

Appendix B

Characterization of Individual NOAA Codes

Oyster Management Review:

2010-2015

A Report Prepared by

Maryland Department of Natural Resources

Draft Report

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Introduction

A review of baywide oyster population and harvest characteristics over time in non-sanctuary areas provides a context to discuss the effectiveness of the location of the Public Shellfish Fishery Area. Available data on oyster populations can be used to examine general oyster characteristics, background information, and oyster population trends over time for each unique area. Recognizing that trends for any given area may shift as future environmental conditions change, an examination of oyster populations before and after the 2010 management regulation changes will facilitate informed discussion of the general characterization of the oyster population in areas available for commercial harvest.

In the late 1980's, small-scale geographical boundaries called NOAA Codes were developed for the reporting of commercial fishery harvest data (Figure B.00-1). Commercial oyster harvest has been reported using these NOAA Code areas since 1988. This appendix will use the NOAA Code boundaries to assess oyster populations and characterize the harvest, which will provide a more detailed examination of the oyster population than would a single baywide examination.

This appendix includes data from Department of Natural Resources programs which have particular information on each NOAA Codes. Not all types of data are available for all NOAA Codes, and the scientific value of the different types of data may vary. Data used in this assessment include the following: replenishment activities, oyster population characteristics (oyster count, recruitment, size structure, and mortality), and harvest. Data used to characterize the productivity of NOAA codes were collected in non-sanctuary areas only. In other words, if a NOAA code encompasses both sanctuary and PSFAs, data for this analysis were collected only from the PSFAs that have remained open to harvest.

The various data sources used in the assessment of each NOAA Codes are described below. The objective and term of the sampling program are presented for each data source. The specific data sets derived from the program are described, and the value and limitations of each of the data sets for assessment purposes are identified.

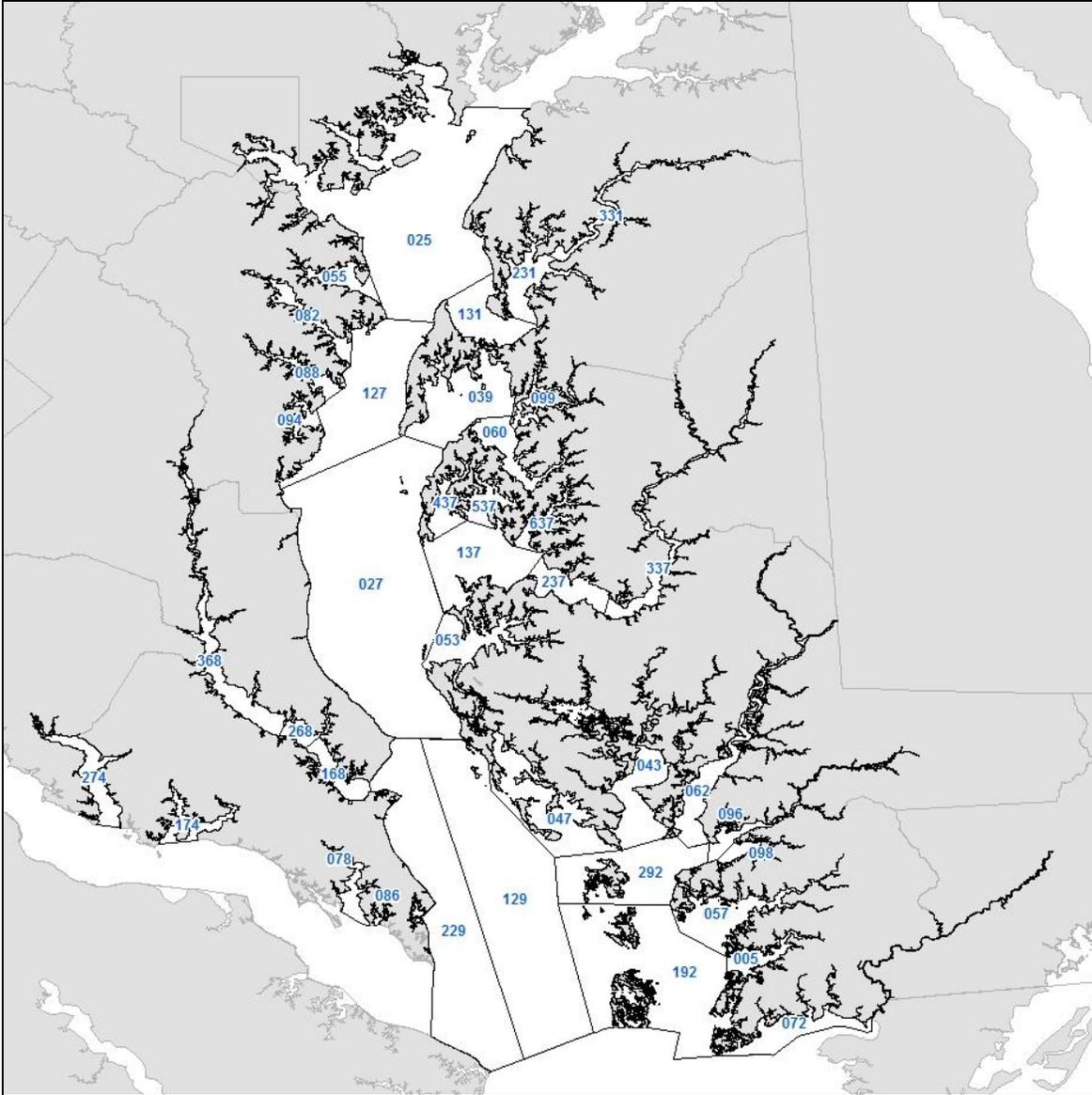


Figure B.00-1. Map of the NOAA Code areas within the Chesapeake Bay.

Data Sources for General Characterization of the Non-Sanctuary Oyster Populations and Harvest

Bay Bottom Surveys

Bay bottom mapping is important to determine the different substrate types of the bay bottom and, if possible, oyster bar boundary delineation. Two surveys have been completed in the past: the Yates Oyster Survey which delineated oyster bars from 1906 to 1912 and the Maryland Bay Bottom Survey which categorized areas of bay bottom types from 1974 to 1983. There has not been a baywide bottom survey completed recently of the area open to the public fishery to determine change in bottom types since 1983. Therefore, bottom type information is not included in the below sections.

Replenishment Efforts

Almost every oyster bar in Maryland has been manipulated over time. In public fishery areas, replenishment efforts were conducted to improve oyster bar productivity and increasing harvest. Enhancements include planting fresh and dredged shell, transplanting natural, wild seed, and planting hatchery-reared spat in hopes of increasing oyster populations. Records of these activities date back to 1960, but shell and seed plantings since 1990 will be presented in this appendix to be consistent with the time period of the general oyster population characteristics to be described for each NOAA Code. Planting activities occurring in areas open to public shellfish harvest are defined as replenishment activities. Replenishment planting activities were used to enhance the public fishery for economic benefit.

The amount of replenishment activities varies per NOAA Code. Some NOAA Code have received numerous plantings, while others received very few or none. The annual planting information provides a general sense of how each NOAA Code was manipulated over time. An analysis to determine if replenishment activities contributed to an increase in oyster population is beyond the scope of this report, since a robust statistically designed project would have to be conducted in order to assess shell and seed planting effectiveness. This type of project is ongoing for smaller-sized areas and may be referenced when applicable for a particular NOAA Code.

Only replenishment activities that have occurred in the area presently available to the public fishery will be presented in this appendix.

There is some uncertainty around the planting activity data recorded in earlier years. This is due to the precision of technology used to record planting locations and incompleteness of records. Prior to around the year 2000 seed and shell plantings were charted using coordinates obtained with LORAN-C, then transposed by hand onto paper or mylar charts, and then digitized by hand for use in electronic format, specifically with ArcGIS and other computer mapping software. Each step is a potential source of error. According to the manufacturer, the absolute accuracy of

LORAN-C varies from 0.10 to 0.25 nautical miles (185 to 463 meter) compared to GPS which is typically less than three meters. The location of plantings prior to 2000 are not known with the same level of accuracy as those post-2000 and could be off potentially by up to 0.25 nautical miles, or an order of magnitude more than modern plantings. With this margin of error, there is much uncertainty of where historic plantings were with regard to modern sanctuary lines or with the digitized Yates bar boundaries.

When the records exist, the volume and area of historic planting is known relatively well. Barges of known volume and carrying capacity were used and carefully measured, and individual workboats used to haul seed were measured and each load was inspected prior to planting. Unfortunately, many records are missing or incomplete. In several cases the volume was known but the area was not recorded or was lost. In some cases the area was recorded but the volume was not recorded or was lost. A few years ago, Department of Natural Resources staff spent a considerable amount of time going through old records and reports to try to fill in as many blanks as possible to update a database and GIS layer with this information. In many cases over the five decade time series, including those between 1990 and 2010, a “best guess” for the volume of material had to be calculated based on available information such as average density of plantings and estimated acreage. Post-2010, the completeness of the planting records has improved as has the precision with which area has been measured. Due to these two issues (lack of precision and incompleteness) surrounding older plantings, caution must be exercised when stating the total amount of planting activity since 1990 in a given area.

Longevity of plantings should also be considered when examining replenishment activities. On average, in the absence of disease it is thought that oysters can live up to 20 years¹. Even without disease related mortality, seed plantings in the Chesapeake Bay for harvest purposes are not likely to last more than three to five years due to harvest pressure. Longevity of shell can vary due to type of shell, pH and alkalinity, sediment burial, and attack from shell-boring organisms. The shell dissolution rate for fresh shell has been found to be much faster than for dredged shell. The half-lives of shell were computed by Waldbusser et al (2011)² and the results ranged from roughly one year for fresh shell under mid and low pH to nearly 40 years. This rate however does not account for loss of shell due to burial, transport, and attack from sponges and other shell-boring organisms, all important sources of shell loss in Chesapeake Bay. A further understanding the fate of historic plantings is important but beyond the scope of this report.

Annual Fall Oyster Dredge Survey

The purpose of Department’s Annual Fall Oyster Dredge Survey (Fall Survey), conducted since 1939, is to assess the overall health of the Maryland’s oyster population. The Fall Survey represents the longest continuous and most geographically comprehensive oyster survey in

¹ Buroker NE. 1983. Population genetics of the American oyster *Crassostrea virginica* along the Atlantic coast and Gulf of Mexico. *Marine Biology* 75:99-112.

² Waldbusser, G.G., R. A. Steenson, and M. A. Green. 2011. Oyster Shell Dissolution Rates in Estuarine Waters: Effects of pH and Shell Legacy. *Journal of Shellfish Research*, Vol. 30, No. 3, 659–669

Maryland. Although the Fall Survey was not developed explicitly for monitoring NOAA Code areas within the public fishery and cannot be used to determine the density of oysters or calculate the total population size, it is useful for tracking general long-term trends of the oyster population characteristics.

The original Fall Survey design included the sampling of spatfall and relative oyster abundance at a subset of Maryland's oyster bars. This report utilizes Fall Survey data since 1990, when the sampling methodology was altered to include disease and biomass components along with the spatfall and relative abundance information. In the fall each year, between 311 and 385 samples are collected. Some NOAA Codes may have samples taken on multiple bars annually, some have only one oyster bar sampled annually, and some have not been sampled at all by the Fall Survey. For each sample, one or (in the case of the 43 fixed disease and biomass bars) two half bushel subsamples of material are collected by an oyster dredge. Detailed methods for the fall survey may be found in Tarnowski (2015)³.

For each sample collected by the Fall Survey, the number of live oysters per one bushel of material collected is counted. Oysters are classified as spat, small-sized oysters, or market sized oysters. Spat are less than one year old. Small-sized oysters are between one and two years old, and generally greater than 40 mm and always less than 76 mm. Market-sized oysters are always greater than 76mm and generally older than 3 years. Changes in the number of oysters over time can provide a general sense of change in oyster abundance and age/size structure.

Samples taken on a fixed 43 bar subset of all the oyster bars sampled provide detailed information on oyster sizes annually. Oyster shell height in millimeters (mm) is recorded for all oysters collected. Oyster size structure is assessed by calculating the frequency distribution of oysters in each five mm size class. A healthy oyster population would have a size distribution with oysters in all size classes from 0-5 mm to greater than 120 mm. This would indicate multiple age classes in the population.

Biomass is estimated from field-collected oyster shell height using laboratory-derived height-weight relationships. Weight is calculated in grams of dry tissue weight. Increases in biomass may reflect increase in the number of oysters and/or oyster size. Greater biomass results in greater water filtration capacity.

Total Observed Mortality is an indicator of annual mortality rates of small and market sized oysters. Mortality can occur from disease or other natural factors such as freshets. Mortality is estimated based on the total count of small and market-sized live oysters and the total count of small and market-sized boxes (dead oysters with the valves still articulated).

Information on oyster diseases is collected from the same fixed subset of 43 bars on which shell heights are collected. Dermo (*Perkinsus marinus*) and MSX (*Haplosporidium nelsoni*) infection prevalence (the percentage of oysters infected) and intensity (the severity of infection) are measured from 30 oysters collected at each site. Disease prevalence and intensity both relate to mortality. For example, all of the oysters in a sample may be infected, but at such low intensity

³ Tarnowski, 2015. Maryland Oyster Population Status Report, 2014 Fall Survey. http://dnr.maryland.gov/fisheries/Documents/FSR_2014.pdf

that few oysters are in danger of dying in the near future. Intensity is based on a 0 to 7 scale with values of 5 or greater representing lethal levels.

The Fall Survey data will be used to explore general characteristics of the oyster populations within those NOAA Codes that were sampled in the Survey. Data presented will examine changes over time, based on the average number of oysters per a bushel of material, oyster shell height, live oyster biomass, recruitment, mortality, and disease on oyster bottom within each NOAA Code.

Seafood Dealer Reports and Oyster Harvester Reports

The Department collects harvest data using two methods: seafood dealer reports and oyster harvester reports. The volume of oysters caught each day by each license holder is reported to the department in bushels. One Maryland oyster bushel is approximately 46 liters, notably larger than a standard U.S. bushel (35 liters).

Seafood dealers must report their oyster purchases to the department. These reports are called buy tickets and have been collected since the 1970's. Buy tickets are submitted weekly by licensed dealers who buy oysters directly from harvesters on the day of catch. Information reported on the buy tickets includes the broad location where harvest occurred (the NOAA Code Area), quantity of oysters harvested, and date of harvest. Both the dealer and the harvester must sign the buy ticket and include their names and license numbers. Harvest reported on buy tickets will be reviewed only since 1990, when NOAA Code Area reporting was already being implemented. Reporting harvest from 1990 to 2015 will be consistent with time frame of the Fall Survey results being presented in the Appendix.

Starting in 2009, the Department required oyster harvesters themselves to report their catch. These reported are submitted to the department monthly. Information reported on the harvester reports include bar-specific harvest location, quantity of oysters harvested, gear used, and the date of harvest. Harvest reported up until June 1, 2016 will be presented in this appendix.

Due to the longer time series available from the buy ticket record, this is the standard data source for long-term trends in harvest. For applications where gear or oyster bar name is considered critical, the oyster harvester report data source is often used because generally these reports are more complete with regard to gear type and oyster bar name.

Overall Harvest and Effort in the Public Fishery

Maryland's oyster harvest has declined significantly since the 1880s (Figure B.00-2). The initial decline into the early part of the 20th century was driven presumably by overharvesting and loss of habitat, both associated with an absence of conservation laws⁴. In the later part of the 20th century, oysters were also affected by mortality from diseases, harvesting and habitat loss, including that from sedimentation and in some cases low dissolved oxygen.⁵

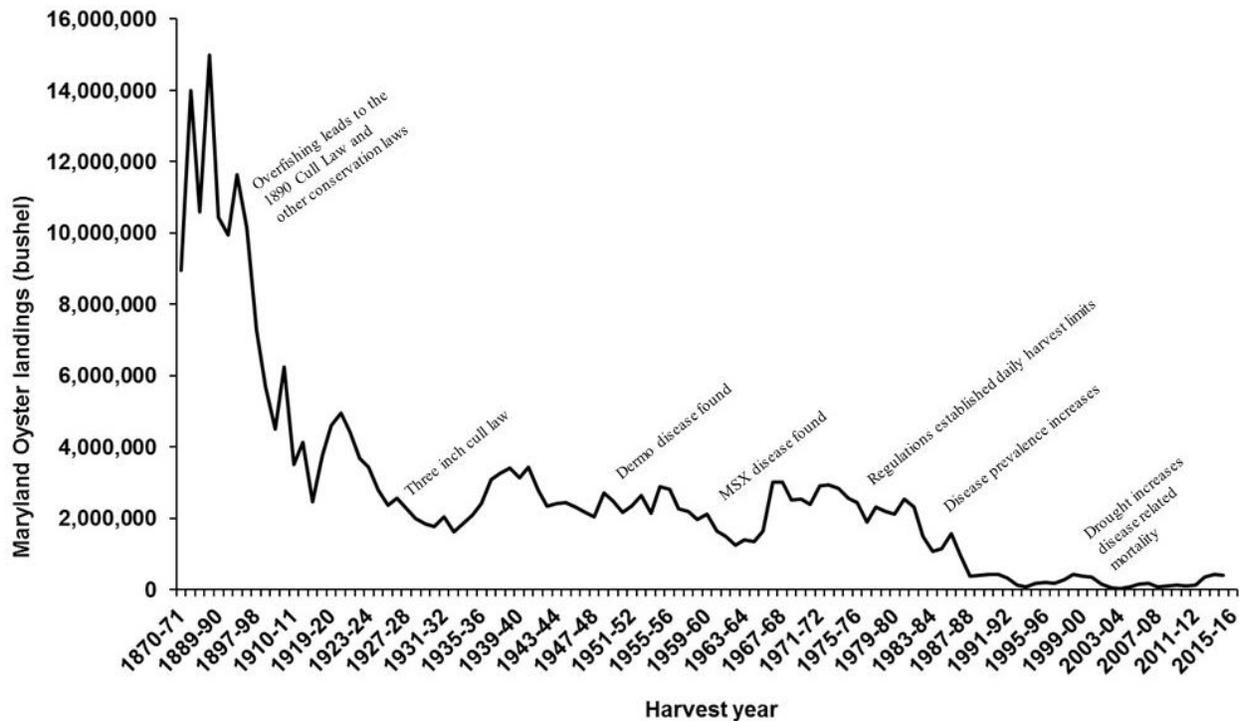


Figure B.00-2. Oyster harvest (Maryland bushels) in Maryland from 1870 to 2016.

Oyster harvest since 1990 has varied widely (Figure B.00-3). There have been numerous disease outbreaks since 1990 with the worst occurring during the drought years of 1999-2003. The lowest harvest on record (26,000 bushels) was recorded during the 2003-2004 season. The highest spatfall in the 26 year time period occurred baywide in 1997, and the high harvest that occurred in the years afterwards may be attributed to the 1997 spatfall. Since 2010, harvest has increased likely as a consequence of two good spatfall years (2010 and 2012) and relatively low (less than 15%) annual disease mortality. In the 2013-2014 season, harvest was the highest since 1990.

⁴ Brooks, W.K., 1891. The oyster, re-issued, 1996 Edition with a foreword by K.T. Paynter, Jr. Johns Hopkins University Press, Baltimore, MD, 230 pp.

⁵ IBID

Currently, oyster harvest is permitted from October 1st (November 1st for power dredging) to March 31st, Monday through Friday only. The current oyster season has been in effect since 1992. Harvest peaks in November and is the lowest in February and March (as reported on seafood dealer buy tickets) (Figure B.00-4). Monthly harvest since 2010 has displayed similar trends as in the years prior to 2010. Harvest per month as reported by the oyster harvester reports starting in 2009 show similar trends as the seafood buy tickets.

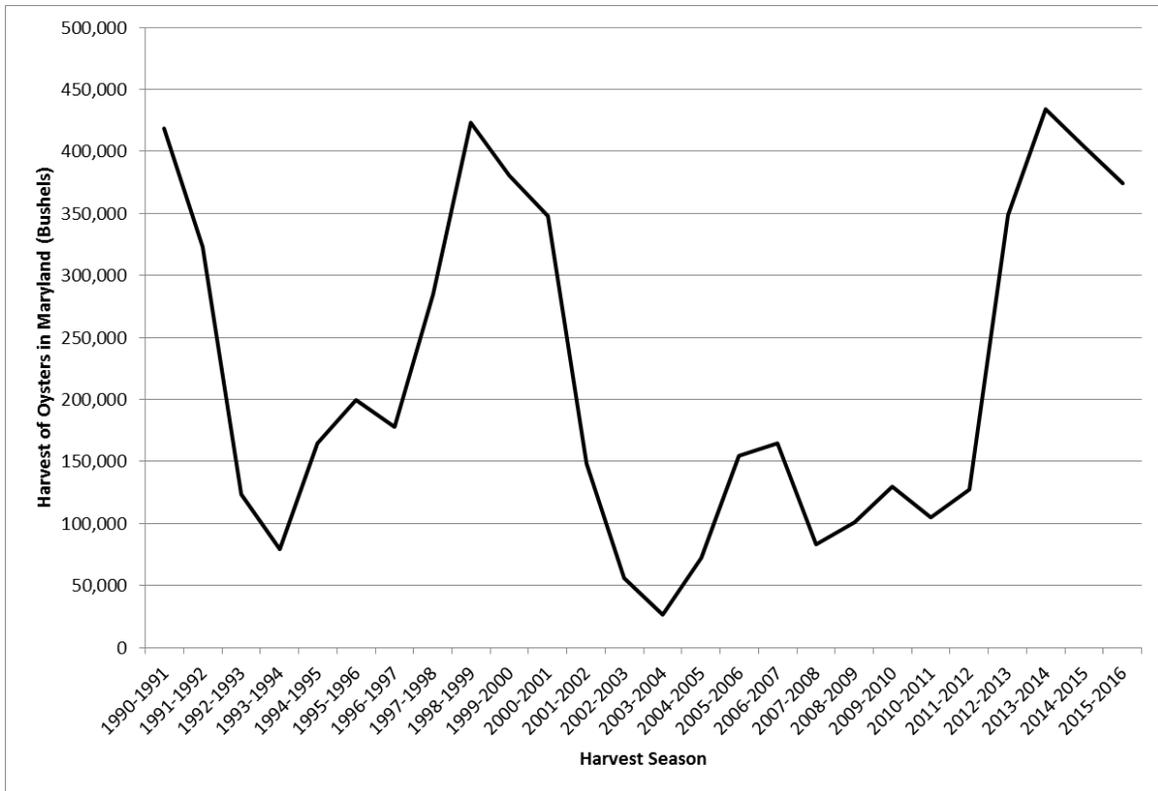


Figure B.00-3. Oyster harvest (Maryland bushels) in Maryland from 1990 to 2016 as reported using seafood dealer buy tickets.

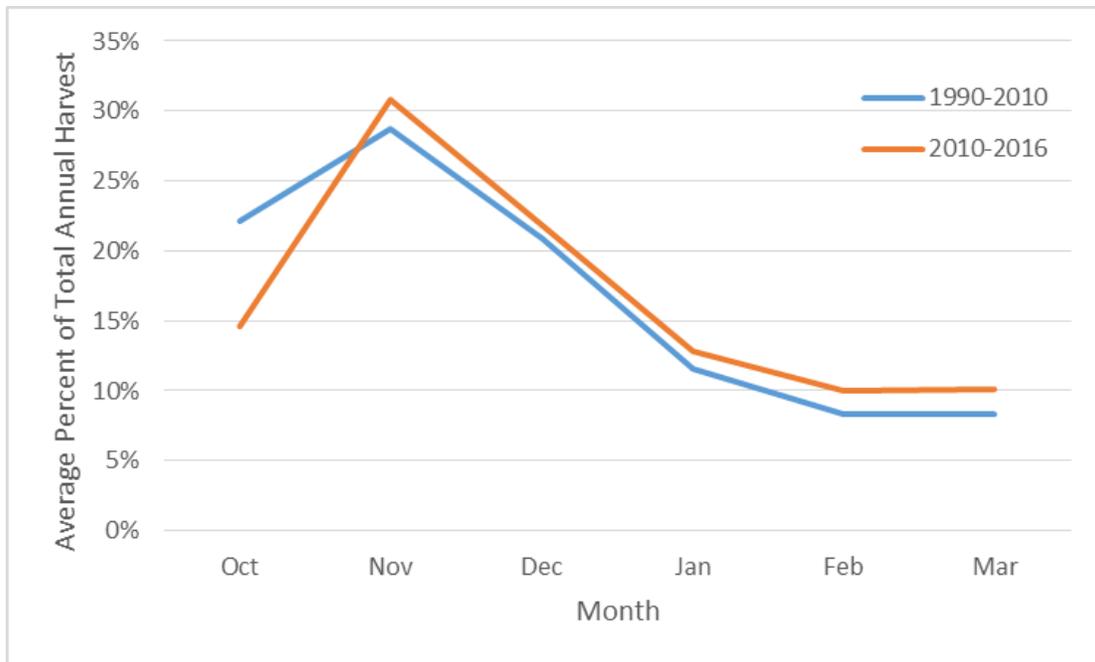


Figure B.00-4. Average monthly percent of total annual harvest as reported using seafood dealer buy tickets for 1990-1991 to 2009-2010 seasons and 2010-2011 to 2015-2016 seasons.

Currently, harvest per license is limited to 15 bushels per day for all gear types except power dredging (12 bushels per day) and sail dredging (150 bushels per day). For all gears types except sail dredge, a maximum of two licenses is permitted on a boat harvesting oysters. The current daily catch limits have been in place since 1971 for sail dredge, 1983 for power dredging, and 1987 for hand tongs, patent tongs, and diving.

Individuals with an Oyster Dredge Boat License, Oyster Harvester License, or an Unlimited Tidal Fish License who have also purchased an oyster surcharge for the current season are permitted to harvest oysters. This equates to a maximum of 2,773 licenses that can be active in any year (once the surcharge requirement is fulfilled). The oyster surcharge is currently \$300 and the funds are used to plant shell and seed for the public fishery. The Department began recording the number of surcharges purchased in 1994 (requirement was enacted in 1991) and since then the number of surcharges purchased has varied, peaking at 1,320 in the 1998-1999 harvest season and decreasing during the drought years of 1999 to 2004, to a low of 310 surcharges in the 2003 -2004 harvest season (Figure B.00-5). Since the 2011-2012 harvest season, the number of surcharges purchased has nearly doubled and is approaching 1,200 participants.

At the time of purchase of a surcharge, the Maryland Department of Natural Resources is required to provide a licensee with a publication of the maps and coordinates of historic oyster bars, oyster sanctuaries, and areas closed to shellfish harvest by the Department of the Environment. The licensee must certify that they have received this publication. All license holders that have purchased an oyster surcharge are required to submit an oyster harvester report

monthly during the oyster season. The reporting rate (the number of surcharge payers submitting harvest reports) has ranged from 74% to 93%, thus some harvest may not be captured in the harvest and effort results described in this section (Table B.00-1).

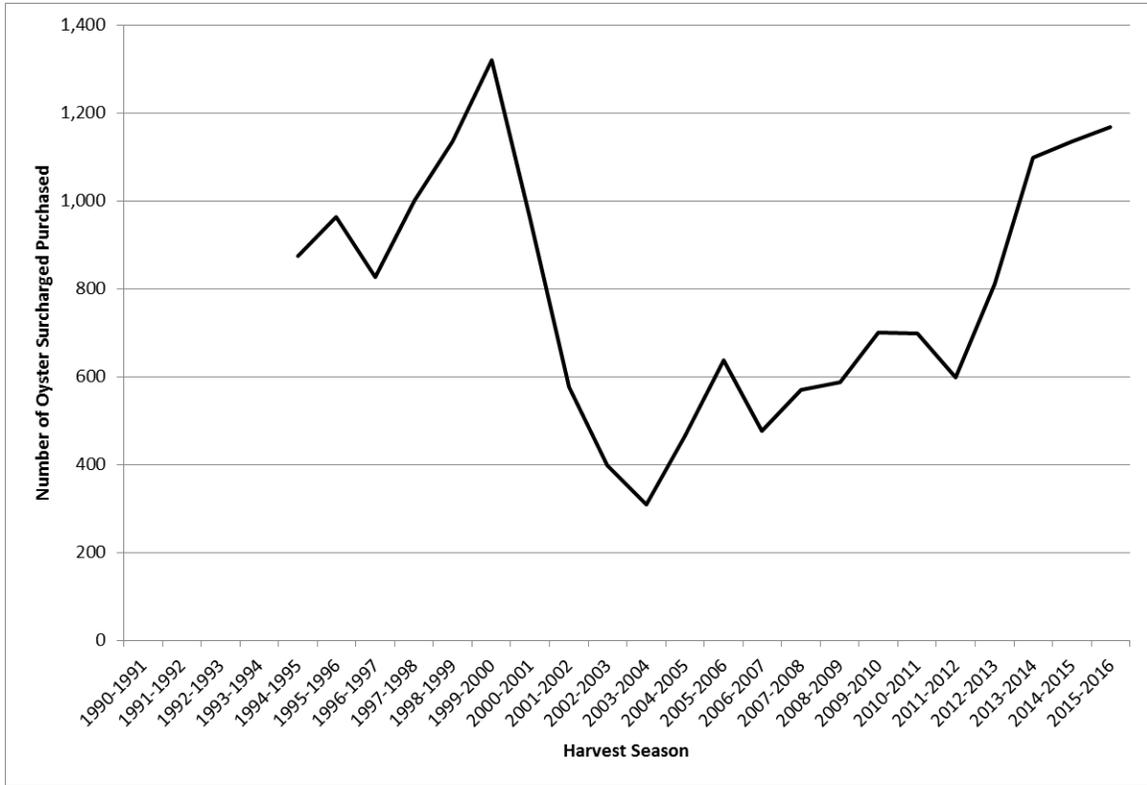


Figure B.00-5. The number of oyster surcharges purchased in Maryland from 1994 to 2016. A license holder can commercially harvest oysters only if an oyster surcharge is purchased.

Table B.00-1. The number of Maryland oyster surcharges purchased and total number of surcharge holders submitting oyster harvester reports.			
Season	Number of Surcharges	Number of Surcharge Payers Submitting Reports	Reporting Rate
2009-2010	701	547	78%
2010-2011	699	567	81%
2011-2012	599	498	83%
2012-2013	812	757	93%
2013-2014	1,098	958	87%
2014-2015	1,134	951	84%
2015-2016	1,167	865	74%

Note: All license holders that have purchased an oyster surcharge are required to submit an oyster harvester report monthly during the oyster season.

Harvest by Gear Types

Oysters can be harvested by multiple gear types: hand tongs, diving, patent tongs, power dredging, and sail dredging. Hand tongs are made of two wooden shafts ranging in length from 16’ to 30’ with rakes attached to each shaft; the shafts are joined together by a pin, mimicking scissors. The oysterman stands on the side of the boat, lowering the tongs into the water, and then opens and closes the tongs catching the oysters in the rakes. Some oyster bars are restricted to hand tonging only. However; harvest by hand tonging is permitted on all oyster bars. All areas open to oystering are open to multiple gear types with the exception of Hand Tong Only areas and the four recently-created Power Dredge Study Areas.

Patent tongs employ the same basic technique as hand tongs. However, they are controlled using hydraulics and have a much bigger head (rake) than the traditional hand tong. To harvest oysters, the tongs are lowered into the water and the head is opened and closed using hydraulics. Patent tongs vary by style and weight with lighter or heavier gear being used on different bottoms. Many boats will choose to deploy two patent tongs, one on each side of the vessel, operated by each license-holder. At the request of the industry, patent tongs, thought to be too efficient, are prohibited from certain county waters and most tributaries. They are primarily employed in the Chesapeake Bay mainstem, the lower Patuxent River, and parts of Somerset County.

Oyster diving was legally established as a gear type in 1973. Divers remove oysters from the bottom by hand. Diving is a two person job; once the person on the bottom fills up a basket, the person on the surface will hoist it up. Diving is allowed on all open bottoms except those reserved for Hand Tong Only and the few small Power Dredge Study Areas but divers typically only work on bars where patent-tonging and dredging are prohibited.

Power dredging for oysters uses a boat with a mast and boom type rig attached. Using foot pedals to control the hydraulics, a chain/mesh bag is lowered on to the bar. It is then dragged over the

bar by the boat, collecting oysters into the bag. The bag is then lifted back onto the boat and the catch is deposited onto the culling station. In 1993, the power dredging gear type was discontinued but it was reestablished in 1997 and further expanded in 1999, 2003, and 2010, to include much of the lower Bay and significant parts of the middle Bay below the Chesapeake Bay Bridge. Power dredging is allowed in much of the lower Choptank River and the majority of bottoms in southern Maryland including the mainstem and much of Dorchester, Somerset, and St. Mary's Counties.

Sail dredging is the historical method used in oyster dredging employing the iconic Chesapeake Bay skipjack sailing vessel. It is similar to power dredging where a chain/mesh type bag is dragged along the bottom to collect oysters, however, for at least 3 of the 5 days each week the boat must be powered completely under sail. For two days a week, the skipjack can be powered using an auxiliary yawl boat to push the skipjack, effectively making it extremely similar to power dredging. Historically skipjacks operated through the mainstem of the Chesapeake Bay as well as some tributaries such as the Choptank but in recent years, fewer than ten boats are in operation and are generally found in the Tangier Sound region, possibly due to densities of oysters elsewhere on the regulated skipjack bottom (primarily mainstem Chesapeake Bay) not being sufficient to harvest economically.

The proportion of harvest by each of the gear types has varied over time since 1990 (Figure B.00-6). Prior to the 2001-2002 harvest season, harvest was mostly obtained by hand tonging. Power dredging was not allowed from 1993-1994 to 1996-1997 harvest seasons. After the 2001-2002 season, harvest by power dredging increased and was used to obtain the majority of harvest (annual average of 49% of harvest after 2001-2002 season). Harvest by patent tonging has varied slightly over the years and averages about 20% of the harvest. Harvest by diving for oysters ranged from 10 to 25% of the harvest. However, since the 2008-2009 season the amount of harvest by diving has been under 10%.

The number of license holders (surcharge payers) reporting harvest by gear type has stayed somewhat constant since 2009 as reported by the oyster harvester reports (Figure B.00-7). Many license holders use multiple gear types over the course of a season to harvest oysters. On average since 2009, 78% of license holders reported using by power dredging and 34% of using patent tongs to report harvest. The percent of license holders using hand tongs has increased from 17% to 38% since 2009. The number of license holders using sail dredge to harvest has remained constant at 1%.

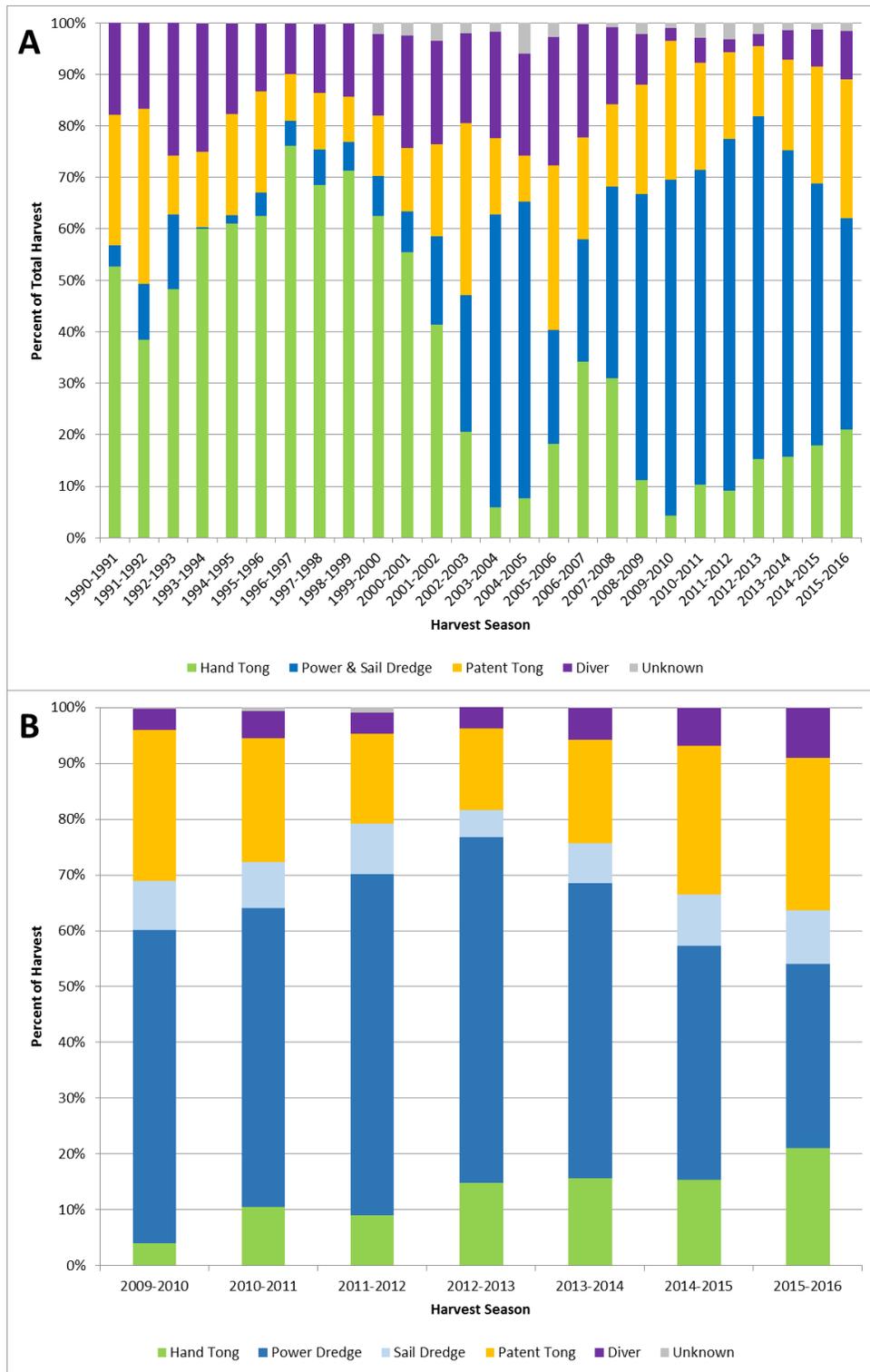


Figure B.00-6. Percent of the total oyster harvest reported in Maryland by each gear type. The first graph (A) is harvest reported by seafood dealer buy tickets since 1990. The second graph (B) is harvest reported on oyster harvester reports since 2009. Unknown gear type harvest occurs when the gear type is not recorded.

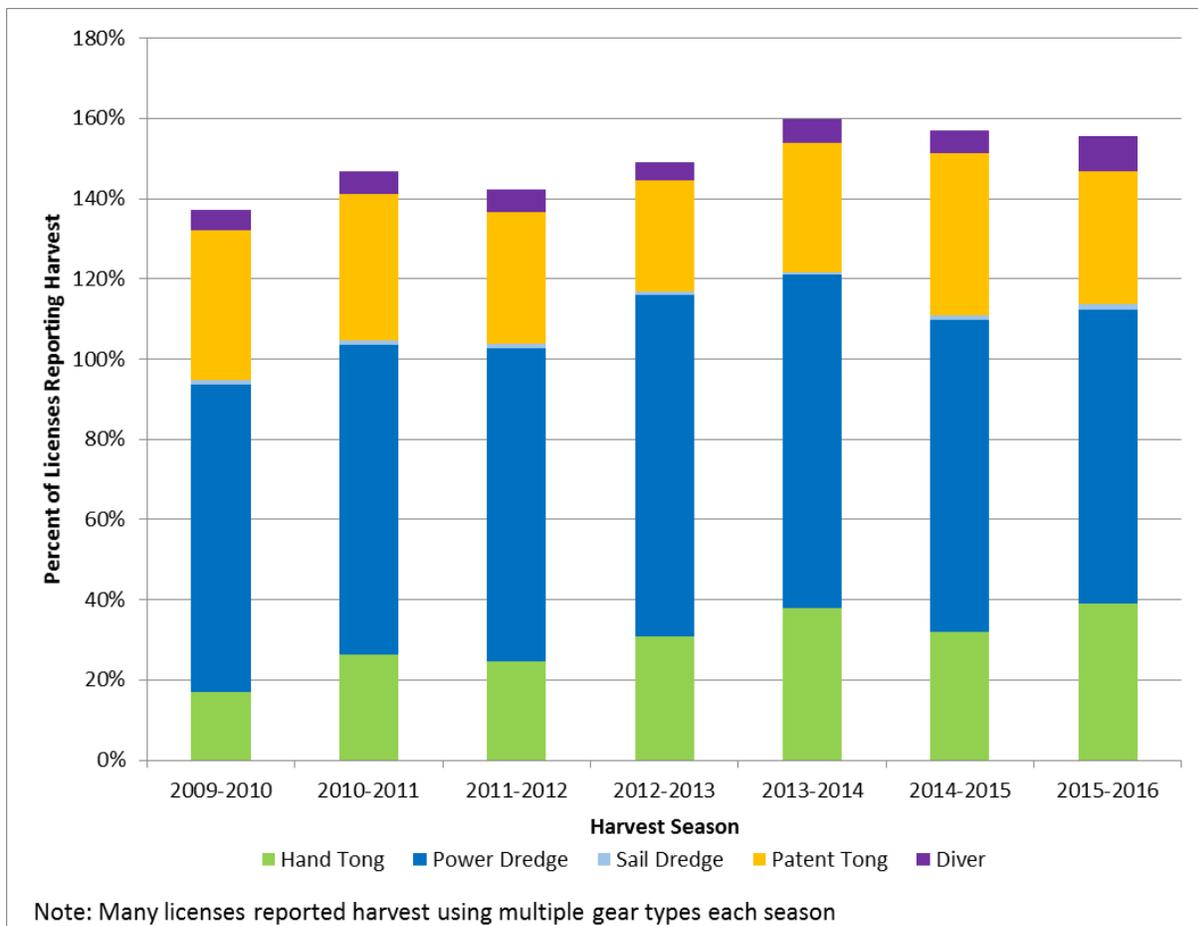


Figure B.00-7. Percent of the total number of licenses (surcharge payers) using different gear types in Maryland as reported by oyster harvester reports. Many license holders will harvest oysters using multiple gear types during one season.

Spatial Extent of Harvest

Harvest reported by seafood dealer buy tickets are recorded by geographically broad areas called NOAA Codes (Figure B.00-1). The areas of high harvest have varied over the years (Table B.00-2). Prior to 1999, high harvest NOAA Code areas were mostly in the upper and middle mainstem of the bay (NOAA Codes 025 and 027), the lower and middle Choptank River (NOAA Codes 131 and 231), and Little Choptank River (053). From 1999 to 2006, the high harvest area shifted to Eastern Bay (NOAA Code 039), upper mainstem of the bay (NOAA Code 025), Tangier Sound (NOAA Code 192), and to a lesser degree the Choptank River and its tributaries (NOAA Codes 231, 437, and 537). The Choptank and upper bay had less mortality from disease during the high disease years from 1999 to 2004, likely the explanation for the high harvests there. In the years after 2006, high harvest areas have consisted of Tangier Sound (NOAA Codes 192 and 292), Broad Creek (NOAA Code 537), and Fishing Bay (NOAA Code 043).

Fifty percent of harvest since the 2010-2011 season has been reported on 24 oyster bars (as reported on the oyster harvester reports). There are over a thousand historic oyster bars (as charted by the 1906 to 1912 Yates Oyster Survey plus its amendments). This equates to approximately 2% of the historic oyster bars producing approximately 50% of the harvest. Six of these oyster bars are located in Tangier Sound (NOAA Codes 192 and 292), five bars in Broad Creek (NOAA Code 537), and four bars in Fishing Bay (NOAA Code 043). The other bars are located in Harris Creek (outside of the sanctuary area), Kedges Strait, Lower Patuxent River, Pocomoke Sound, and Nanticoke and Wicomico Rivers. Harvest from the “best bars” as defined by Jones and Rothschild (2009)⁶ accounted for approximately 5% of total harvest.

Harvest Effort

Harvest effort has varied over the 26 year period since 1990 (Figure B.00-8). Effort, as defined as the total number of days during which oyster harvest occurred for all license holders, has been as low as 4,000 days in the 2003-2004 season and as high as 80,000 days in 1990-1991 season. The 2003-2004 harvest season also corresponded to the low harvest year (26,000 bushels) and the fewest number of surcharges purchased (310). The 2003-2004 season was also the fourth year of the 1999-2003 disease epizootic and drought. Since the 2003-2004 season, effort has been increasing.

Catch per unit effort, as defined as the total harvest divided by the total number of days fished, is a measure of two indices: efficiency of the fishery and oyster abundance. Catch per unit effort has been generally increasing over the 26 year time period, although has been variable from year to year and generally unpredictable (Figure B.00-8). The highest catch per unit effort was in the 2012-2013 season.

The average monthly catch per unit effort is highest in October and November, and then decreases from December to March (Figure B.00-9). These results may indicate that the availability of marketable oysters decreases later in the season as a result of extraction during the initial months of the season, with the amount of effort declining as a result. Average catch per unit effort is highest for the sail dredge gear type, ranging from 52 to 118 bushels per day (Figure B.00-10). The bushel limit is the highest for the sail dredge gear type (150 bushels per day) and there is an average of seven licenses reporting harvest using sail dredge since 2009. Diving for oysters has the second highest average catch per unit effort. On average, 44 license holders report harvest a year and there is a bushel limit of 15 bushels per license per day. All gear types have similar patterns of catch per unit effort since 2009.

⁶ Jones, P.W. and Rothschild, B.J. 2009. Maryland’s Oyster Redevelopment Program – Sanctuaries and Harvest Reserves. Final Report to the Maryland Department of Natural Resources. http://dnr.maryland.gov/fisheries/Documents/Best_Bar_Report_summary.pdf

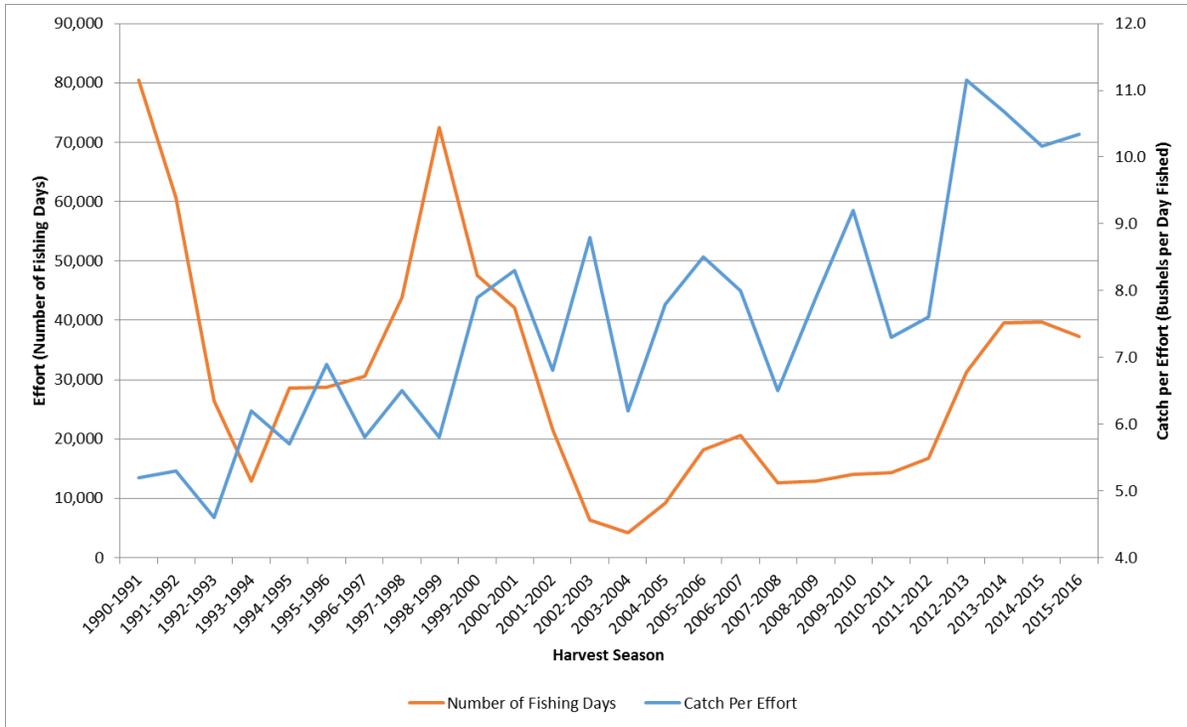


Figure B.00-8. Effort and catch per unit effort (bushels per day) for oyster harvest in Maryland since 1990 as reported on seafood dealer buy tickets.

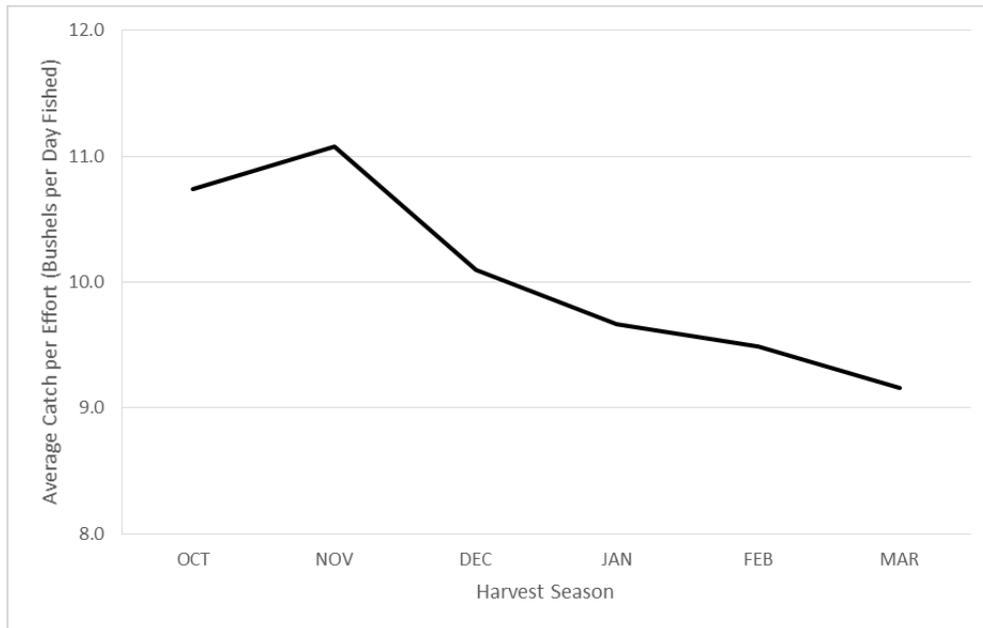


Figure B.00-9. Average monthly catch per effort for oyster harvest in Maryland as reported on the monthly oyster harvester reports since 2009. Catch per effort is defined as total monthly harvest in bushels divided by the total number of days fished by all harvesters.



