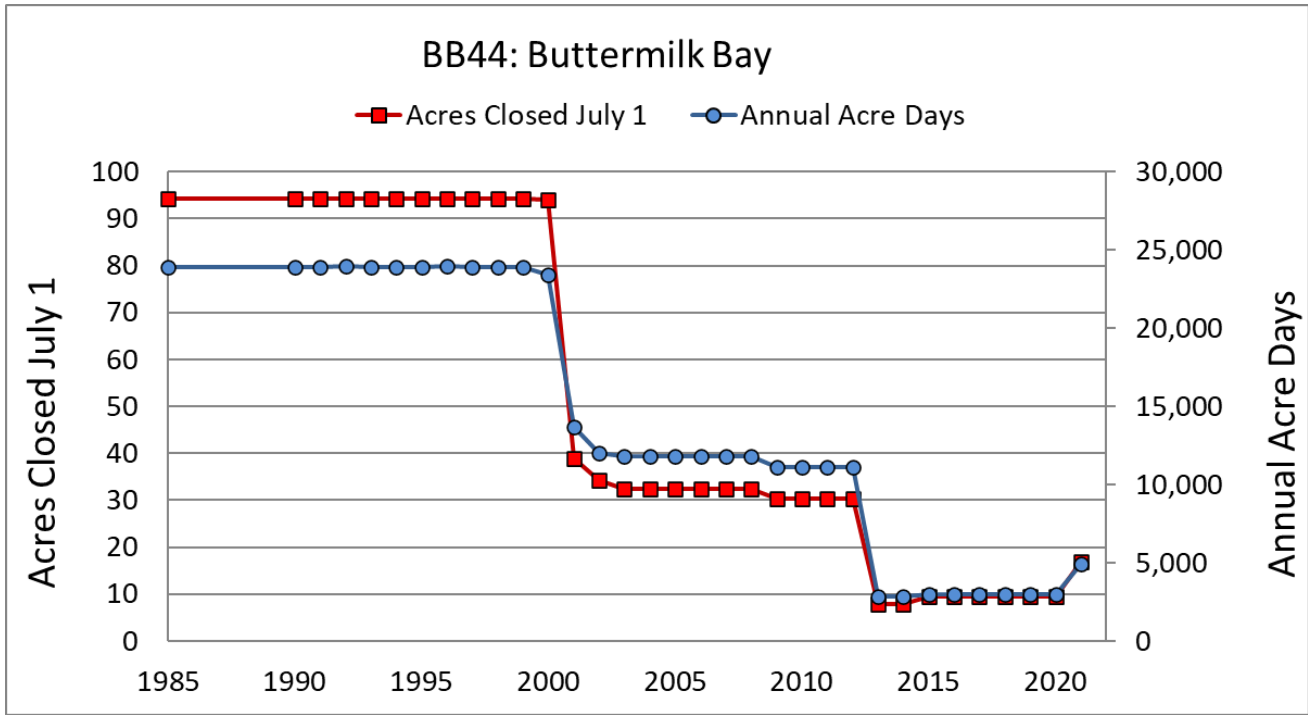


Fig. 24 Closure history of DSGA BB46, Phinneys Harbor