Figure B.00-10. Catch per unit effort by gear type for oyster harvest in Maryland as reported on the monthly oyster harvester reports since 2009. Catch per unit effort is defined as total monthly harvest in bushels divided by the total number of days fished by all harvesters. Note the different y-axis ranges in the two graphs.

Section B.01: NOAA Code 005 – Big Annemessex River

NOAA Code 005 encompasses the Big Annemessex River and is located in Maryland's lower eastern portion of Chesapeake Bay (Figure B.01-1). The entire NOAA Code is 7,343 acres and has 15 historic oyster bars⁷. The Big Annemessex River Sanctuary encompasses 10% (749 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 6,595 acres. There are 3,935 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010, 671 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland's high salinity zone.

Replenishment Activities

There have been no replenishment activities in this NOAA Code since 1990.

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled one oyster bar in NOAA Code 005 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 12 to 350 per bushel with an average of 105 (Figure B.01-2). The number of oysters has been variable over the last 26 year time period. The average number of live oysters was greater from 2010 to 2015 than prior to 2010, which may be attributed to the three high spat counts after 2010 (Table B.01-2).

⁷ See chart 45 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

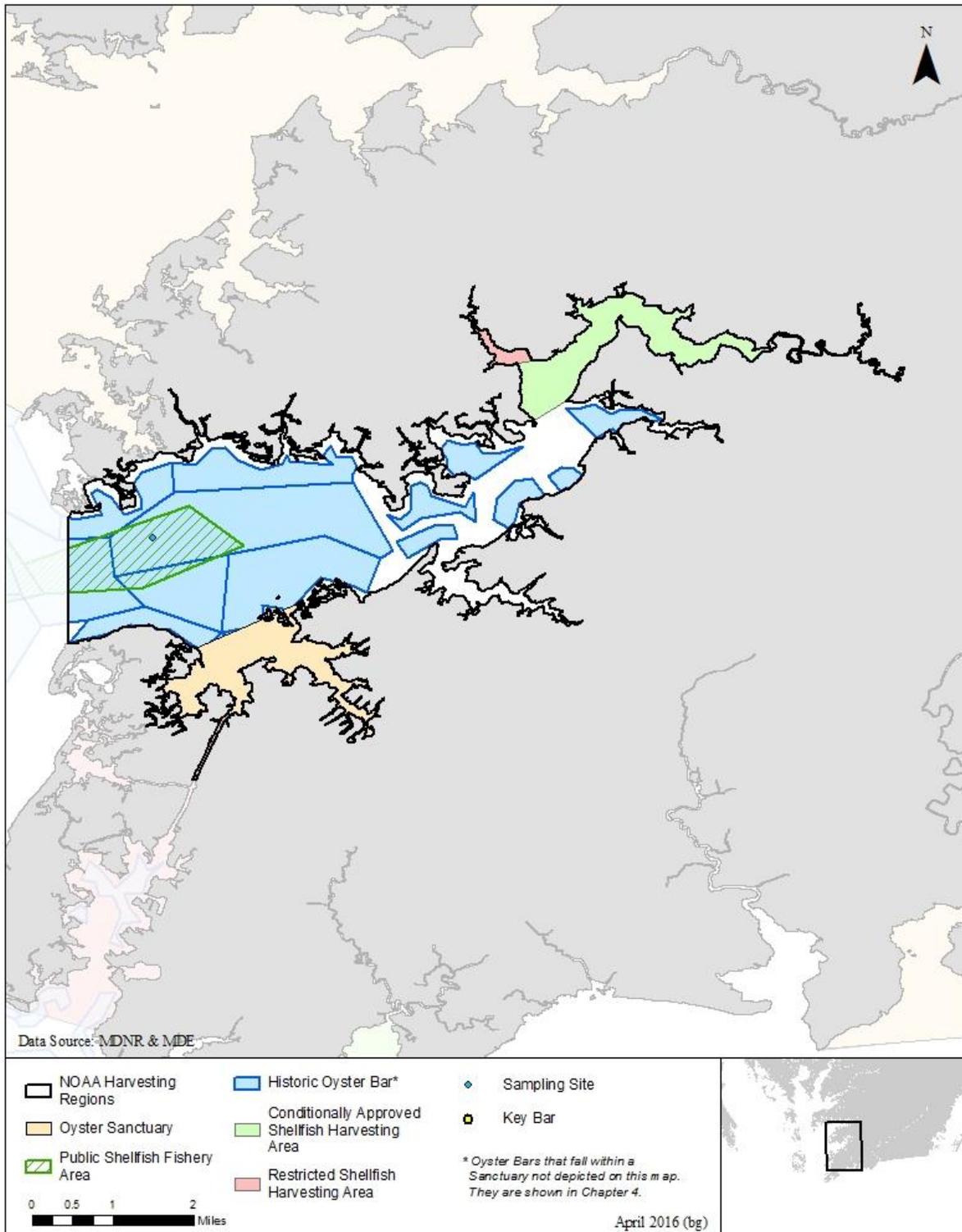


Figure B.01 -1. Map of NOAA Code 005 (Big Annemessex River).

Table B.01-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 005 (Big Annemessex River). ND = No Data. Values are given as mean \pm standard error.

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	18 / 19	5 / 5
Number of Live Oysters per Bushel	95 \pm 19	140 \pm 29
Number of Live Small-Sized Oysters per Bushel	36 \pm 10	6 \pm 4
Number of Live Market-Sized Oysters per Bushel	3 \pm 1	2 \pm 1
Live Oyster Biomass (g Dry Weight per Bushel)	ND	ND
Mortality (%)	31.1 \pm 5.7	33.3 \pm 18.3

Oyster Size Structure

The Fall Survey has not collected information on oyster shell heights in this NOAA Code since 1990.

Biomass

The Fall Survey has not collected information on oyster biomass in this NOAA Code since 1990.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 2 to 346 spat per bushel (Figure B.01-2). The largest spatfall occurred in 2006. From 1990 to 2005, there was very little spatfall. Since 2006, spatfall has been variable but high, averaging 125 per bushel.

Mortality

Mortality ranged from 0% to 100% (Figure B.01-3). The average mortality was slightly higher from 2010 to 2015 than prior to 2010 (Table B.01-2).

Disease

The Fall Survey has not collected information on oyster disease in this NOAA Code since 1990.

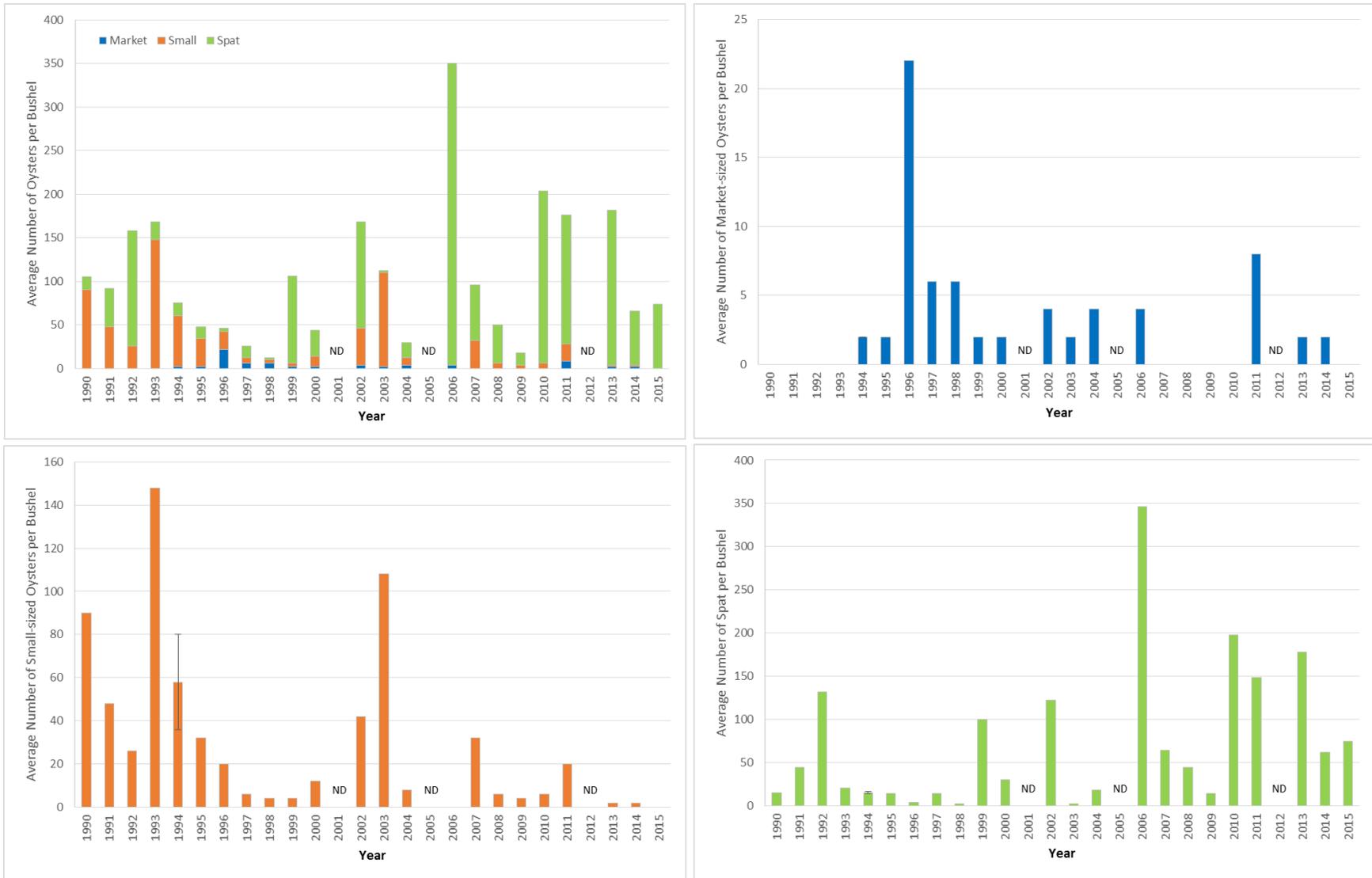


Figure B.01-2. Average number of live oysters per bushel of material by size class in the NOAA Code 005 (Big Annessex River). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales. ND = No Data.

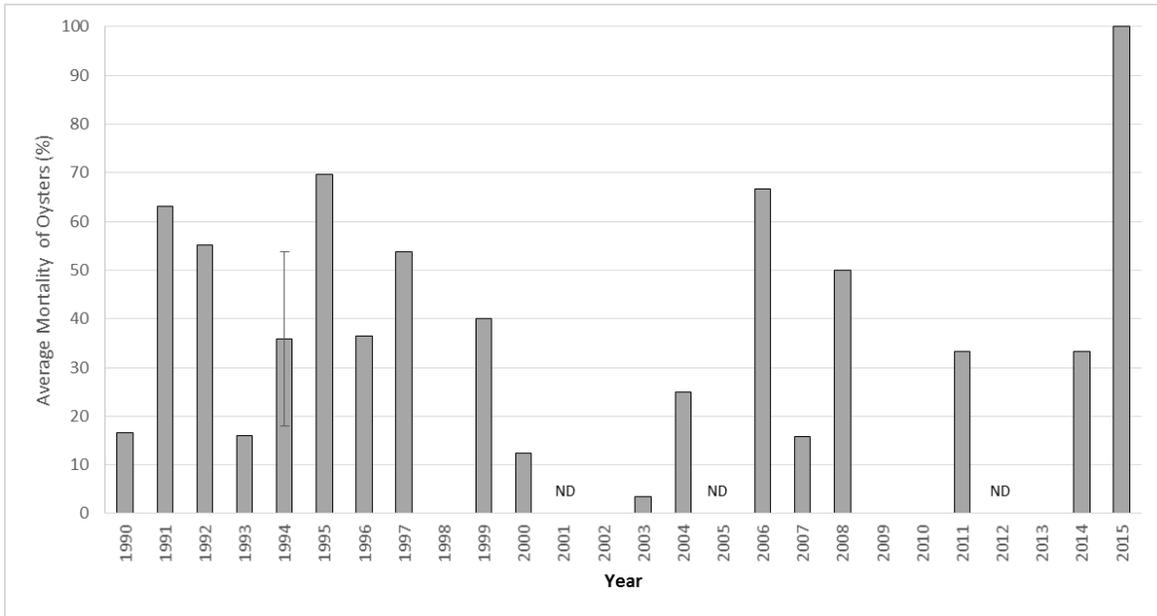


Figure B.01-3. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 005 (Big Annemessex River). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error. ND = No Data.

Harvest

Harvest for the entire NOAA Code 005 (Big Annemessex River) since 1990 is presented in Figure B.01-4. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 10% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in 12 years to a maximum of approximately 4,053 bushels in the 2015-2016 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. The majority of harvest in this area as reported on the oyster harvest reports to obtained by power dredging.

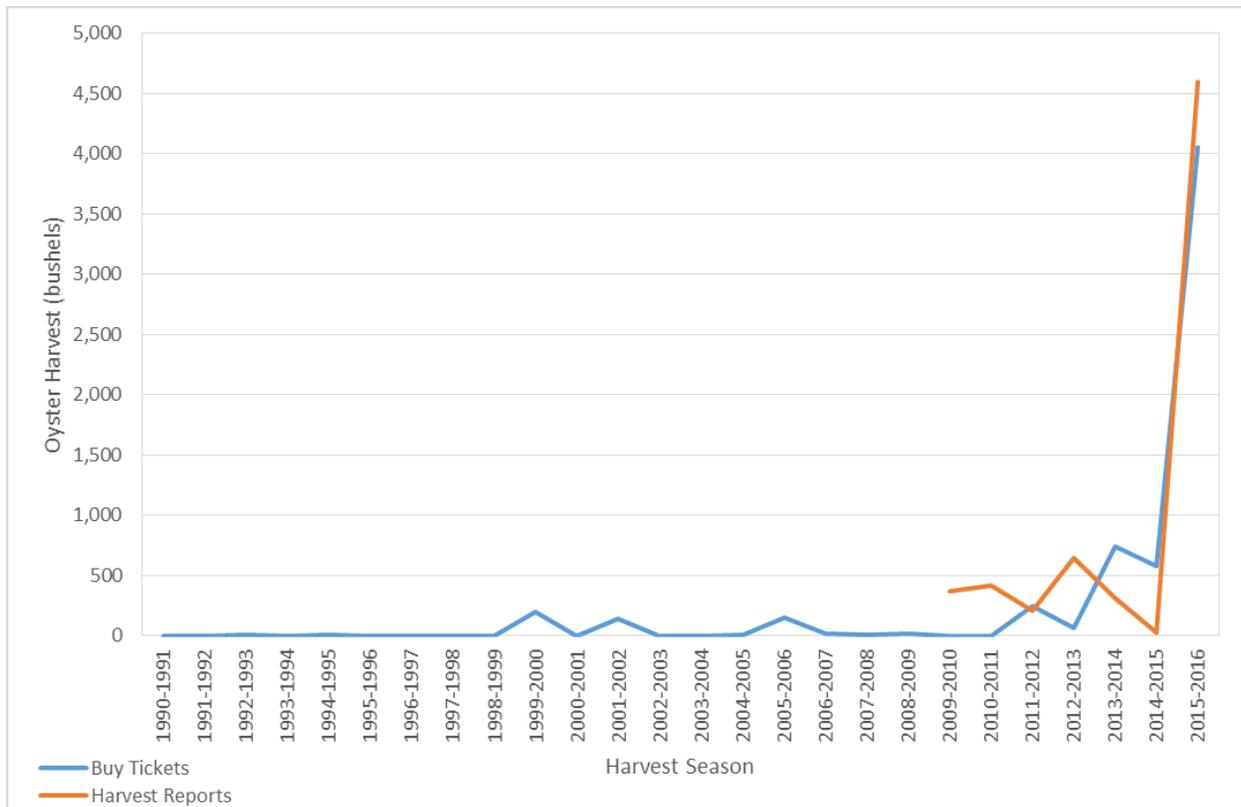


Figure B.01-4. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 005 (Big Annemessex River). After the 2009-2010 season, 10% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.02: NOAA Code 025 – Chesapeake Bay Upper

NOAA Code 025 is located in Maryland’s upper portion of Chesapeake Bay, north of the Chesapeake Bay Bridge (Figure B.02-1). The entire NOAA Code is 164,314 acres and has 40 historic oyster bars⁸. The Lower Chester River, Man-O-War/Gales Lump, and Fort Carroll sanctuaries encompass 10% (16,730 acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 147,584 acres. There are 19,300 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010, 15,456 acres within the NOAA Code were designated as a Public Shellfish Fishery Area in 2010 prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s low salinity zone.

Restoration and Replenishment Activities

Since 1990, 92,000 bushels of shell, 900,000 bushels of wild seed, and 366 million hatchery spat-on-shell have been planted in NOAA Code 025 outside of the current sanctuary area (Table B.02-1).

⁸ See charts 4, 5, 6, and 7 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

Table B.02-1. Replenishment planting activities occurring since 1990 in NOAA Code 025 (Chesapeake Bay Upper).

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Dredged Shell	12.9	48.9	-
1990	Fresh Shell	24.9	2.4	-
1990	Wild Seed	197.0	13.6	-
1991	Fresh Shell	0.5	4.8	-
1991	Wild Seed	45.0	19.1	-
1992	Fresh Shell	2.4	9.0	-
1992	Wild Seed	310.5	117.3	-
1993	Fresh Shell	2.6	9.2	-
1993	Wild Seed	15.0	9.7	-
1994	Fresh Shell	9.9	8.7	-
1994	Wild Seed	147.5	56.2	-
1995	Wild Seed	41.9	31.7	-
1996	Wild Seed	37.7	22.9	-
1997	Fresh Shell	3.2	9.3	-
1997	Wild Seed	26.3	20.4	-
1998	Wild Seed	237.9	89.6	-
1999	Wild Seed	37.3	14.7	-
2000	Wild Seed	202.7	57.8	-
2001	Wild Seed	94.9	59.4	-
2002	Wild Seed	108.1	51.1	-
2003	Wild Seed	215.0	84.4	-
2004	Wild Seed	82.9	93.9	-
2006	Wild Seed	163.7	77.2	-
2007	Wild Seed	90.9	75.0	-
2008	Hatchery Spat-on-Shell	8.3	-	13.6
2008	Wild Seed	55.4	24.4	-
2010	Hatchery Spat-on-Shell	31.1	-	52.2
2012	Hatchery Spat-on-Shell	74.0	-	169.3
2013	Hatchery Spat-on-Shell	11.7	-	46.4
2015	Hatchery Spat-on-Shell	103.0	-	84.6

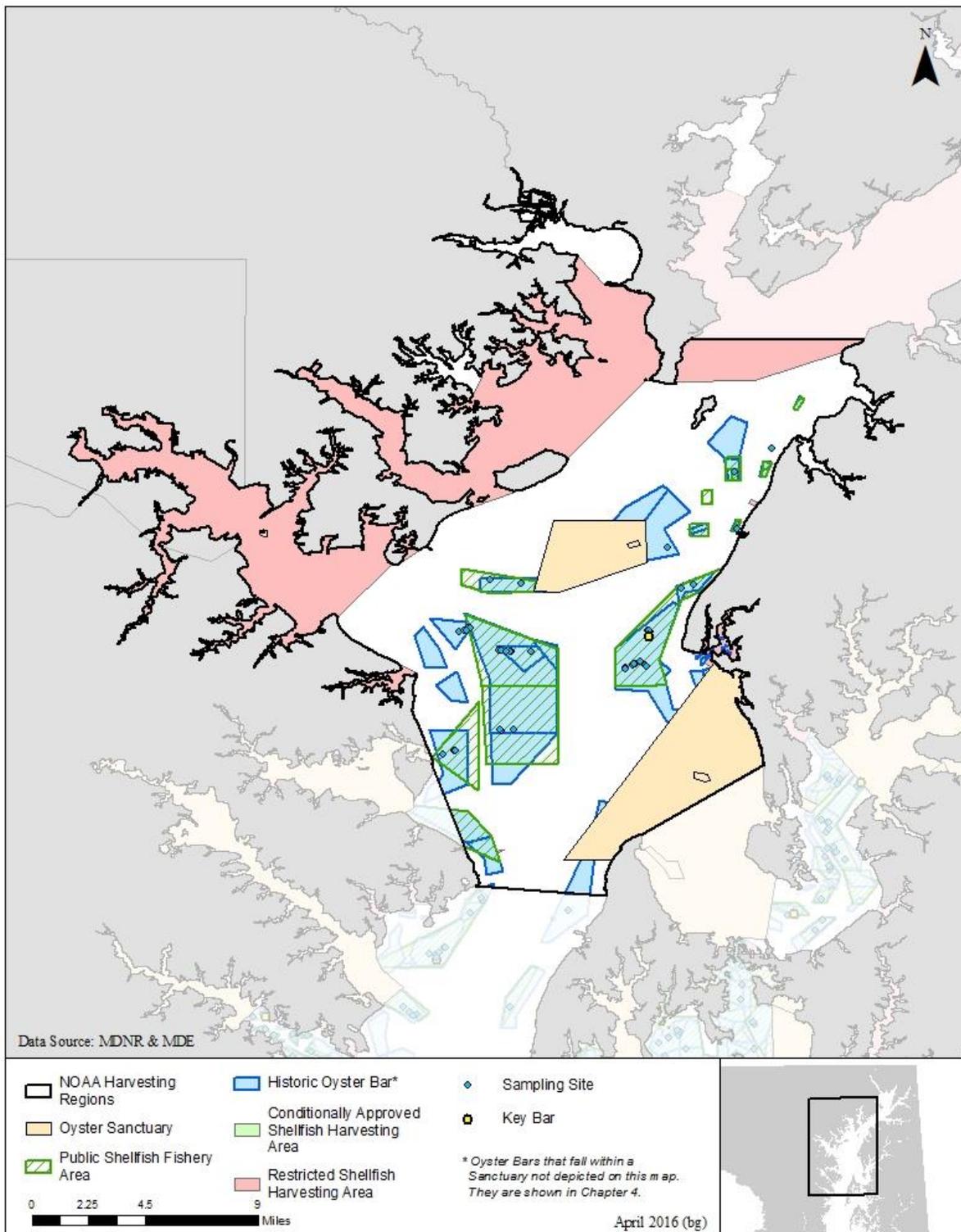


Figure B.02 -1. Map of NOAA Code 025 (Chesapeake Bay Upper).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled three to thirteen oyster bars annually in NOAA Code 025 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 15 to 297 per bushel with an average of 87 (Figure B.02-2). The average number of live oysters was greater from 2010 to 2015 than prior to 2010, likely due to some hatchery seed plantings (Table B.02-2). The average number of small-sized and market-sized oysters was lower from 2010 to 2015 than prior to 2010.

Table B.02-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 025 (Chesapeake Bay Upper). Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 288	6 / 101
Number of Live Oysters per Bushel	84 \pm 8	97 \pm 42
Number of Live Small-Sized Oysters per Bushel	48 \pm 8	14 \pm 5
Number of Live Market-Sized Oysters per Bushel	35 \pm 2	15 \pm 1
Live Oyster Biomass (g Dry Weight per Bushel)	137 \pm 12	125 \pm 35
Mortality (%)	9.4 \pm 1.6	19.5 \pm 7.8

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Swan Point bar within NOAA Code 025 (Figure B.02-3). Oysters on this bar were relatively, with 14% of oysters exceeded 120 mm. Sizes were similar for both time periods, with approximately 80% of oysters exceeding 80 mm.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on Swan Point bar within NOAA Code 025. The annual biomass ranged 35 to 295 grams of dry weight per bushel and the average is 134.5 \pm 11.7 (mean \pm SE; Figure B.02-4). The average biomass was lower from 2010 to 2015 than prior to 2010 (Table B.02-2).

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall had ranged from 0 to 272 spat per bushel (Figure B.02-2). This figure included four samples on hatchery plantings. Without those plantings included, natural spatfall ranged from 0 to 7 per bushel and average 1 (Figure B.02-5).

Mortality

Mortality ranged from 3% to 53% and has increased since 2011 (Figure B.02-6). The average mortality was greater from 2010 to 2015 than prior to 2010 (Table B.02-2).

Disease

From 1990 to 2015, dermo prevalence has ranged from 0% to 97% (Figure B.02-7). Dermo prevalence was greater than 80% for 4 of the 26 years disease information was collected. Dermo intensity ranged from 0 to 3.4, below lethal levels (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence was 0% from 1990 to 2015.

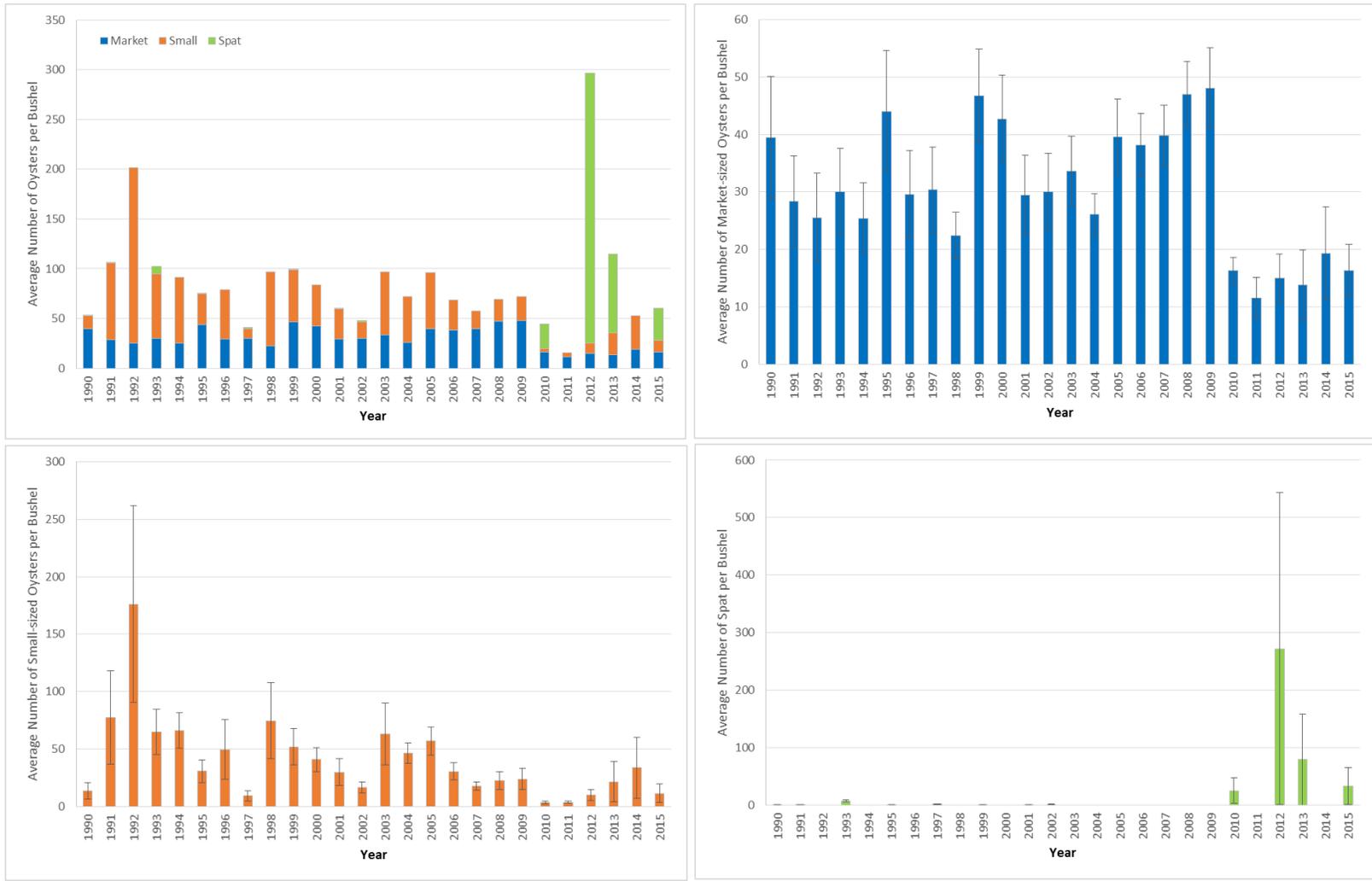


Figure B.02-2. Average number of live oysters per bushel of material by size class in the NOAA Code 025 (Chesapeake Bay Upper). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

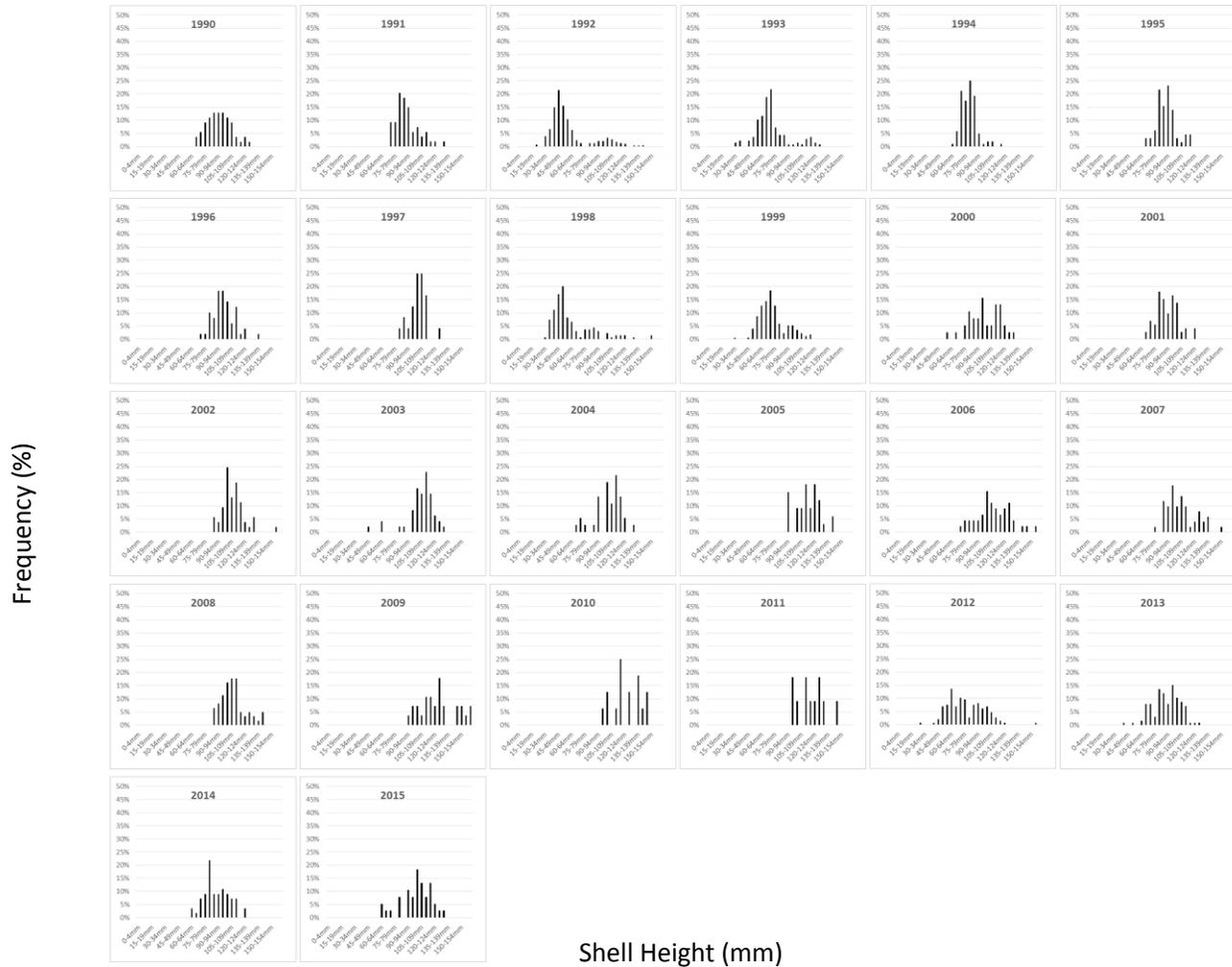


Figure B.02-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 025 (Chesapeake Bay Upper). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

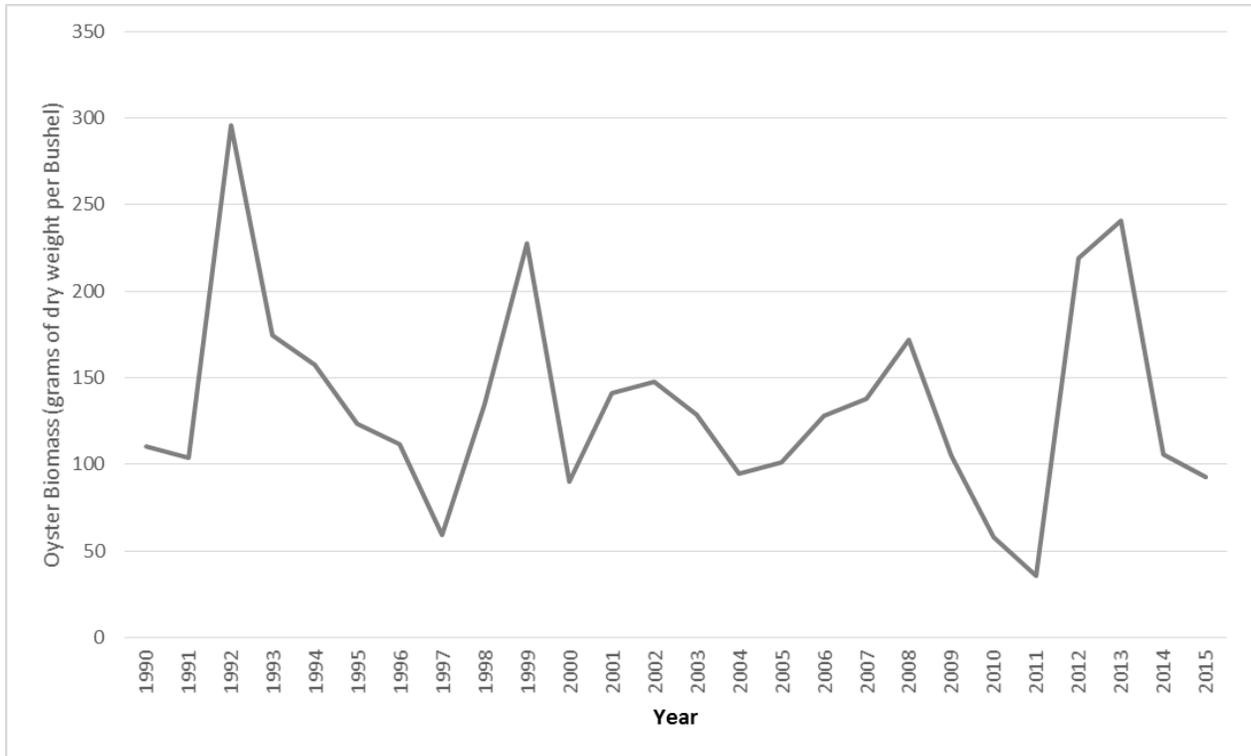


Figure B.02-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 025 (Chesapeake Bay Upper). Data from Maryland’s Annual Fall Oyster Dredge Survey.

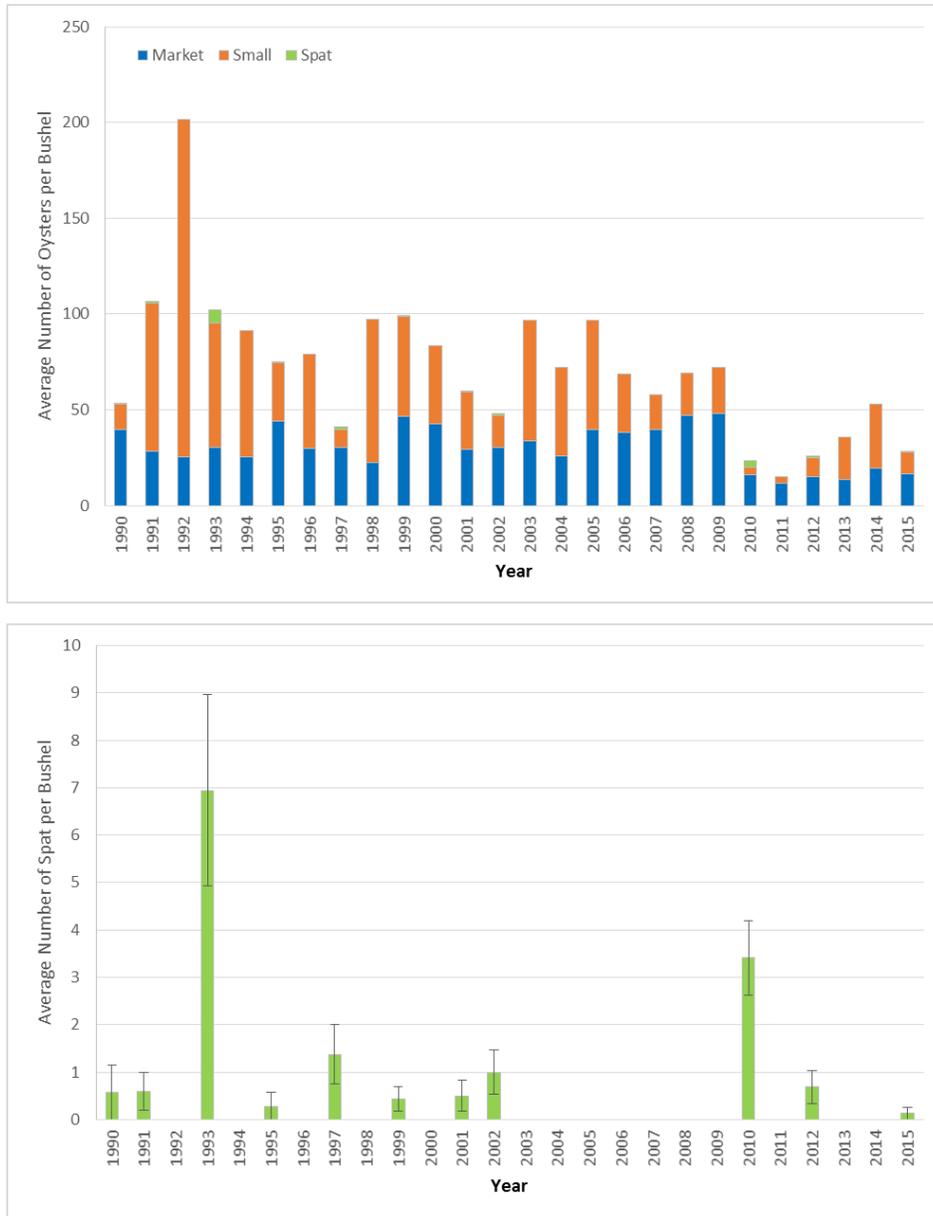


Figure B.02-5. Average number of live oysters per bushel of material by size class in the NOAA Code 025 (Chesapeake Bay Upper) excluding Fall Survey samples taken on hatchery seed plantings. Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

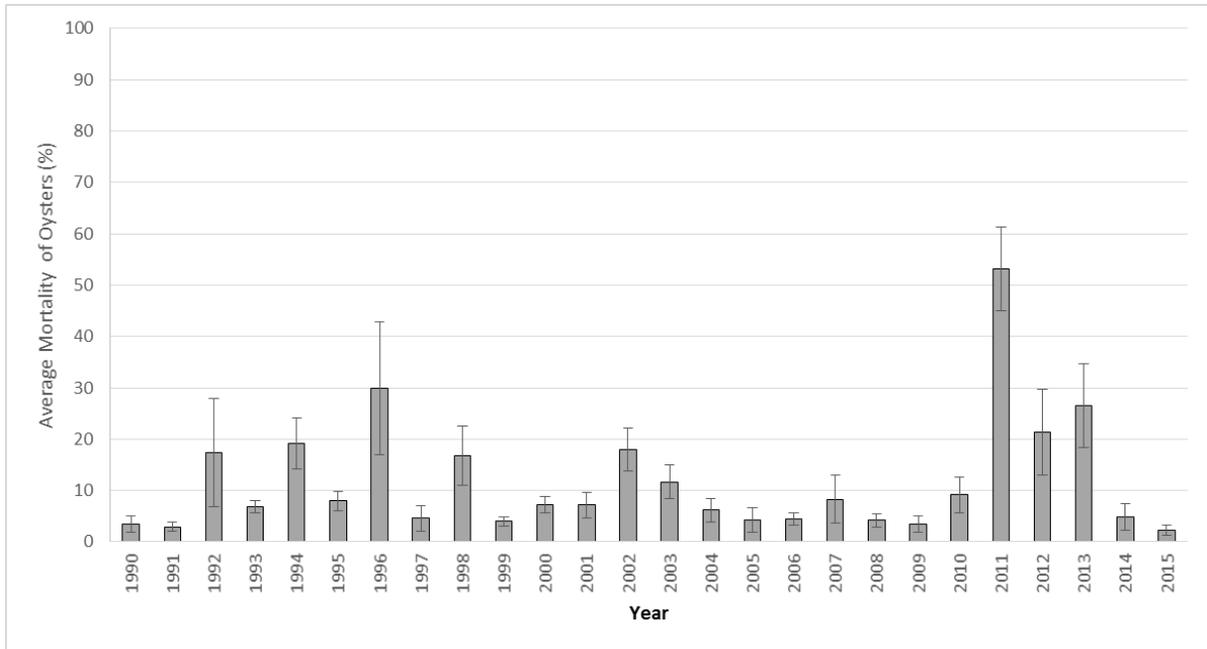


Figure B.02-6. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 025 (Chesapeake Bay Upper). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

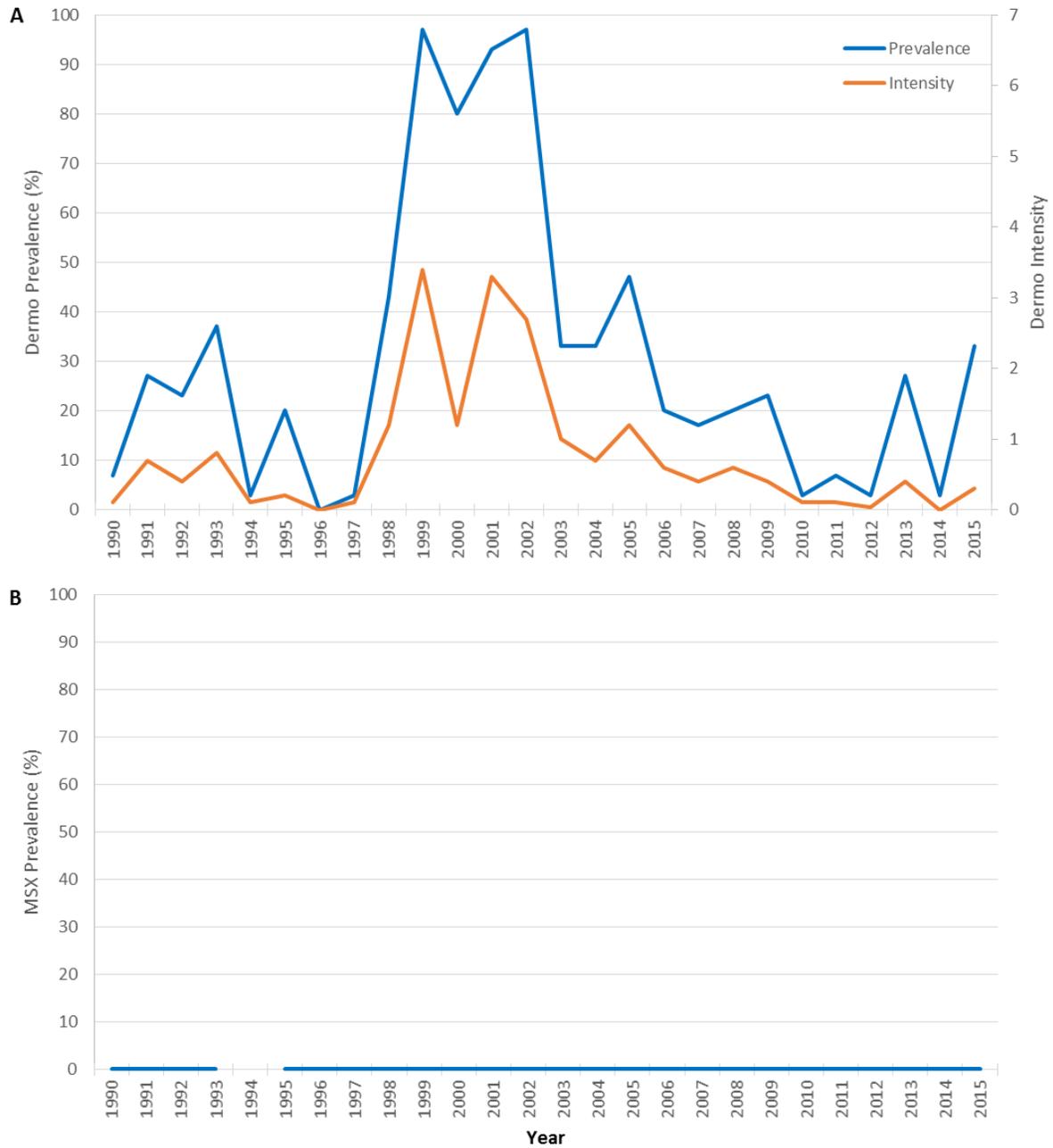


Figure B.02-7. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 025 (Chesapeake Bay Upper). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland’s Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 025 since 1990 is presented in Figure B.02-8. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 10% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from 13 bushels in the 2011-2012 season to a maximum of approximately 35,000 bushels in the 1991-1992 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Patent tongs and sail dredge accounted for a combined 70% of the harvest, with diving and power dredging accounting for most of the rest, as reported on oyster harvester reports.

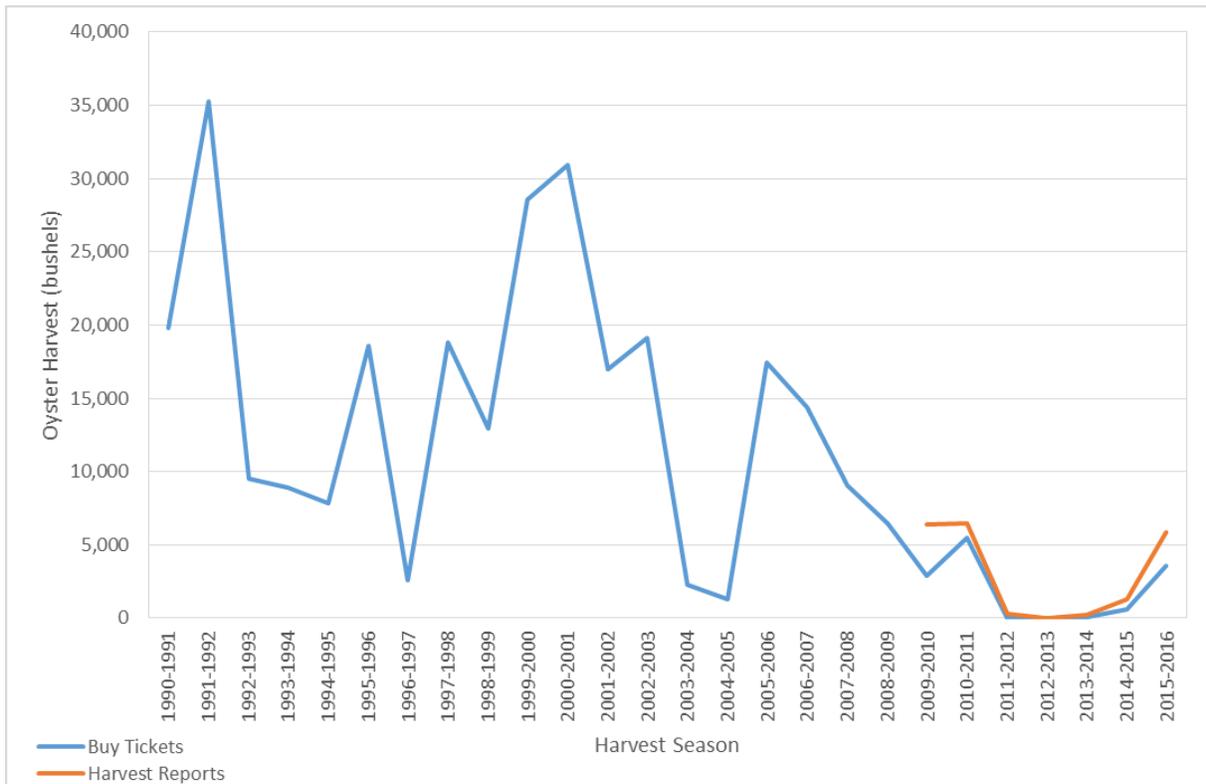


Figure B.02-8. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 025 (Chesapeake Bay Upper). After the 2009-2010 season, 10% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.03: NOAA Code 027 – Chesapeake Bay Lower Middle

NOAA Code 027 is located in Maryland’s middle portion of Chesapeake Bay, north of Cove Point (Figure B.03-1). The entire NOAA Code is 186,830 acres and has 50 historic oyster bars⁹. Multiple sanctuaries encompass 12% (22,836 total acres) of the NOAA Code (Plum Point, Popular Island, Tilghman Island, Calvert Shore, and Herring Bay). This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 163,994 acres. There are 21,939 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside the sanctuaries. In 2010, 8,408 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s medium salinity zone.

Replenishment Activities

Since 1990, 1.5 million bushels of shell, 17,000 bushels of wild seed, and 600,000 hatchery spat-on-shell have been planted in NOAA Code 027 outside of the current sanctuary area (Table B.03-1).

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Dredged Shell	84.4	696.8	-
1992	Dredged Shell	63.2	706.8	-
1992	Fresh Shell	2.3	9.8	-
1998	Dredged Shell	46.0	93.8	-
2003	Dredged Shell	8.2	3.7	-
2007	Wild Seed	13.3	6.6	-
2008	Hatchery Spat-on-Shell	7.3	-	0.6
2008	Wild Seed	13.8	10.2	-
2012	Dredged Shell	47.7	12.8	-

⁹ See chart 13, 14, 17, 23, and 24 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

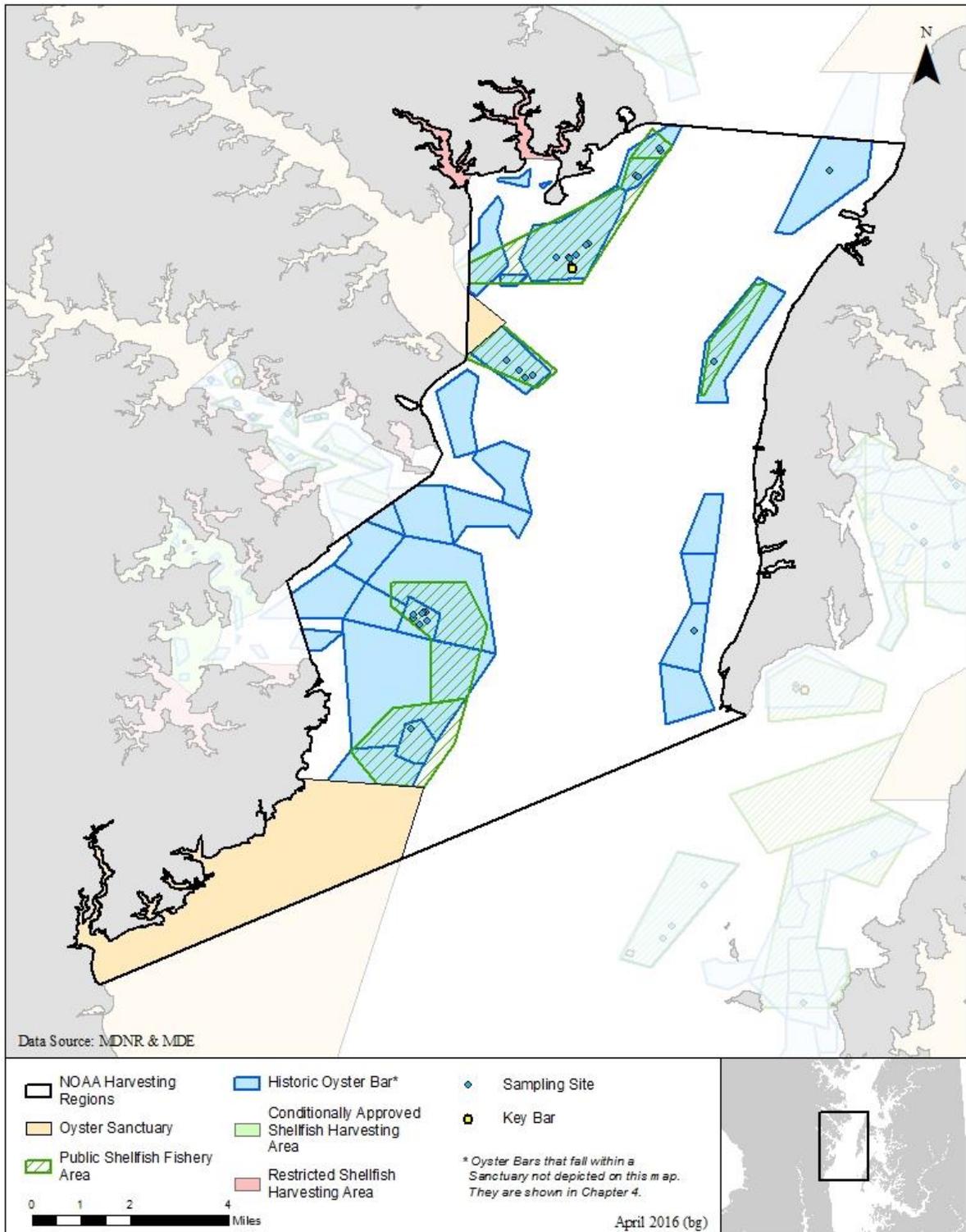


Figure B.03 -1. Map of NOAA Code 027 (Chesapeake Bay Lower Middle).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled one to seven oyster bars annually in NOAA Code 027 outside of the current sanctuary area. The average number of live oysters (market, small, and spat) ranged from 12 to 210 per bushel with an average of 76 (Figure B.03-2). There has been a general increase in market-sized oysters since 2003 and, in 2014, the average number of markets was the highest in the 26 year time period. The average number of live oysters was greater from 2010 to 2015 than prior to 2010 (Table B.03-2).

Table B.03-2 Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 027 (Chesapeake Bay Lower Middle). Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 98	6 / 37
Number of Live Oysters per Bushel	65 \pm 9	112 \pm 9
Number of Live Small-Sized Oysters per Bushel	29 \pm 4	41 \pm 6
Number of Live Market-Sized Oysters per Bushel	21 \pm 4	57 \pm 11
Live Oyster Biomass (g Dry Weight per Bushel)	107 \pm 20	186 \pm 39
Mortality (%)	22.9 \pm 4.3	6.3 \pm 1.6

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Stone bar within NOAA Code 027 (Figure B.03-3). Oysters were larger from 2010 to 2015, with 34% larger than 80 mm, than prior to 2010, when 22% exceeded 80 mm.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on Stone bar within NOAA Code 027. The annual biomass ranged from 19 to 355 grams of dry weight per bushel and the average is 125.4 \pm 18.5 (average \pm SE; Figure B.03-4). The average biomass was greater from 2010 to 2015 than prior to 2010 (Table B.03-2). Biomass was variable but generally low from 1992 to 2010, when it began to increase.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 0 to 62 spat per bushel, averaging 15 (Figure B.03-2). The largest spatfall occurred in 2002.

Mortality

Mortality ranged from 0% to 69%. Since 2006, mortality has been relatively low (Figure B.03-5). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.03-2).

Disease

From 1990 to 2015, dermo prevalence has ranged from 10% to 100% (Figure B.03-6). Dermo prevalence was greater than 80% during 14 of the 26 years disease information was collected. Dermo intensity ranged from 0.2 to 4.5 from 1990 to 2015, below lethal levels (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 47%. From 1999 to 2002, there was an extended period of MSX prevalence.

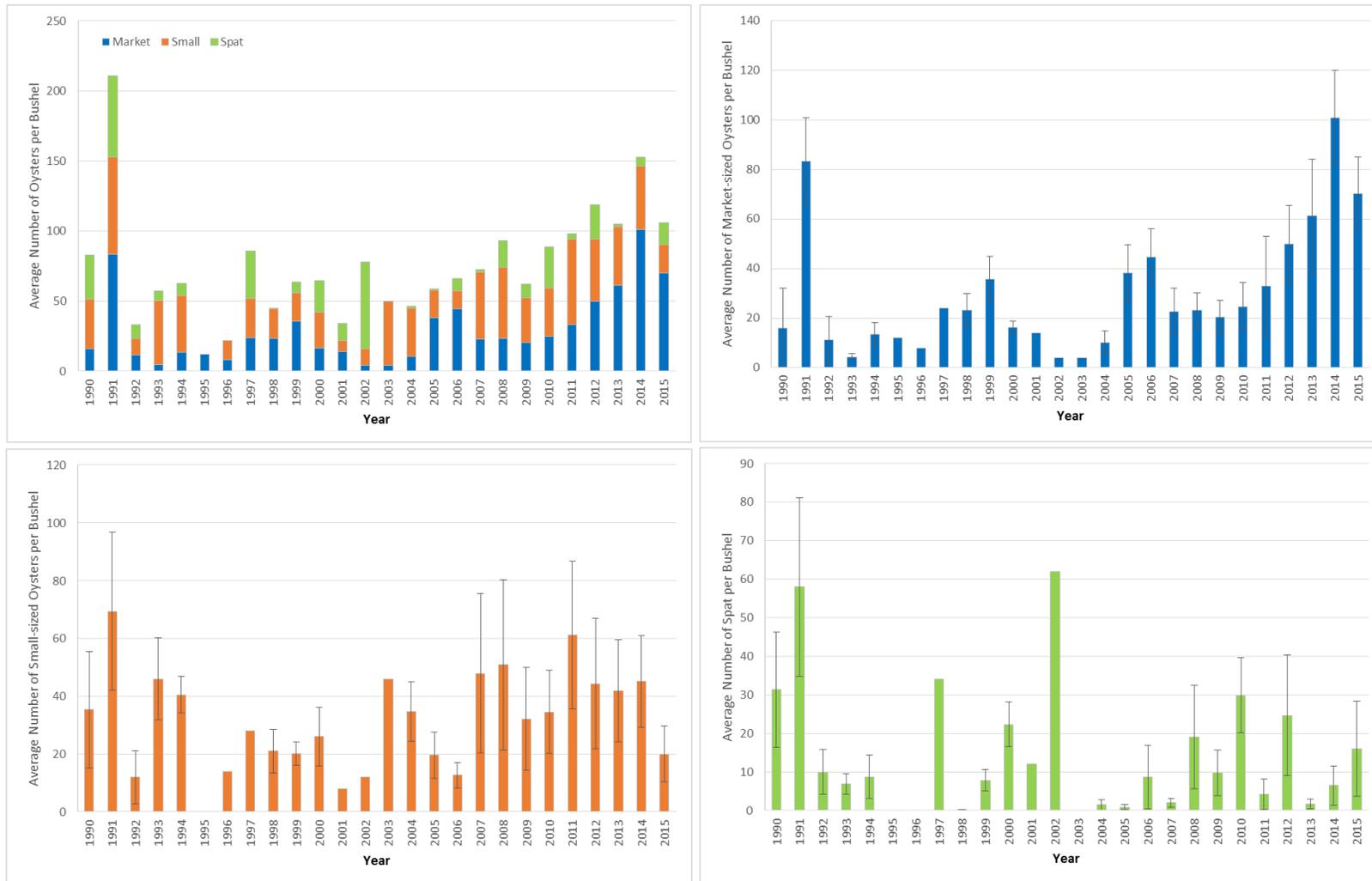
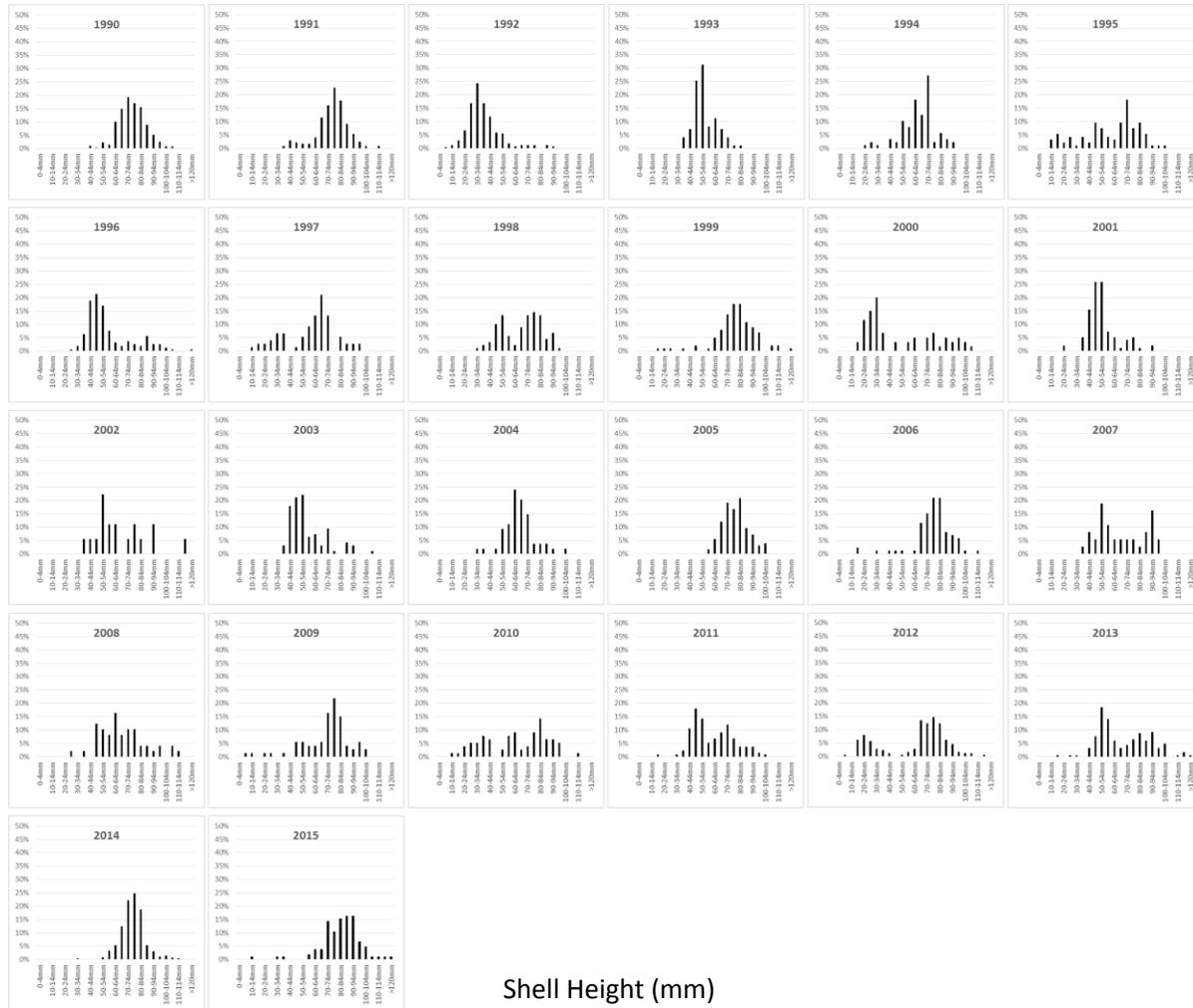


Figure B.03-2. Average number of live oysters per bushel of material by size class in the NOAA Code 027 (Chesapeake Bay Lower Middle). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

Frequency (%)



Shell Height (mm)

Figure B.03-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 027 (Chesapeake Bay Lower Middle). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

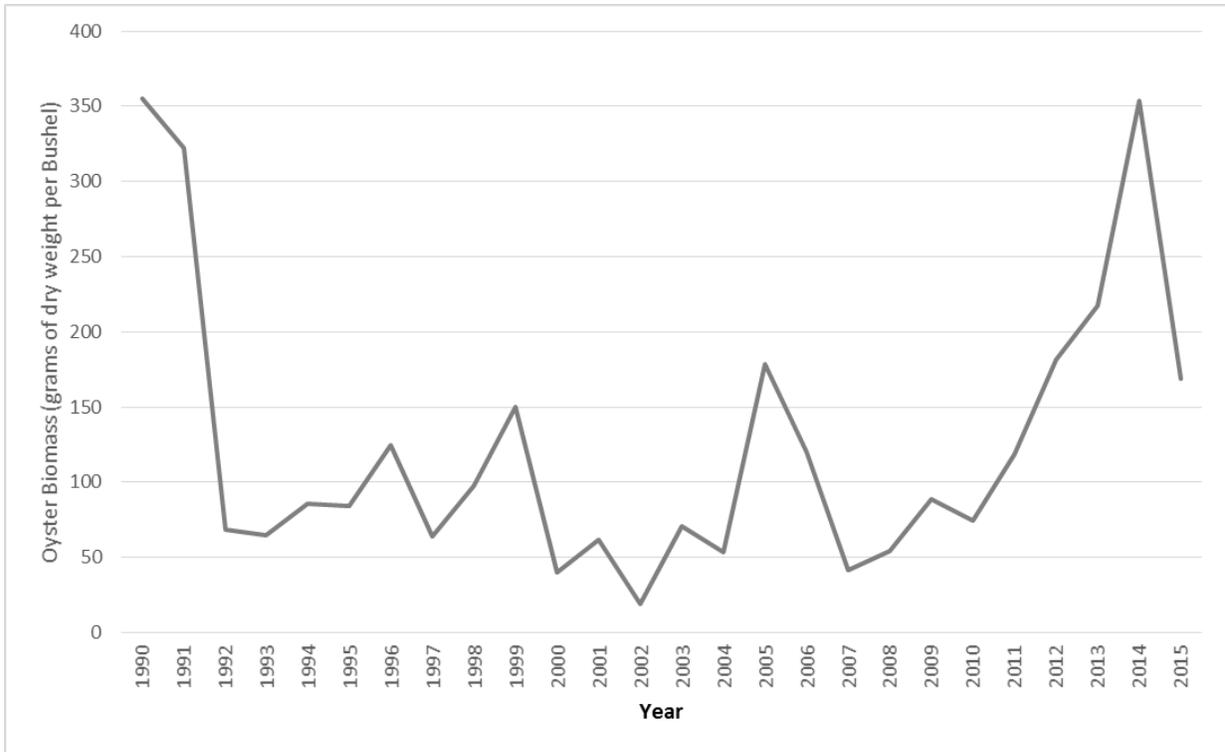


Figure B.03-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 027 (Chesapeake Bay Lower Middle). Data from Maryland’s Annual Fall Oyster Dredge Survey.

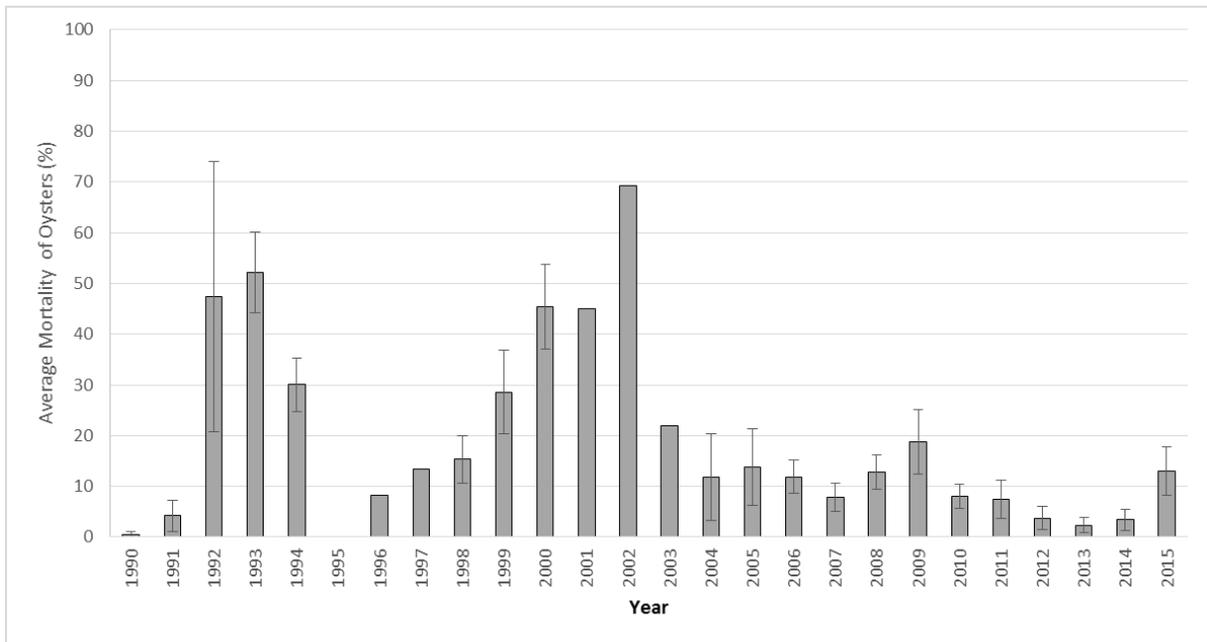


Figure B.03-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 027 (Chesapeake Bay Lower Middle). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

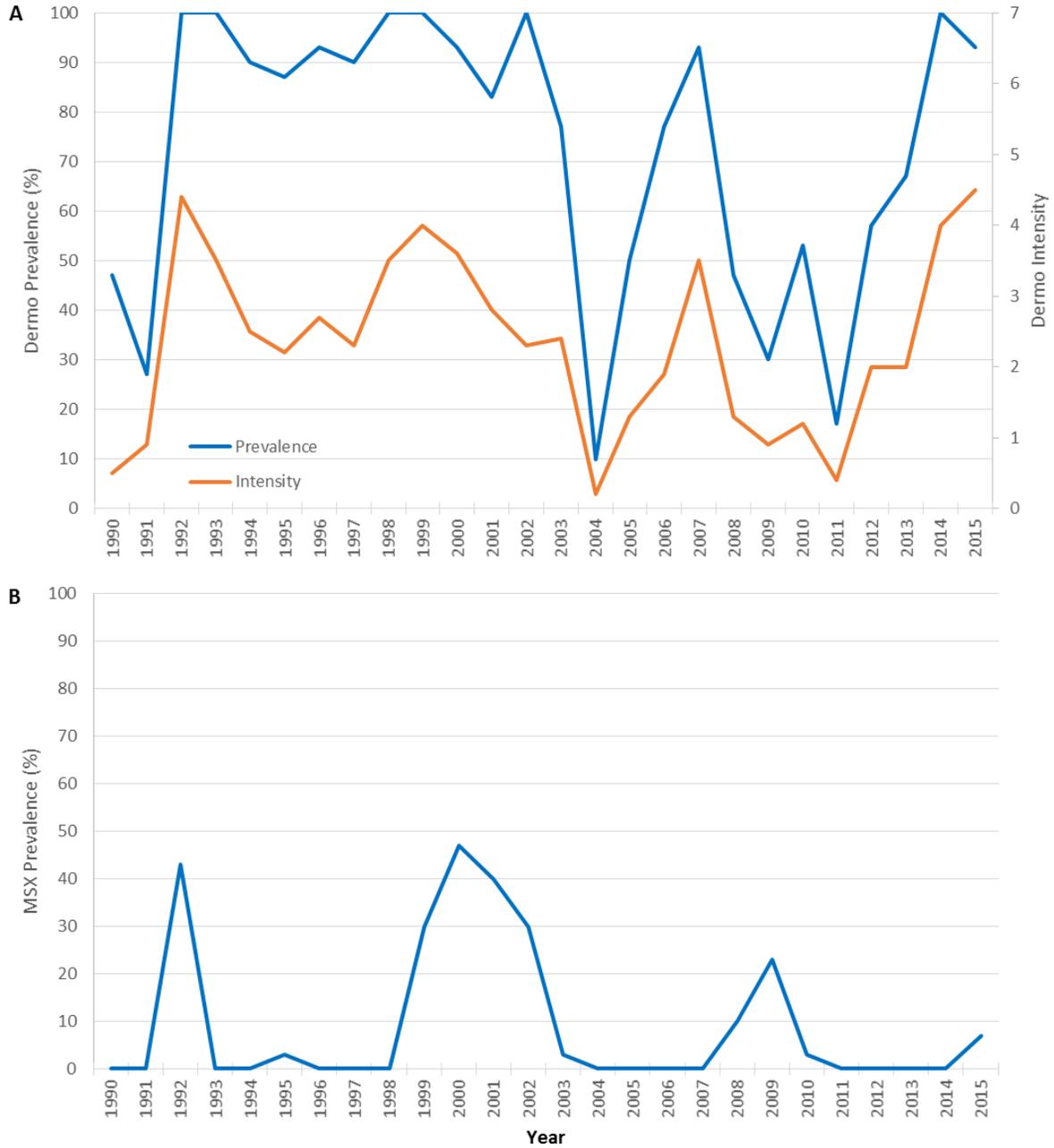


Figure B.03-6. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 027 (Chesapeake Bay Lower Middle). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland’s Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 027 since 1990 is presented in Figure B.03-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 12% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from 370 bushels in the 2003-2004 season to a maximum of approximately 54,000 bushels in the 1998-1999 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Patent tonging accounted for 77% of the harvest, as reported on the oyster harvester reports.

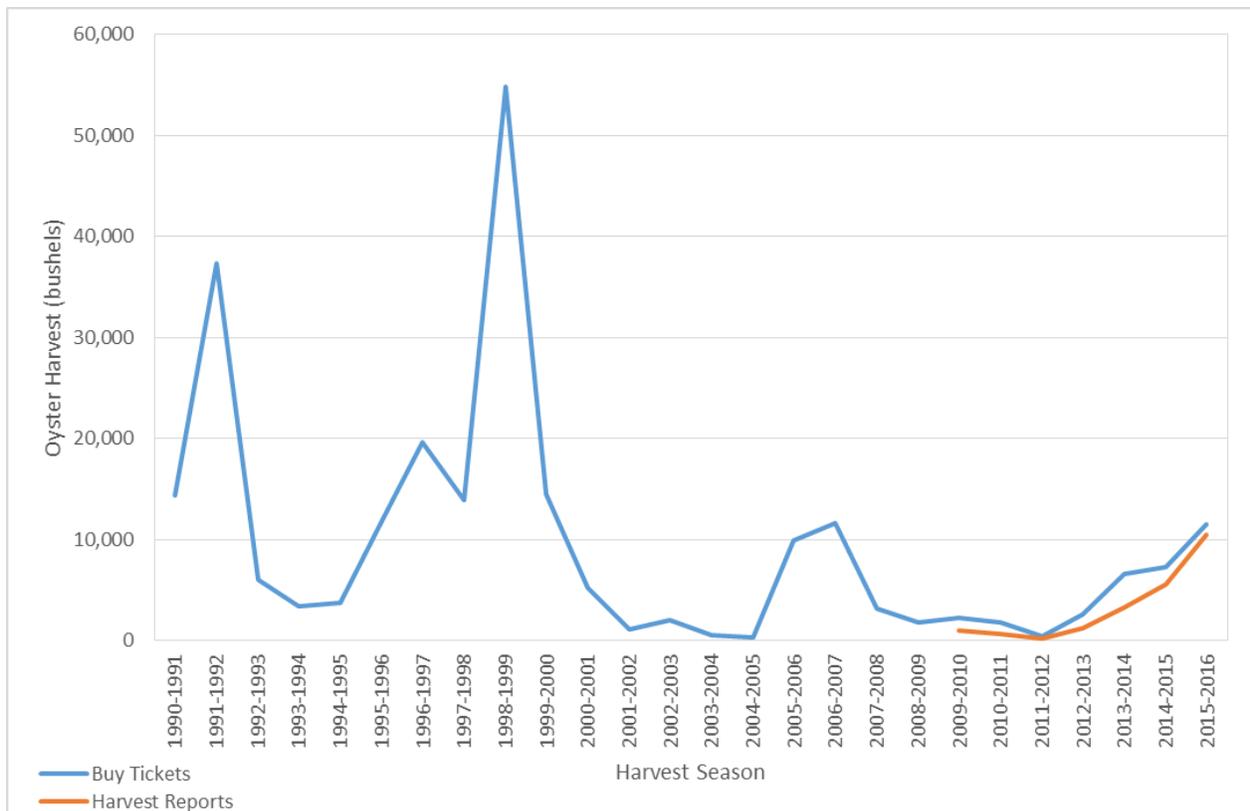


Figure B.03-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 027 (Chesapeake Bay Lower Middle). After the 2009-2010 season, 12% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.04: NOAA Code 039 – Eastern Bay

NOAA Code 039 encompasses Eastern Bay and is located in Maryland's middle eastern portion of Chesapeake Bay (Figure B.04-1). The entire NOAA Code is 33,334 acres and has 66 historic oyster bars¹⁰. Five sanctuaries (Cox Creek, Eastern Bay, Prospect Bay, Mill Hill, and Cabin Creek) encompass 25% (8,253 acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 25,081 acres. There are 12,269 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and not within a sanctuary. In 2010, 17,366 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland's low salinity zone.

Replenishment Activities

Since 1990, approximately four million bushels of dredged shell and 385,000 bushels of fresh shell have been planted in NOAA Code 039 outside of the current sanctuary area (Table B.04-1). Wild seed was planted multiple times totaling 217,000 bushels but hatchery seed was only planted once in 2007.

¹⁰ See chart 11 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

Table B.04-1. Replenishment planting activities occurring since 1990 in NOAA Code 039 (Eastern Bay). ND = No Data.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Dredged Shell	56.5	440.9	-
1990	Wild Seed	11.6	6.8	-
1991	Fresh Shell	2.9	14.7	-
1992	Fresh Shell	8.7	45.9	-
1992	Wild Seed	106.9	14.2	-
1993	Fresh Shell	8.8	44.4	-
1994	Fresh Shell	7.7	23.4	-
1994	Wild Seed	4.1	2.6	-
1995	Fresh Shell	9.2	44.6	-
1995	Wild Seed	5.9	4.8	-
1996	Dredged Shell	49.6	407.4	-
1996	Fresh Shell	3.7	18.3	-
1997	Fresh Shell	11.0	47.1	-
1997	Wild Seed	5.0	3.4	-
1998	Dredged Shell	76.8	390.6	-
1998	Fresh Shell	4.5	17.9	-
1998	Wild Seed	16.4	7.6	-
1999	Dredged Shell	131.3	1,159.2	-
1999	Wild Seed	4.9	5.9	-
2000	Dredged Shell	75.7	713.0	-
2000	Fresh Shell	6.3	25.8	-
2000	Wild Seed	4.6	146.3	-
2001	Dredged Shell	140.3	867.4	-
2002	Dredged Shell	27.2	107.6	-
2002	Fresh Shell	7.3	82.8	-
2004	Dredged Shell	36.7	366.3	-
2005	Dredged Shell	42.9	278.7	-
2007	Hatchery Seed	8.6	-	8.7
2007	Wild Seed	1.2	3.1	-
2008	Wild Seed	5.1	4.0	-
2009	Wild Seed	12.7	17.9	-
2015	Fresh Shell	20.0	20.1	-

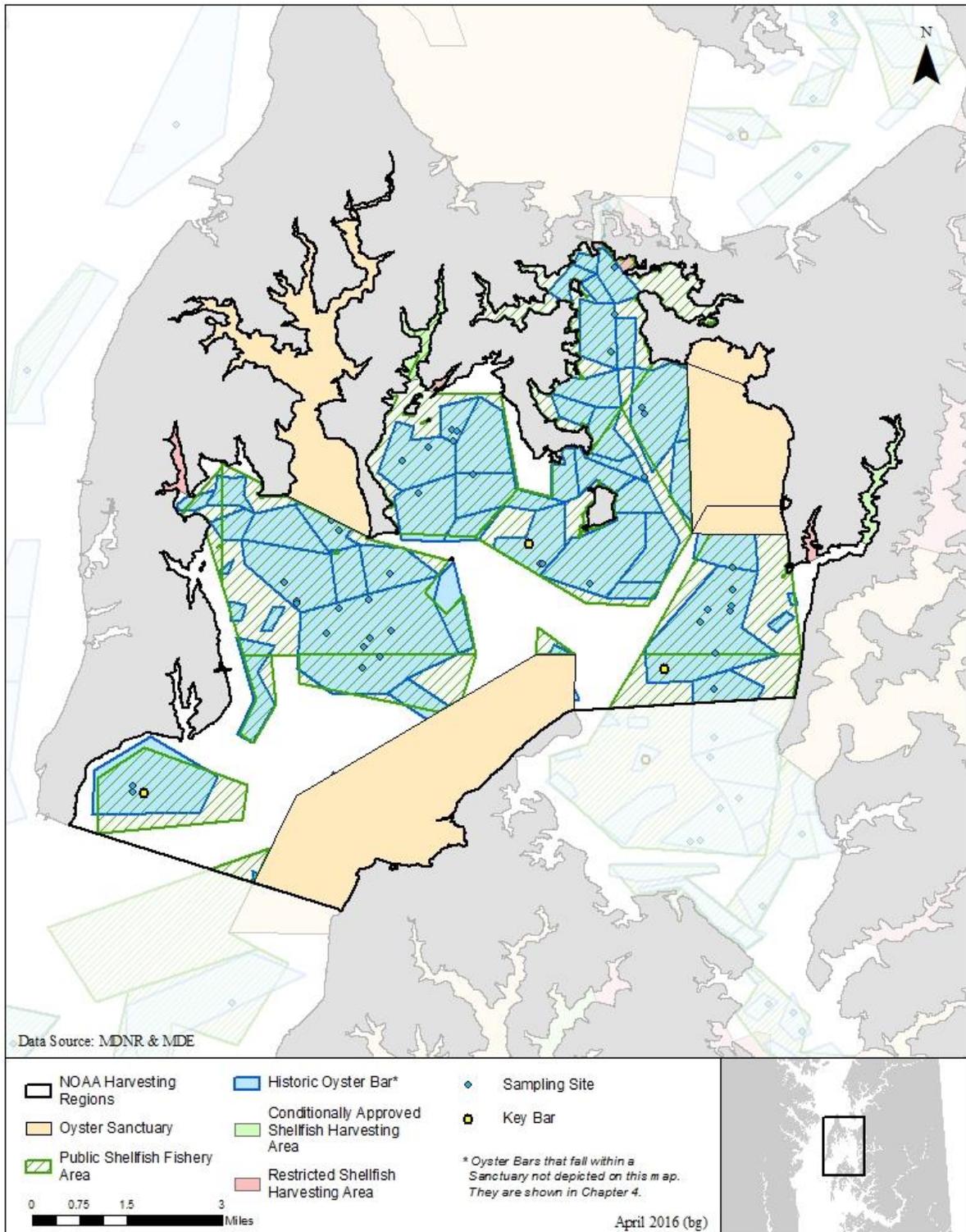


Figure B.04 -1. Map of NOAA Code 039 (Eastern Bay).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled 11 to 17 oyster bars annually in NOAA Code 039 outside of the current sanctuary area. Because the Hollicutt’s Noose bar is close to mainstem of Chesapeake Bay, it exhibits differences in several oyster population characteristics than the rest of Eastern Bay Fall Survey samples. For this reason, there are two sets of charts and tables in this section, one with data from all the bars in Eastern Bay other than Hollicutt’s Noose and one set with only data from Hollicutt’s Noose.

For all bars except Hollicutt’s Noose, the average number of total live oysters (market, small, and spat) ranged from 21 to 1757 per bushel with an average of 153 (Figure B.04-2A). There has been a general increase in market-sized oysters since 2011. The average number of live oysters was greater from 1990 to 2009 than from 2010 to 2015, likely due to the high number of spat in 1997 (Table B.04-2A).

For Hollicutt’s Noose bar, the average number of total live oysters (market, small, and spat) ranged from 15 to 137 per bushel with an average of 71 (Figure B.04-2B). The average number of live oysters on Hollicutt’s Noose was slightly greater from 2010 to 2015 than prior to 2010 (Table B.04-2B). Both the number of live oysters overall and the number of market oysters increased on Hollicutt’s Noose after 2010; while the opposite occurred for the rest of the bars in the NOAA code.

Table B.04-2A. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 039 (Eastern Bay) for all samples except on the oyster bar Hollicutts Noose. Values are given as mean \pm standard error.

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 391	6 / 131
Number of Live Oysters per Bushel	183 \pm 85	55 \pm 6
Number of Live Small-Sized Oysters per Bushel	53 \pm 17	21 \pm 3
Number of Live Market-Sized Oysters per Bushel	33 \pm 4	30 \pm 8
Live Oyster Biomass (g Dry Weight per Bushel)	97 \pm 11	69 \pm 11
Mortality (%)	26.5 \pm 2.6	8.3 \pm 2.1

Table B.04-2B. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 039 (Eastern Bay) for the oyster bar Hollicutts Noose. Values are given as mean \pm standard error.

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 33	6 / 6
Number of Live Oysters per Bushel	68 \pm 7	80 \pm 20
Number of Live Small-Sized Oysters per Bushel	26 \pm 4	15 \pm 4
Number of Live Market-Sized Oysters per Bushel	36 \pm 5	62 \pm 19
Live Oyster Biomass (g Dry Weight per Bushel)	98 \pm 9	147 \pm 42
Mortality (%)	23.6 \pm 4.4	6.6 \pm 3.6

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on three bars within NOAA Code 039 (Figure B.04-3A and Figure B.03-4B). Oysters on Bugby and Parson’s Island bars have declined in size (Figure B.04-3A). From 1990 to 2009, approximately 50% exceeded 80 mm. From 2010 to 2015, 28% were larger than 80 mm and 54% of oysters measured were between 40 and 75 mm. Oysters on Hollicutt’s Noose bar have increased in size (Figure B.04-3B). From 1990 to 2009, 53% of oysters were larger than 80 mm, compared to 64% from 2010 to 2015.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on three bars within NOAA Code 039. The annual biomass on Bugby and Parson’s Island bars ranged from 34 to 232 grams of dry weight per bushel and the average was 90.9 \pm 8.9 (average \pm SE; Figure B.04-4A). The average biomass was lower from 2010 to 2015 than prior to 2010 (Table B.04-2A). Biomass peaked in 2001. Biomass on Hollicutt’s Noose bar ranged from 15 to 276 grams of dry weight per bushel and the average was 109 \pm 12.2 (average \pm SE; Figure B.04-4B). Unlike the other bars in NOAA Code 039, biomass was greater from 2010 to 2015 than prior to 2010 (Table B.04-2B).

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall on Bugby and Parson’s Island bars ranged from 0 to 1677 spat per bushel (Figure B.04-2A). The largest spatfall occurred in 1997. The average spatfall was 76 per bushel. For Hollicutt’s Noose, spatfall ranged from 0 to 56 per bushel, averaging 5.

Mortality

Mortality on Bugby and Parson's Island bars ranged from 3% to 47%, however, since 2008 mortality has been relatively low (Figure B.04-5A). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.04-2A). Mortality on Hollicutt's Noose was similar to mortality on the other bars, ranging from 0% to 69% (Figure B.04-5B). Mortality was lower from 2010 to 2015 than prior to 2015 (Table B.04-2B).

Disease

Dermo prevalence on Bugby and Parson's island bars ranged from 19 % to 100% (Figure B.04-6A). Dermo prevalence was greater than 80% for 11 of the 26 years disease information was collected. Dermo intensity ranged from 0.5 to 4.6, remaining below lethal levels (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 22%. On Hollicutt's Noose, dermo prevalence ranged from 13% to 100% (Figure B.04-6B). It was greater than 80% for 12 of the 26 years of disease data collection. Dermo intensity ranged from 0.3 to 4.8, remaining below lethal levels. MSX prevalence ranged from 0% to 37%, with an extended period of prevalence from 1999 to 2002.

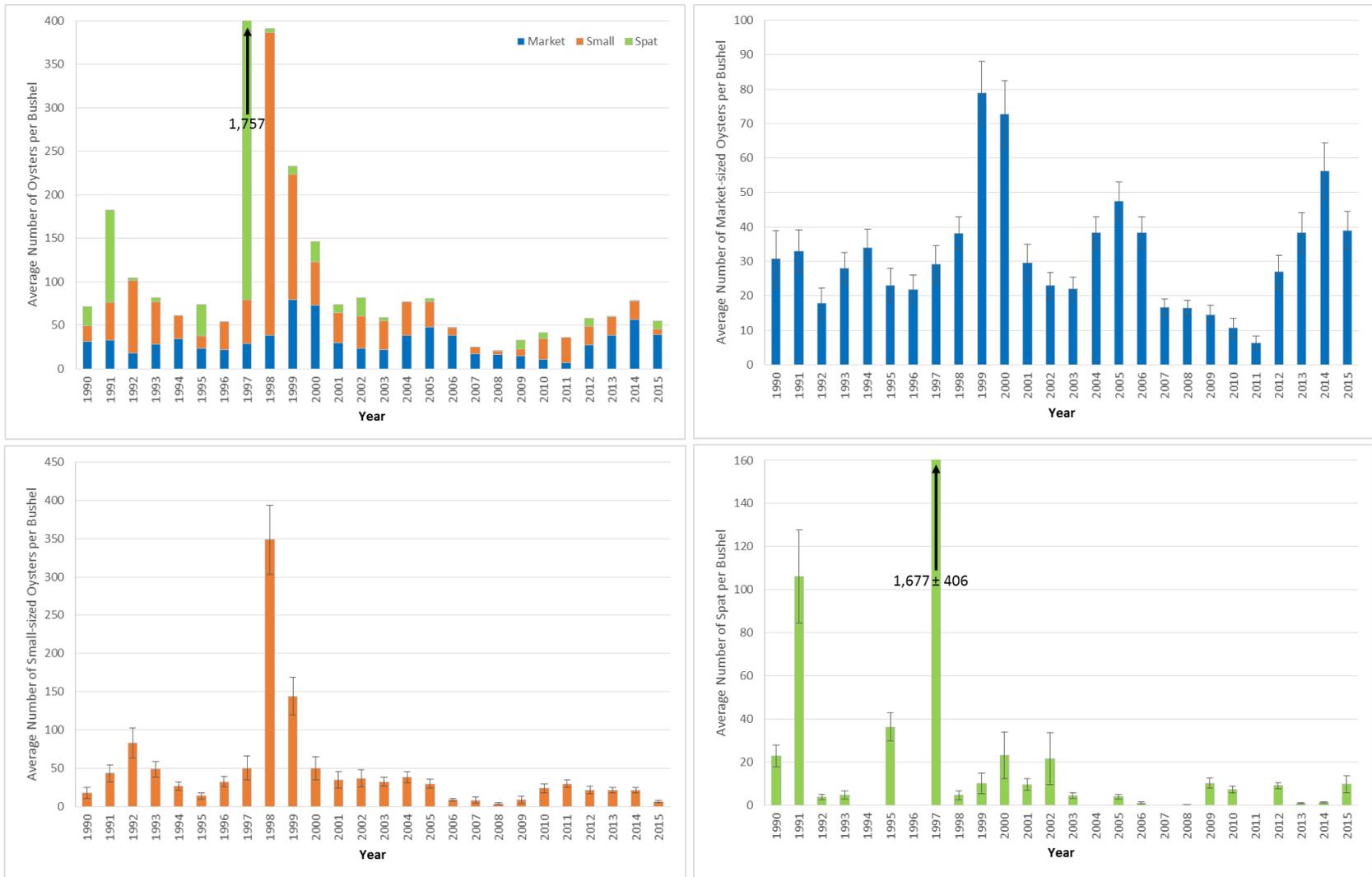


Figure B.04-2A. Average number of live oysters per bushel of material by size class in the NOAA Code 039 (Eastern Bay) for all samples except on the oyster bar Hollicutts Noose. Error bars represent ± 1 standard error. Data from Maryland's Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

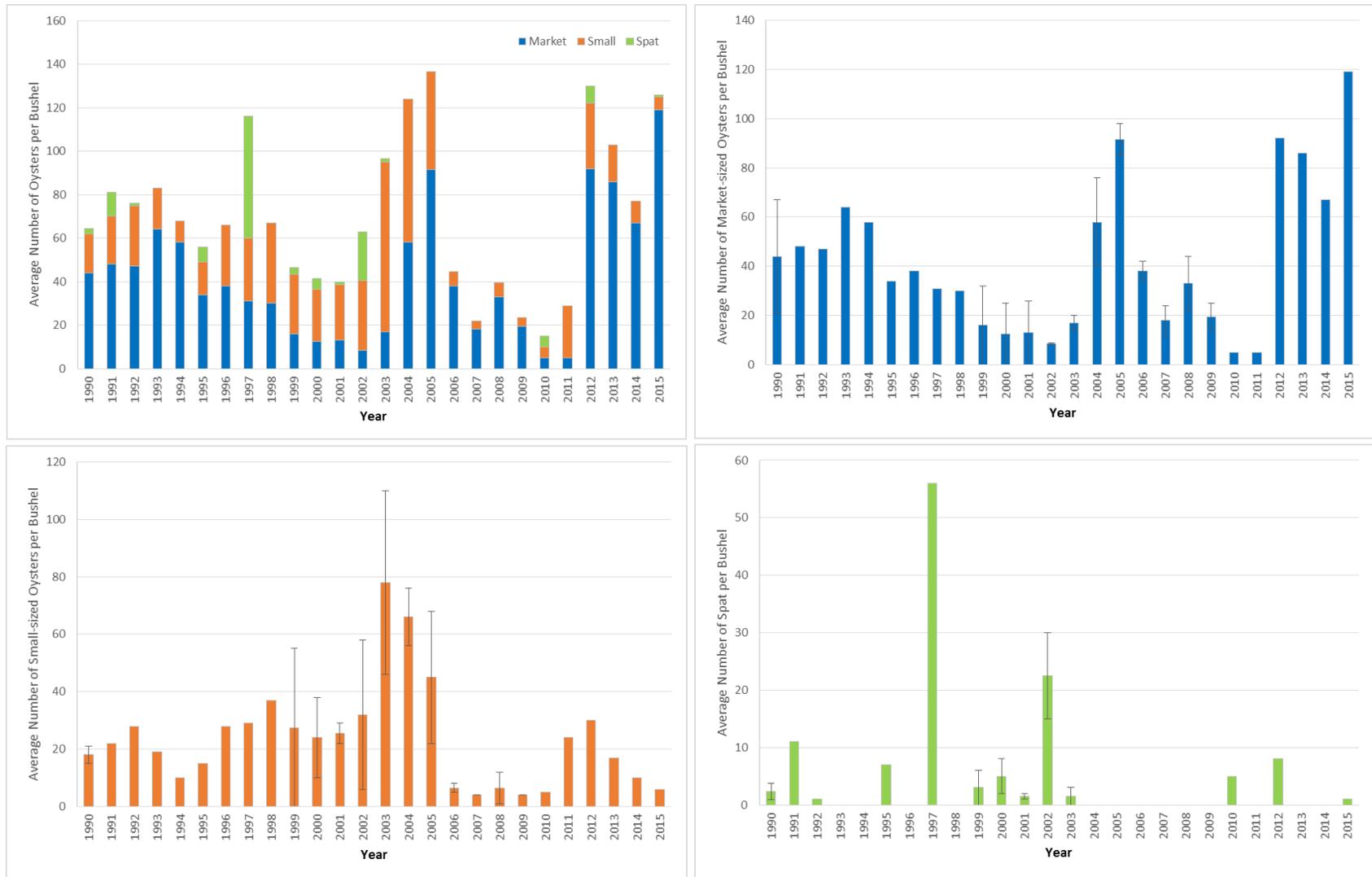


Figure B.04-2B. Average number of live oysters per bushel of material by size class in the NOAA Code 039 (Eastern Bay) on the oyster bar Hollicutts Noose. Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

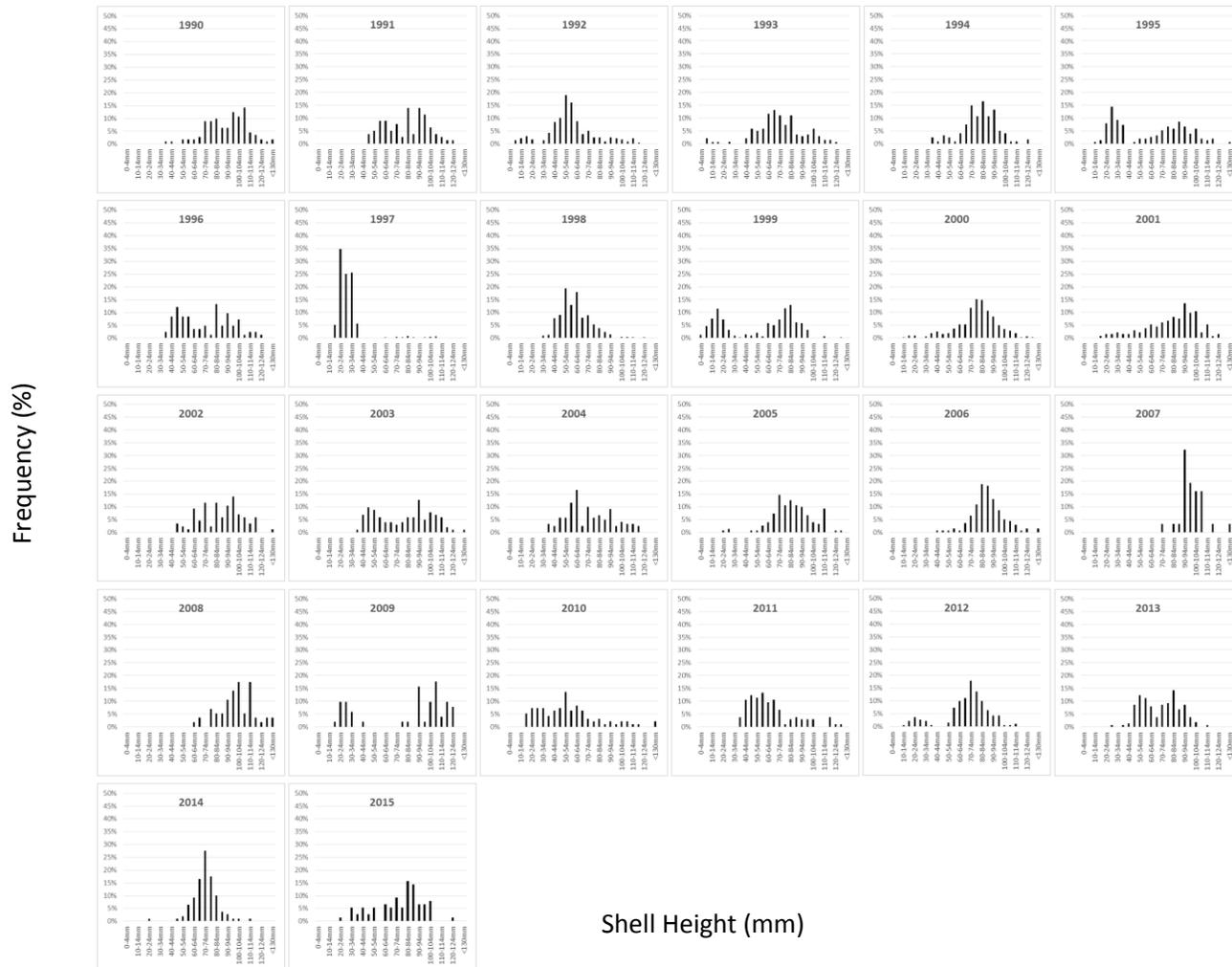


Figure B.04-3A. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 039 (Eastern Bay) for all samples except on the oyster bar Hollicutts Noose. Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

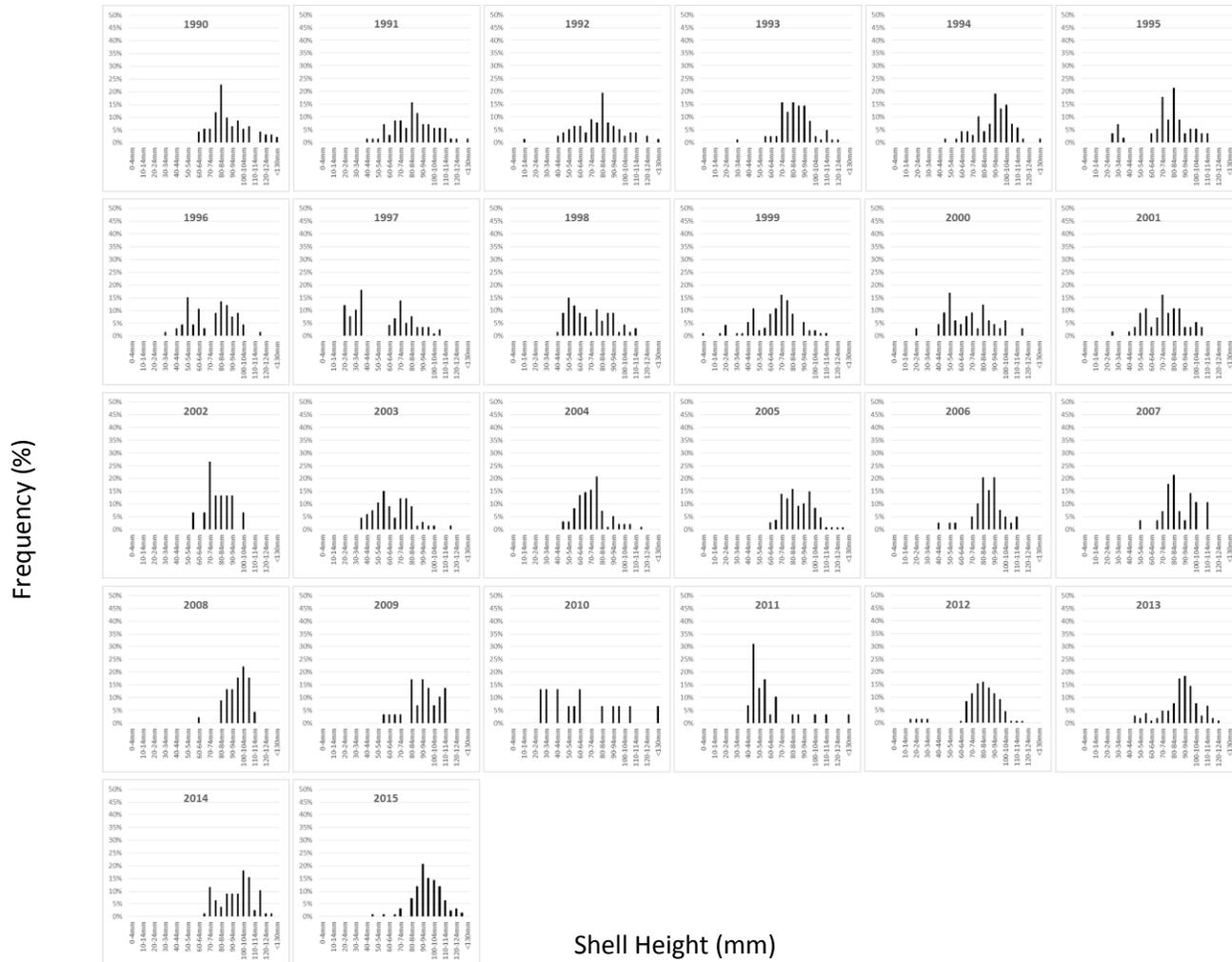


Figure B.04-3B. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 039 (Eastern Bay) on the oyster bar Hollicutts Noose. Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

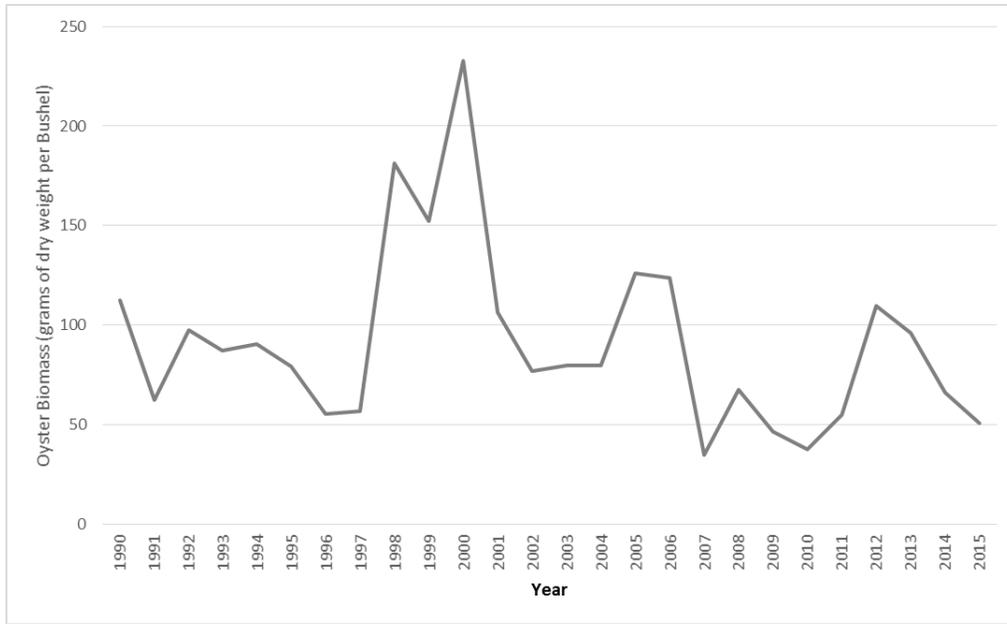


Figure B.04-4A. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 039 (Eastern Bay) for all samples except on the oyster bar Hollicutts Noose. Data from Maryland’s Annual Fall Oyster Dredge Survey.