BB44: Buttermilk Bay

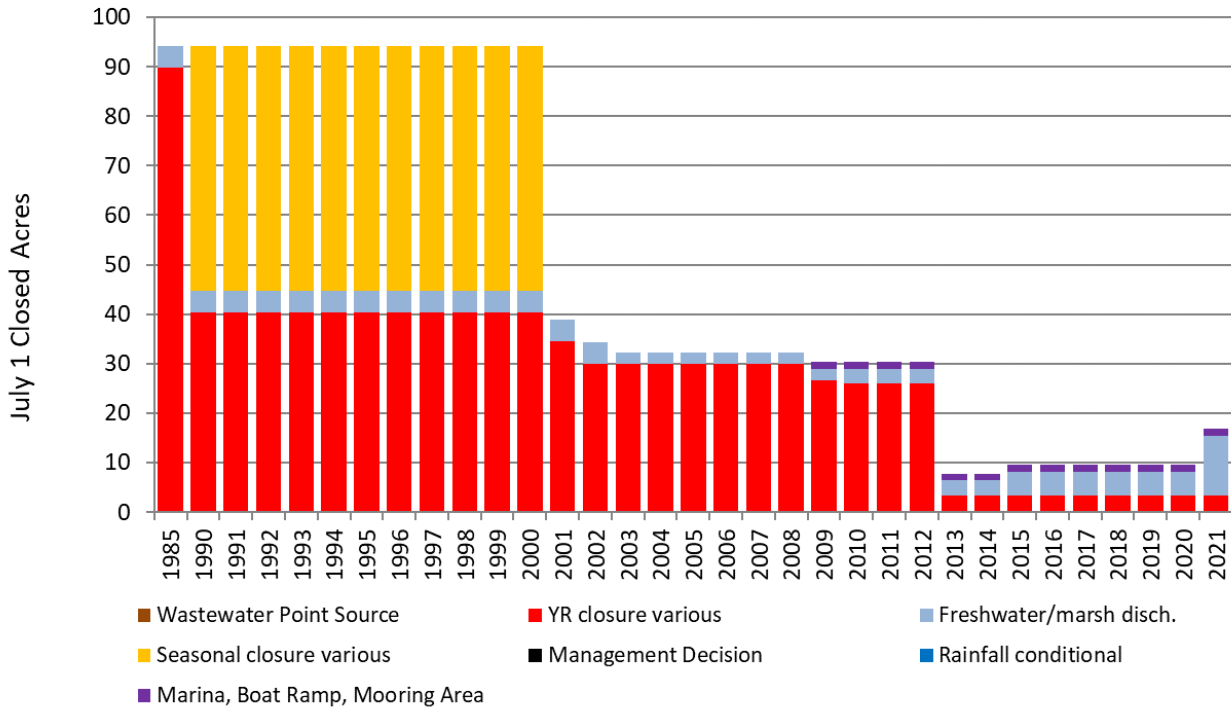
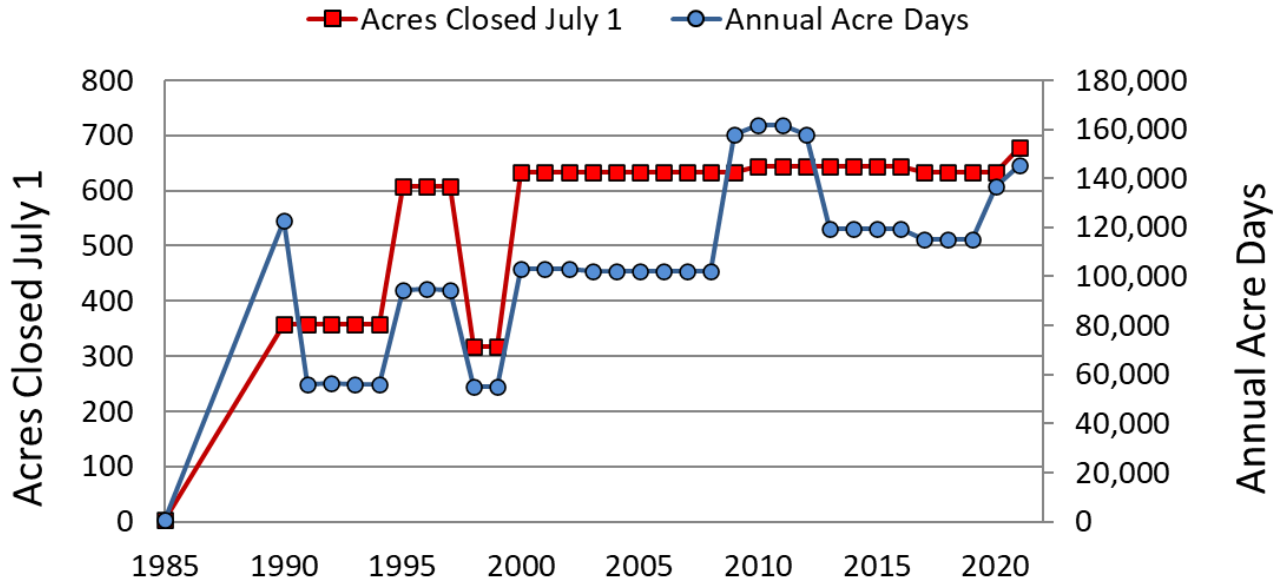