Figure B.04-4B. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 039 (Eastern Bay) on the oyster bar Hollicutts Noose. Data from Maryland’s Annual Fall Oyster Dredge Survey.

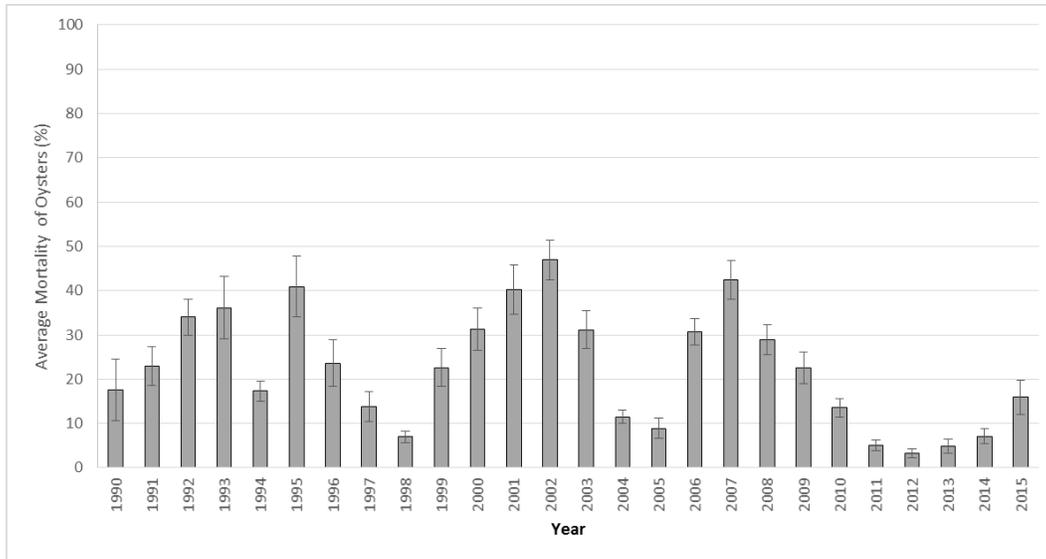


Figure B.04-5A. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 039 (Eastern Bay) for all samples except on the oyster bar Hollicutts Noose. Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

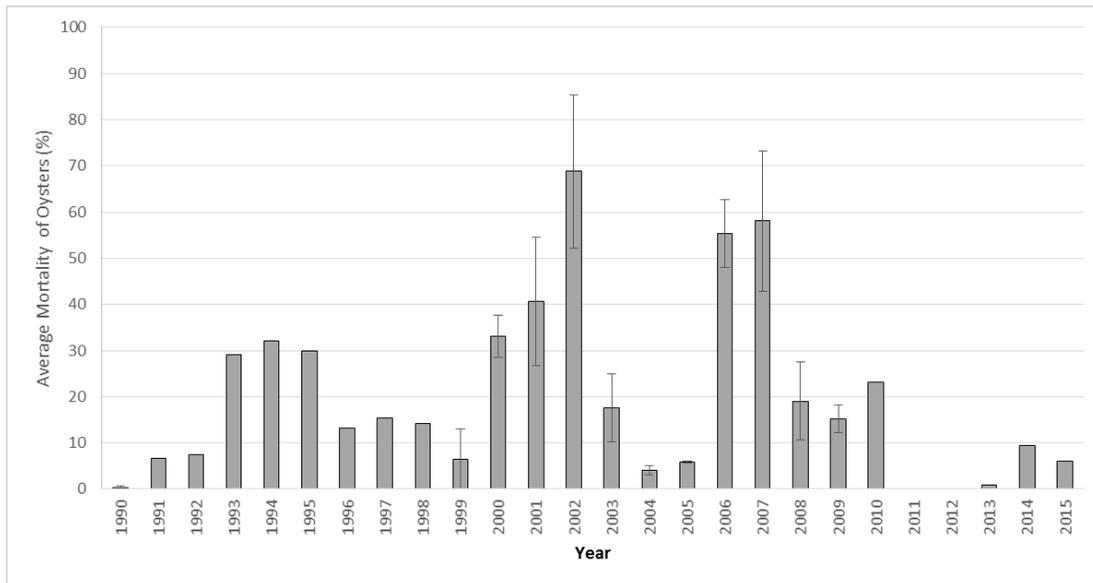


Figure B.04-5B. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 039 (Eastern Bay) on the oyster bar Hollicutts Noose. Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

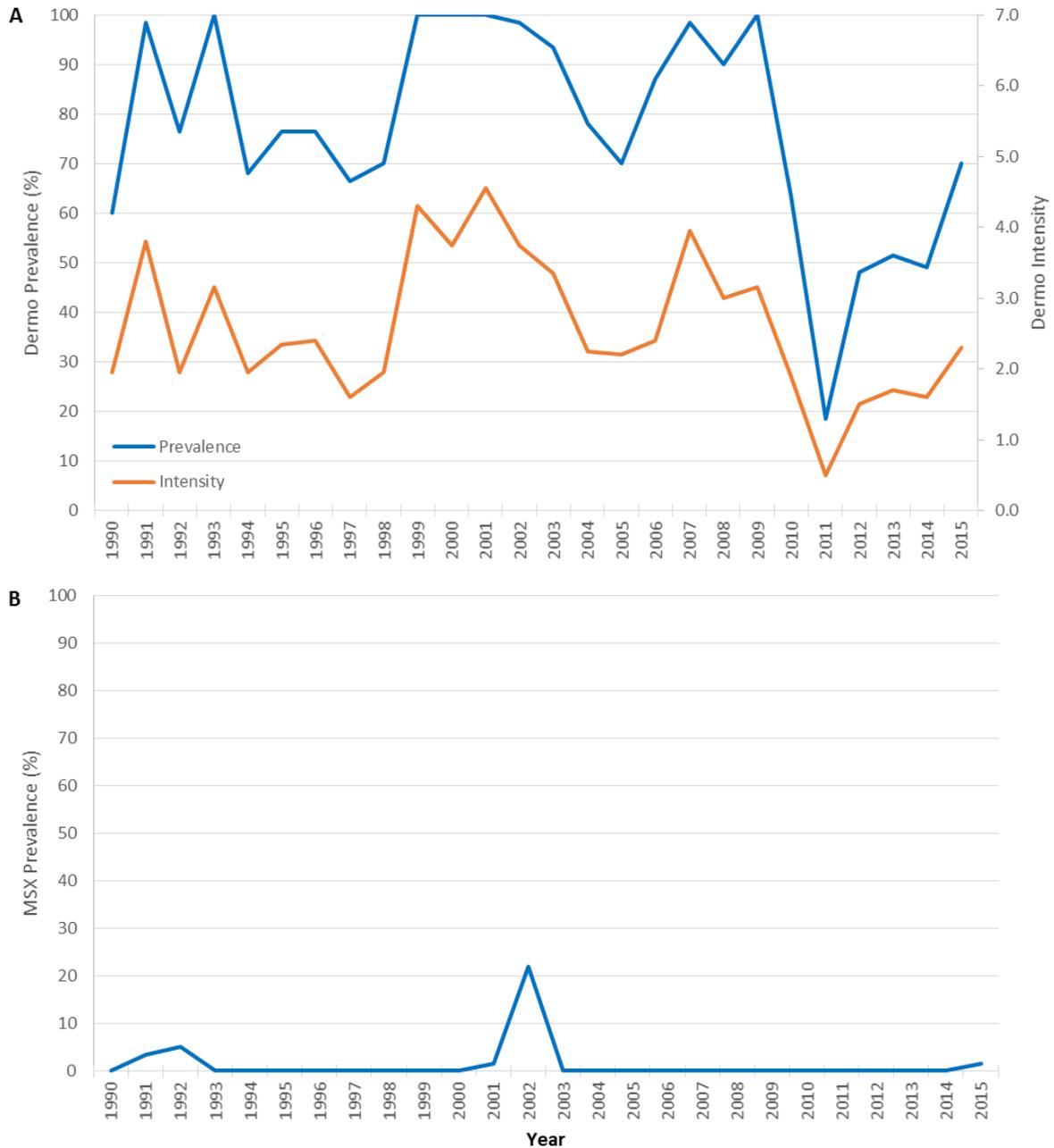


Figure B.04-6A. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA 039 (Eastern Bay) for all samples except on the oyster bar Hollicutts Noose. (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland’s Annual Fall Oyster Dredge Survey.

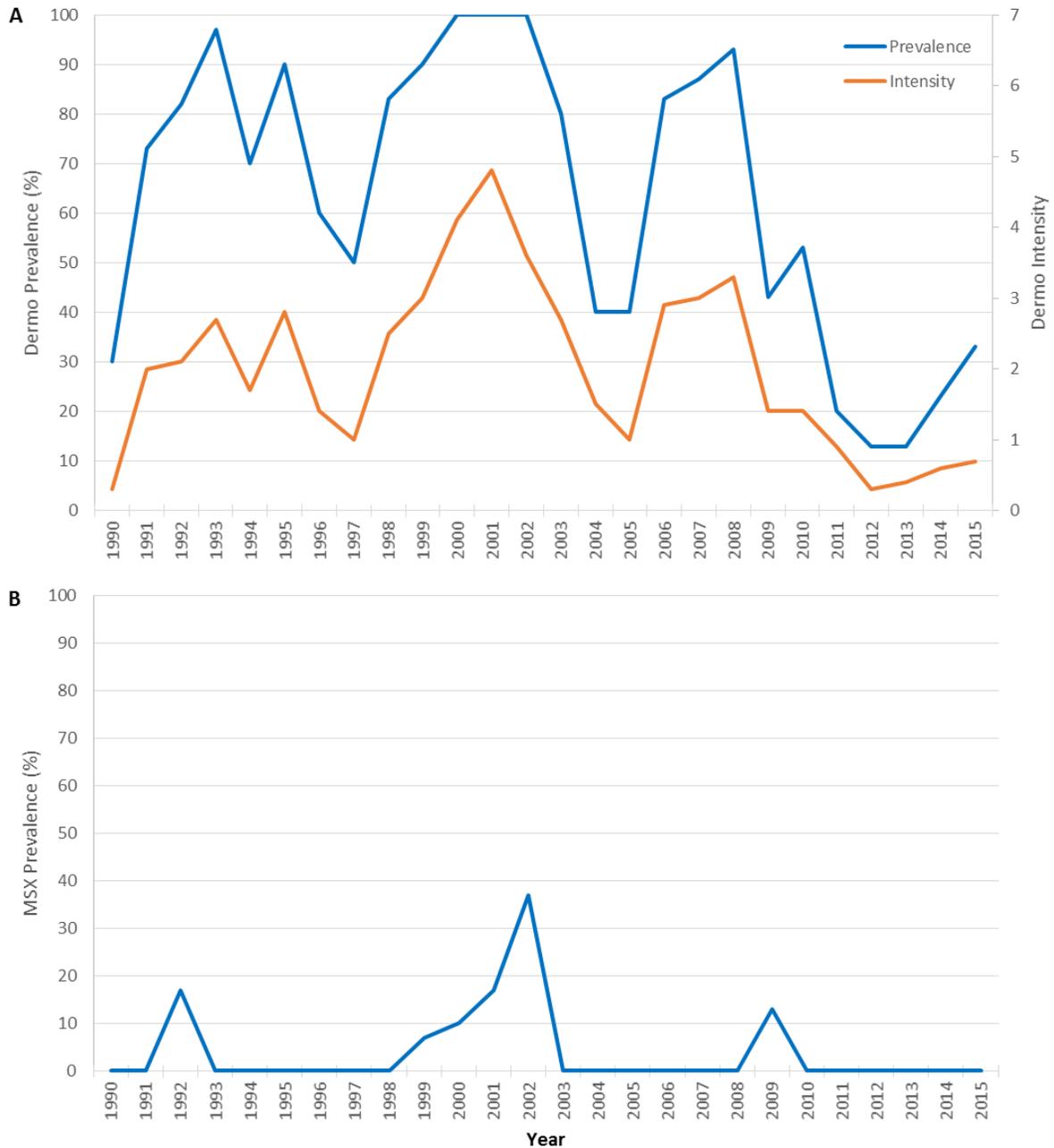


Figure B.04-6B. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA 039 (Eastern Bay) on the oyster bar Hollicutts Noose. (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland’s Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 039 (Eastern Bay) since 1990 is presented in Figure B.04-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 25% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from 168 bushels in 2011-2012 to a maximum of approximately 119,000 bushels in the 2000-2001 season. This peak in harvest in 2000-2001 was most likely due to the 1997 spatfall. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Diving accounted for the majority of harvest in this area as reported on the oyster harvest reports.

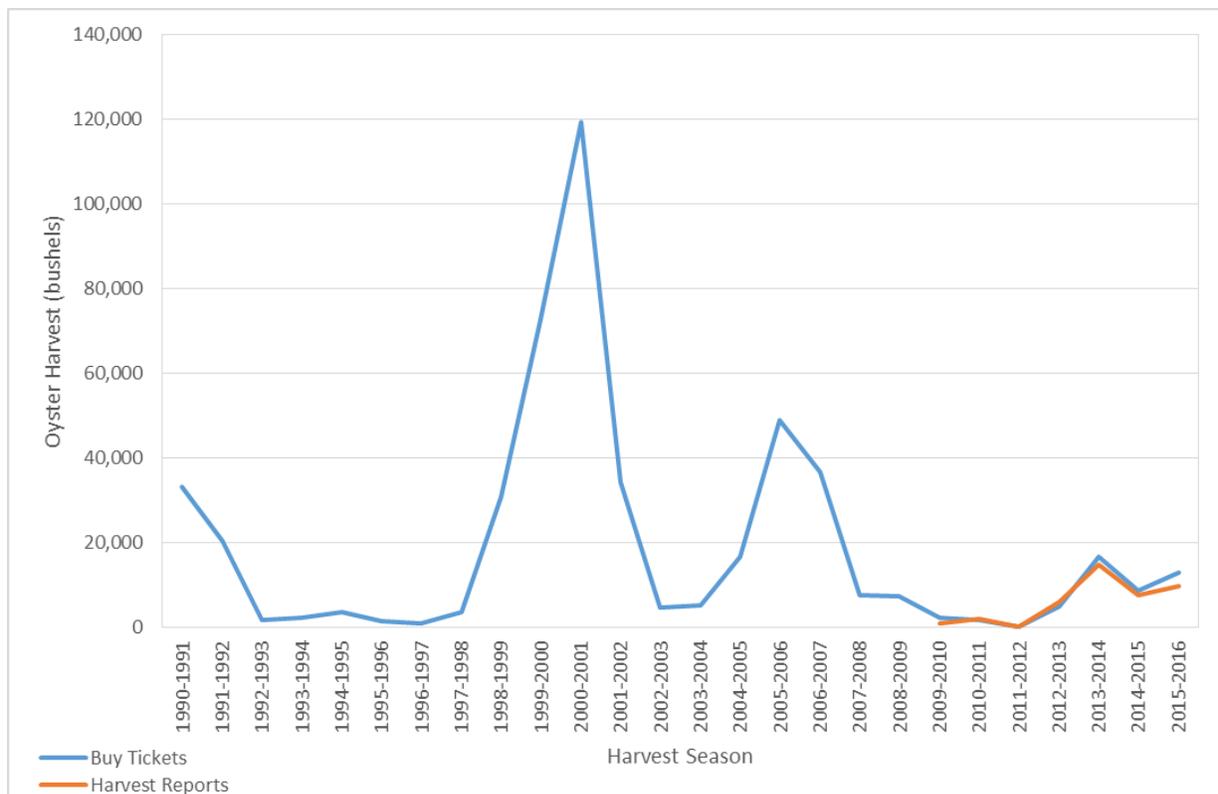


Figure B.04-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 039 (Eastern Bay). After the 2009-2010 season, 25% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.05: NOAA Code 043 – Fishing Bay

NOAA Code 043 encompasses Fishing Bay and is located in Maryland’s lower eastern portion of Chesapeake Bay (Figure B.05-1). The entire NOAA Code is 31,138 acres and 28 historic oyster bars¹¹. Currently, none of the area within the NOAA Code is within an oyster sanctuary. There are 11,820 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code. There are 4,555 acres within the NOAA Code that were designated as a Public Shellfish Fishery Area in 2010 where aquaculture leasing is prohibited. This NOAA Code is generally located within Maryland’s low salinity zone.

Replenishment Activities

Since 1990, approximately 177 thousands of bushels of shell, 6.7 thousands of bushels of wild seed, and 19 million hatchery spat-on-shell have been planted in NOAA Code 043 (Table B.05-1).

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Dredged Shell	19.5	79.8	-
1990	Fresh Shell	1.5	2.0	-
1991	Wild Seed	6.7	2.3	-
1992	Wild Seed	38.9	12.7	-
1996	Dredged Shell	26.3	43.4	-
2001	Wild Seed	8.6	5.1	-
2013	Fresh Shell	6.0	11.9	-
2014	Fresh Shell	20.0	20.2	-
2014	Hatchery Spat-on-Shell	8.7	-	19.0
2015	Fresh Shell	14.7	20.4	-

¹¹ See chart 30 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

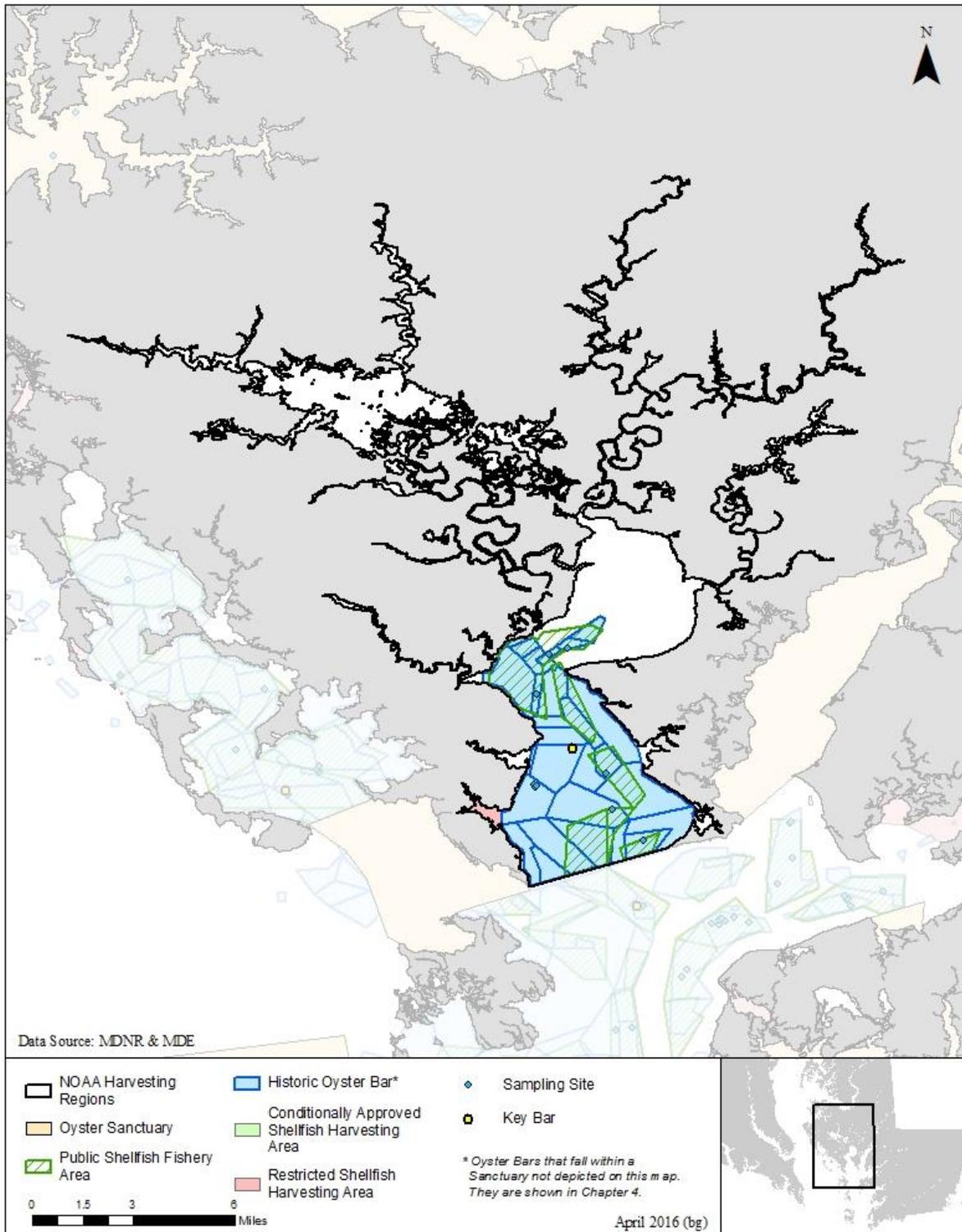


Figure B.01 -1. Map of NOAA Code 043 – Fishing Bay, Maryland.

Oyster Population Characteristics

The Fall Survey has sampled seven to nine oyster bars annually in NOAA Code 043 since 1990. The average number of total live oysters (market, small, and spat) ranged from 1 to 304 per bushel with an average of 108 (Figure B.05-2). The number of oysters decreased from 1996 to 2005, and then began to increase starting in 2006. The average number of live oysters was greater from 2010 to 2015 than prior to 2010 (Table B.05-2). On average, there were more small-sized oysters annually than market-sized oysters.

Table B.05-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 043 (Fishing Bay). Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 146	6 / 42
Number of Live Oysters per Bushel	79 \pm 16	201 \pm 34
Number of Live Small-Sized Oysters per Bushel	36 \pm 10	83 \pm 15
Number of Live Market-Sized Oysters per Bushel	20 \pm 4	38 \pm 11
Live Oyster Biomass (g Dry Weight per Bushel)	67 \pm 12	161 \pm 26
Mortality (%)	36.9 \pm 5.2	11 \pm 3.6

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Goose Creek bar within NOAA Code 043 (Figure B.05-3). The largest oysters (greater than 120mm shell height) were collected from 1998 to 2003 which also corresponded to the time period where the least amount of oysters per bushel was recorded. After 2010, a bi-modal oyster shell height distribution generally occurred, indicating two distinct classes of oysters, spat and adult oysters. The largest percent frequency of shell height occurred before the 80mm size class in most years.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on Goose Creek bar within NOAA Code 043. The annual biomass has varied over the years from 3 to 227 grams of dry weight per bushel and the average is 88.8 \pm 13.6 (average \pm SE; Figure B.05-4). The average biomass was greater from 2010 to 2015 than prior to 2010 (Table B.05-2). From 2001 to 2006, biomass was the lowest and it peaked in 1995 and again in 2013. In 2014 and 2015, biomass began to decrease from the peak in 2013.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall had ranged from 0 to 148 spat per bushel from 1990 to 2015 (Figure B.05-2). The largest spatfall occurred in 1991. From 1996 to 2005, there was very little spatfall. From 2006 to 2013, there was a consistent period of high spatfall.

Mortality

Mortality ranged from 3% to 69%. Since 2006, mortality has been relatively low (Figure B.05-5). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.05-2).

Disease

From 1990 to 2015, dermo prevalence has ranged from 0% to 100% (Figure B.05-6). Dermo prevalence was greater than 80% for 14 of the 26 years disease information was collected. Dermo intensity ranged from 0 to 5.4. From 1999 to 2002, dermo intensity was consistently high with lethal infections occurring in 1999 (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 47% from 1990 to 2015. In 1999 to 2002, there was an extended period of MSX prevalence.

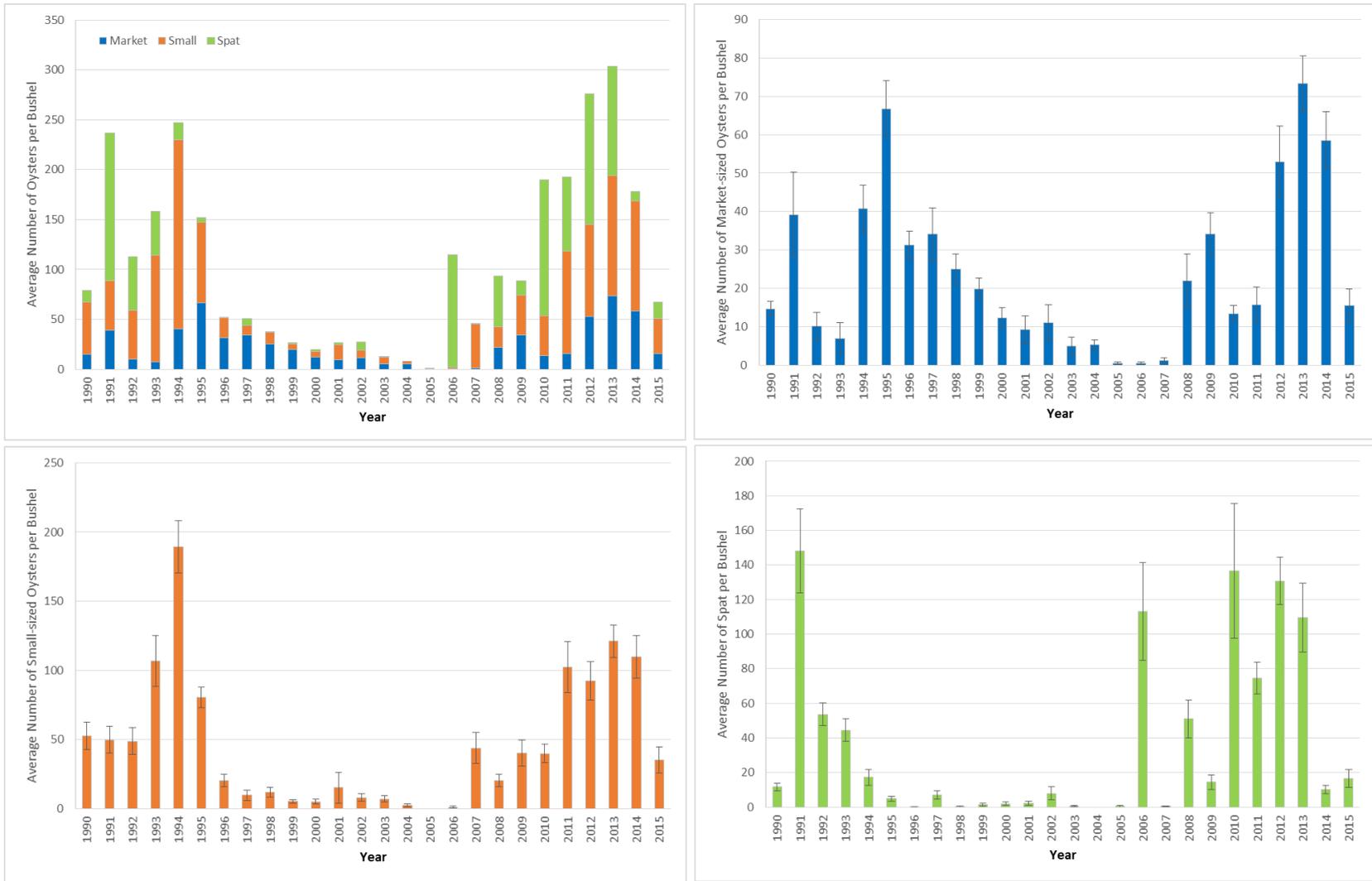
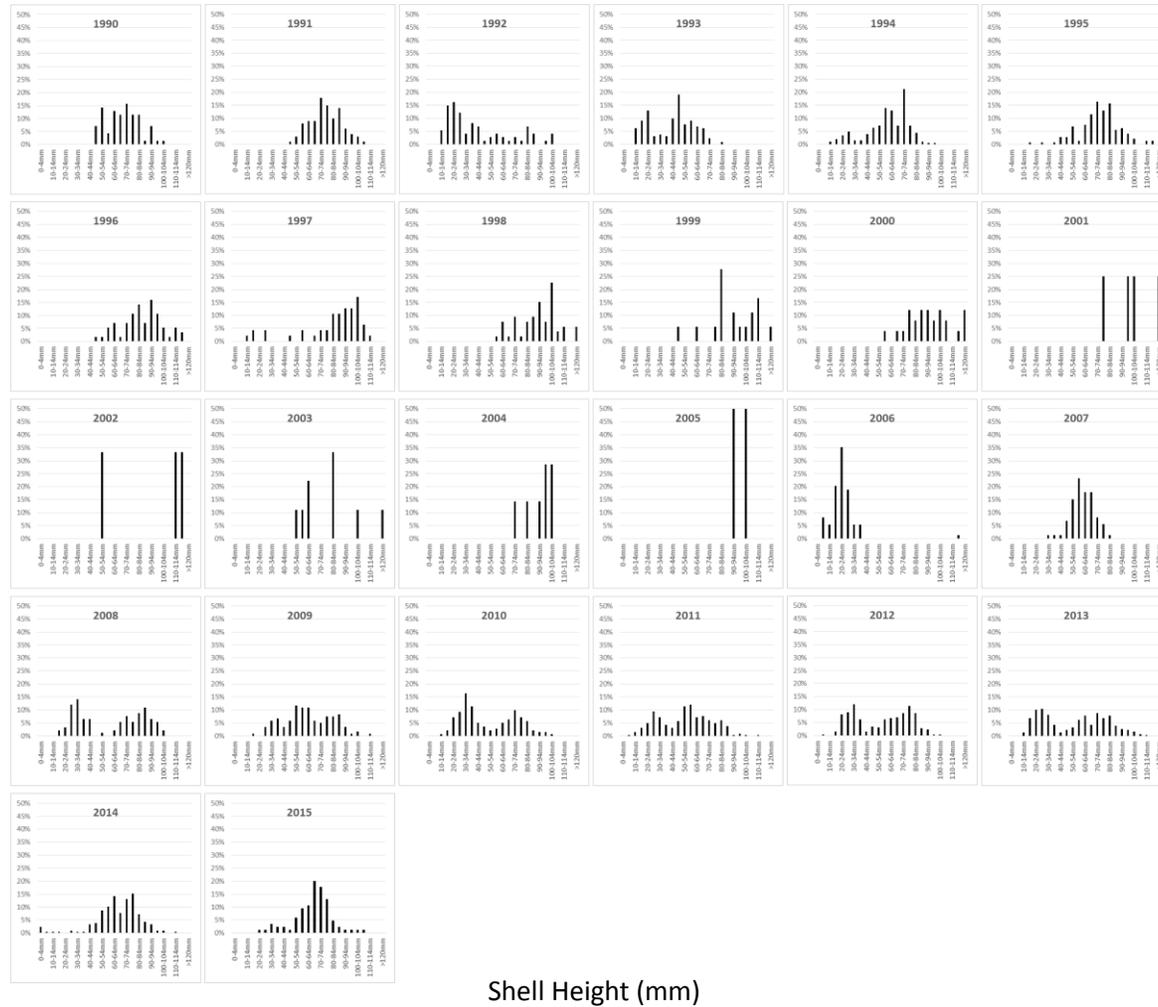


Figure B.05-2. Average number of live oysters per bushel of material by size class in the NOAA Code 043 (Fishing Bay). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

Frequency (%)



Shell Height (mm)

Figure B.05-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 043 (Fishing Bay). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

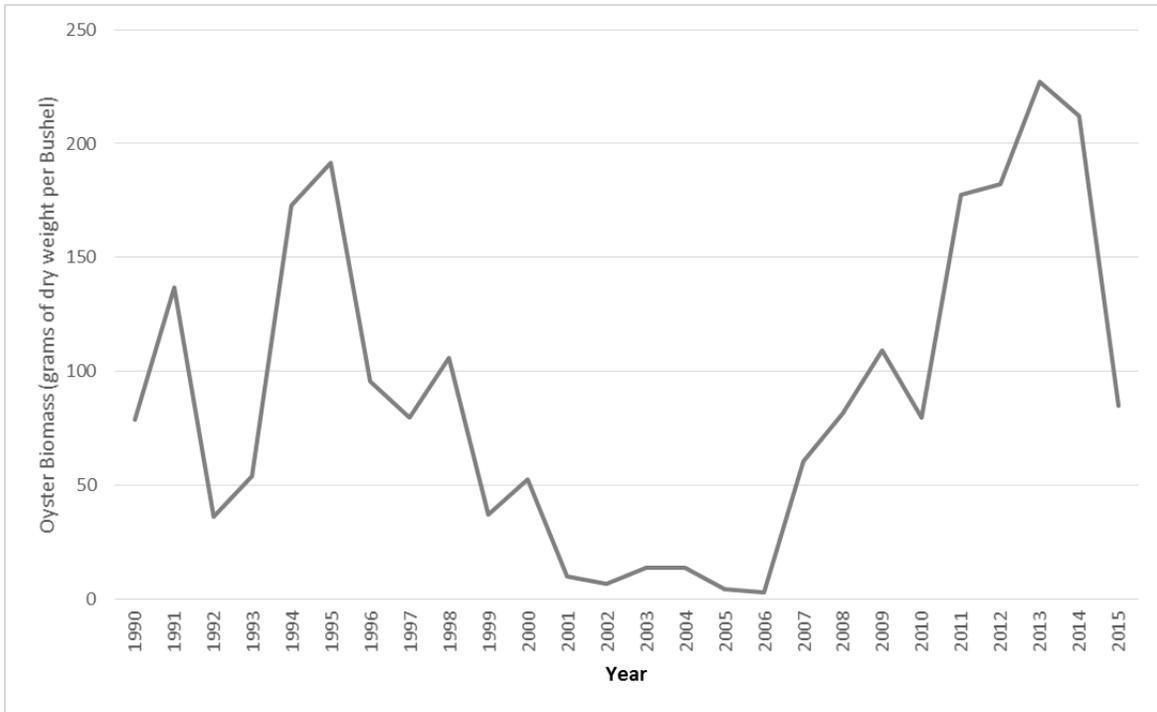


Figure B.05-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 043 (Fishing Bay). Data from Maryland’s Annual Fall Oyster Dredge Survey.

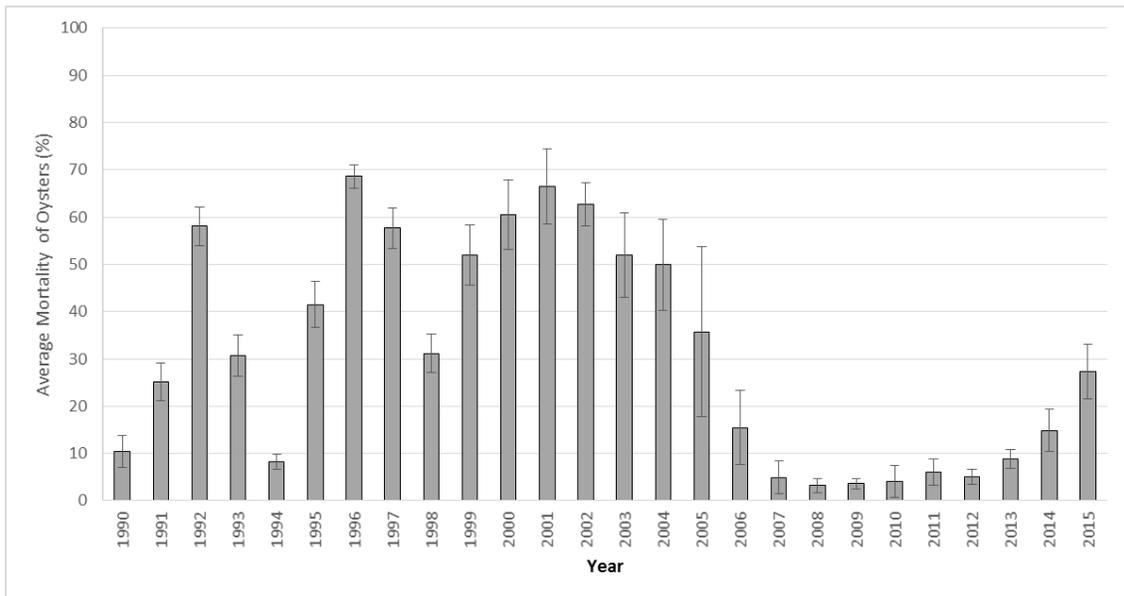


Figure B.05-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 043 (Fishing Bay). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

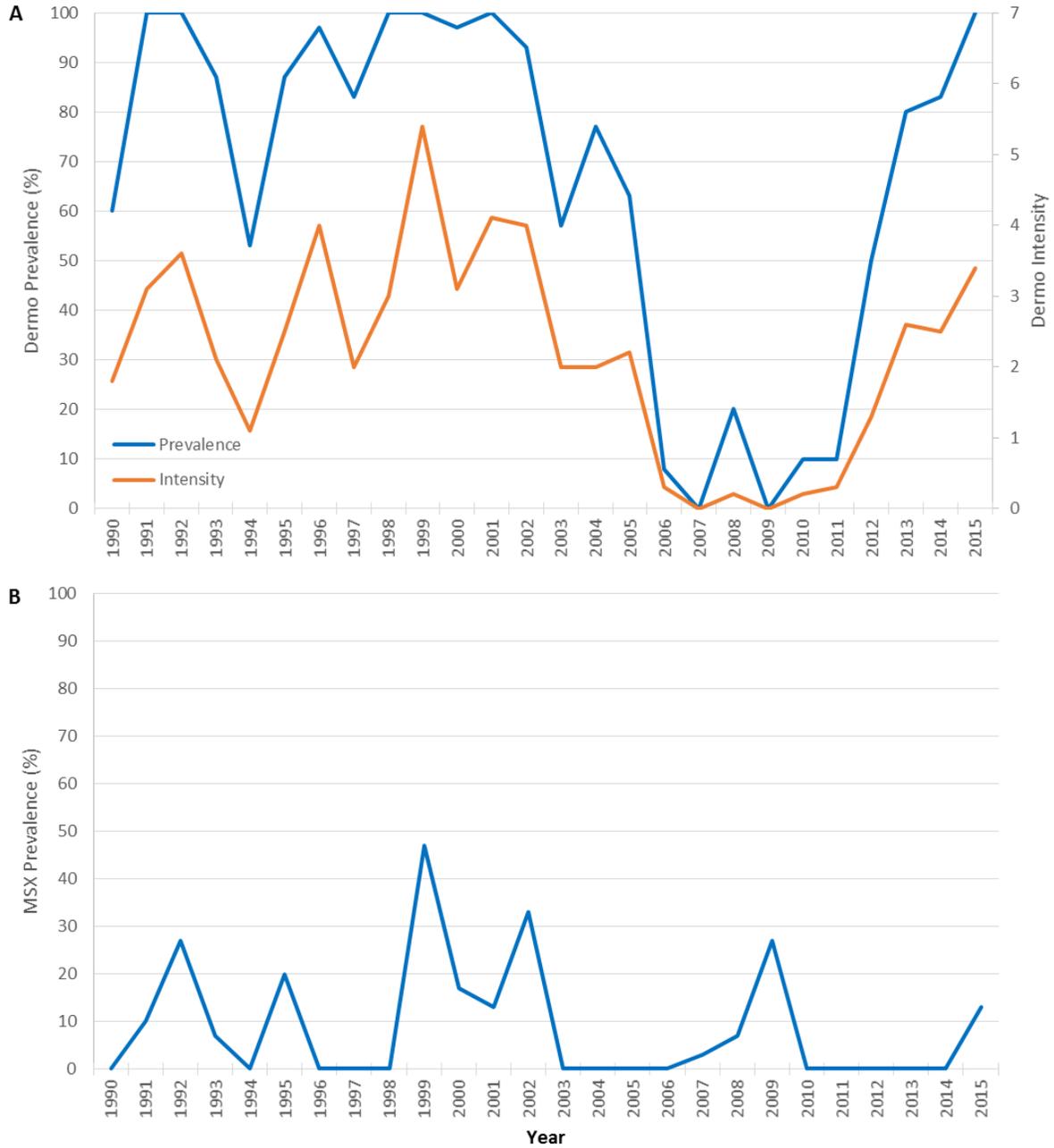


Figure B.05-6. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 043 (Fishing Bay). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland’s Annual Fall Oyster Dredge Survey.

Harvest

Harvest for NOAA Code 043 since 1990 is presented in Figure B.05-7. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in the 2000-2001 and 2002-2003 seasons to a maximum of approximately 62,000 bushels in the 2013-2014 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Power dredging accounted for 94% of the harvest, as reported on oyster harvester reports.

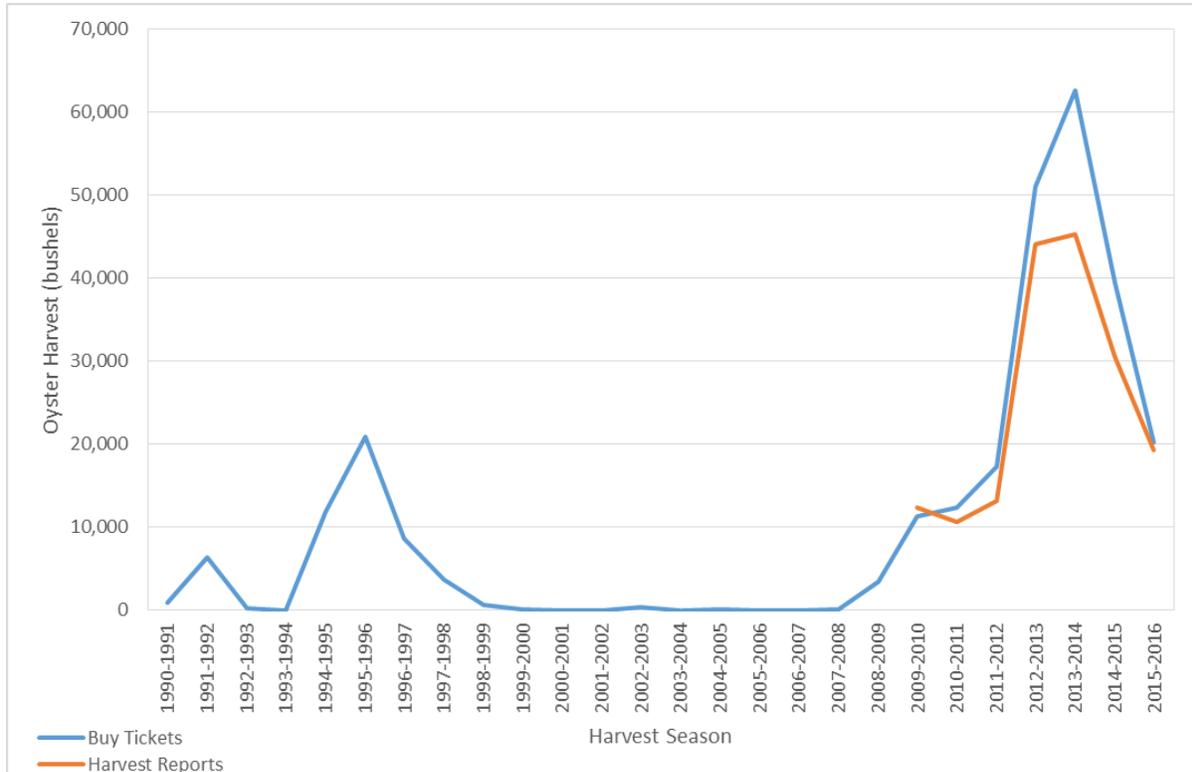


Figure B.05-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 043 (Fishing Bay).