Fig. 25 Closure history of DSGA BB44, Buttermilk Bay

Nasketucket Bay and South Side of Sconticut Neck and West Island



Nasketucket Bay and South Side of Sconticut Neck and West Island

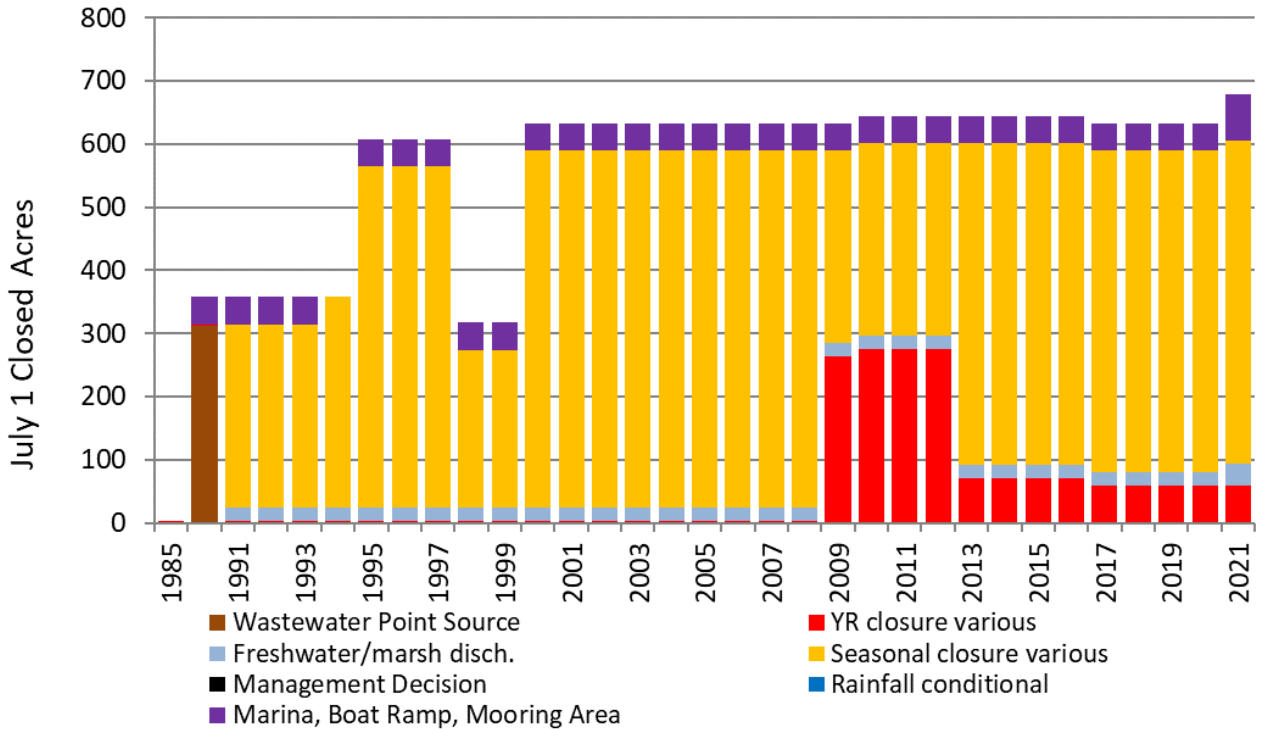
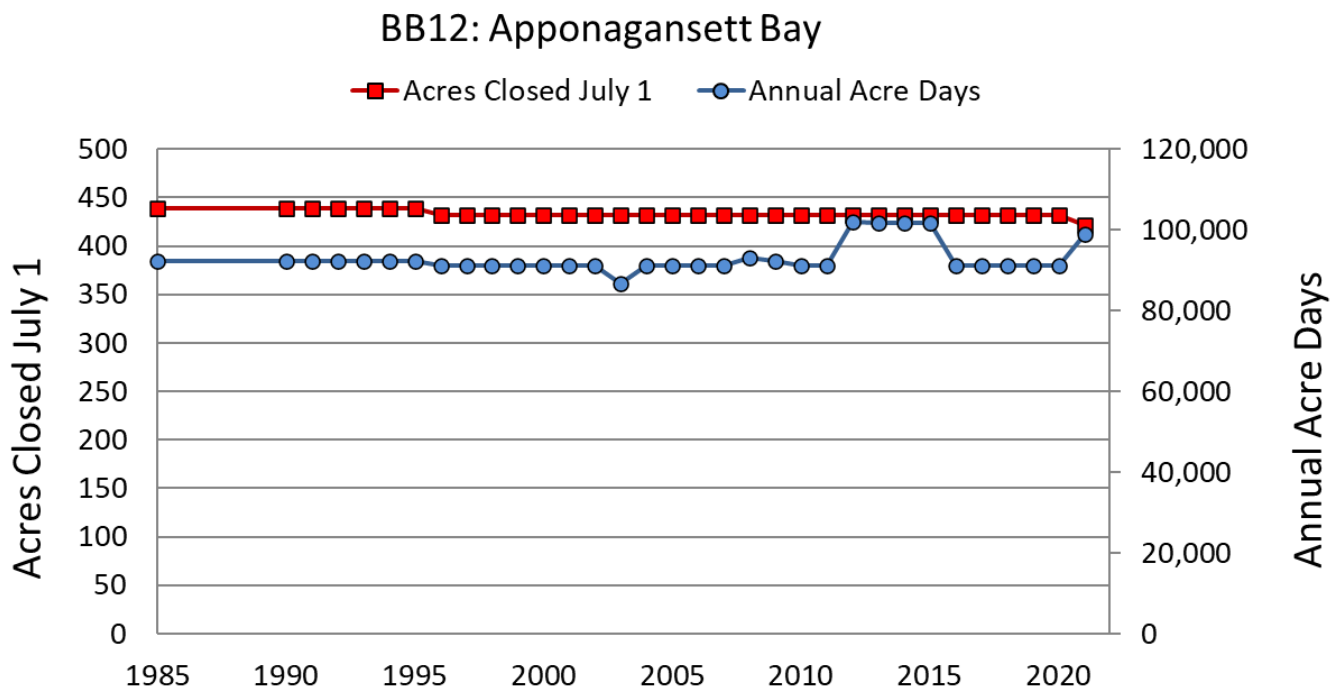