Section B.06: NOAA Code 047 – Honga River

NOAA Code 047 encompasses the Honga River and is located in Maryland’s lower eastern portion of Chesapeake Bay (Figure B.06-1). The entire NOAA Code is 31,445 acres and has 55 historic oyster bars¹². The Hooper Straits Sanctuary encompasses 16% (5,087 acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 26,358 acres. There are 16,317 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010, 13,390 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s medium salinity zone.

Replenishment Activities

Since 1990, approximately, 244,000 bushels of shell have been planted in NOAA Code 047 outside of the current sanctuary area (Table B.06-1). One wild seed planting and one hatchery spat-on-shell planting has also occurred since 1990.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
2004	Wild Seed	20.9	7.6	-
2005	Dredged Shell	27.3	152.0	-
2009	Hatchery Spat-on-Shell	13.4	-	20.7
2012	Dredged Shell	88.2	37.3	-
2013	Fresh Shell	4.4	17.4	-
2014	Fresh Shell	63.4	15.7	-
2015	Fresh Shell	23.2	21.7	-

¹² See chart 29 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

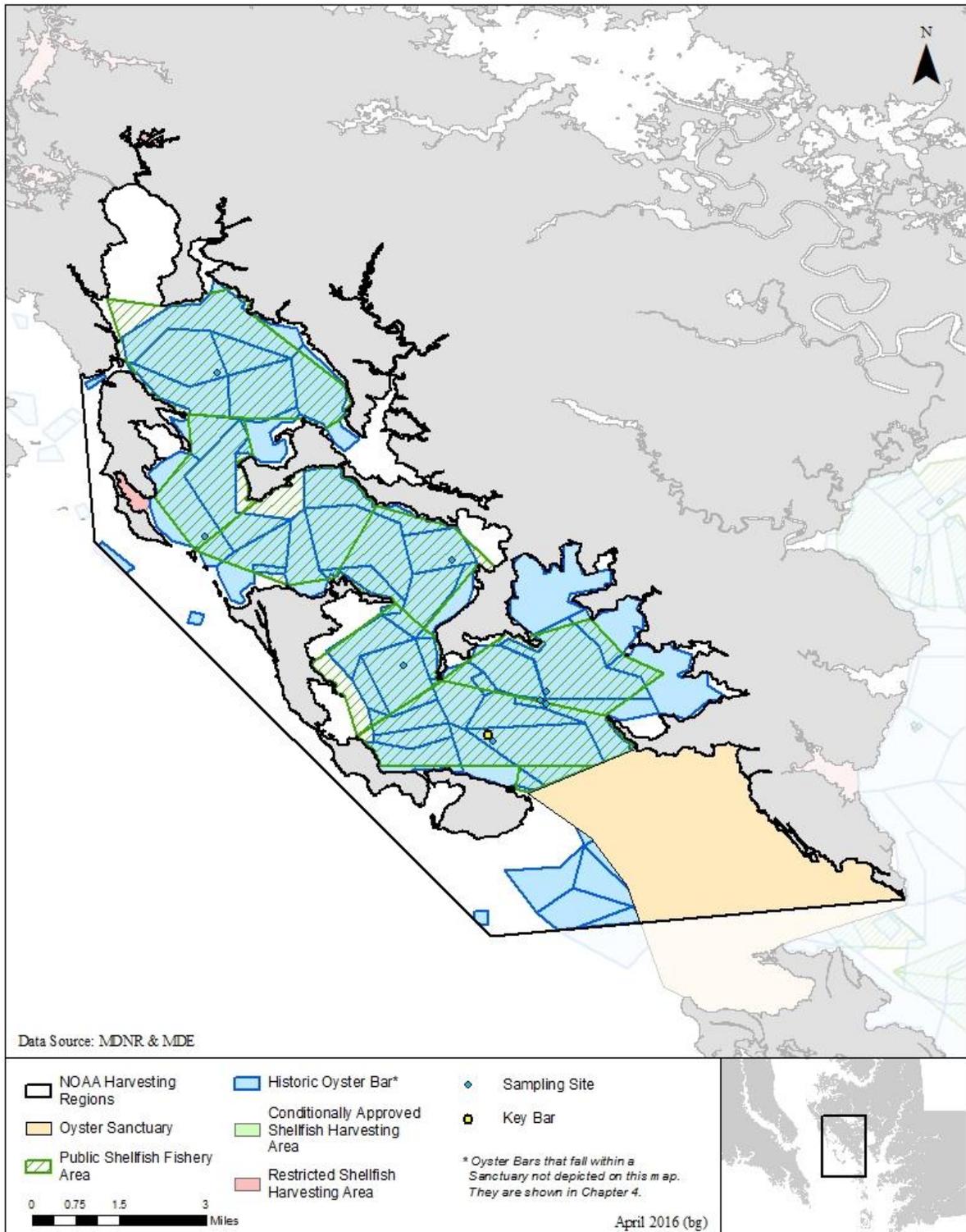


Figure B.06 -1. Map of NOAA Code 047 (Honga River).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled four to eight oyster bars annually in NOAA Code 047 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 16 to 800 per bushel with an average of 184 (Figure B.06-2). The number of oysters decreased from 1996 to 2005, and then began to increase starting in 2006. The average number of live oysters was greater from 2010 to 2015 than prior to 2010 (Table B.06-2). On average, there were more small-sized oysters annually than market-sized oysters.

Table B.06-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 047 (Honga River). Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 120	6 / 34
Number of Live Oysters per Bushel	155 \pm 37	281 \pm 26
Number of Live Small-Sized Oysters per Bushel	74 \pm 12	149 \pm 21
Number of Live Market-Sized Oysters per Bushel	14 \pm 2	31 \pm 5
Live Oyster Biomass (g Dry Weight per Bushel)	55 \pm 8	158 \pm 15
Mortality (%)	32.2 \pm 4.2	12 \pm 1.9

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Norman's Addition bar within NOAA Code 047 (Figure B.06-3). Oysters were larger prior to 2010; 27% measured 75 mm or greater, compared to 17% for those measured from 2010 to 2015. Overall, approximately 50% of oysters were between 40 and 75 mm.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on Norman's Addition bar within NOAA Code 047. The annual biomass ranged from 13 to 219 grams of dry weight per bushel and the average is 78.7 \pm 11.2 (average \pm SE; Figure B.06-2). The average biomass was greater from 2010 to 2015 than prior to 2010 (Table B.06-2). From 1996 to 2006, biomass was the lowest then began increasing, peaking in 2013.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 0 to 670 spat per bushel from 1990 to 2015 (Figure B.06-2). The largest spatfall occurred in 1991. From 1994 to 2005, there was very little spatfall, averaging 14 per bushel. From 2006, spatfall was inconsistent but generally higher, averaging 91 per bushel.

Mortality

Mortality ranged from 3% to 68%; since 2006 mortality has been relatively low (Figure B.06-5). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.06-2).

Disease

From 1990 to 2015, dermo prevalence has ranged from 23% to 100% (Figure B.06-6). Dermo prevalence was greater than 80% for 18 of the 26 years disease information was collected. Dermo intensity ranged from 0.7 to 4.3, below lethal levels for the time period (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 63%. From 1999 to 2002, there was an extended period of MSX prevalence.

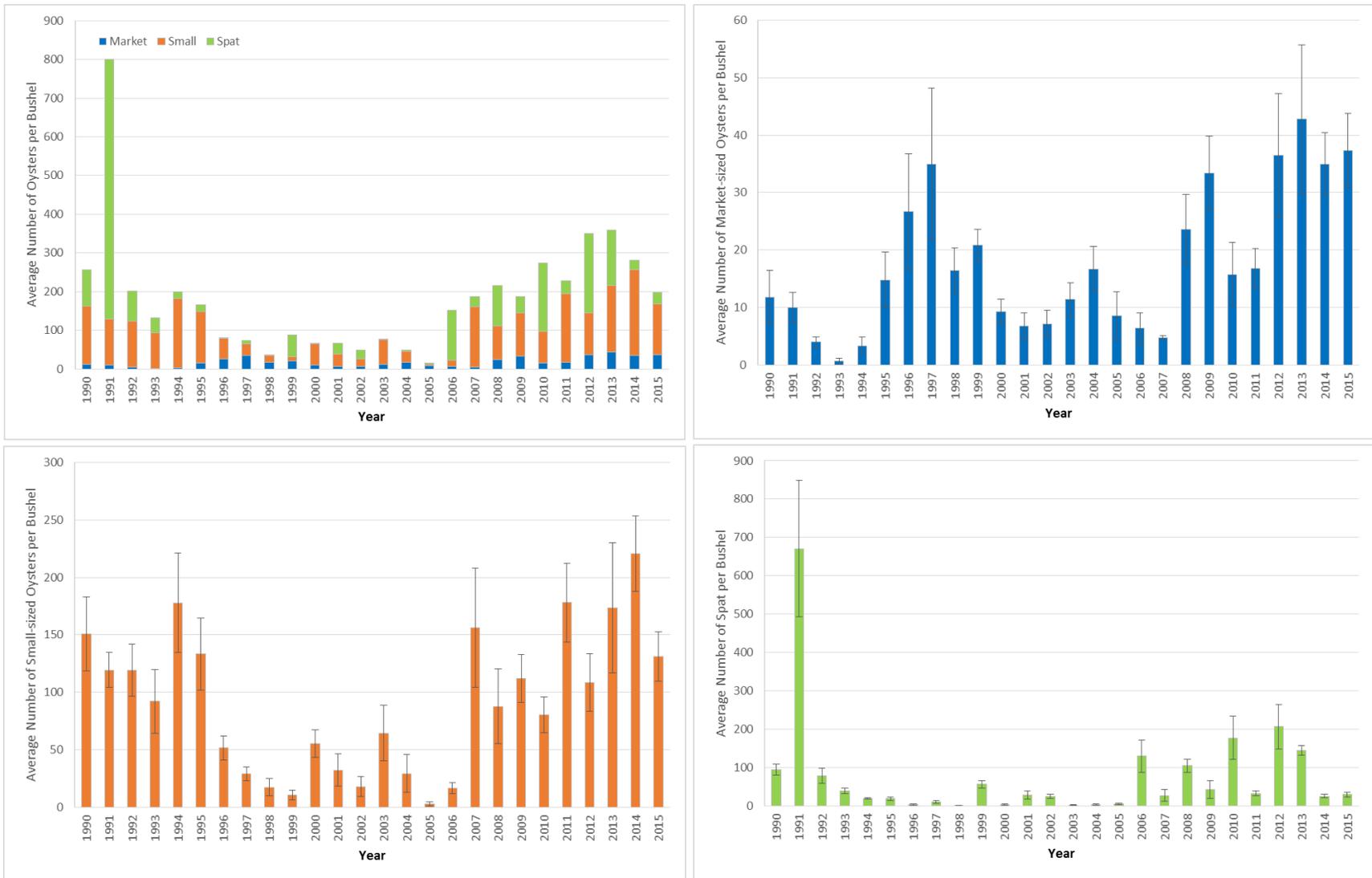
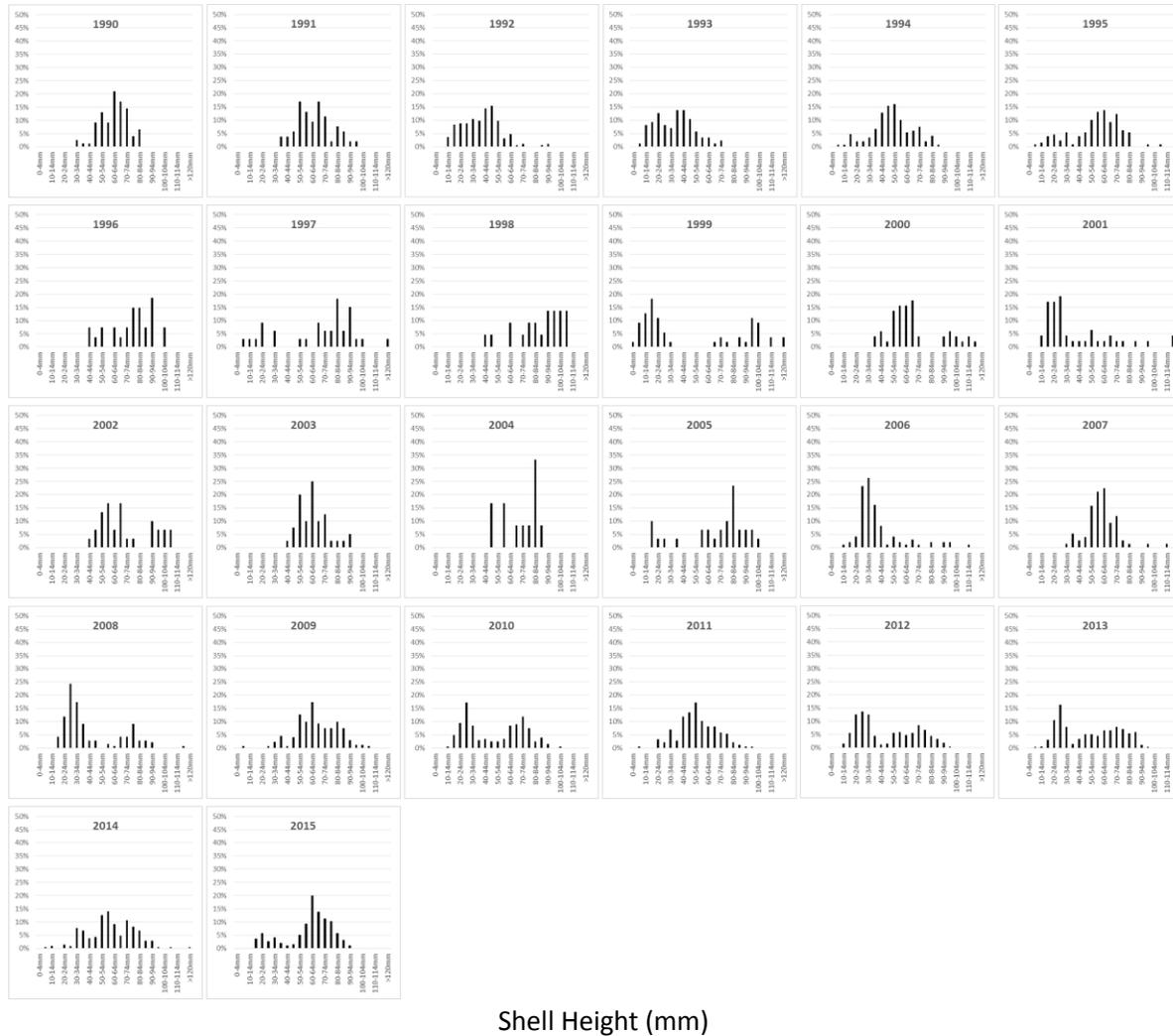


Figure B.06-2. Average number of live oysters per bushel of material by size class in the NOAA Code 047 (Honga River). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

Frequency (%)



Shell Height (mm)

Figure B.06-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 047 (Honga River). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

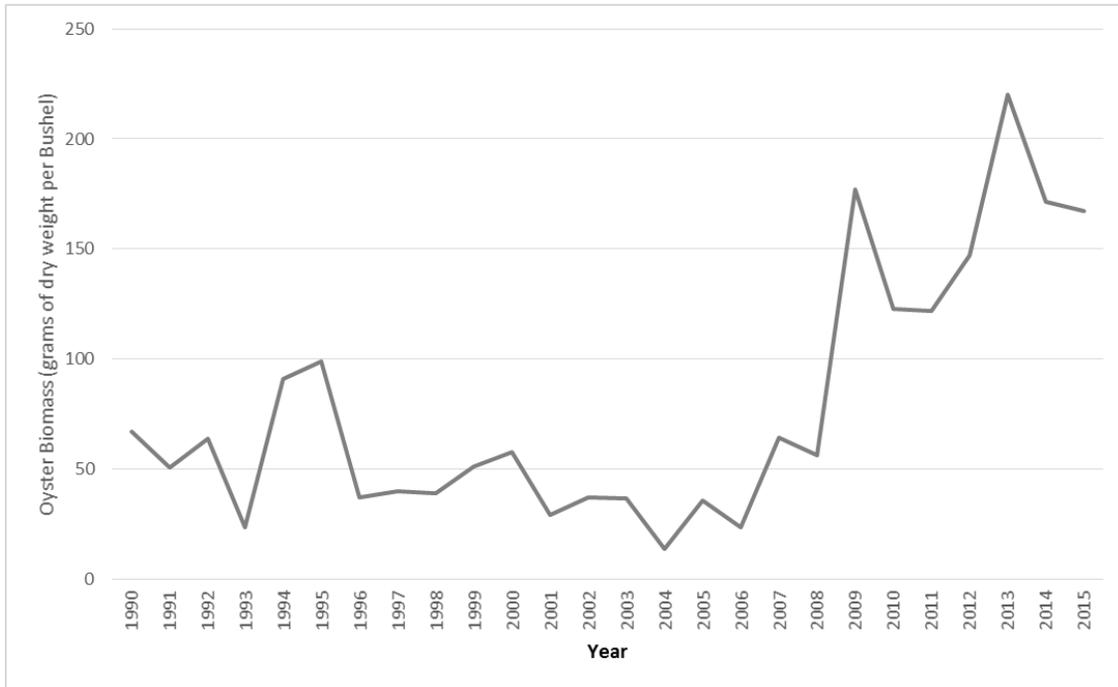


Figure B.06-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 047 (Honga River). Data from Maryland’s Annual Fall Oyster Dredge Survey.

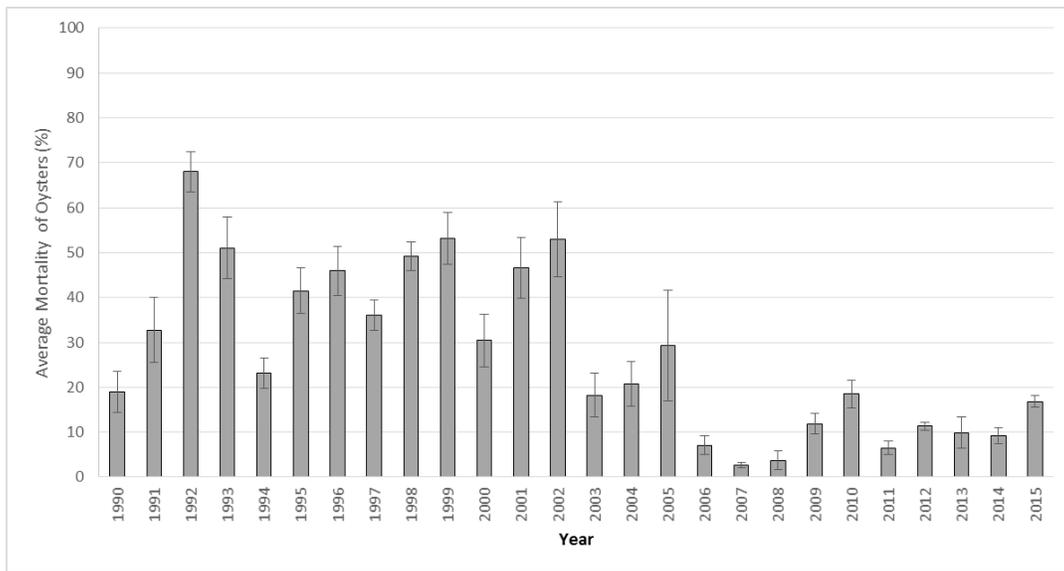


Figure B.06-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 047 (Honga River). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

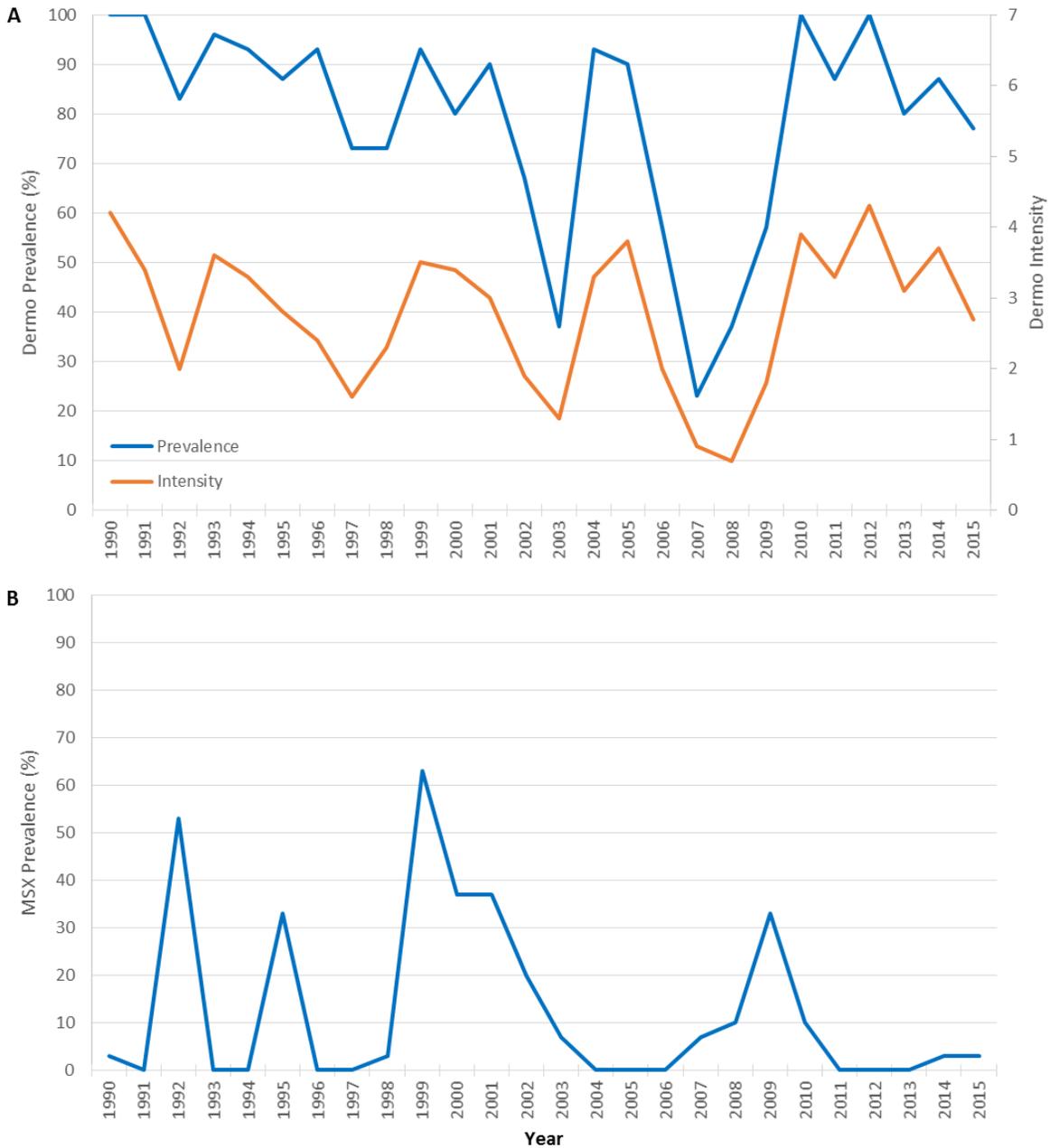


Figure B.06-6. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 047 (Honga River). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland’s Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 047 since 1990 is presented in Figure B.06-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 16% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in the 2000-2001 and 2001-2002 seasons to approximately 25,000 bushels in the 2013-2014 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Power dredging accounted for 91% of the harvest, as reported on oyster harvester reports.

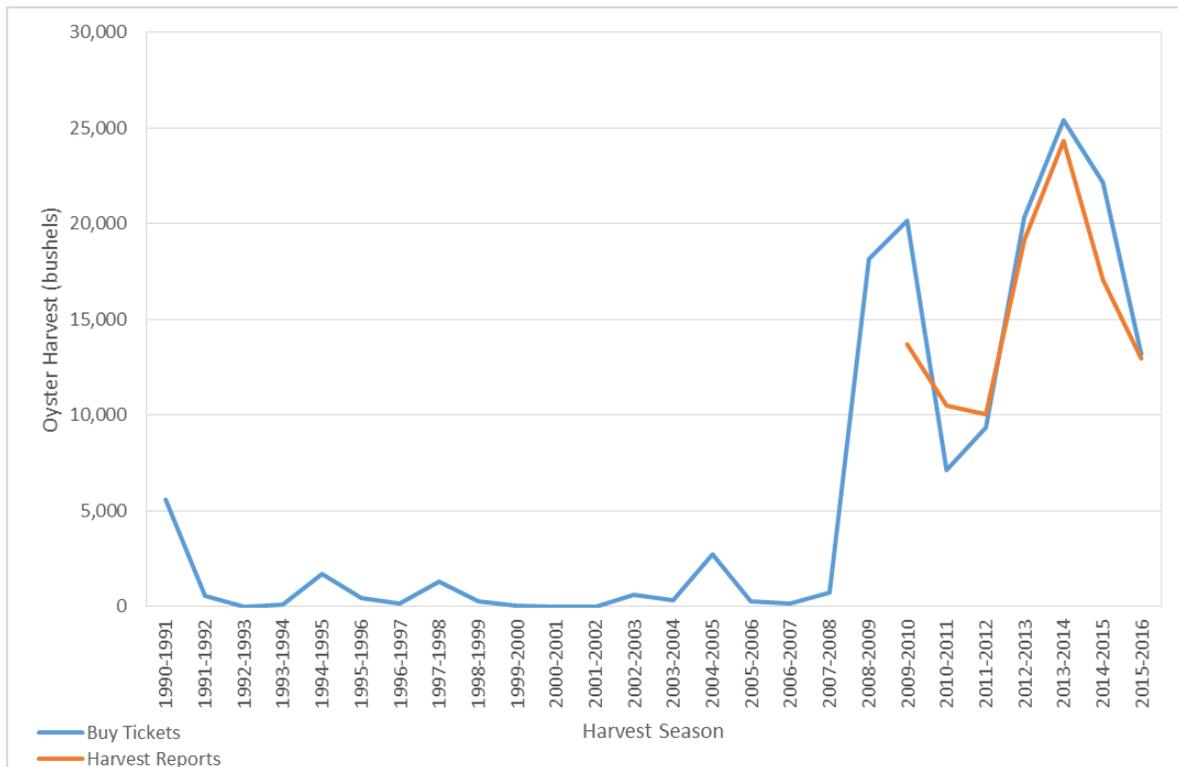


Figure B.06-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 047 (Honga River). After the 2009-2010 season, 16% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.07: NOAA Code 053 – Little Choptank River

NOAA Code 053 encompasses the Little Choptank River and is located in Maryland’s mid-eastern portion of Chesapeake Bay (Figure B.07-1). The entire NOAA Code is 19,423 acres and has 33 historic oyster bars¹³. The Little Choptank River Sanctuary encompasses 48% (9,415 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 10,008 acres. There are 2,472 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010, 6,326 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s medium salinity zone.

Replenishment Activities

Since 1990, approximately 250,000 bushels of shell and 3,300 bushels of wild seed have been planted in NOAA Code 053 outside of the current sanctuary area (Table B.07-1). No wild seed or hatchery spat-on-shell has been planted since 1990.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Dredged Shell	48.1	304.8	-
1991	Dredged Shell	50.9	586.7	-
1991	Fresh Shell	3.2	11.7	-
1992	Dredged Shell	41.3	437.4	-
1998	Dredged Shell	30.6	162.0	-
2000	Wild Seed	4.3	3.3	-
2012	Dredged Shell	36.4	17.1	-

¹³ See chart 25 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

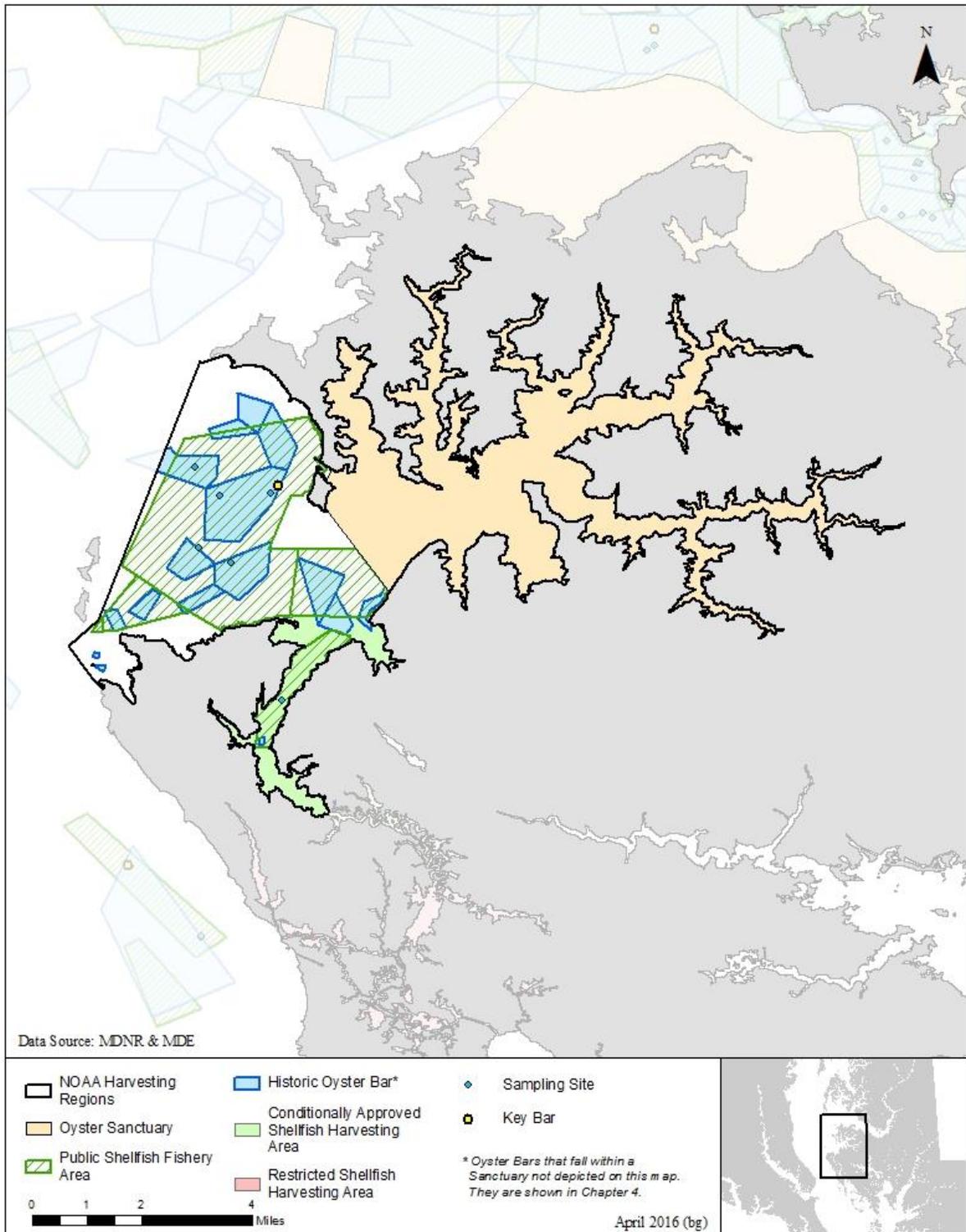


Figure B.07 -1. Map of NOAA Code 053 (Little Choptank River).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled three to seven oyster bars annually in NOAA Code 053 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) from 1990) ranged from 8 to 1031 with an average of 172 (Figure B.07-2). The number of oysters decreased from 2001 to 2005, and then began to increase starting in 2006. The number of small-sized and market-sized oysters has generally increased since 2004. The average number of live oysters was similar from 1990 to 2009 than from 2010 to 2015, most likely because of two exceptional spatfalls in 1991 and 1997 (Table B.07-2). On average, there were more small-sized oysters annually than market-sized oysters.

Table B.07-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 053 (Little Choptank River). Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 98	6 / 30
Number of Live Oysters per Bushel	174 \pm 58	167 \pm 16
Number of Live Small-Sized Oysters per Bushel	53 \pm 9	80 \pm 11
Number of Live Market-Sized Oysters per Bushel	21 \pm 4	75 \pm 15
Live Oyster Biomass (g Dry Weight per Bushel)	86 \pm 13	238 \pm 44
Mortality (%)	31.1 \pm 5.3	14 \pm 2.9

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Ragged Point bar within NOAA Code 053 (Figure B.07-3). Oysters were larger after 2010, with 52% measuring more than 80 mm, compared to 28% for those collected before 2010.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on Ragged Point bar within NOAA Code 053. The annual biomass ranged from 4 to 351 grams of dry weight per bushel and the average was 120.8 \pm 18.8 (average \pm SE; Figure B.07-4). The average biomass was greater from 2010 to 2015 than prior to 2010 (Table B.07-2). Biomass declined after 2001 and remained low before increasing to a peak in 2014.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall had ranged from 0 to 919 spat per bushel (Figure B.07-2, Figure B.07-5). The largest spatfalls occurred in 1990, 1991 and 1997. Without those years, spatfall averaged 10 per bushel.

Mortality

Mortality ranged from 5% to 95%, however, since 2004 mortality has been relatively low (Figure B.07-6). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.07-2).

Disease

From 1990 to 2015, dermo prevalence has ranged from 10% to 100% (Figure B.07-7). Dermo prevalence was greater than 80% for 20 of the 26 years disease information was collected. Dermo intensity ranged from 0.2 to 5.0. In 1992, dermo intensity reached lethal levels (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 57%. From 1999 to 2002, there was an extended period of MSX prevalence.

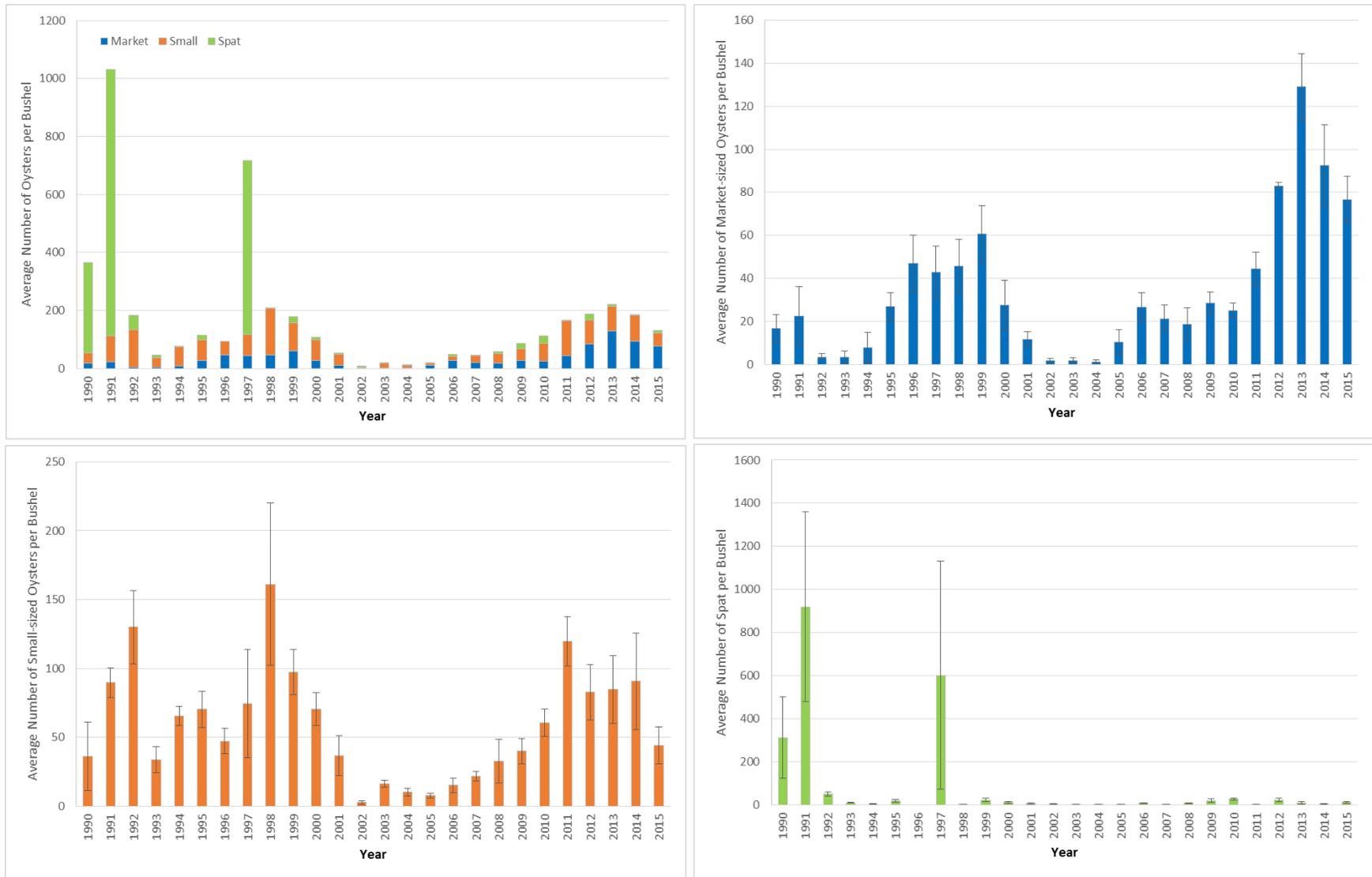
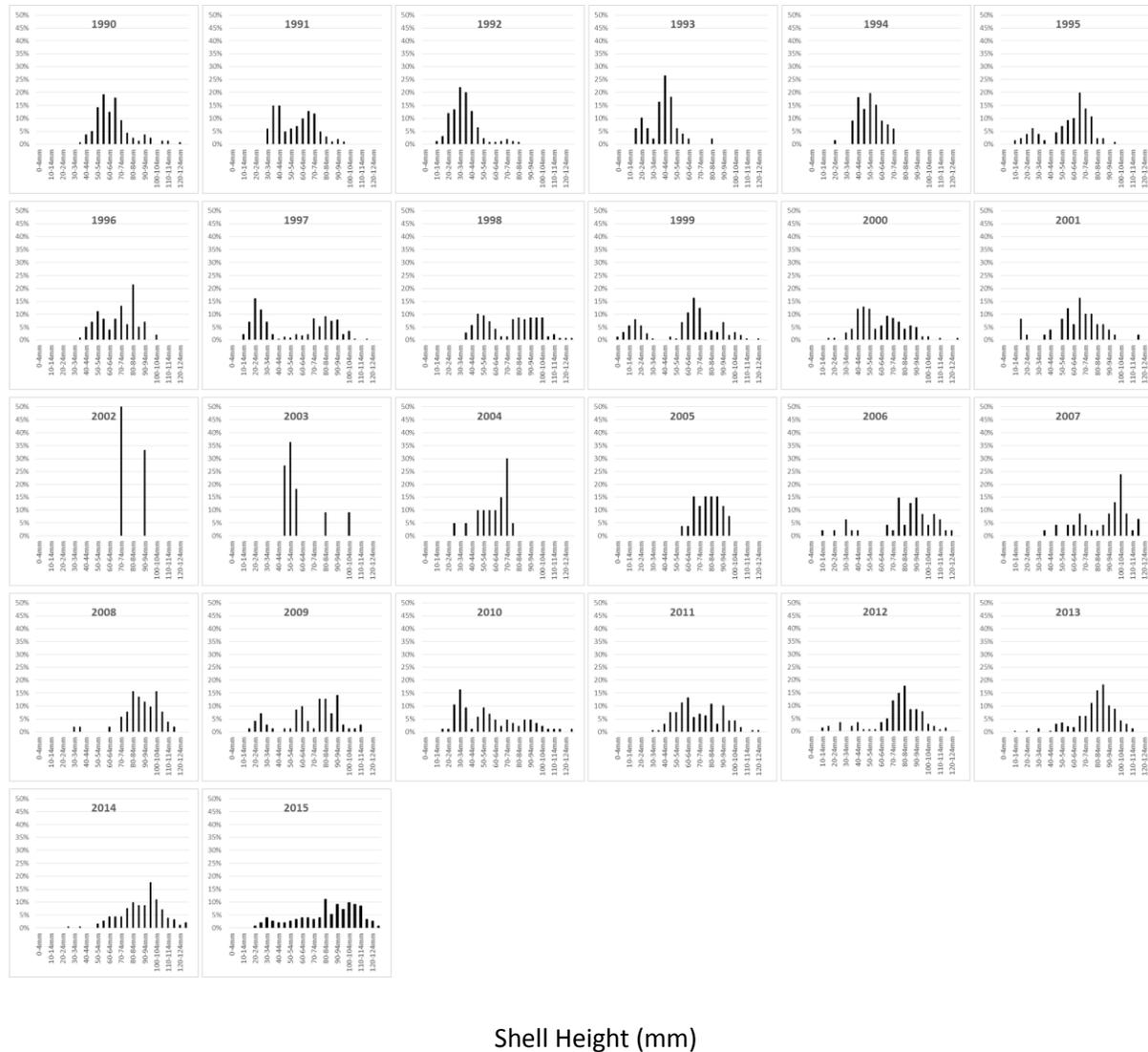


Figure B.07-2. Average number of live oysters per bushel of material by size class in the NOAA Code 053 (Little Choptank River). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

Frequency (%)



Shell Height (mm)

Figure B.07-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 053 (Little Choptank River). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

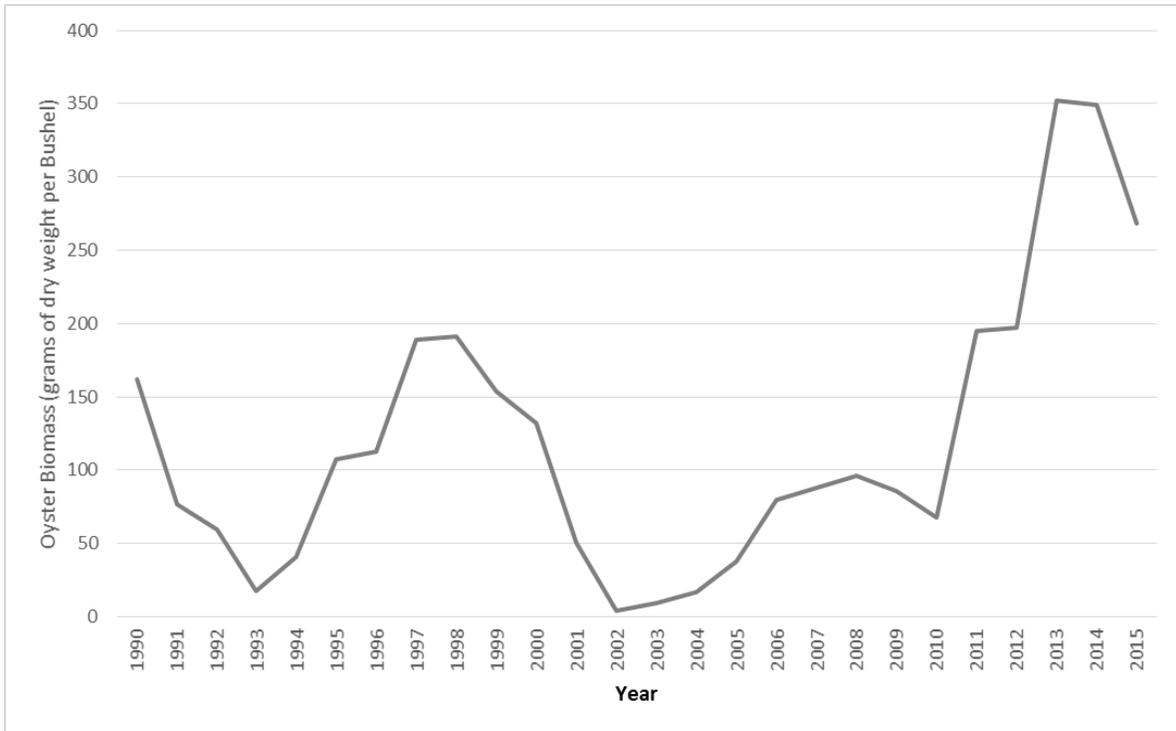


Figure B.07-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 053 (Little Choptank River). Data from Maryland’s Annual Fall Oyster Dredge Survey.

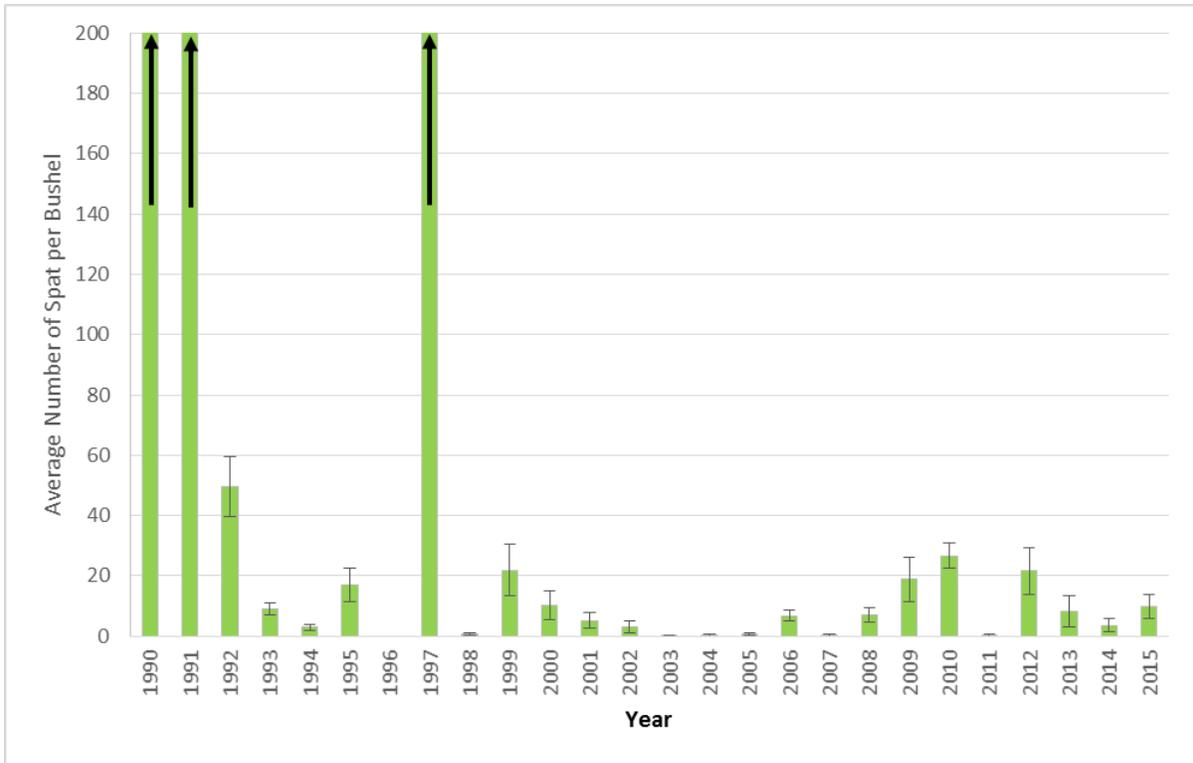


Figure B.07-5. Average number of spat per bushel of material by size class in the NOAA Code 053 (Little Choptank River). Error bars represent ± 1 standard error. Data from Maryland's Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

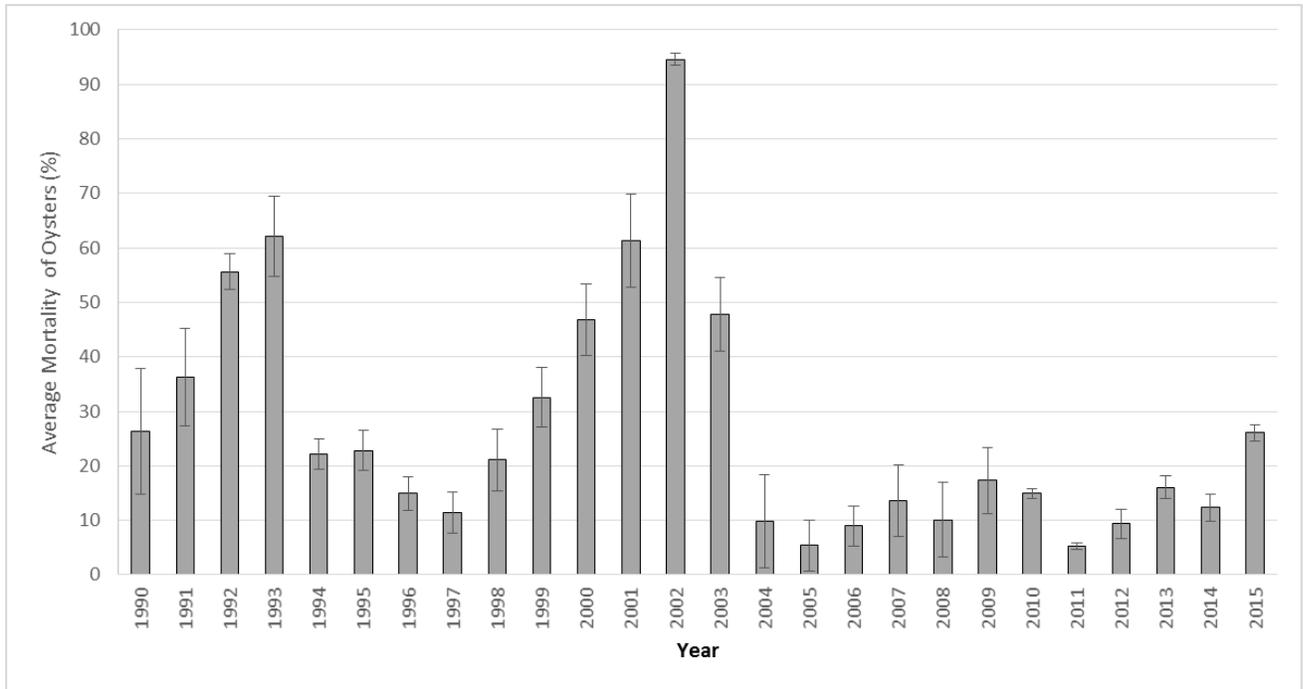


Figure B.07-6. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 053 (Little Choptank River). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

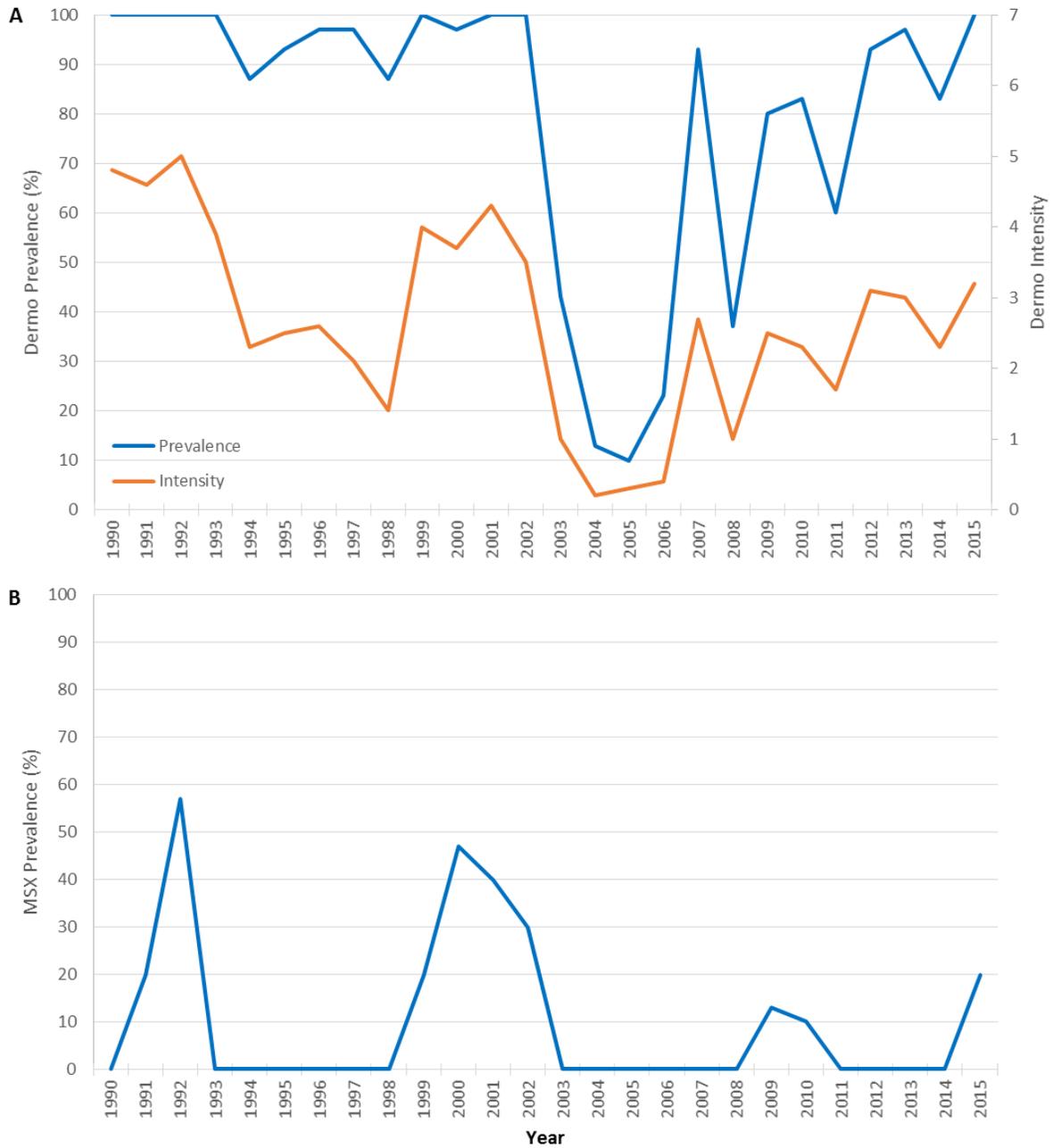


Figure B.07-7. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 053 (Little Choptank River). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland's Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 053 since 1990 is presented in Figure B.07-8. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 48% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from 41 bushels in the 2010-2011 season to a maximum of approximately 84,000 bushels in the 1998-1999 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Diving accounted for 73% of the harvest, with hand tonging accounting for another 24%, as reported on oyster harvester reports.