Fig. 26 Closure history of DSGAs BB17,18,21,22 in Nasketucket Bay and South Side of Sconticut Neck and West Island



BB12: Apponagansett Bay

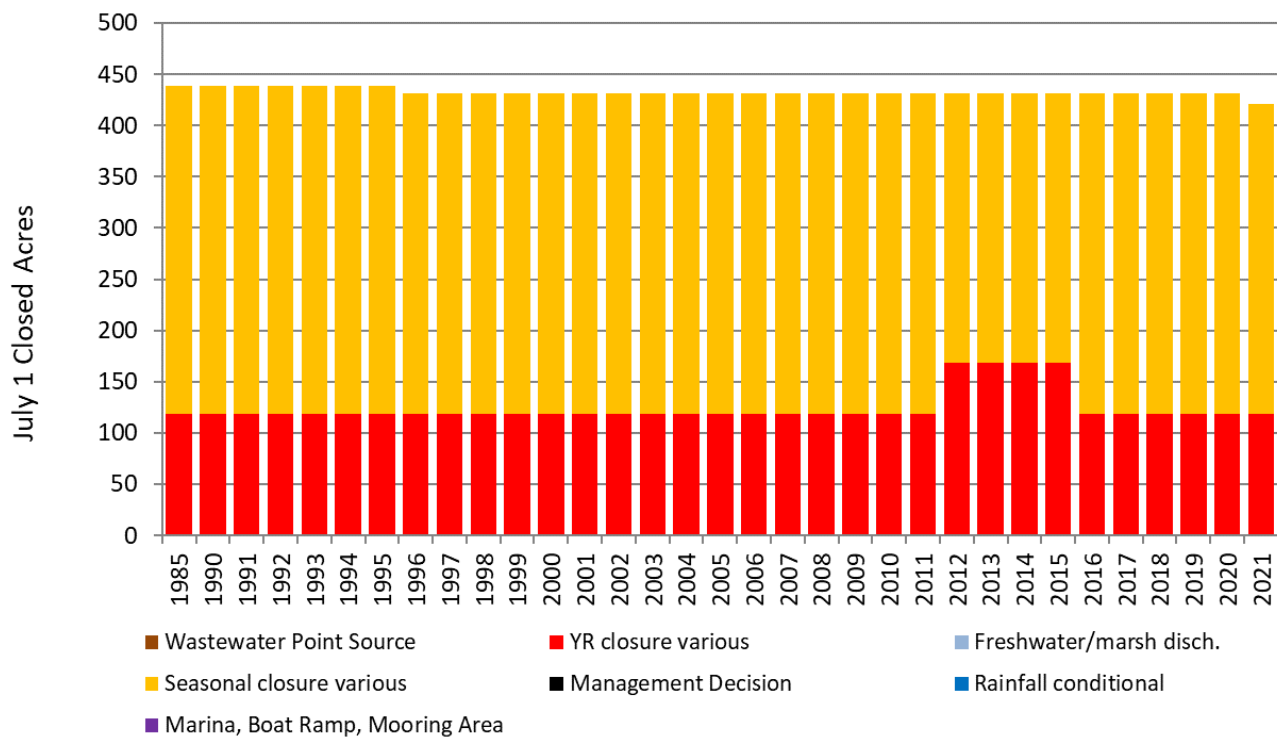