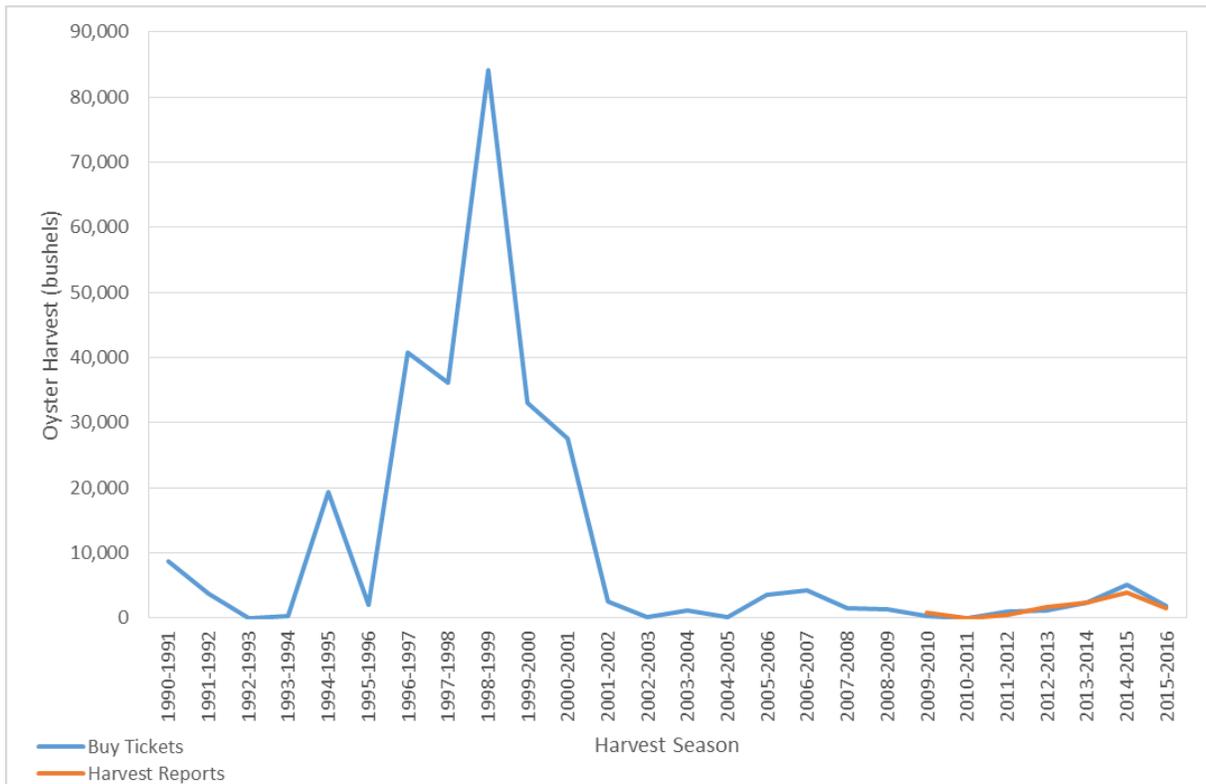


Figure B.07-8. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 053 (Little Choptank River). After the 2009-2010 season, 48% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.08: NOAA Code 055 – Magothy River

NOAA Code 055 encompasses the Magothy River and is located in Maryland’s upper western portion of Chesapeake Bay (Figure B.08-1). The entire NOAA Code is 7,098 acres and has 9 historic oyster bars¹⁴. The Magothy River Sanctuary encompasses 79% (5,607 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 1,492 acres. There are 717 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside within a sanctuary. In 2010, 821 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s low salinity zone.

Replenishment Activities

Since 1990, approximately 3,200 bushels of shell and 5,300 bushels of wild seed have been planted in NOAA Code 055 outside of the current sanctuary area (Table B.08-1). No wild seed or hatchery spat-on-shell has been planted since 1990.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Wild Seed	33.9	5.3	
2001	Dredged Shell	167.1	3.2	

Oyster Population Characteristics

The Fall Survey sampled one oyster bar in NOAA Code 055 from 1990 to 1993 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 32 to 188 per bushel with an average of 94 (Figure B.08-2).

¹⁴ See chart 6 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

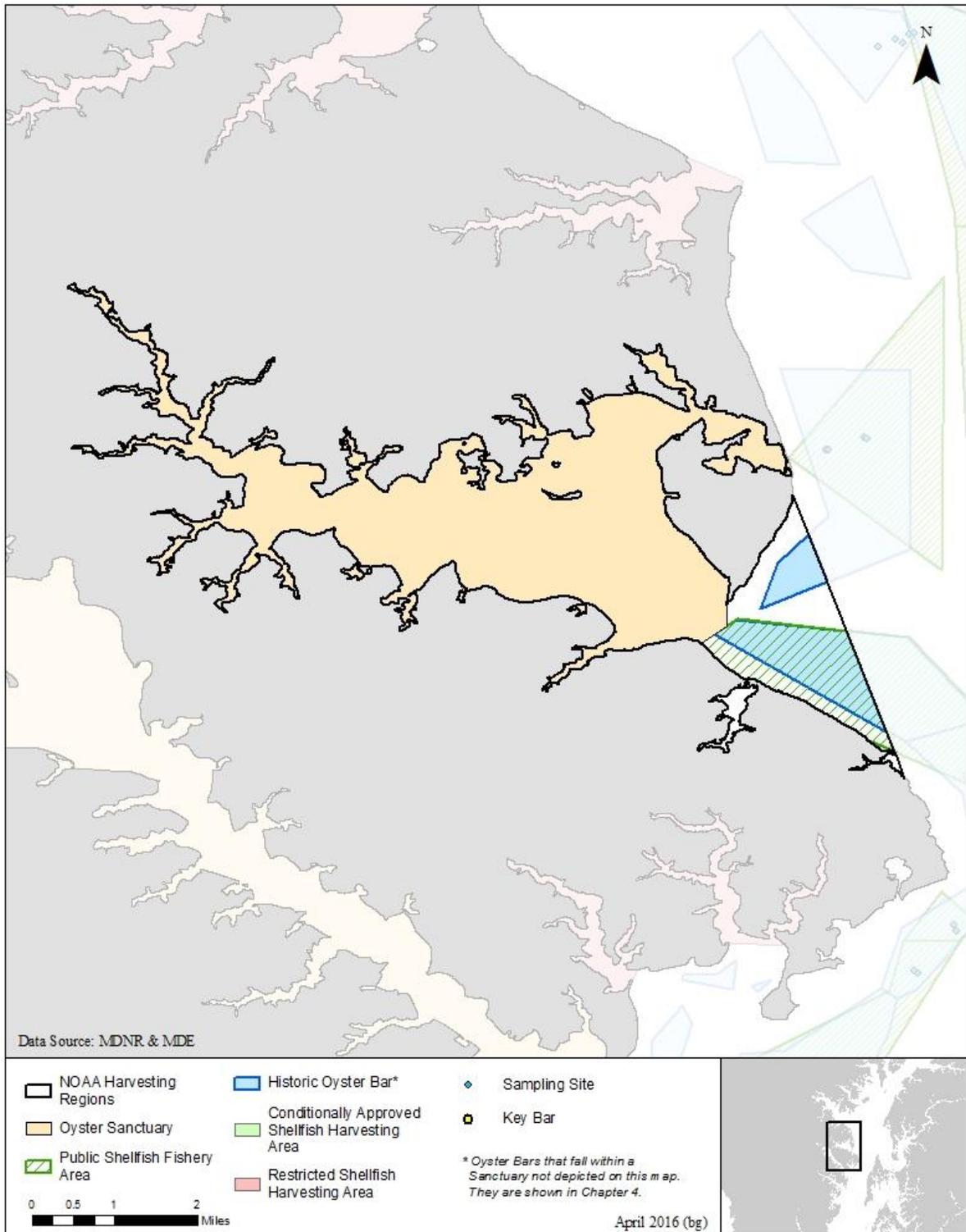


Figure B.08 -1. Map of NOAA Code 055 (Magothy River).

Table B.08-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 055 (Magothy River). ND = No Data. Values are given as mean \pm standard error.

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	4/4	ND
Number of Live Oysters per Bushel	94 \pm 33	ND
Number of Live Small-Sized Oysters per Bushel	30 \pm 14	ND
Number of Live Market-Sized Oysters per Bushel	64 \pm 25	ND
Live Oyster Biomass (g Dry Weight per Bushel)	ND	ND
Mortality (%)	30 \pm 12.9	ND

Oyster Size Structure

The Fall Survey has not collected information on oyster shell heights in this NOAA Code since 1990.

Biomass

The Fall Survey has not collected information on oyster biomass in this NOAA Code since 1990.

Recruitment (Spatfall)

A total of two spat have been collected by the Fall Survey on Outer Magothy bar (Figure B.08-2).

Mortality

Mortality ranged from 0% to 63% (Table B.08-2).

Disease

The Fall Survey has not collected information on oyster disease in this NOAA Code since 1990.

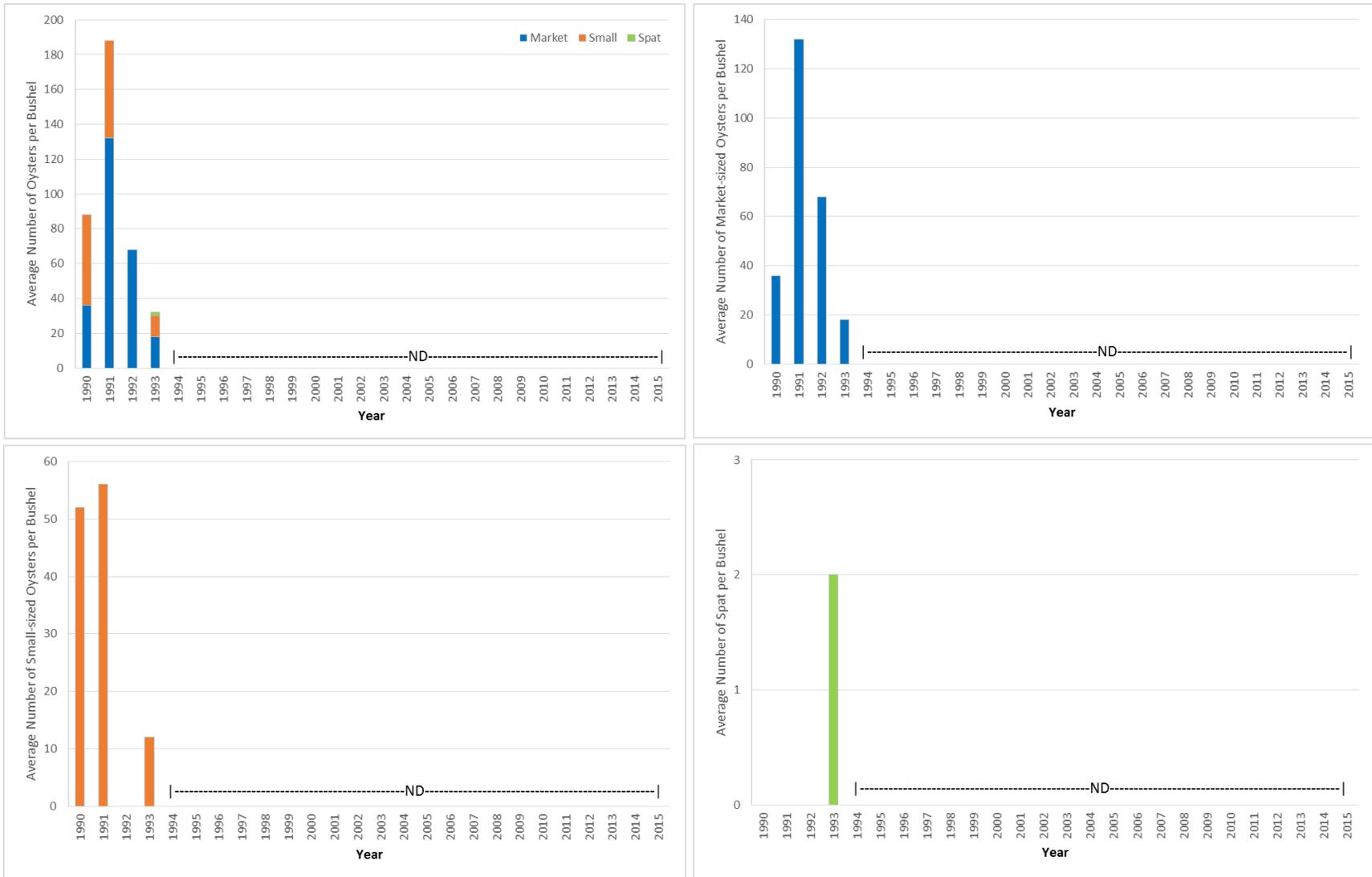


Figure B.08-2. Average number of live oysters per bushel of material by size class in the NOAA Code 055 (Magothy River). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales. ND = No Data.

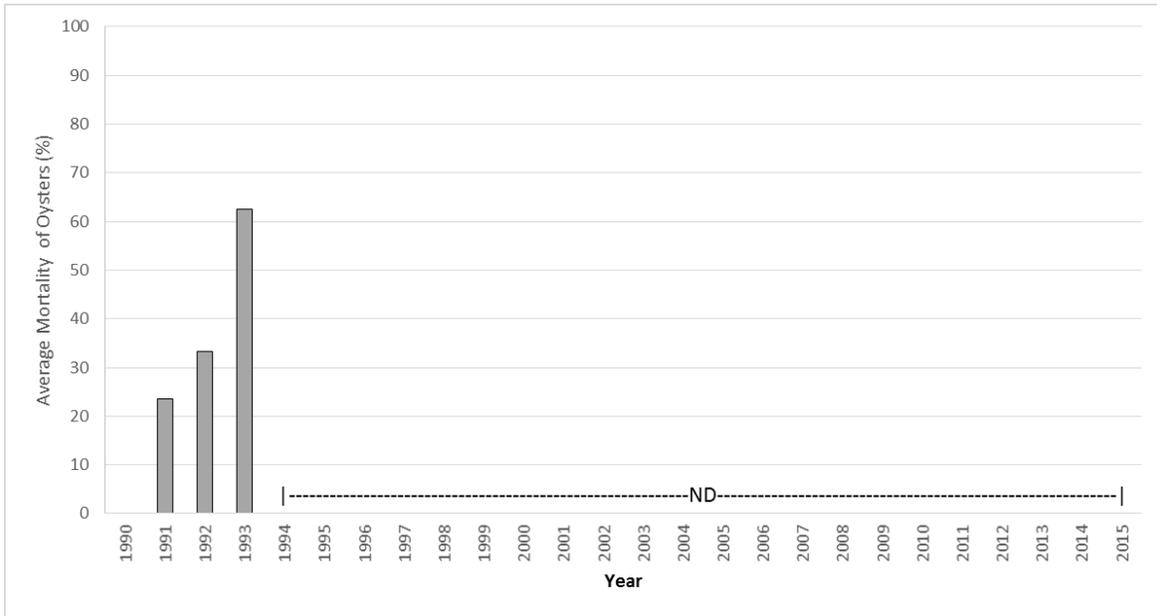


Figure B.08-3. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 055 (Magothy River). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

Harvest

Harvest for the entire NOAA Code 055 since 1990 is presented in Figure B.08-4. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 79% of the NOAA Code area was a sanctuary where harvest is prohibited. No harvest has been recorded since the 2006-2007 season. The highest harvest recorded was in 1999-2000 season and was 133 bushels. Power dredging accounted for 73% of the harvest, as reported on buy tickets.

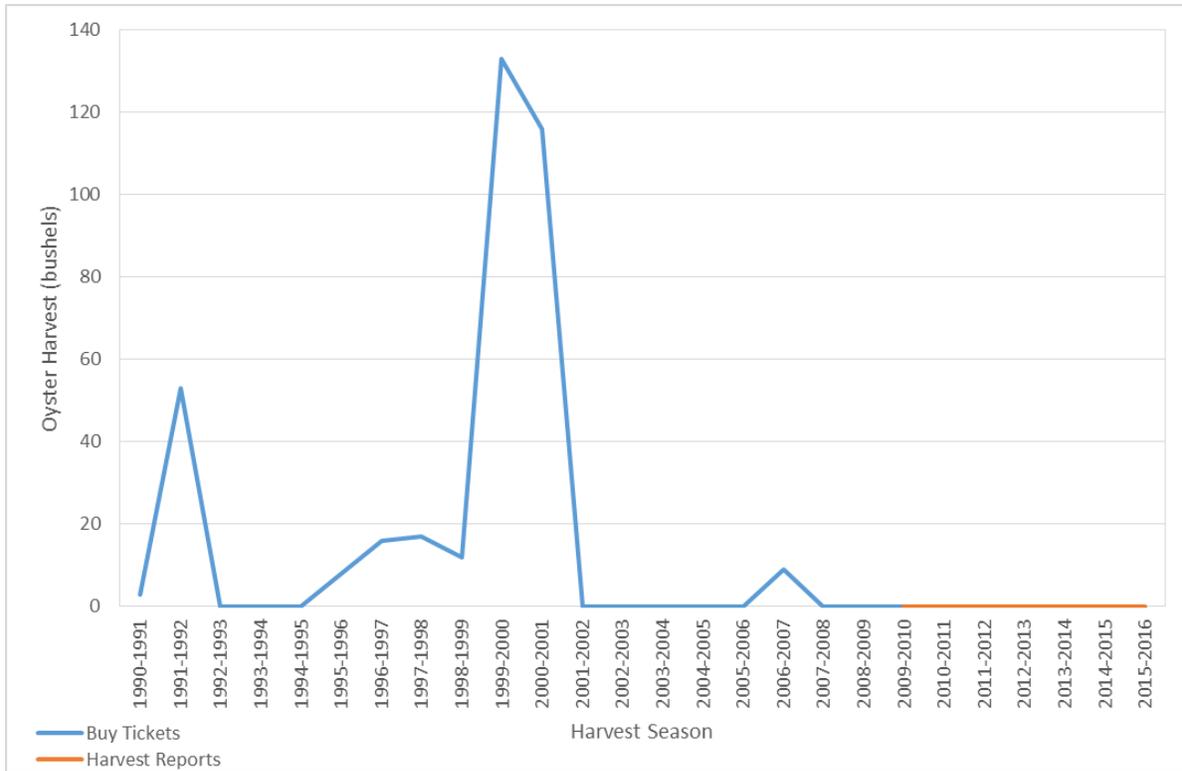


Figure B.08-4. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 055 (Magothy River). After the 2009-2010 season, 79% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.09: NOAA Code 057 – Manokin River

NOAA Code 057 (Manokin River) is 19,909 acres; however, 16,320 acres (82%) of the area is within a current sanctuary boundary (Manokin River Sanctuary, established in 2010). There are 1,825 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010, 520 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. See Appendix A, Section A.23 for more information on the oyster population characteristics.

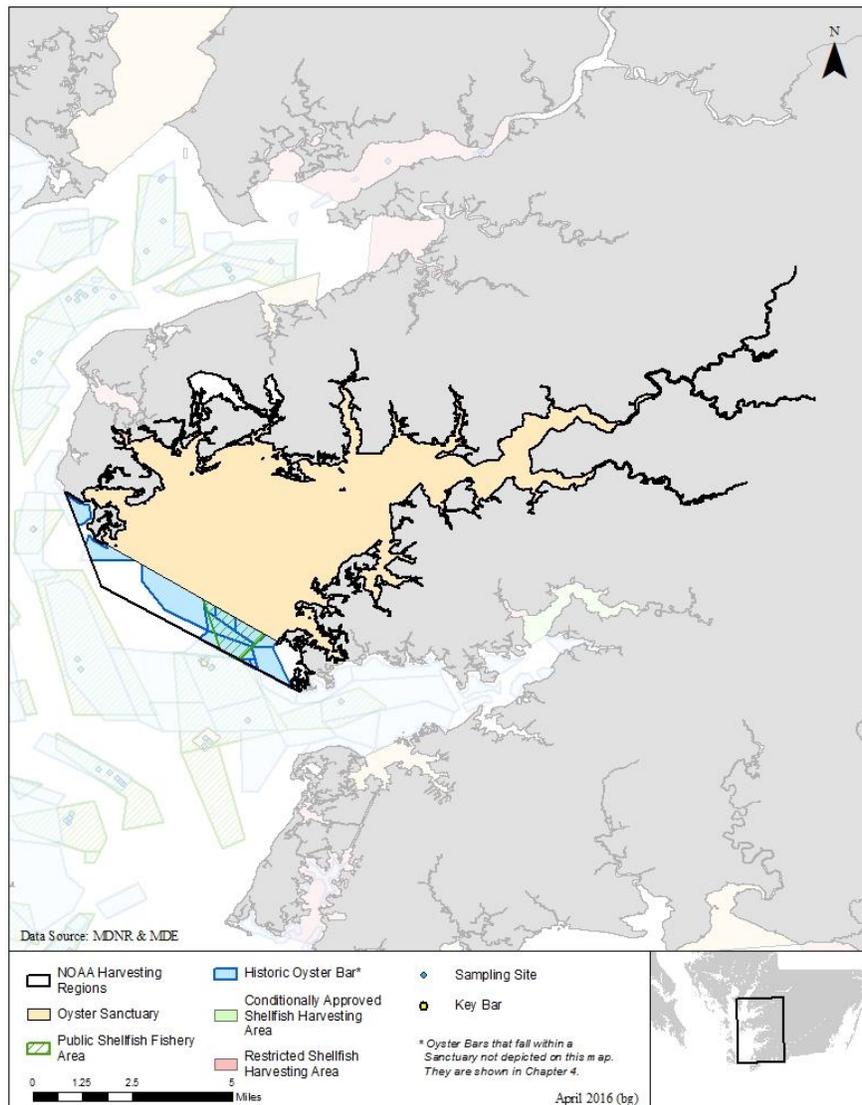


Figure B.09 -1. Map of NOAA Code 060 (Manokin River).

Section B.10: NOAA Code 060 – Miles River

NOAA Code 060 encompasses the Miles River and is located in Maryland’s upper eastern portion of Chesapeake Bay (Figure B.10-1). The entire NOAA Code is 12,778 acres and has 26 historic oyster bars¹⁵. The Miles River Sanctuary encompasses 27% (3,449 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 9,329 acres. There are 3,089 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010, 5,422 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s low salinity zone.

Replenishment Activities

Since 1990, approximately 550,000 bushels of shell has been planted in NOAA Code 060 outside of the current sanctuary area (Table B.10-1). There has been one wild seed planting and one hatchery spat-on-shell planting since 1990.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Dredged Shell	22.5	173.2	-
1998	Dredged Shell	98.0	132.1	-
1999	Dredged Shell	7.8	48.6	-
2000	Dredged Shell	10.7	56.9	-
2000	Wild Seed	4.0	4.0	-
2001	Dredged Shell	10.9	76.0	-
2002	Dredged Shell	10.6	64.1	-
2008	Hatchery Spat-on-Shell	3.7	-	9.7

¹⁵ See chart 12 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

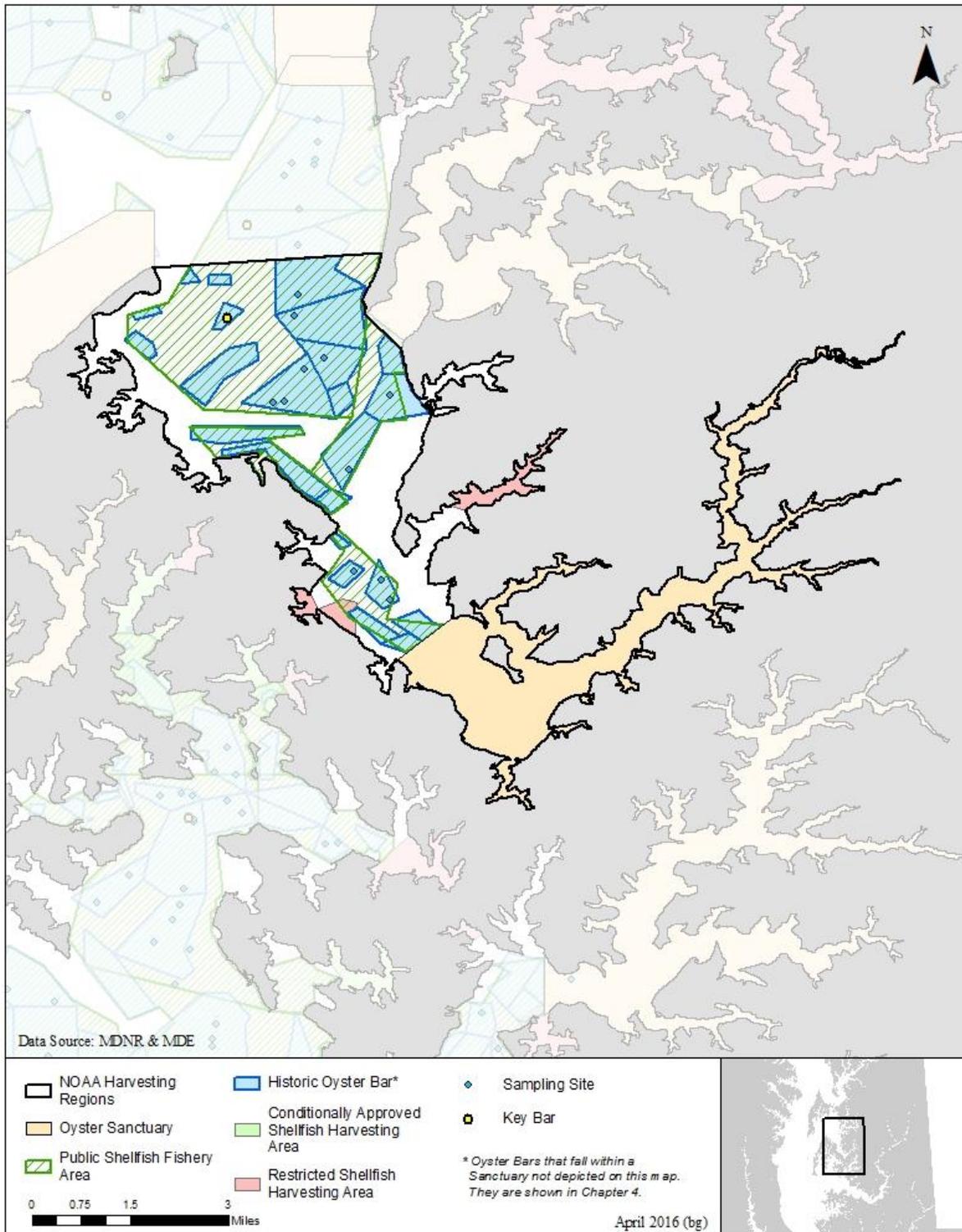


Figure B.10 -1. Map of NOAA Code 060 (Miles River).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled four to eight oyster bars annually in NOAA Code 060 outside of the current sanctuary area. Average number of total live oysters (market, small, and spat) ranged from 36 to 2291 with an average of 184 (Figure B.10-2). The highest number of market-sized oysters over the 26 year time period occurred in 2014. The average number of total live oysters was greater from 1990 to 2009 than 2010 to 2015 (Table B.10-2).

Table B.10-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 060 (Miles River). Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 139	6 / 46
Number of Live Oysters per Bushel	221 \pm 111	62 \pm 14
Number of Live Small-Sized Oysters per Bushel	58 \pm 16	16 \pm 3
Number of Live Market-Sized Oysters per Bushel	37 \pm 4	43 \pm 13
Live Oyster Biomass (g Dry Weight per Bushel)	118 \pm 14	108 \pm 44
Mortality (%)	26.6 \pm 2.8	8.2 \pm 1.7

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Turtle Back bar within NOAA Code 060 (Figure B.10-3). The largest oysters (greater than 120mm shell height) made up less than 1% of oysters measured. Most oysters (51%) measured between 40 and 80 mm. Oysters were slightly larger after 2010, with 41% measuring more than 80 mm, compared to 33% for those oysters collected before 2010.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on Turtle Back bar within NOAA Code 060. The annual biomass ranged from 27 to 319 grams of dry weight per bushel and the average is 115.8 \pm 14.6 (average \pm SE; Figure B.10-4). The average biomass was similar from 1990 to 2009 than from 2010 to 2015 (Table B.10-2). From 2000 to 2013, biomass was the lowest and then increased to a peak in 2014.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall had ranged from 0 to 2189 spat per bushel from 1990 to 2015 (Figure B.10-2, Figure B.10-5). The largest spatfall occurred in 1997, when it was

unusually high. Without that year included, spatfall averaged 13 per bushel. From 2002 to 2015, there was very little spatfall, averaging 3 spat per bushel.

Mortality

Mortality ranged from 1% to 52%; since 2009, mortality has been relatively low (Figure B.10-6). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.10-2).

Disease

From 1990 to 2015, dermo prevalence ranged from 23% to 100% (Figure B.10-7). Dermo prevalence was greater than 80% during 19 of the 26 years disease information was collected. Dermo intensity ranged from 0.6 to 4.7, below lethal levels (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 33% from 1990 to 2015.

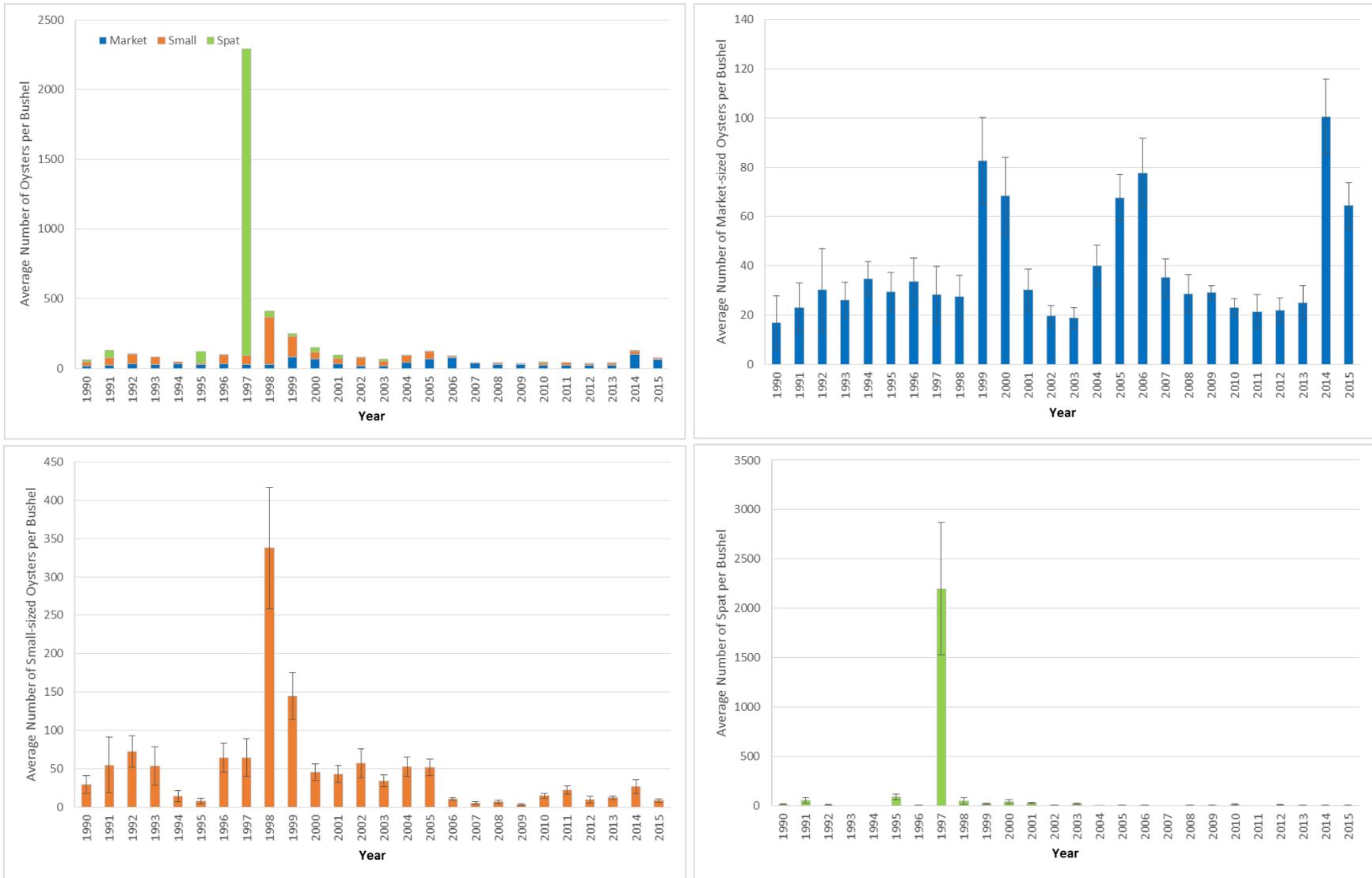


Figure B.10-2. Average number of live oysters per bushel of material by size class in the NOAA Code 060 (Miles River). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

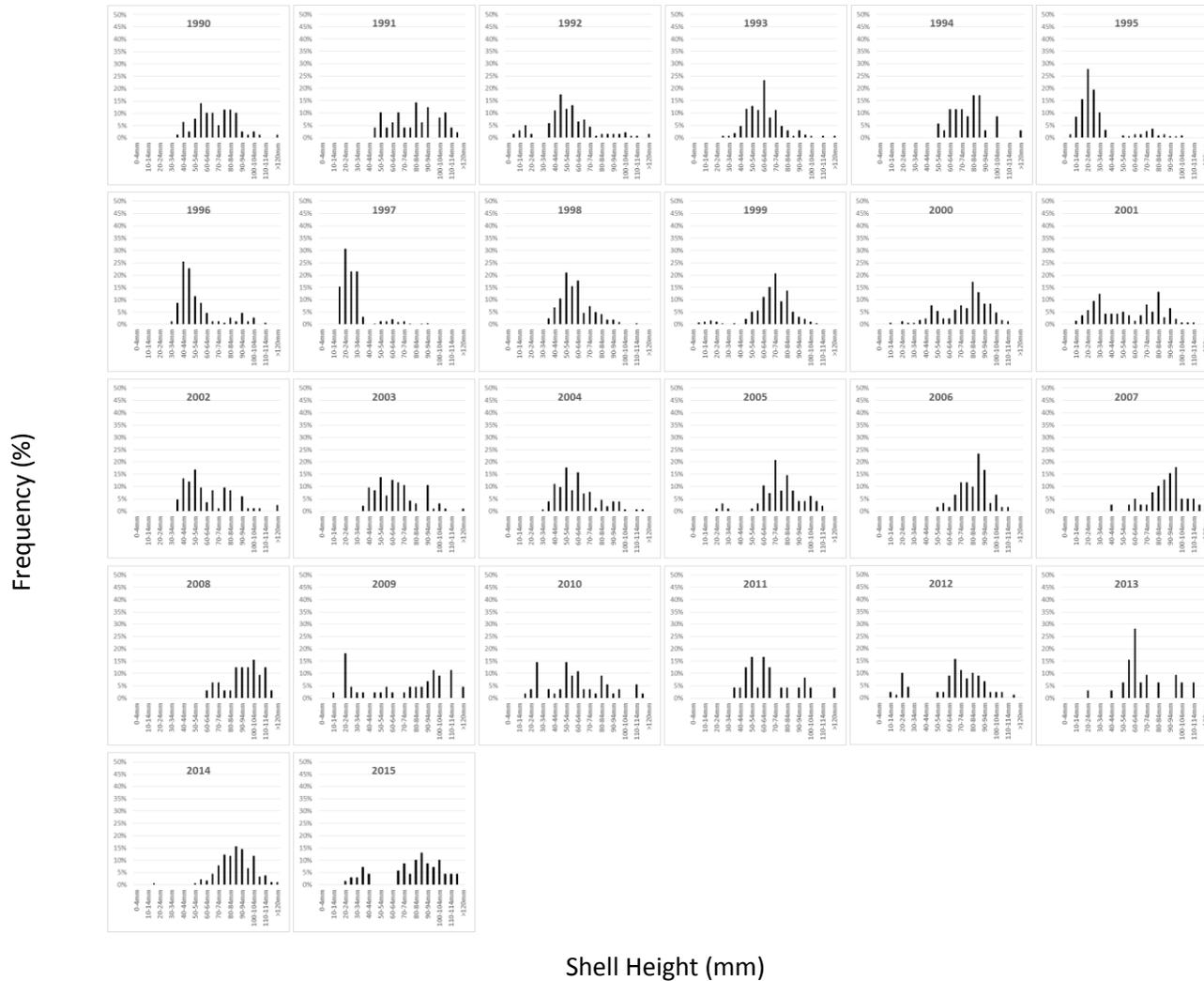


Figure B.10-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 060 (Miles River). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

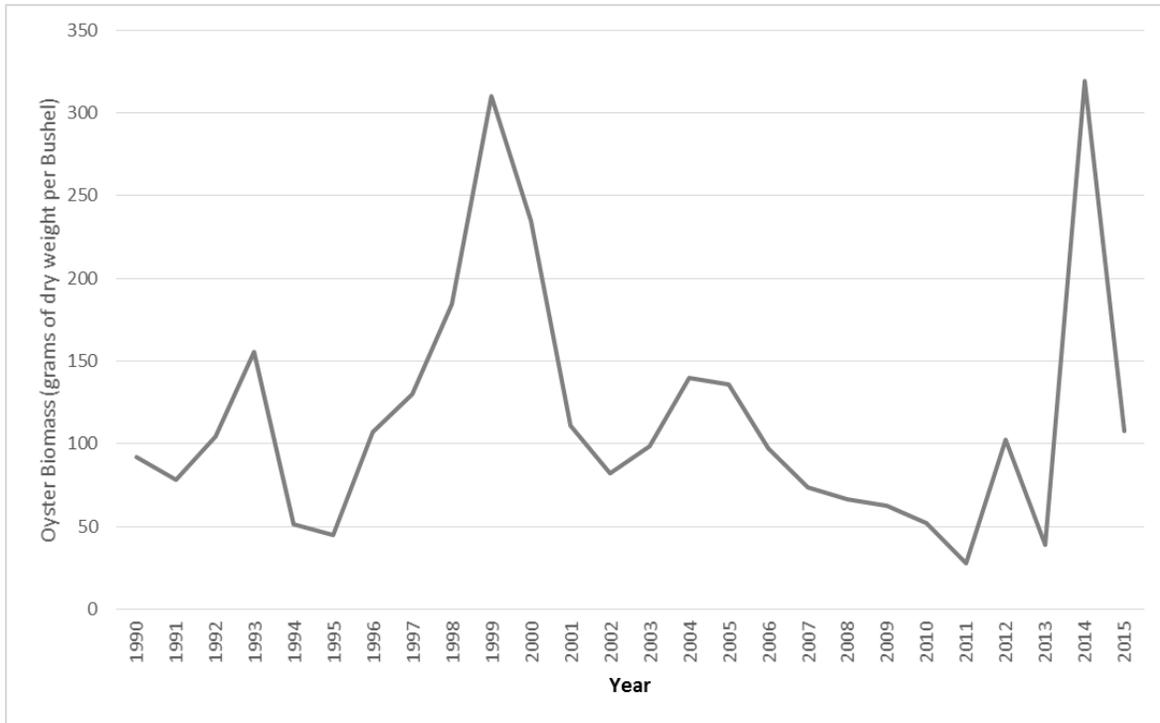


Figure B.10-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 060 (Miles River). Data from Maryland’s Annual Fall Oyster Dredge Survey.

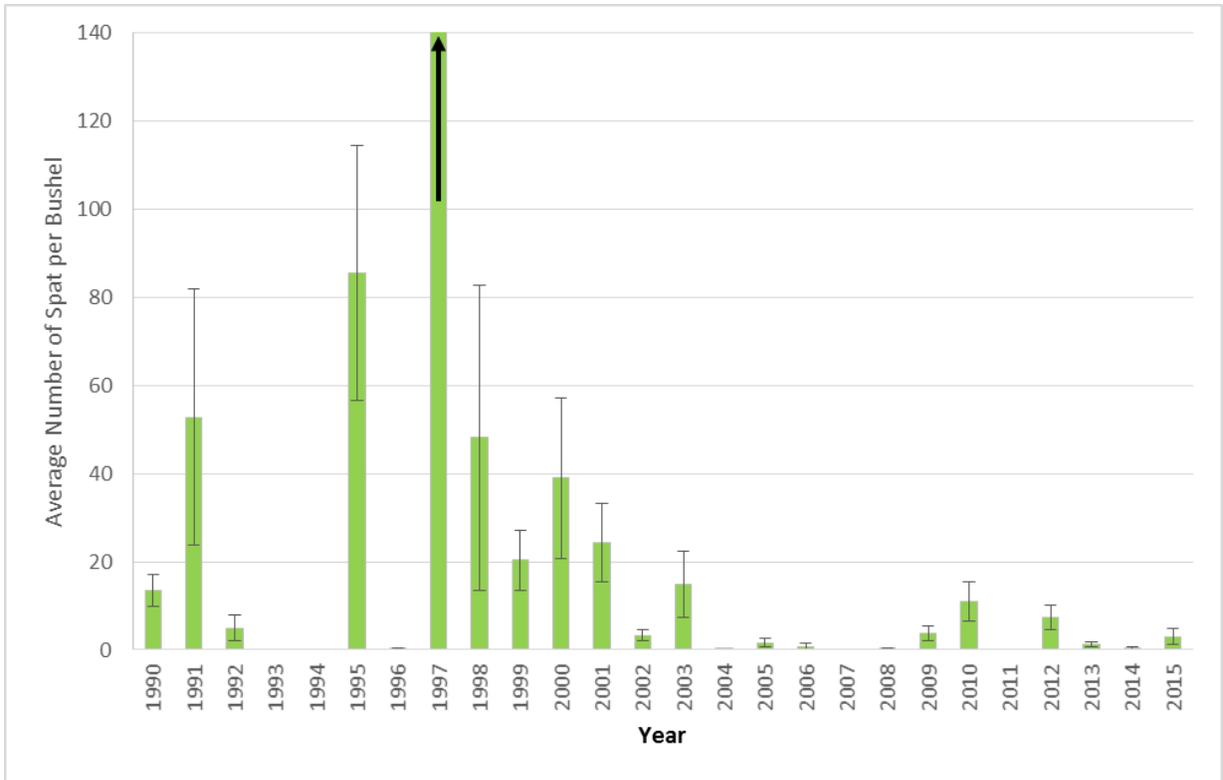


Figure B.10-5 Average number of spat per bushel of material by size class in the NOAA Code 060 (Miles River). In 1997, the average number of spat per bushel was $2,199 \pm 674$. Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey.