Fig. 27 Closure history of DSGA BB12, Apponagansett Bay.

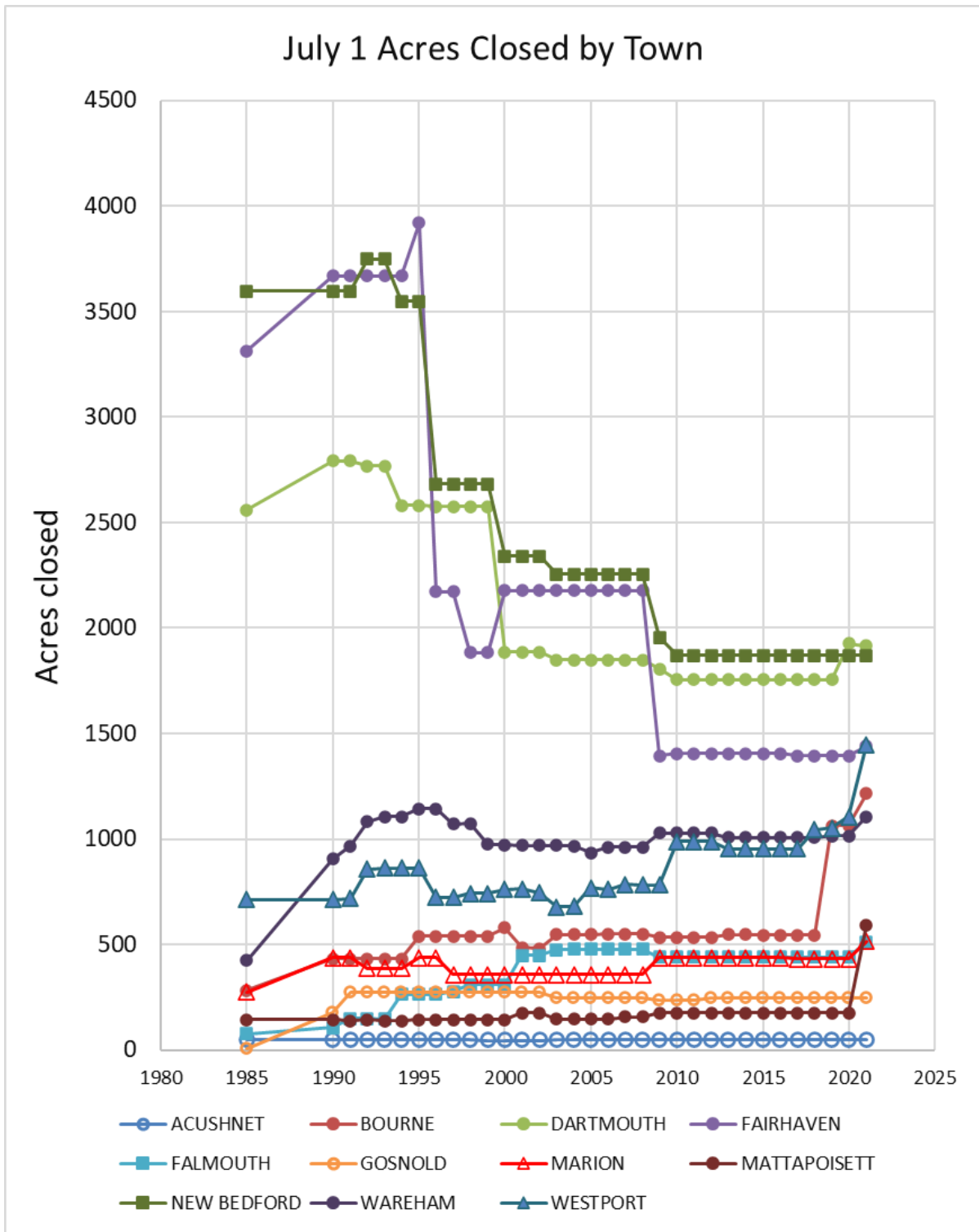


Fig. 28 July 1 acres closed for each municipality during the study period.