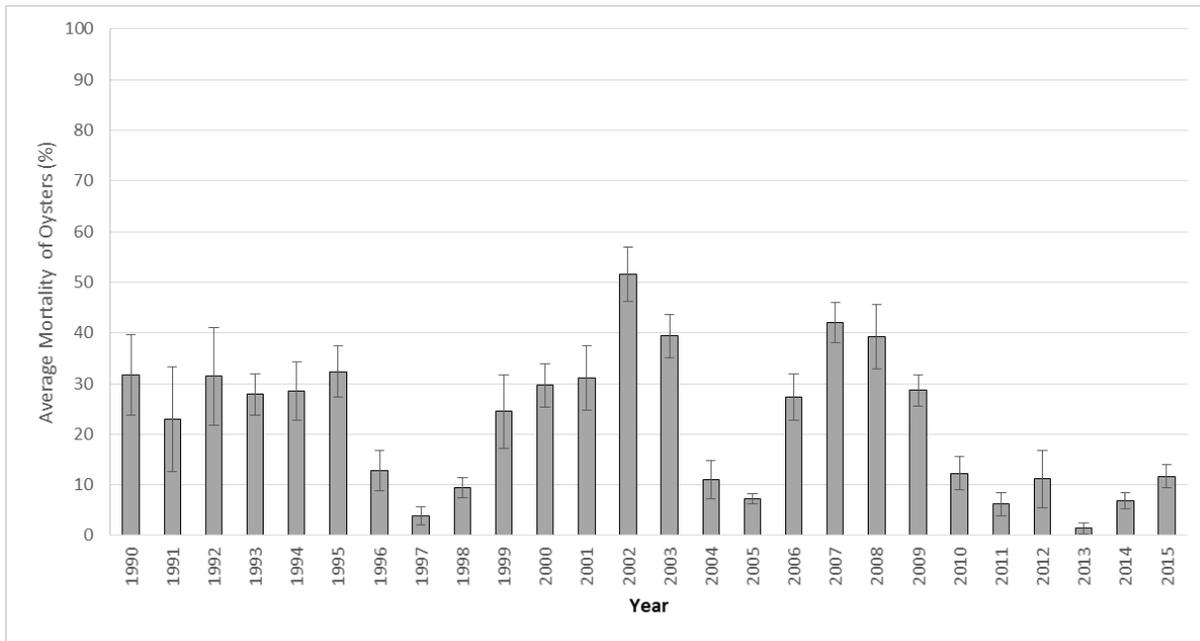


Figure B.10-6. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 060 (Miles River). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

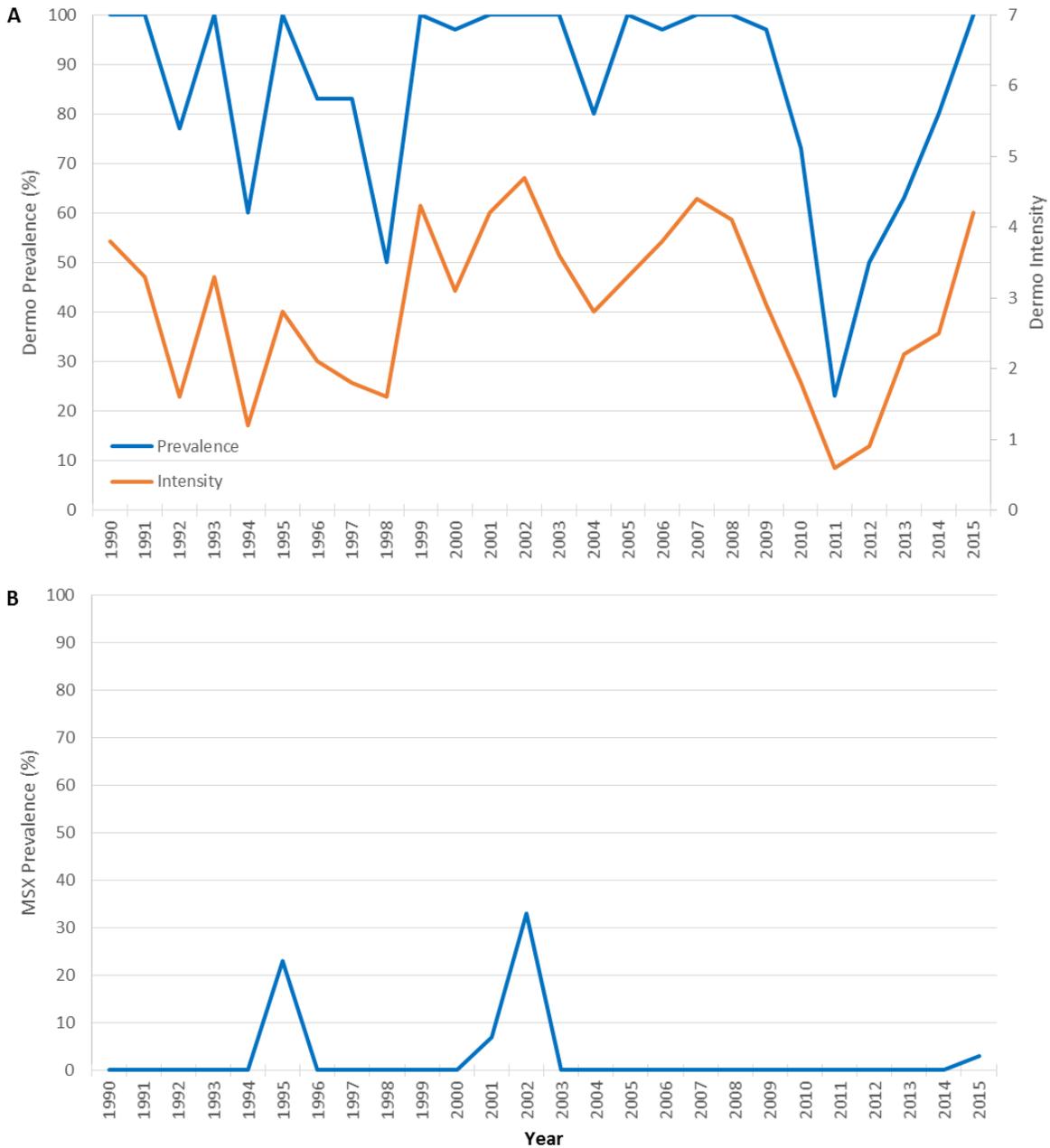


Figure B.10-7. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 060 (Miles River). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland's Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 060 since 1990 is presented in Figure B.10-8. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 27% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in the 2012-2013 season to a maximum of approximately 35,000 bushels in the 1999-2000 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Hand tonging accounted for approximately 50% of the harvest, with diving accounting for 47%, as reported on oyster harvester reports.

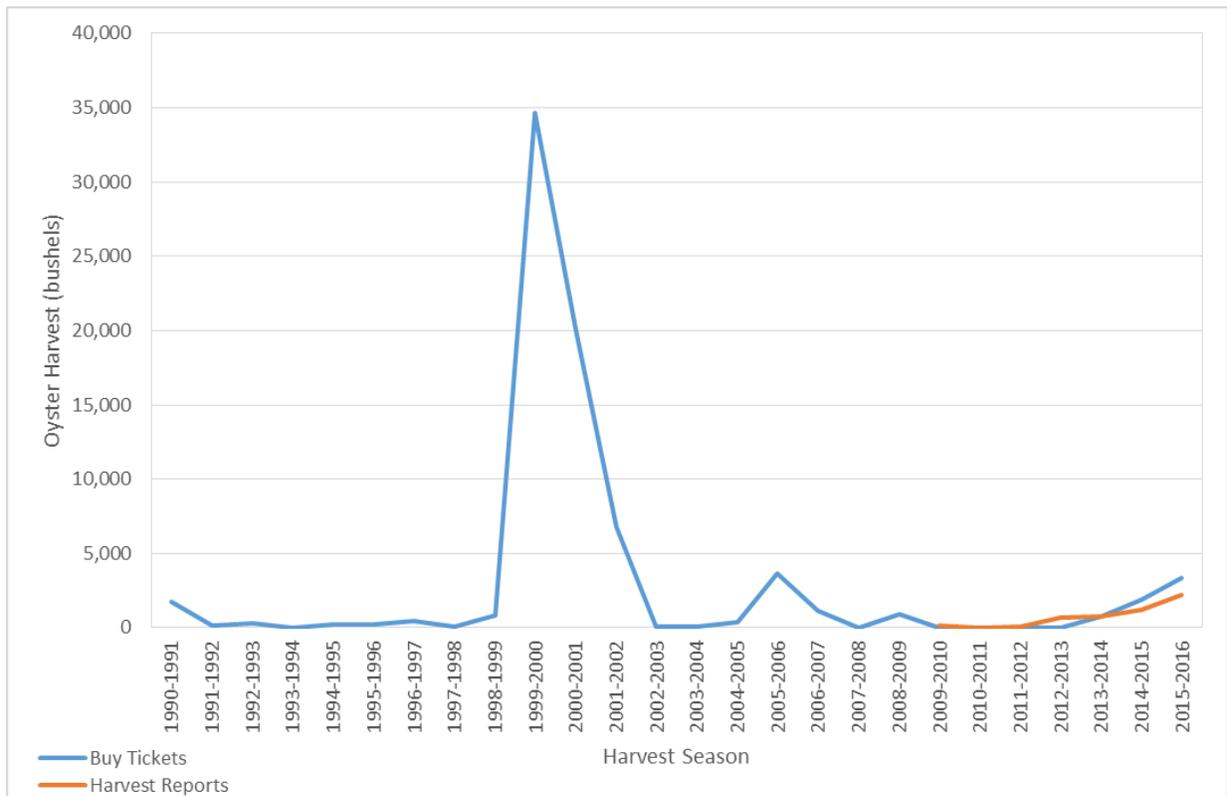


Figure B.10-8. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 060 (Miles River). After the 2009-2010 season, 27% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.11: NOAA Code 062 – Nanticoke River

NOAA Code 062 encompasses the Nanticoke River and is located in Maryland’s lower eastern portion of Chesapeake Bay (Figure B.11-1). The entire NOAA Code is 19,661 acres and has 20 historic oyster bars¹⁶. The Nanticoke River Sanctuary encompasses 85% (16,699 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 2,962 acres. There are 680 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010, 807 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s low salinity zone.

Replenishment Activities

Since 1990, approximately 141,000 bushels of shell, 11,000 bushels of wild seed and 35 million hatchery spat-on-shell have been planted in NOAA Code 072 outside of the current sanctuary area (Table B.11-1).

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1998	Dredged Shell	34.2	50.2	-
2000	Fresh Shell	2.3	25.8	-
2001	Fresh Shell	6.4	38.0	-
2001	Wild Seed	8.2	11.7	-
2002	Fresh Shell	10.2	13.8	-
2012	Dredged Shell	191.0	67.3	-
2013	Fresh Shell	43.8	14.0	-
2014	Hatchery Spat-on-Shell	5.3	-	30.6
2015	Hatchery Spat-on-Shell	2.5	-	4.4

¹⁶ See chart 31 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

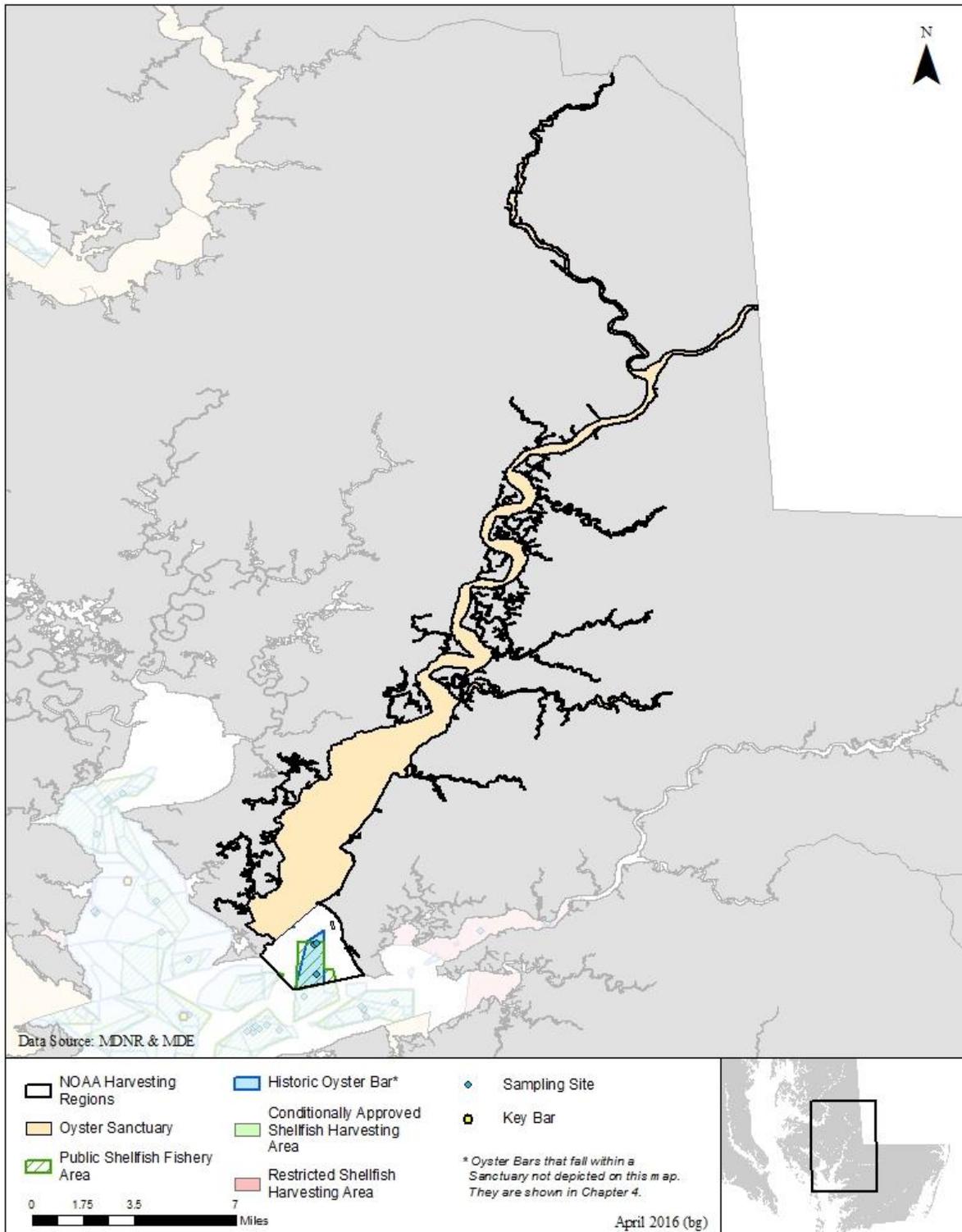


Figure B.11 -1. Map of NOAA Code 062 (Nanticoke River).

Oyster Population Characteristics

The Fall Survey sampled one oyster bar in NOAA Code 072 from 1998-2007 outside of the current sanctuary area (Table B.11-2). The average number of total live oysters (market, small, and spat) ranged from 2 to 52 with an average of 16 (Figure B.11-2).

Table B.11-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 062 (Nanticoke River). ND = No Data. Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	9/9	ND
Number of Live Oysters per Bushel	16 \pm 5	ND
Number of Live Small-Sized Oysters per Bushel	5 \pm 3	ND
Number of Live Market-Sized Oysters per Bushel	5 \pm 3	ND
Live Oyster Biomass (g Dry Weight per Bushel)	ND	ND
Mortality (%)	23 \pm 9.4	ND

Oyster Size Structure

The Fall Survey has not collected information on oyster shell height in this NOAA Code since 1990.

Biomass

The Fall Survey has not collected information on oyster biomass in this NOAA Code since 1990.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall had ranged from 0 to 24 spat per bushel (Figure B.11-2). The largest spatfall occurred in 2002.

Mortality

Mortality ranged from 0% to 67%, averaging 23% (Figure B.11-3).

Disease

The Fall Survey has not collected information on oyster diseases in this NOAA Code since 1990.

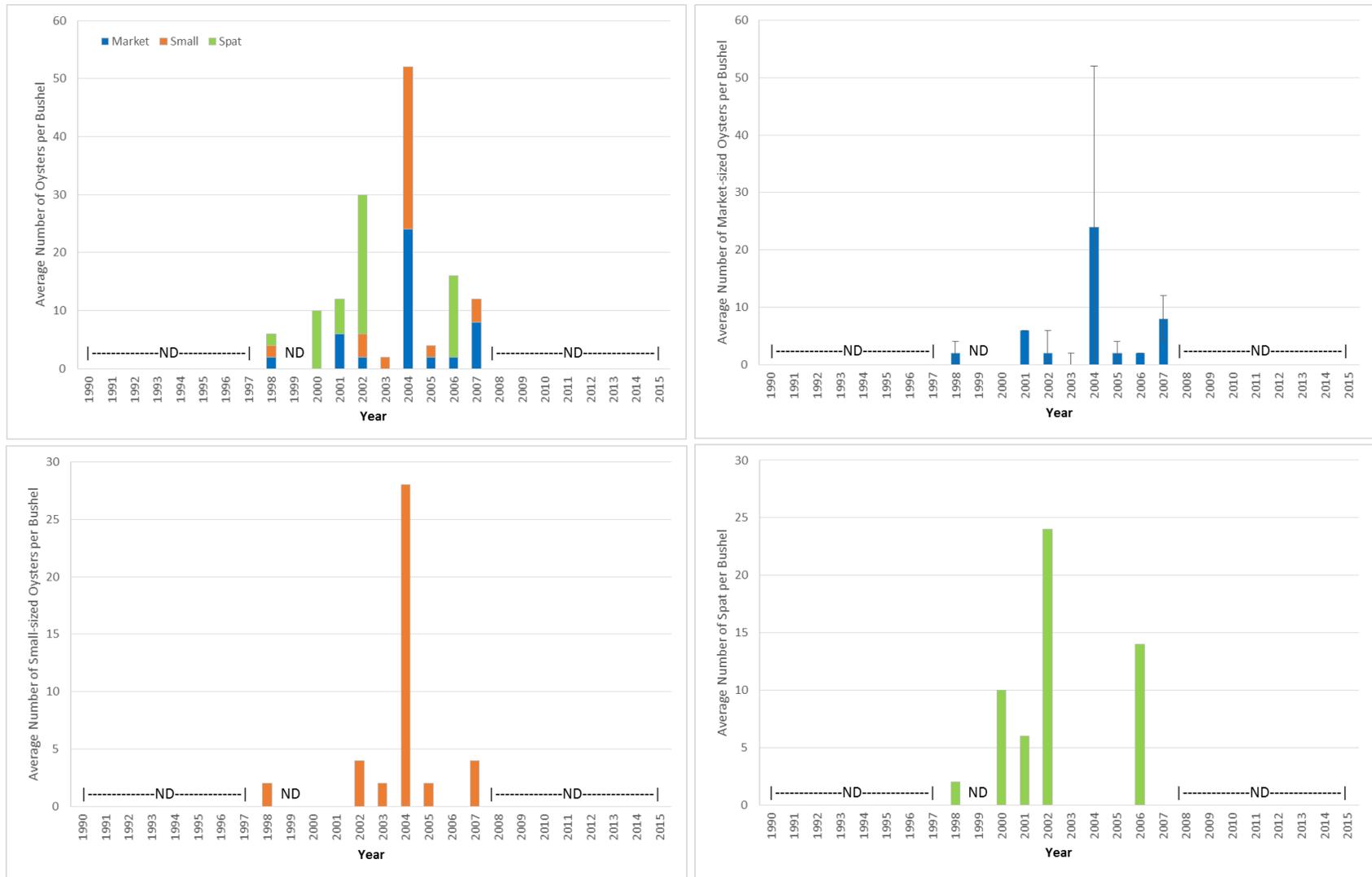


Figure B.11-2. Average number of live oysters per bushel of material by size class in the NOAA Code 062 (Nanticoke River). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales. ND = No Data.

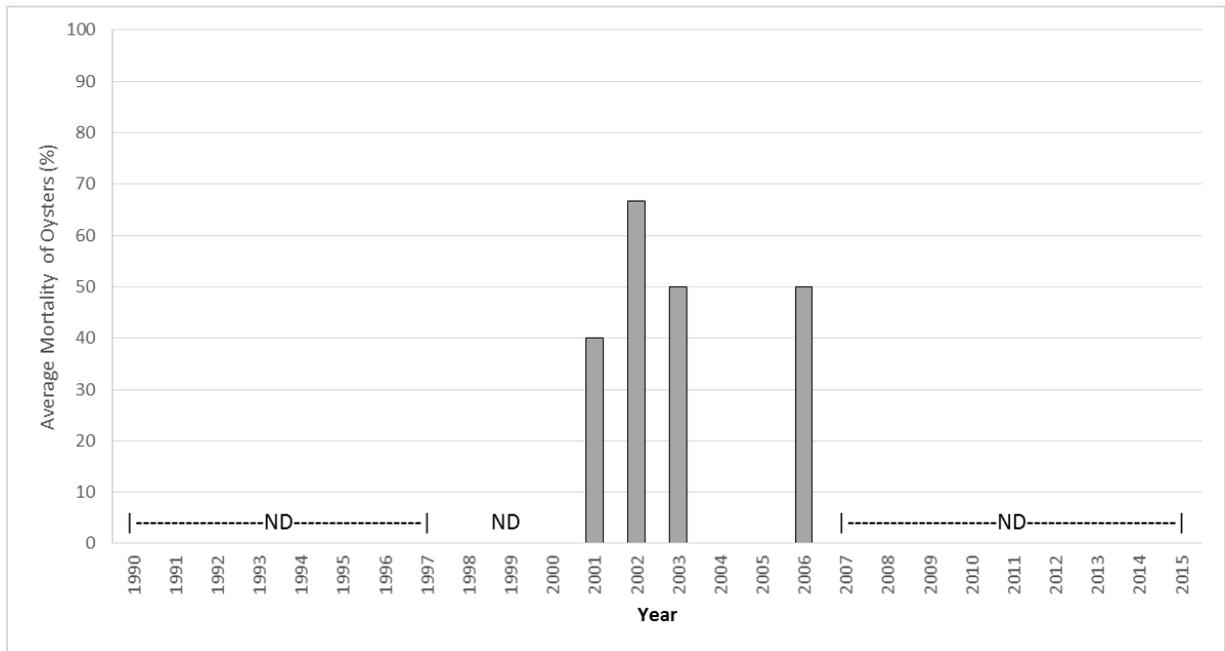


Figure B.11-3. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 062 (Nanticoke River). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error. ND = No Data.

Harvest

Harvest for the entire NOAA Code 062 since 1990 is presented in Figure B.11-4. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 85% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from 57 bushels in the 2003-2004 season to a maximum of approximately 23,000 bushels in the 1997-1998 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Power dredging accounted for 94% of the harvest, as reported on oyster harvester reports.

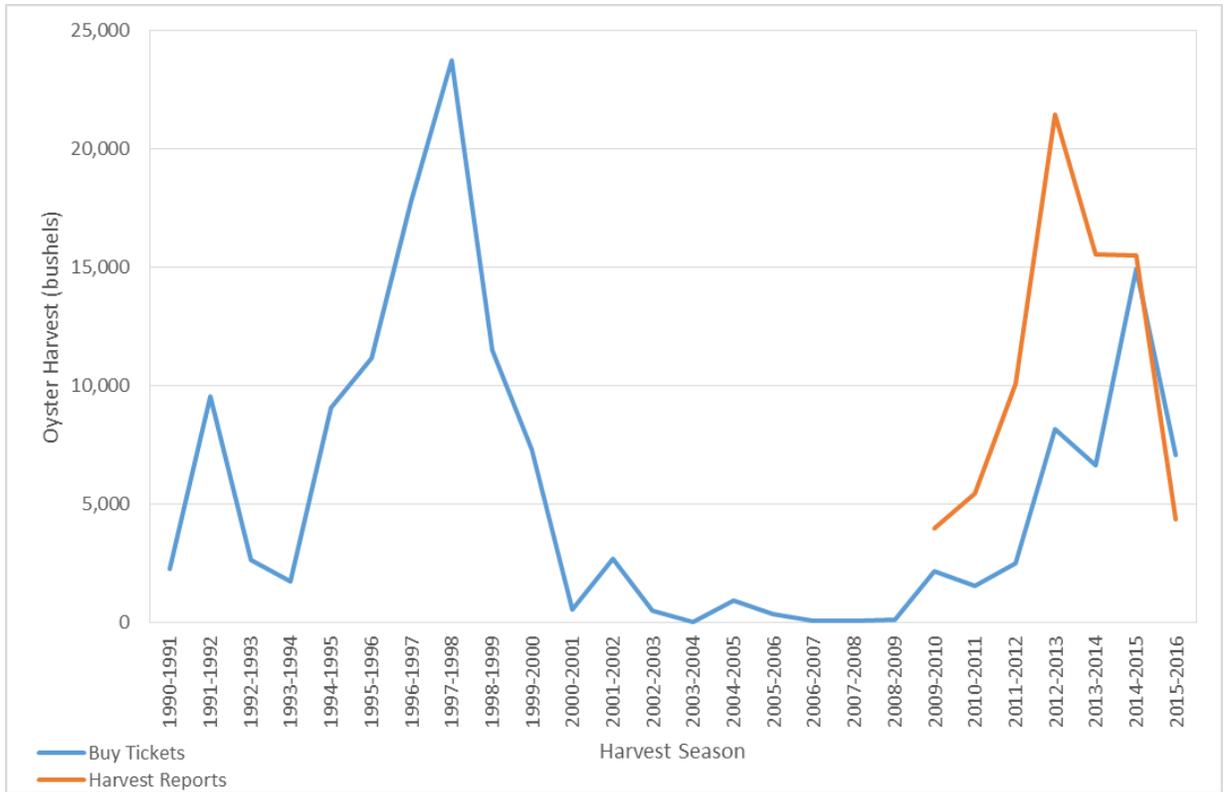


Figure B.11-4. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 062 (Nanticoke River). After the 2009-2010 season, 85% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.12: NOAA Code 072 – Pocomoke Sound

NOAA Code 072 encompasses Pocomoke Sound and is located in Maryland’s lower eastern portion of Chesapeake Bay (Figure B.12-1). The entire NOAA Code is 17,434 acres and has 16 historic oyster bars¹⁷. The Kitts Creek Sanctuary encompasses 7% (1,181 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 16,253 acres. There are 4,018 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. None of the area within the NOAA Code was designated as a Public Shellfish Fishery Area. This NOAA Code is generally located within Maryland’s high salinity zone.

Replenishment Activities

Since 1990, approximately 6,700 bushels of wild seed had been planted in NOAA Code 072 outside of the current sanctuary area (Table B.12-1). No shell or hatchery spat-on-shell has been planted since 1990.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1998	Wild Seed	6.8	4.5	-
1999	Wild Seed	3.3	2.2	-

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled five to six oyster bars annually in NOAA Code 072 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 45 to 400 per bushel with an average of 144 (Figure B.12-2). Since 2005, there has been a general increase in the number of oysters. The average number of oysters was greater from 2010 to 2015 than prior to 2010 (Table B.12-2). On average, there were more small-sized oysters annually than market-sized oysters.

¹⁷ See chart 48 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

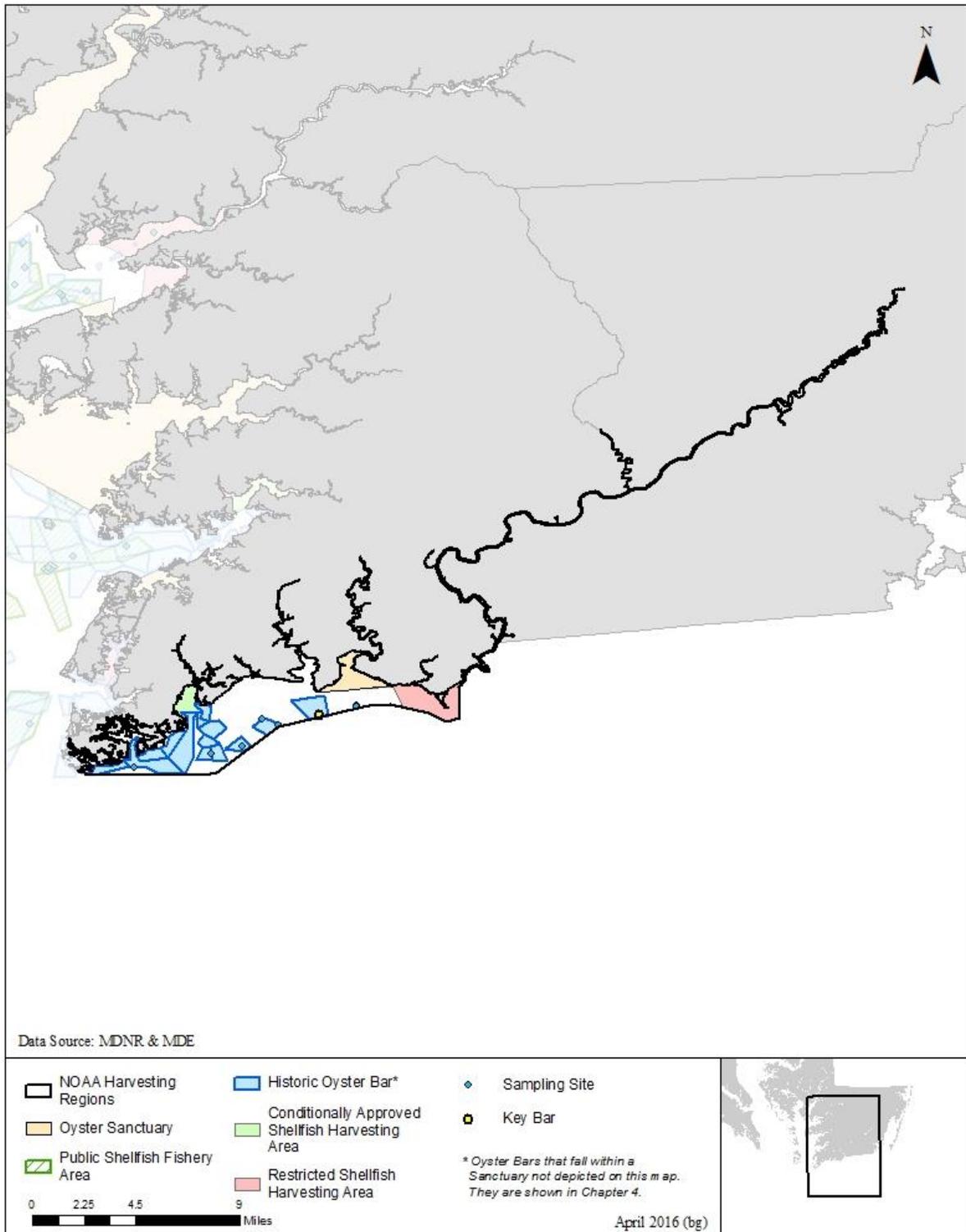


Figure B.12 -1. Map of NOAA Code 072 (Pocomoke Sound).

Table B.12-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 072 (Pocomoke Sound). Values are given as mean \pm standard error.

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 138	6 / 36
Number of Live Oysters per Bushel	103 \pm 10	280 \pm 33
Number of Live Small-Sized Oysters per Bushel	50 \pm 7	123 \pm 40
Number of Live Market-Sized Oysters per Bushel	15 \pm 2	39 \pm 8
Live Oyster Biomass (g Dry Weight per Bushel)	56 \pm 8	182 \pm 40
Mortality (%)	29.8 \pm 3.8	10.5 \pm 2

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Marumsco bar within NOAA Code (Figure B.12-3). Approximately 80% of oysters were 80 mm or smaller, with 50% between 40 and 75 mm. Less than 1% of oysters were 120 mm or greater in size.

Biomass

The Fall Survey has measured oyster biomass since 1990 on Marumsco bar within NOAA Code 072. The annual biomass ranged from 19 to 295 grams of dry weight per bushel and the average is 85.3 \pm 14.9 (average \pm SE; Figure B.12-4). The average biomass was greater from 2010 to 2015 than prior to 2010 (Table B.12-2). Peak biomass occurred in 2011.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 1 to 273 spat per bushel from 1990 to 2015 (Figure B.12-2). The largest spatfall occurred in 2010. Spatfall was variable but generally increasing after 2009.

Mortality

Mortality ranged from 2% to 73%, however, since 2006 mortality has been relatively low (Figure B.12-5). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.12-2).

Disease

From 1990 to 2015, dermo prevalence ranged from 37% to 100% (Figure B.12-6). Dermo prevalence was greater than 80% during 18 of the 26 years disease information was collected. Dermo intensity ranged from 1.1 to 5.0. In 2001, dermo intensity reached a lethal infection level (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 37% from 1990 to 2015. In 1999 to 2002, there was an extended period of MSX prevalence.

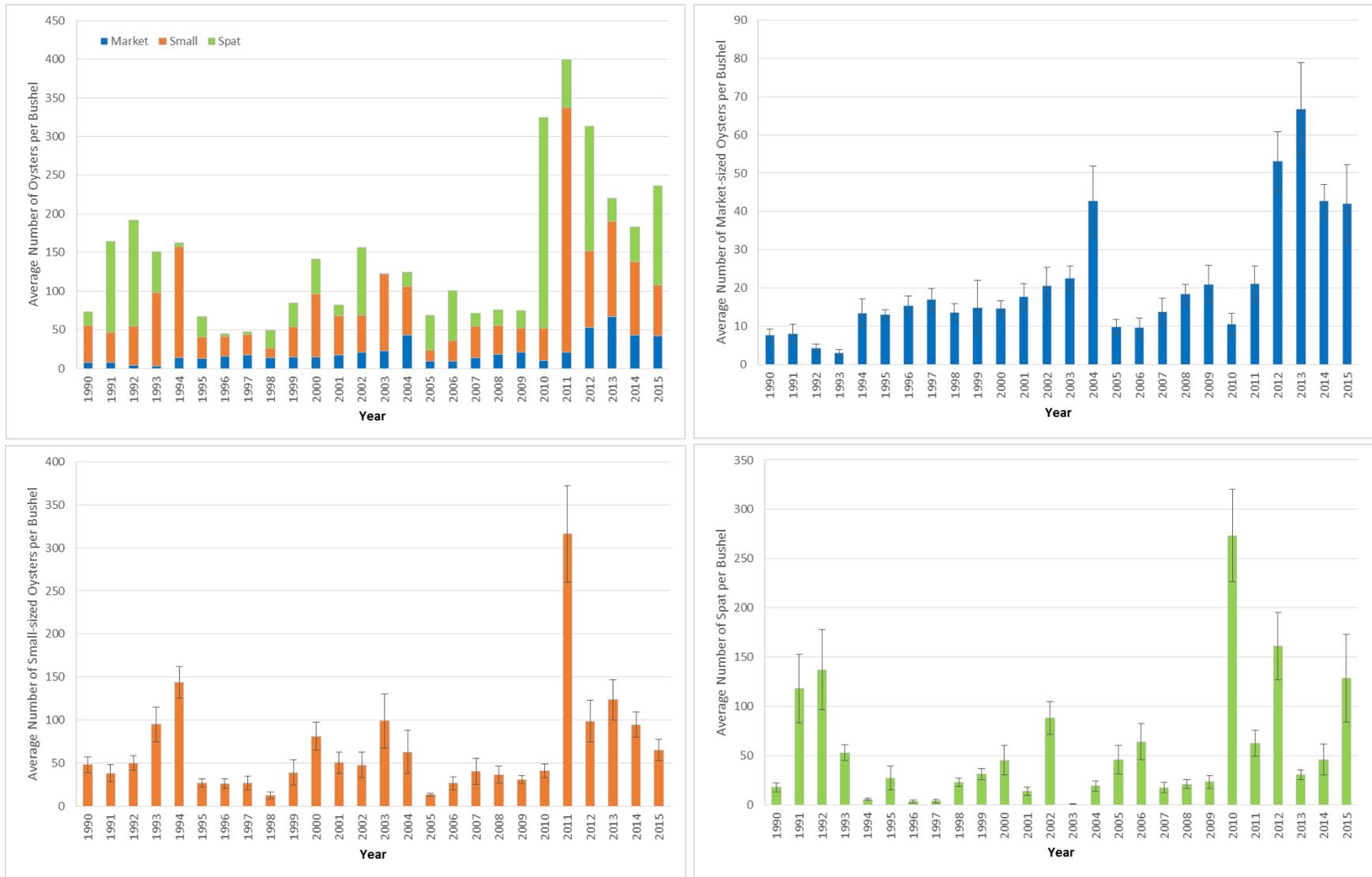
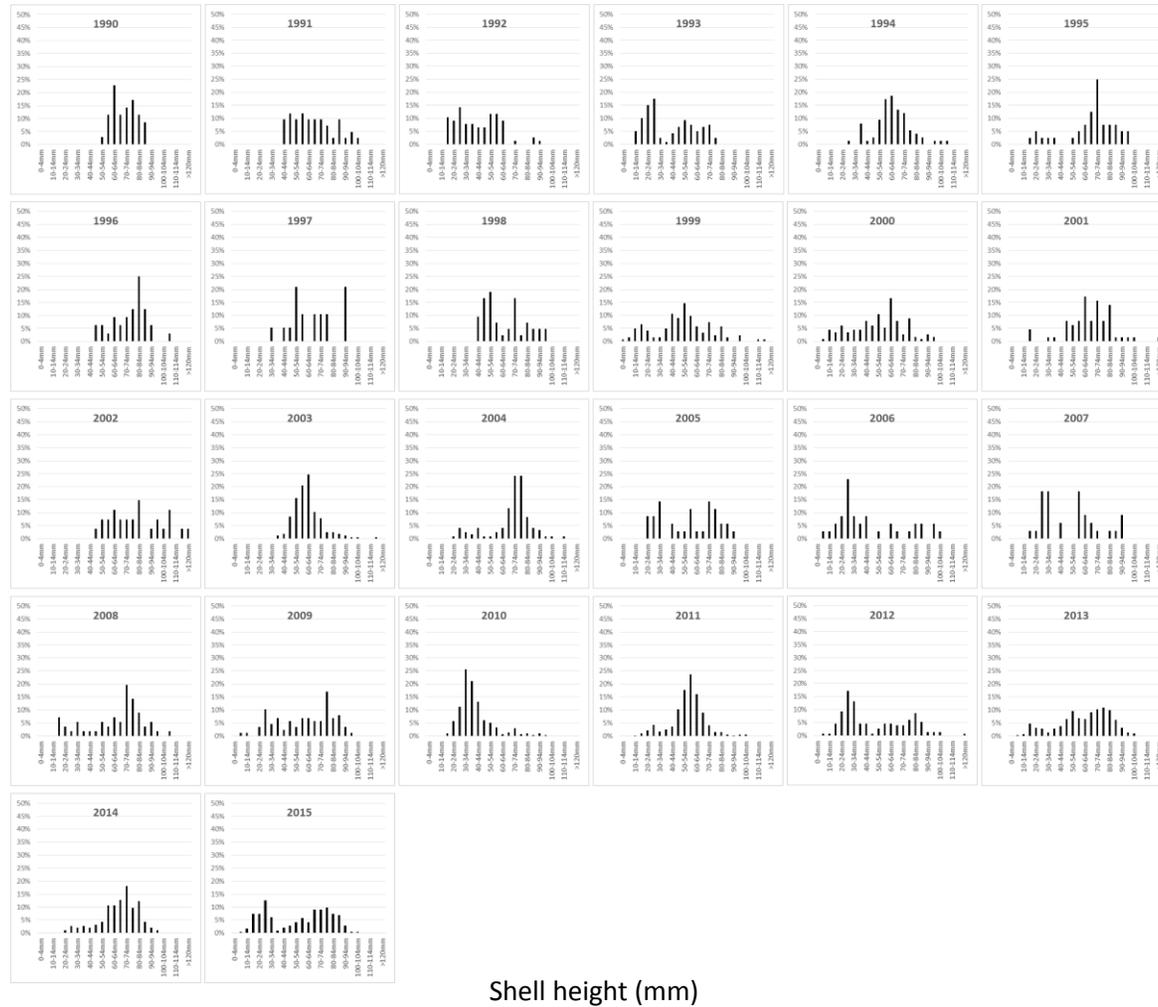


Figure B.12-2. Average number of live oysters per bushel of material by size class in the NOAA Code 072 (Pocomoke Sound). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

Frequency (%)



Shell height (mm)

Figure B.12-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 072 (Pocomoke Sound). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

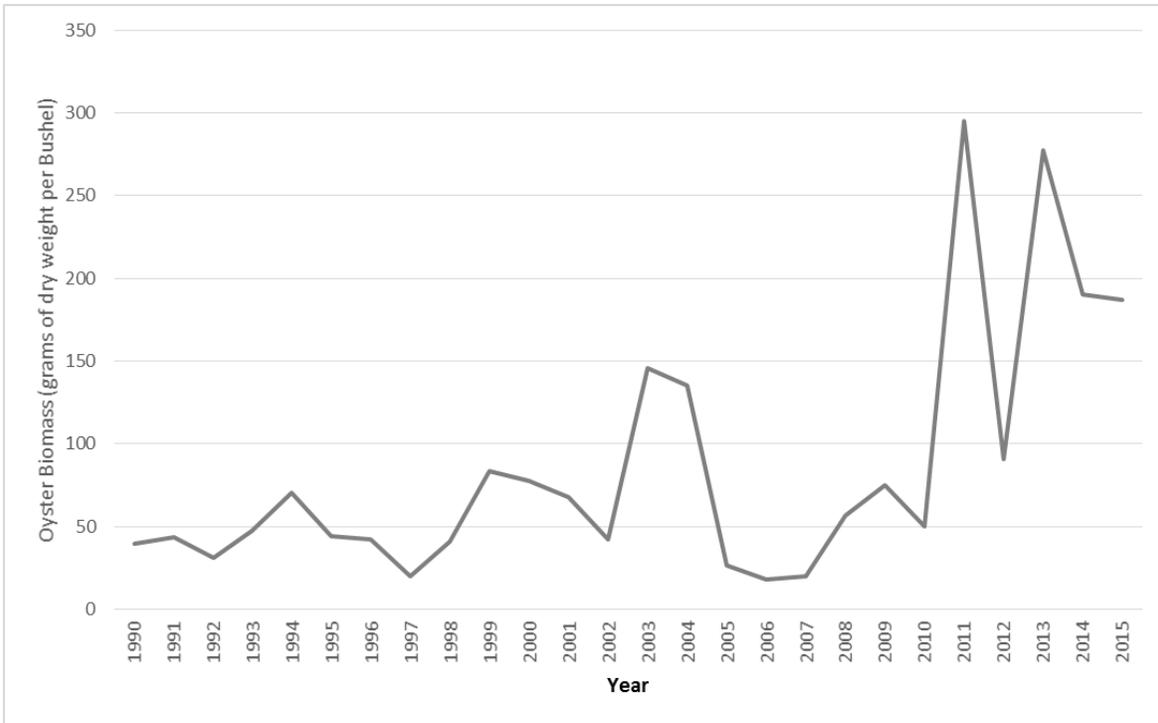


Figure B.12-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 072 (Pocomoke Sound). Data from Maryland’s Annual Fall Oyster Dredge Survey.

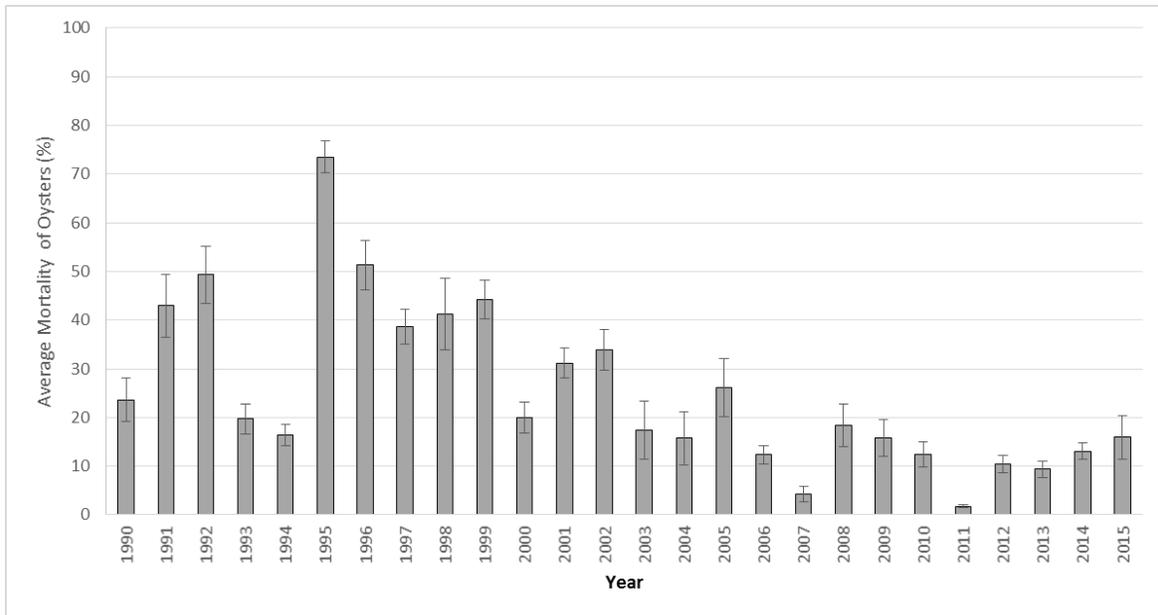


Figure B.12-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 072 (Pocomoke Sound). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

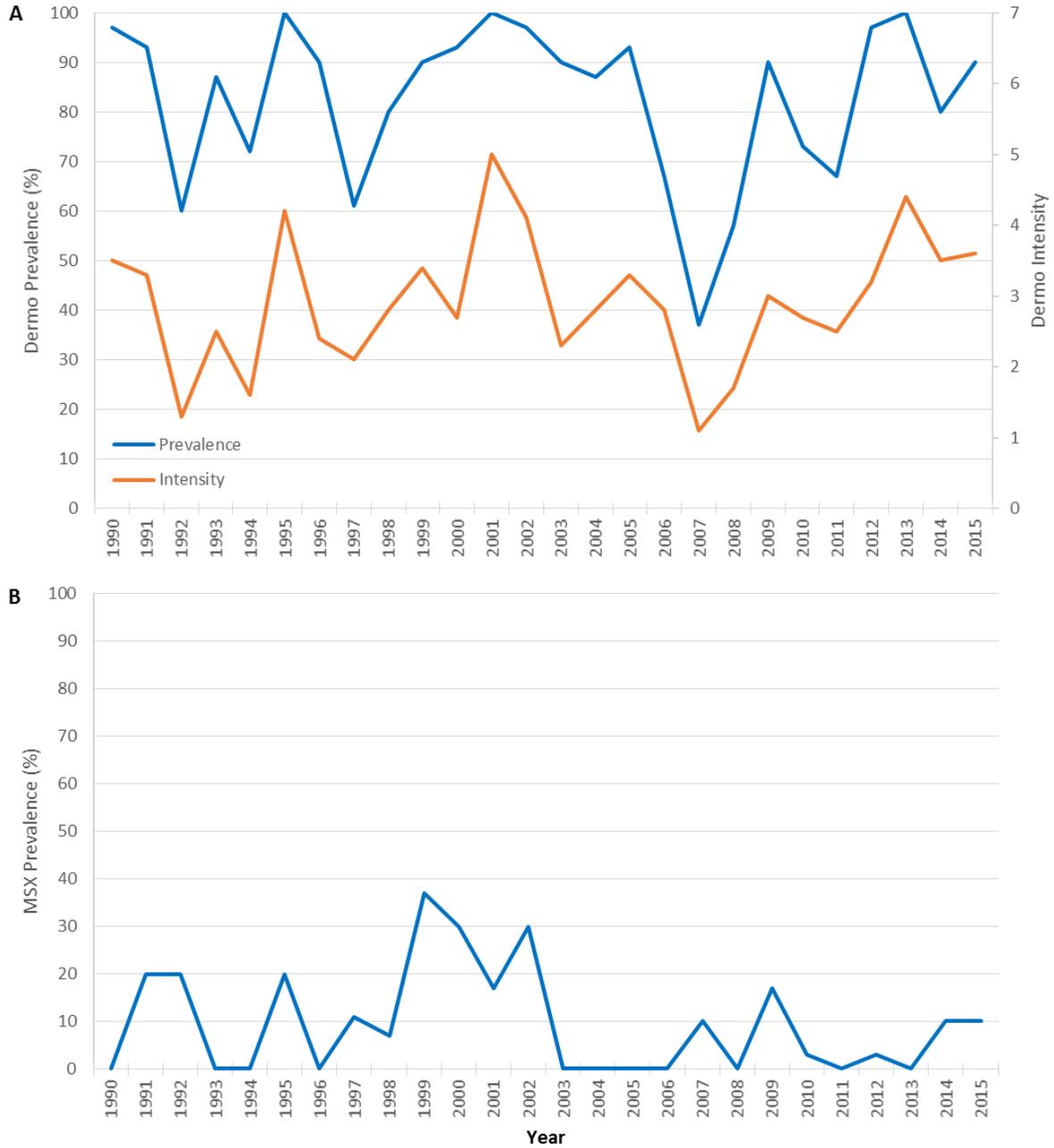


Figure B.12-6. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 072 (Pocomoke Sound). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland's Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 072 is presented in Figure B.12-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 7% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest to a maximum of approximately 35,000 bushels in the 2012-2013 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Power dredging accounted for 78% of the harvest, as reported on oyster harvester reports. Patent tongs accounted for 20% of the harvest.

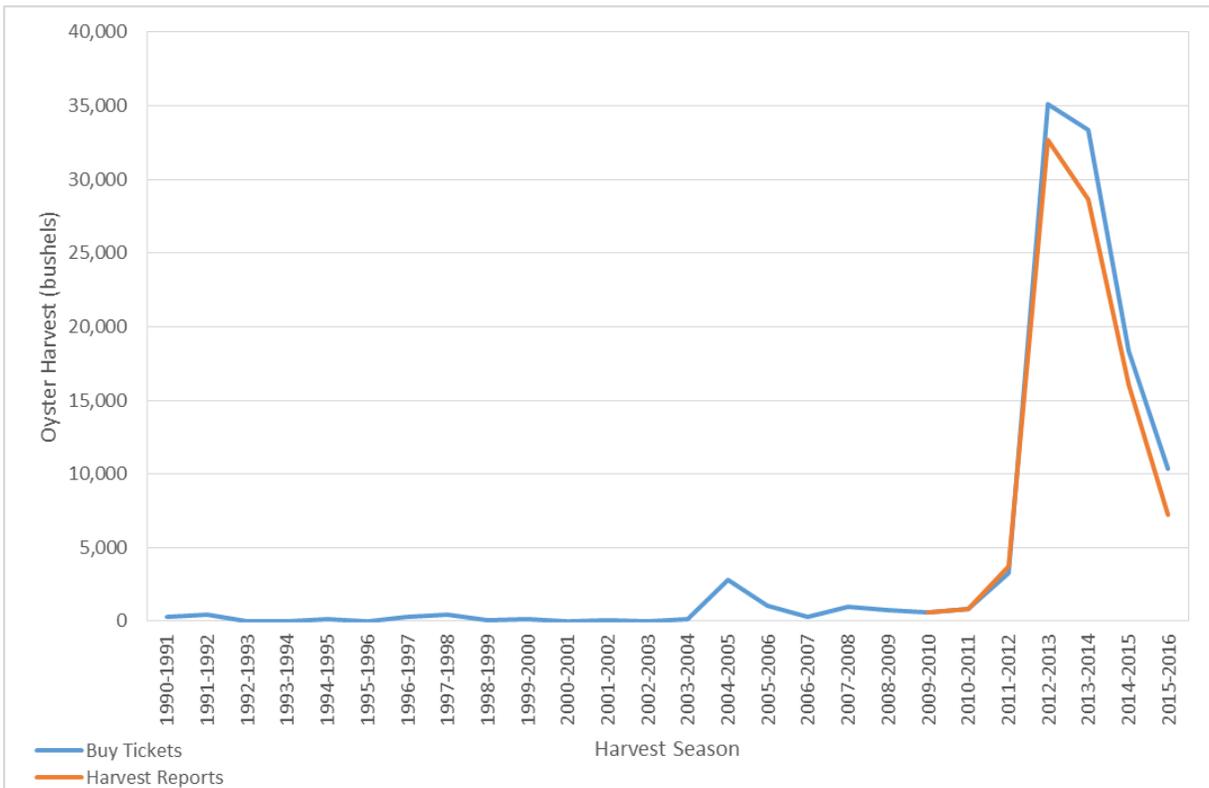


Figure B.12-8. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 072 (Pocomoke Sound). After the 2009-2010 season, 7% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.13: NOAA Code 078 – St. Mary’s River

NOAA Code 078 encompasses the St. Mary’s River, a tributary of the Potomac River, and is located in Maryland’s lower western portion of Chesapeake Bay (Figure B.13-1). The entire NOAA Code is 6,124 acres and has 32 historic oyster bars¹⁸. The St Mary’s Sanctuary encompasses 21% (1,304 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 4,820 acres. There are 1,096 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010 1,995 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture. This NOAA Code is generally located within Maryland’s medium salinity zone.