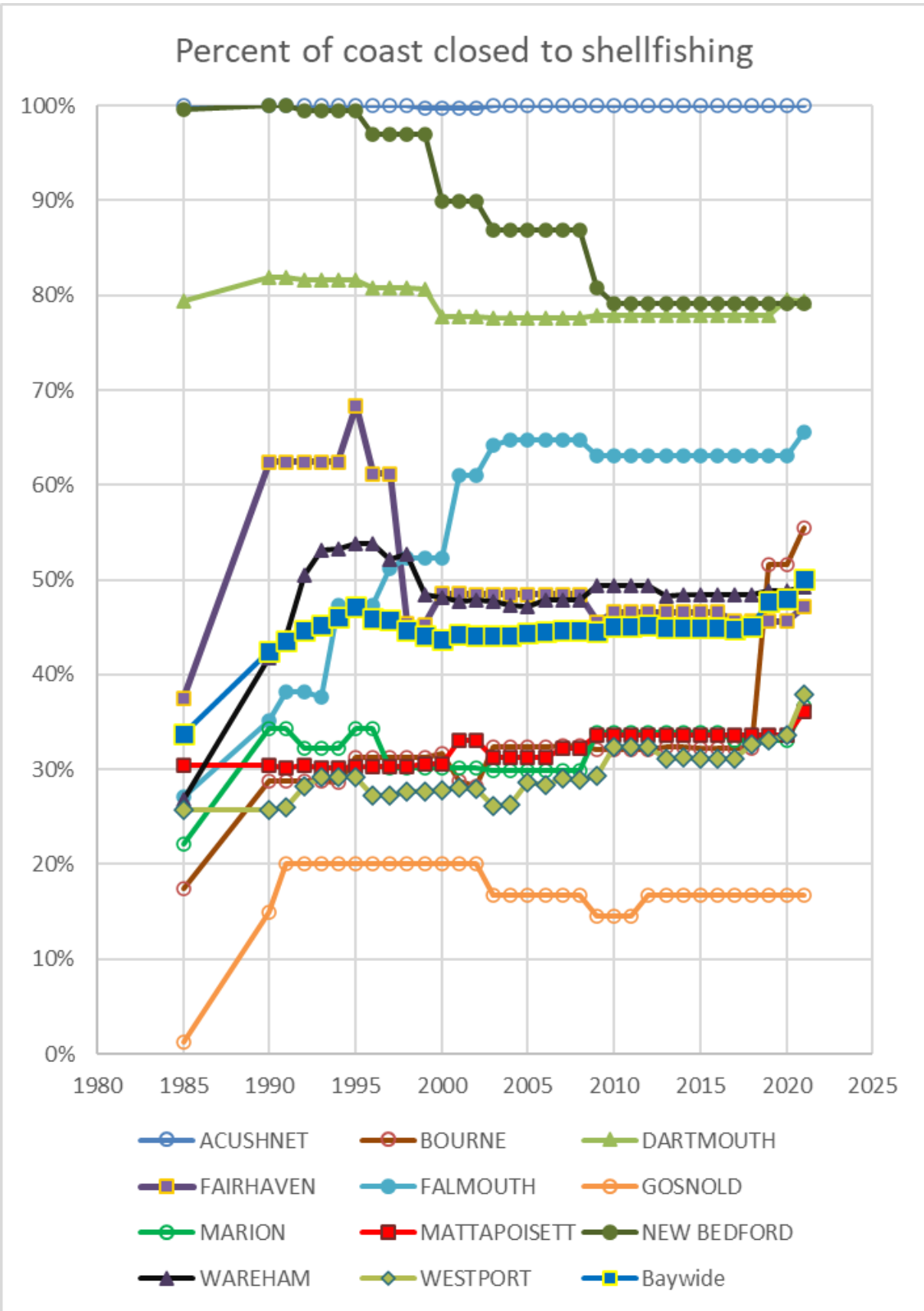


Fig. 29 Shellfish bed closures on July 1 as a percent of the municipality's marine coastline over time.