Replenishment Activities

Since 1990, approximately 200,000 bushels of shell, 4,000 bushels of wild seed and 16 million hatchery spat-on-shell have been planted in NOAA Code 078 outside of the current sanctuary area (Table B.13-1).

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1998	Dredged Shell	40.0	107.7	-
2000	Dredged Shell	8.1	91.7	-
2004	Wild Seed	5.2	2.3	-
2009	Wild Seed	3.7	2.2	-
2014	Hatchery Spat-on-Shell	1.6	-	5.8
2015	Hatchery Spat-on-Shell	5.3	-	10.5

¹⁸ See chart 38 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

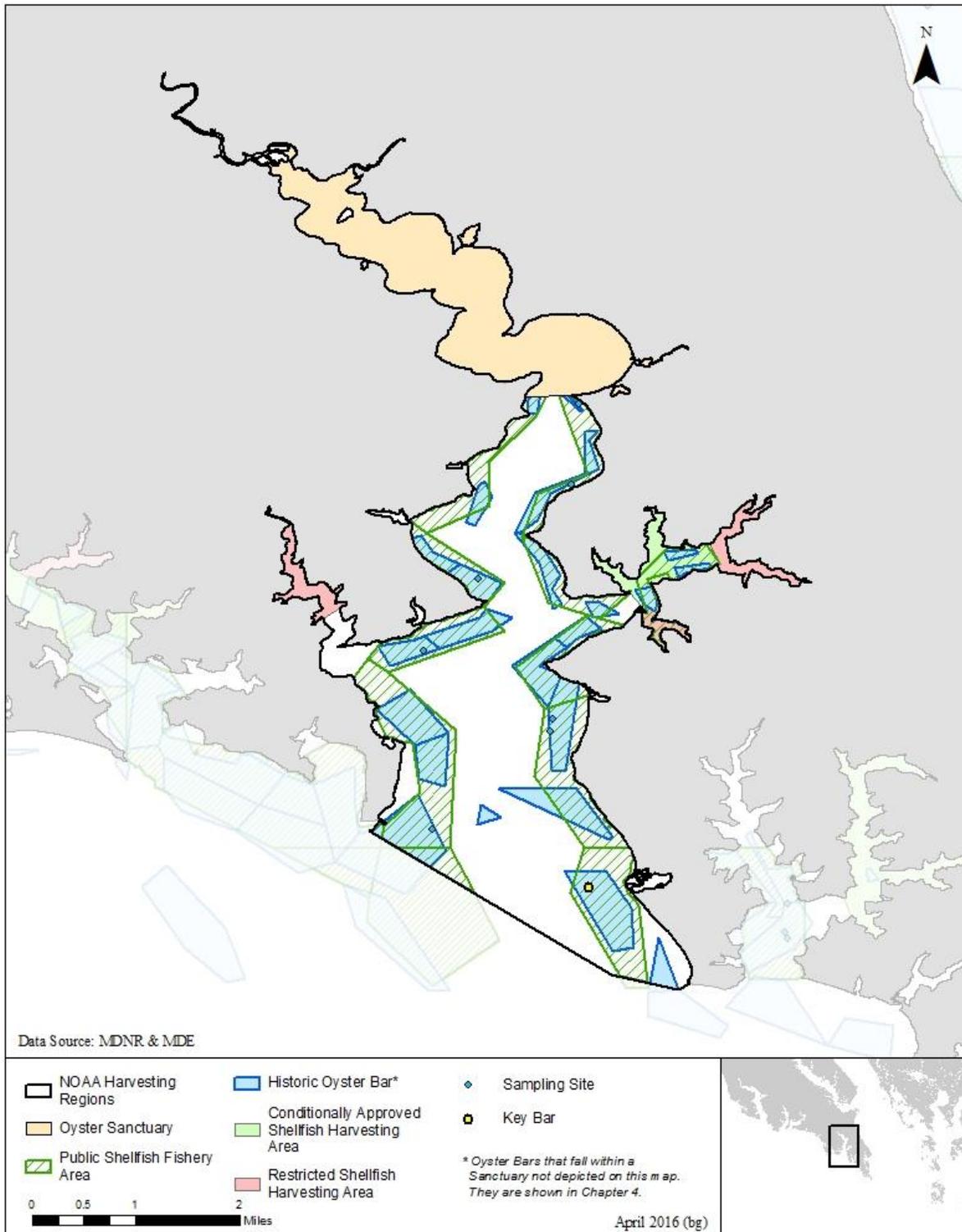


Figure B.13 -1. Map of NOAA Code 078 (St. Mary's River).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled three to five oyster bars annually in NOAA Code 078 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 42 to 659 per bushel with an average of 265 (Figure B.13-2). Since 2002, there has been a general increase in market-sized oysters. The average number of total live oysters was similar from 2010 to 2015 than prior to 2010 (Table B.13-2). On average, there were more small-sized oysters annually than market-sized oysters.

Table B.13-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 078 (St. Mary's River). Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 80	6 / 30
Number of Live Oysters per Bushel	259 \pm 29	287 \pm 45
Number of Live Small-Sized Oysters per Bushel	145 \pm 17	145 \pm 26
Number of Live Market-Sized Oysters per Bushel	22 \pm 4	41 \pm 9
Live Oyster Biomass (g Dry Weight per Bushel)	101 \pm 18	105 \pm 30
Mortality (%)	30.7 \pm 4.5	20 \pm 3.4

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Chicken Cock bar within NOAA Code 078 (Figure B.13-3). Overall, 55% of oysters measured 40-75 mm (58% for 1990-2009, 44% for 2010-2015). For 2010-2015, 27% of oysters were greater than 80 mm, compared to 14% for 1990-2009.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on Chicken Cock bar within NOAA Code 078. The annual biomass ranged from 13 to 293 grams of dry weight per bushel and the average is 102.1 \pm 15.1 (average \pm SE; Figure B.13-4). The average biomass was similar from 2010 to 2015 than prior to 2010 (Table B.13-2). Biomass peaked in 1997 and 2013.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall had ranged from 1 to 487 spat per bushel from 1990 to 2015 (Figure B.13-2). The largest spatfall occurred in 1997. Spatfall has been variable, but slightly higher from 2010-2015.

Mortality

Mortality ranged from 2% to 86% (Figure B.13-5). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.13-2).

Disease

From 1990 to 2015, dermo prevalence has ranged from 20% to 100% (Figure B.13-6). Dermo prevalence was greater than 80% during 14 of the 26 years disease information was collected. Dermo intensity ranged from 0.6 to 5.0, reaching a lethal level in 1999 (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 77% from 1990 to 2015. In 1999 to 2002, there was an extended period of MSX prevalence.

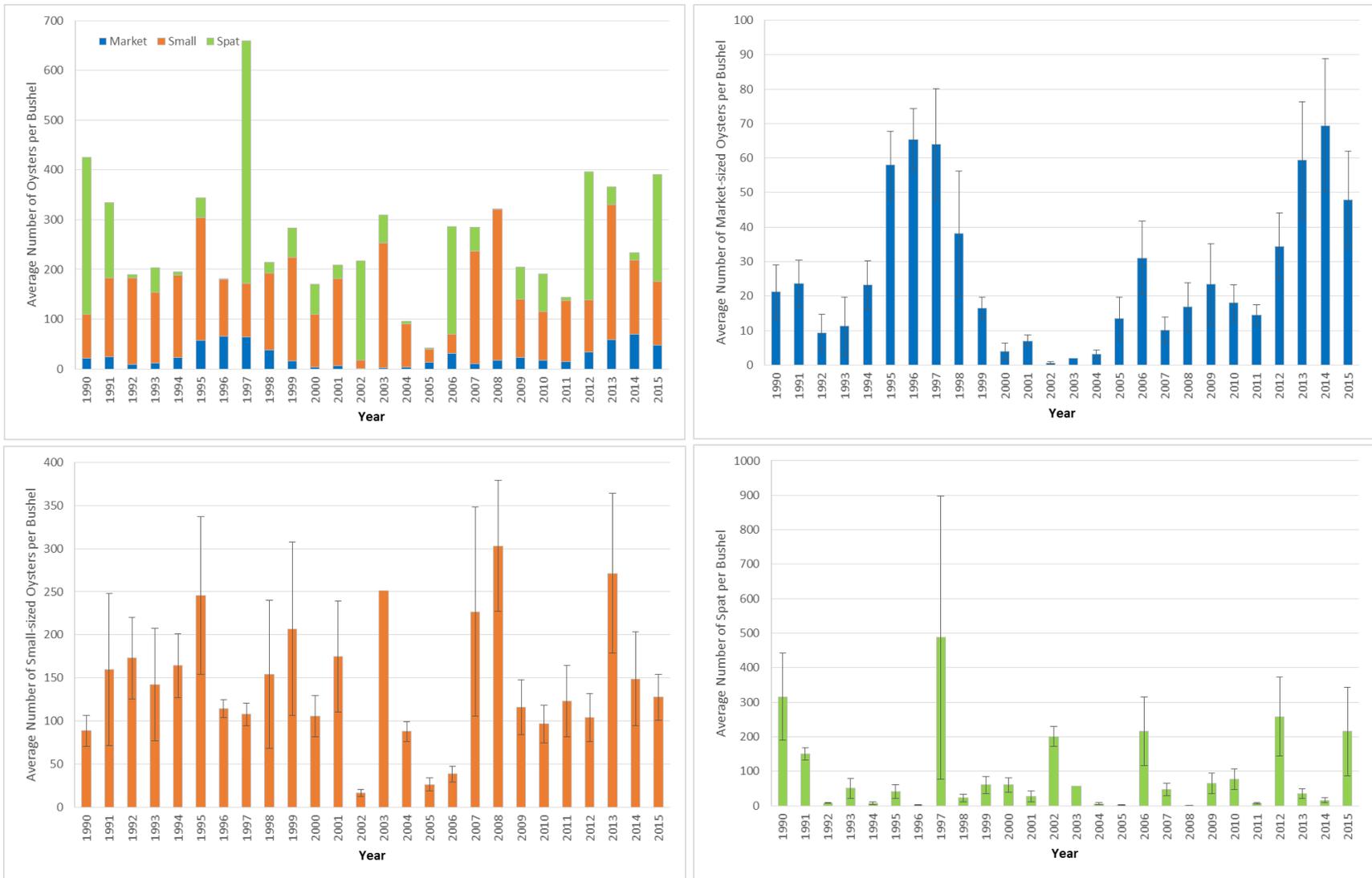
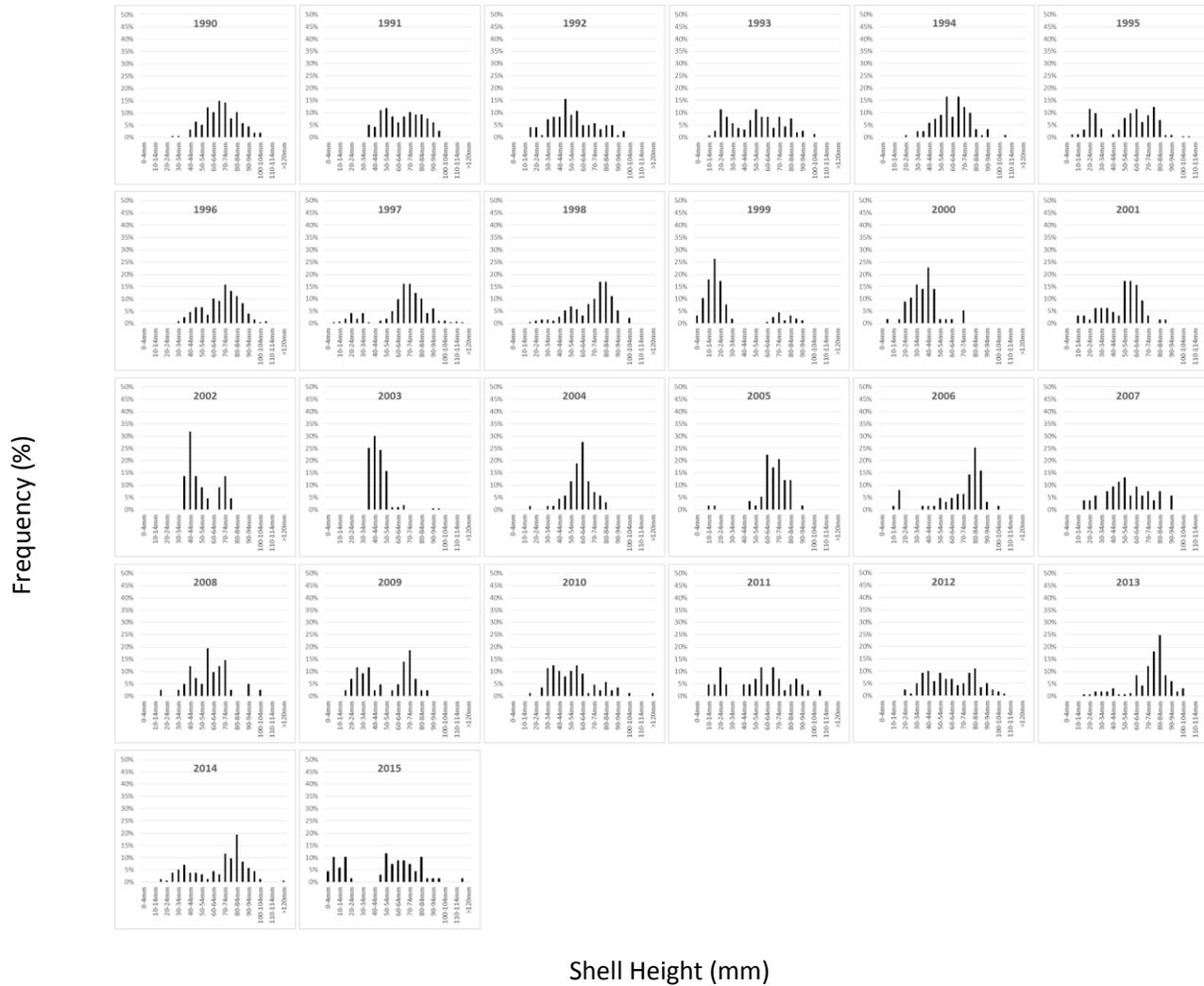


Figure B.13-2. Average number of live oysters per bushel of material by size class in the NOAA Code 078 (St. Mary's River). Error bars represent ± 1 standard error. Data from Maryland's Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.



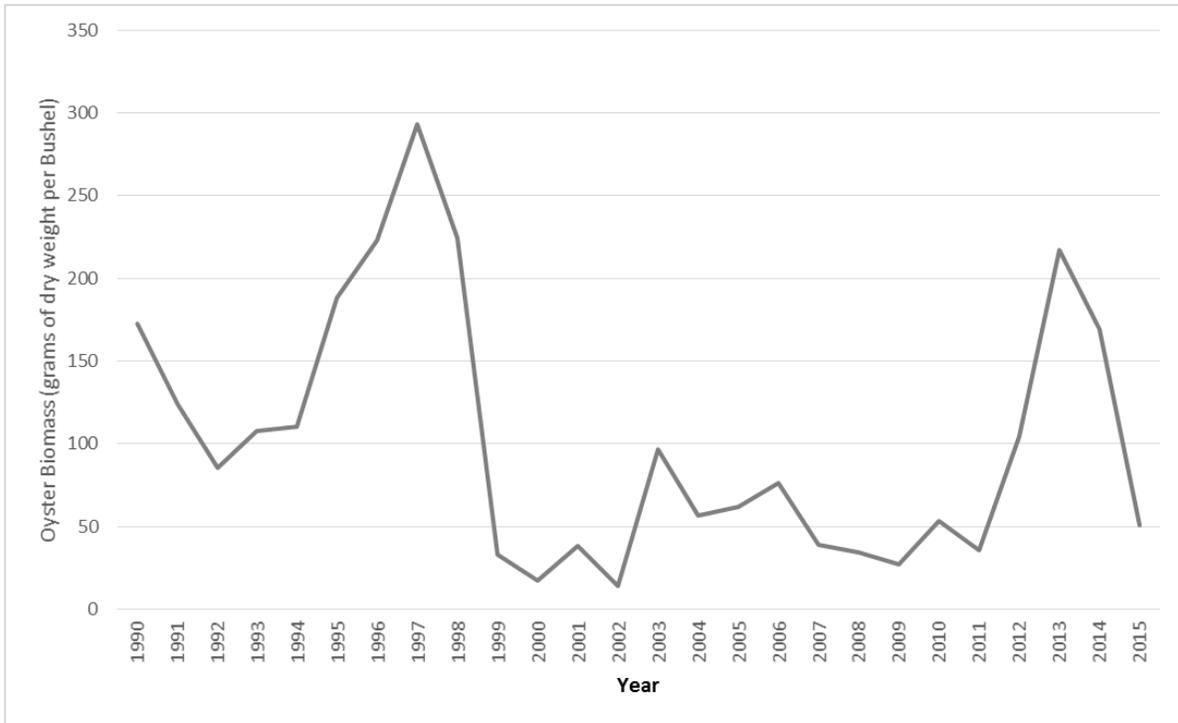


Figure B.13-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 078 (St. Mary's River). Data from Maryland's Annual Fall Oyster Dredge Survey.

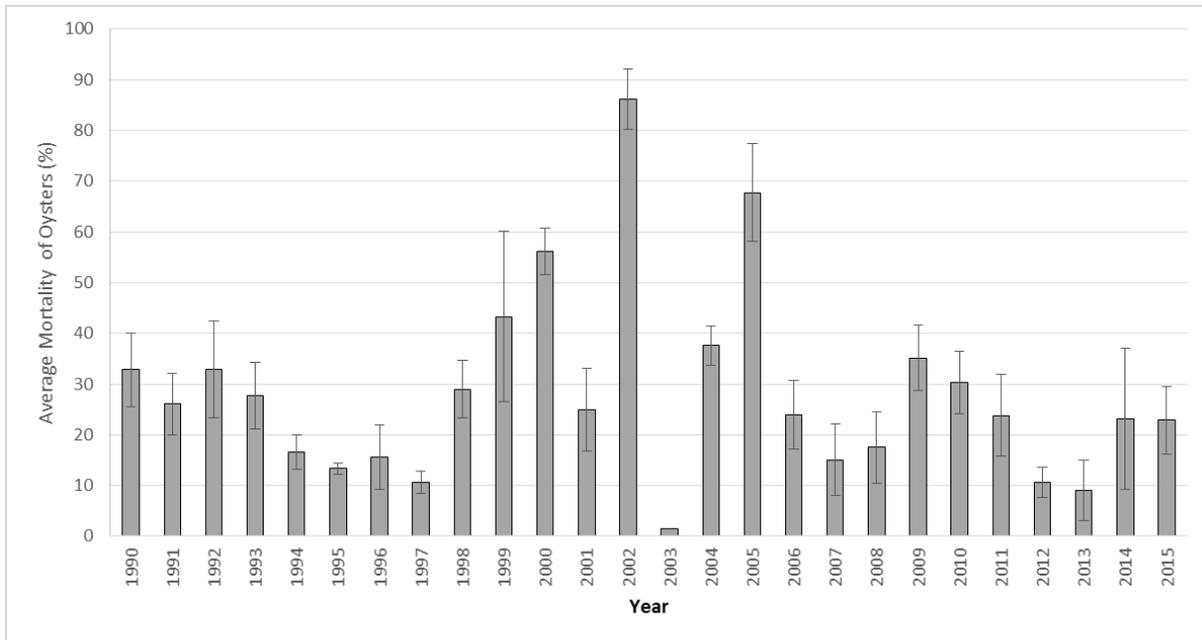


Figure B.13-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 078 (St. Mary's River). Data from Maryland's Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

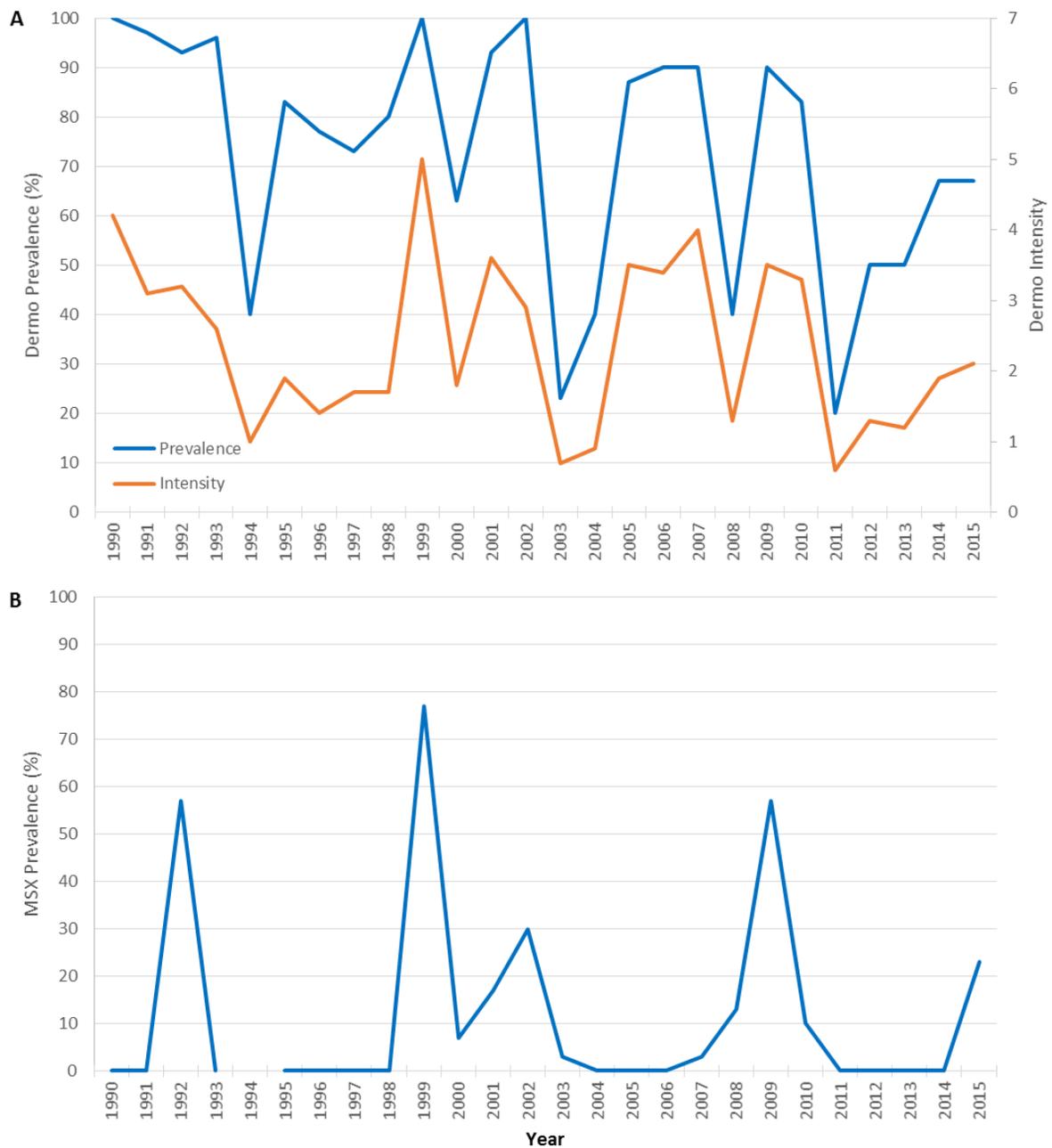


Figure B.13-6. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 078 (St. Mary’s River). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland’s Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 078 since 1990 is presented in Figure B.13-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 21% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in the 2002-2003 and 2003-2004 seasons to a maximum of approximately 35,000 bushels in the 1997-1998 season. Harvest in the 2014-2015 season was the highest harvest since 1998-1999 prior to the 1999-2004 disease epizootic. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Power dredging accounted for approximately 70% of harvest in this area as reported on the oyster harvest reports. Hand tonging accounted for approximately 22%.

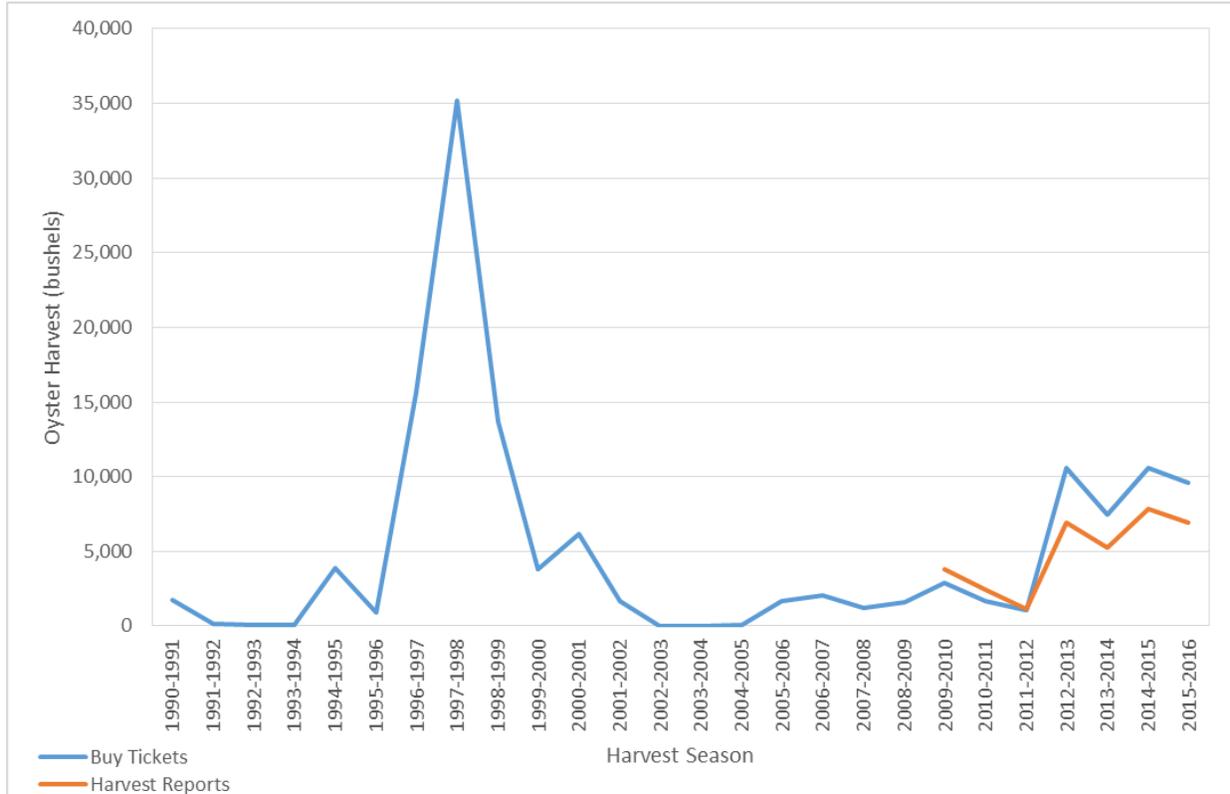


Figure B.13-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 078 (St. Mary's River). After the 2009-2010 season, 21% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.14: NOAA Code 082 – Severn River

NOAA Code 082 (Severn River) is 7,711 acres; however, most of the area (7,550 acres) is within a current sanctuary boundary, Severn River Sanctuary (established in 1998). In 2010, 74 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. See Appendix A Section A.39 for more information on the oyster population characteristics.

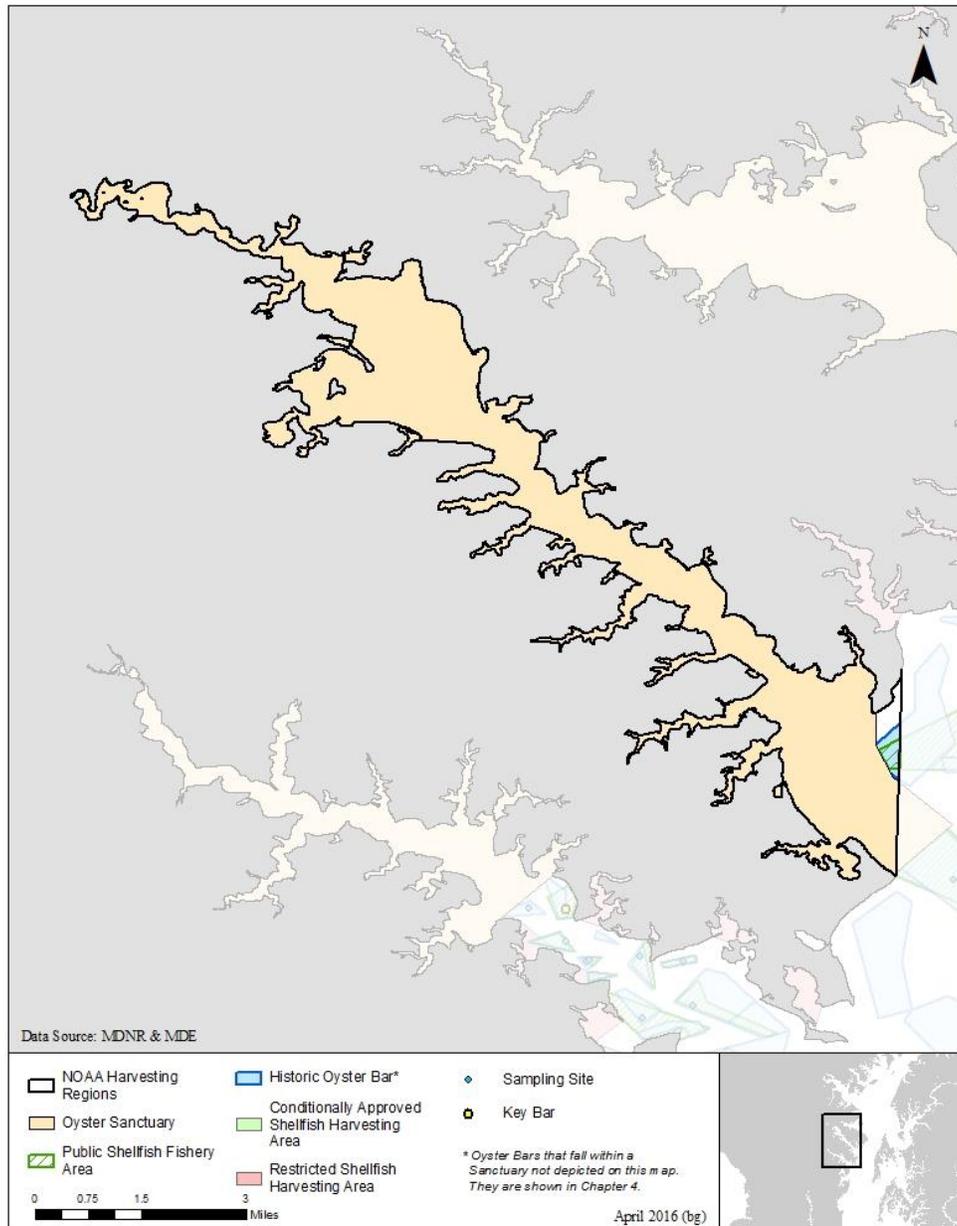


Figure B.14 -1. Map of NOAA Code 088 (Severn River).

Section B.15: NOAA Code 086 – Smith Creek

NOAA Code 086 encompasses Smith Creek and is a tributary of the Potomac River located below the St. Mary's River. (Figure B.15-1). The entire NOAA Code is 890 acres and has 6 historic oyster bars¹⁹. None of the area of the NOAA Code is a sanctuary. There is 246 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and not within a sanctuary. There are 337 acres within the NOAA Code that is designated as a Public Shellfish Fishery Area in 2010 where aquaculture leasing is prohibited. This NOAA Code is generally located within Maryland's medium salinity zone.

Replenishment Activities

Since 1990, approximately 5,000 bushels of wild seed have been planted in NOAA Code (Table B.15-1). No shell or hatchery spat-on-shell has been planted since 1990.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1996	Wild Seed	1.2	1.2	-
1998	Wild Seed	3.9	1.8	-
1999	Wild Seed	3.1	2.4	-

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled one to two oyster bars annually in NOAA Code 086 since. The average number of total live oysters (market, small, and spat) ranged from 35 to 474 per bushel with an average of 143 (Figure B.15-2). The number of oysters decreased from 1999 to 2007, and then began to increase starting in 2008. Years 2013 and 2014 had the highest number of market-sized oysters during the 26 year time period. The average number of live oysters was similar from 1990 to 2009 than from 2010 to 2015 (Table B.15-2). On average, there were more small-sized oysters annually than market-sized oysters.

¹⁹ See chart 38 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

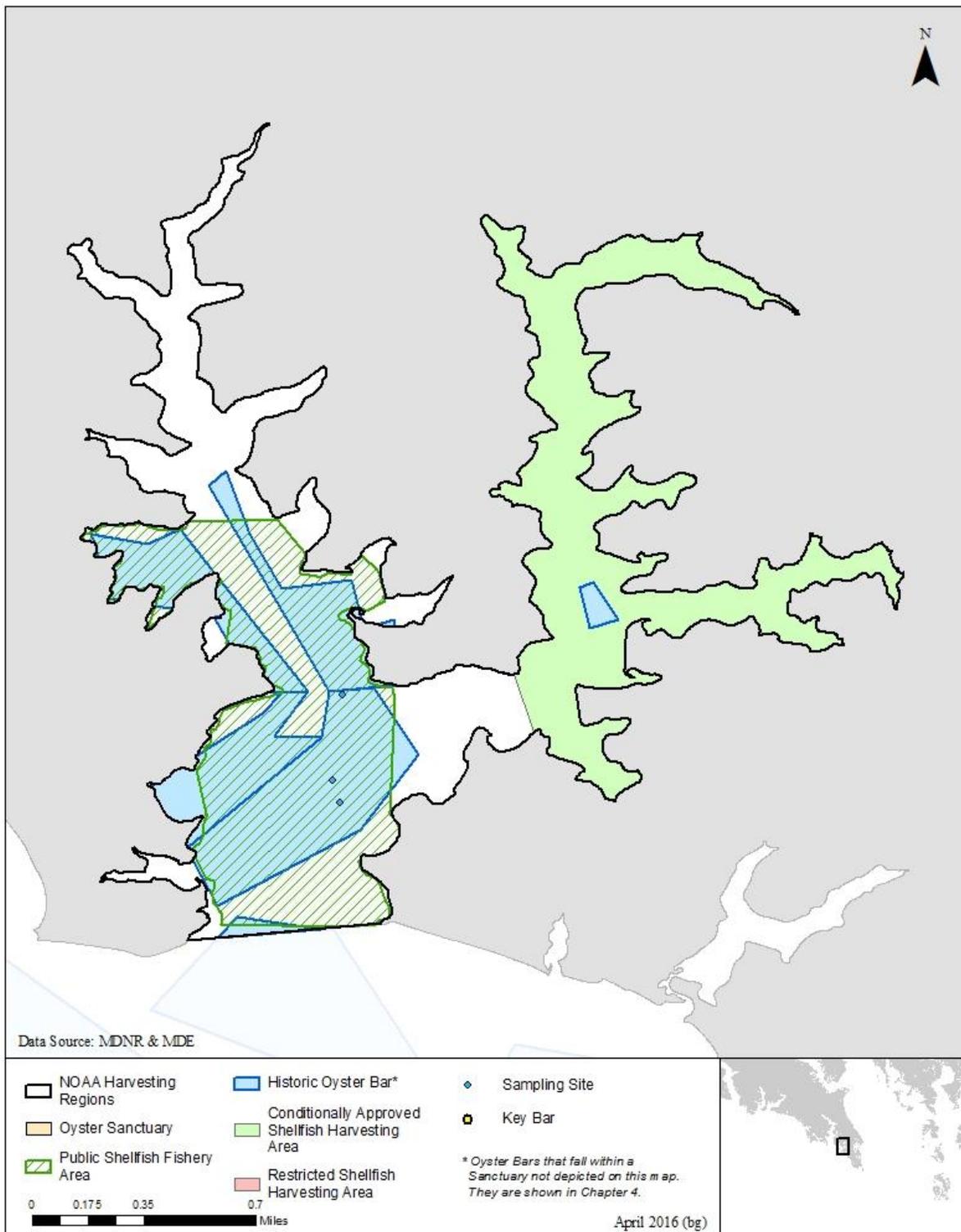


Figure B.15 -1. Map of NOAA Code 086 (Smith Creek).

Table B.15-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 086 (Smith Creek). ND = No Data. Values are given as mean \pm standard error.

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 30	5 / 5
Number of Live Oysters per Bushel	145 \pm 27	139 \pm 30
Number of Live Small-Sized Oysters per Bushel	75 \pm 13	43 \pm 8
Number of Live Market-Sized Oysters per Bushel	29 \pm 6	71 \pm 21
Live Oyster Biomass (g Dry Weight per Bushel)	ND	ND
Mortality (%)	31.9 \pm 5.1	14.9 \pm 6.2

Oyster Size Structure

The Fall Survey has not collected information on oyster shell heights in this NOAA Code since 1990.

Biomass

The Fall Survey has not collected information on oyster biomass in this NOAA Code since 1990.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 0 to 344 spat per bushel (Figure B.15-2). The largest spatfall occurred in 1997. Spatfall has been inconsistent from 1998 to 2011, averaging 13 per bushel, but has averaged 32 per bushel since 2012.

Mortality

Mortality ranged from 0% to 76%, however, since 2010 mortality has been relatively low (Figure B.15-3). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.15-2).

Disease

The Fall Survey has not collected information on oyster disease in this NOAA Code since 1990.

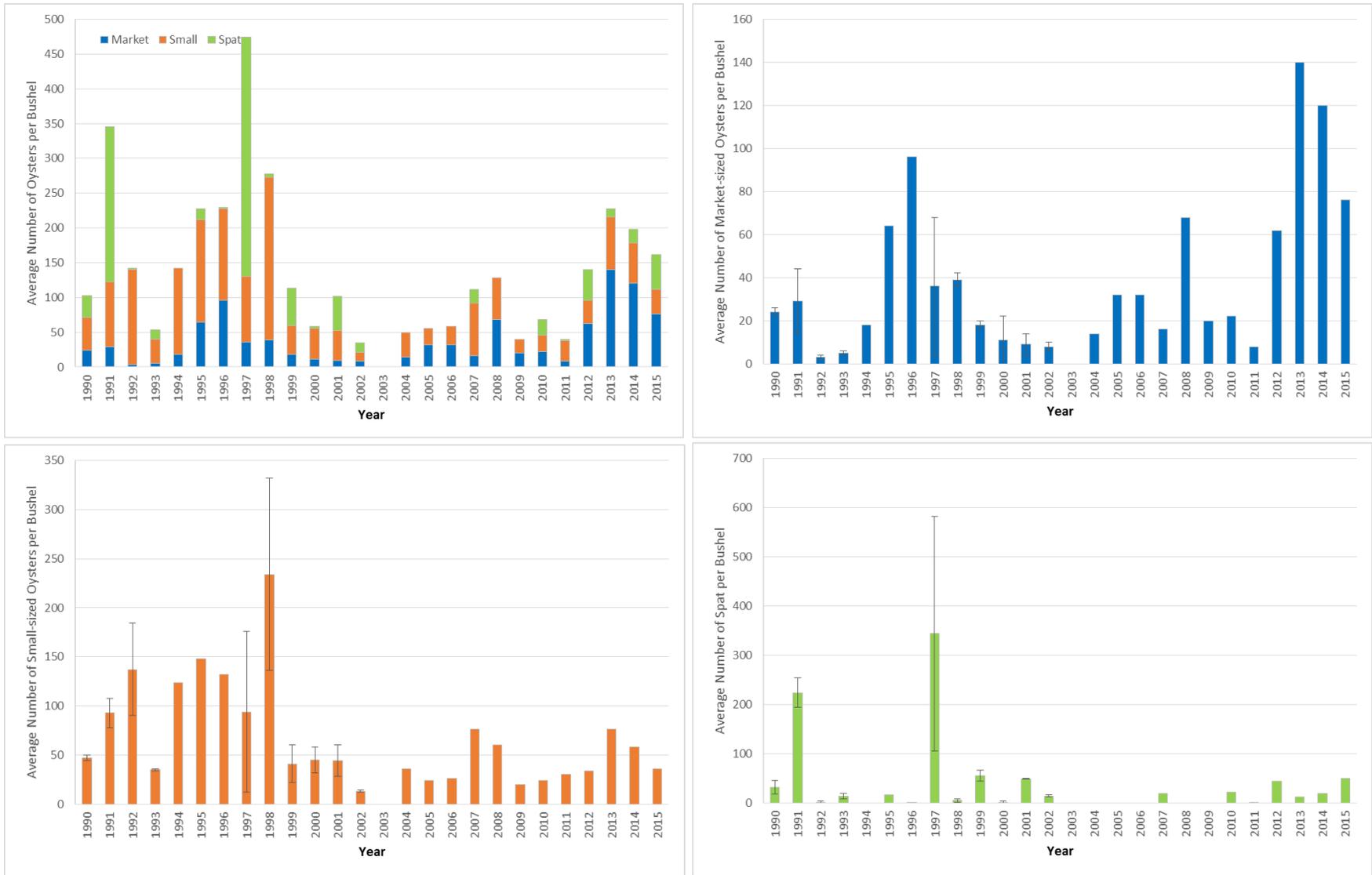


Figure B.15-2. Average number of live oysters per bushel of material by size class in the NOAA Code 086 (Smith Creek). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

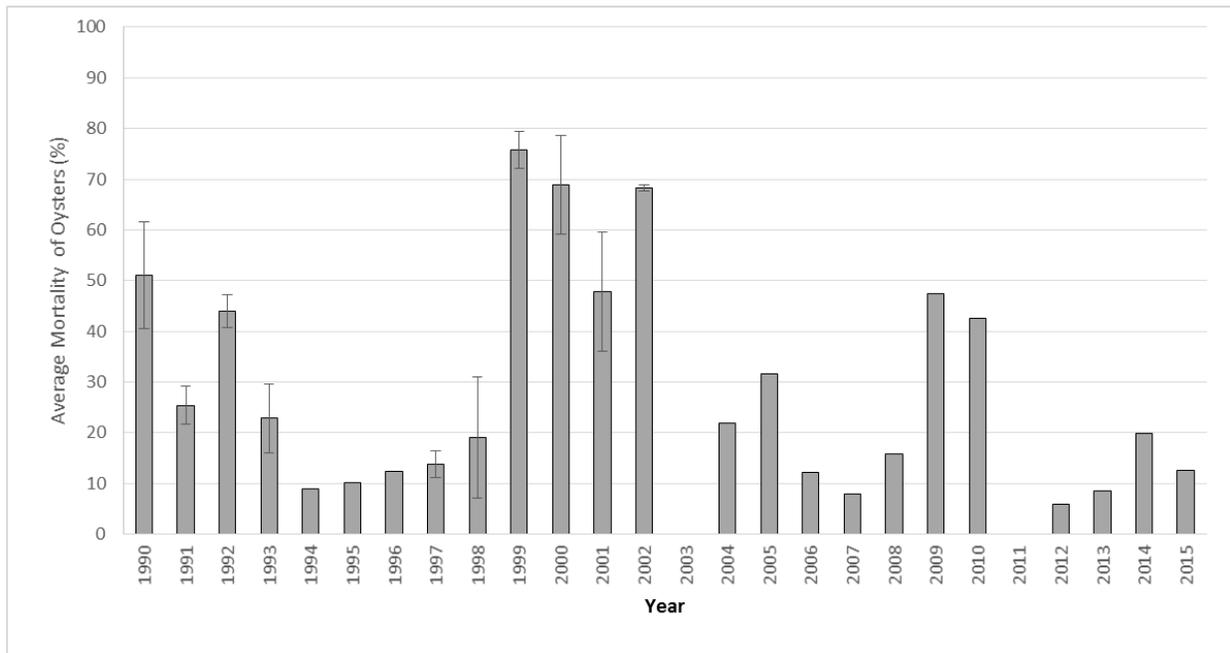


Figure B.15-3. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 086 (Smith Creek) in Maryland’s portion of the Chesapeake Bay. Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

Harvest

Harvest for the entire NOAA Code 086 since 1990 is presented in Figure B.15-4. Harvest reported by seafood dealers on buy tickets has ranged from no harvest for eight seasons to a maximum of approximately 2,700 bushels in the 1998-1999 season. Harvest in 2014-2015 was the second highest harvest recorded. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Diving accounted for 72% of the harvest and hand tonging accounted for 26%, as reported on oyster harvester reports.

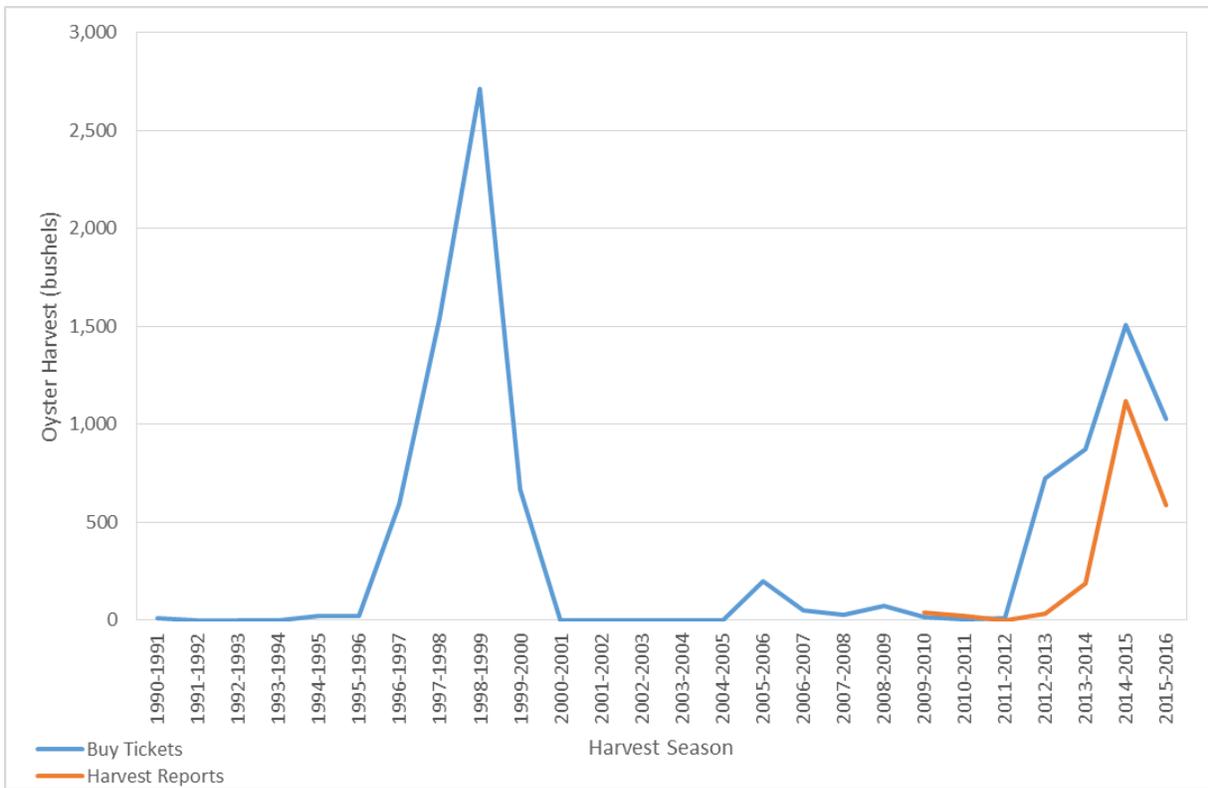


Figure B.15-4. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 086 (Smith Creek).

Section B.16: NOAA Code 088 – South River

NOAA Code 088 encompasses the South River and is located in Maryland's upper western portion of Chesapeake Bay (Figure B.16-1). The entire NOAA Code is 6,099 acres and has 20 historic oyster bars²⁰. The South River Sanctuary encompasses 38% (2,327 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 3,773 acres. There are 1,310 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010, 621 acres within the NOAA Code that were designated as a Public Shellfish Fishery Area, prohibiting aquaculture. This NOAA Code is generally located within Maryland's low salinity zone.

Replenishment Activities

Since 1990, approximately 8,000 bushels of shell, 62,000 bushels of wild seed, and 62 million hatchery spat-on-shell have been planted in NOAA Code 088 outside of the current sanctuary area (Table B.16-1).

²⁰ See chart 9 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

Table B.16-1. Replenishment planting activities occurring since 1990 in NOAA Code 088 (South River). ND = No Data.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Wild Seed	7.6	2.1	-
1991	Wild Seed	11.1	2.1	-
1992	Wild Seed	22.5	14.3	-
1996	Wild Seed	6.8	5.8	-
1997	Wild Seed	2.5	4.3	-
1998	Wild Seed	5.6	6.4	-
1999	Wild Seed	11.2	7.5	-
2000	Wild Seed	2.3	5.3	-
2002	Wild Seed	2.6	1.4	-
2003	Dredged Shell	0.3	8.1	-
2003	Wild Seed	1.2	2.4	-
2004	Wild Seed	1.6	2.0	-
2006	Hatchery Spat-on-Shell	11.6	-	17.2
2007	Hatchery Spat-on-Shell	1.5	-	1.7
2007	Wild Seed	5.3	6.3	-
2008	Wild Seed	2.4	2.0	-
2009	Hatchery Spat-on-Shell	3.7	-	3.3
2009	Wild Seed	1.4	2.2	-
2010	Hatchery Spat-on-Shell	17.9	-	29.1
2013	Wild Seed	6.0	3.4	-
2014	Hatchery Spat-on-Shell	2.4	-	11.0

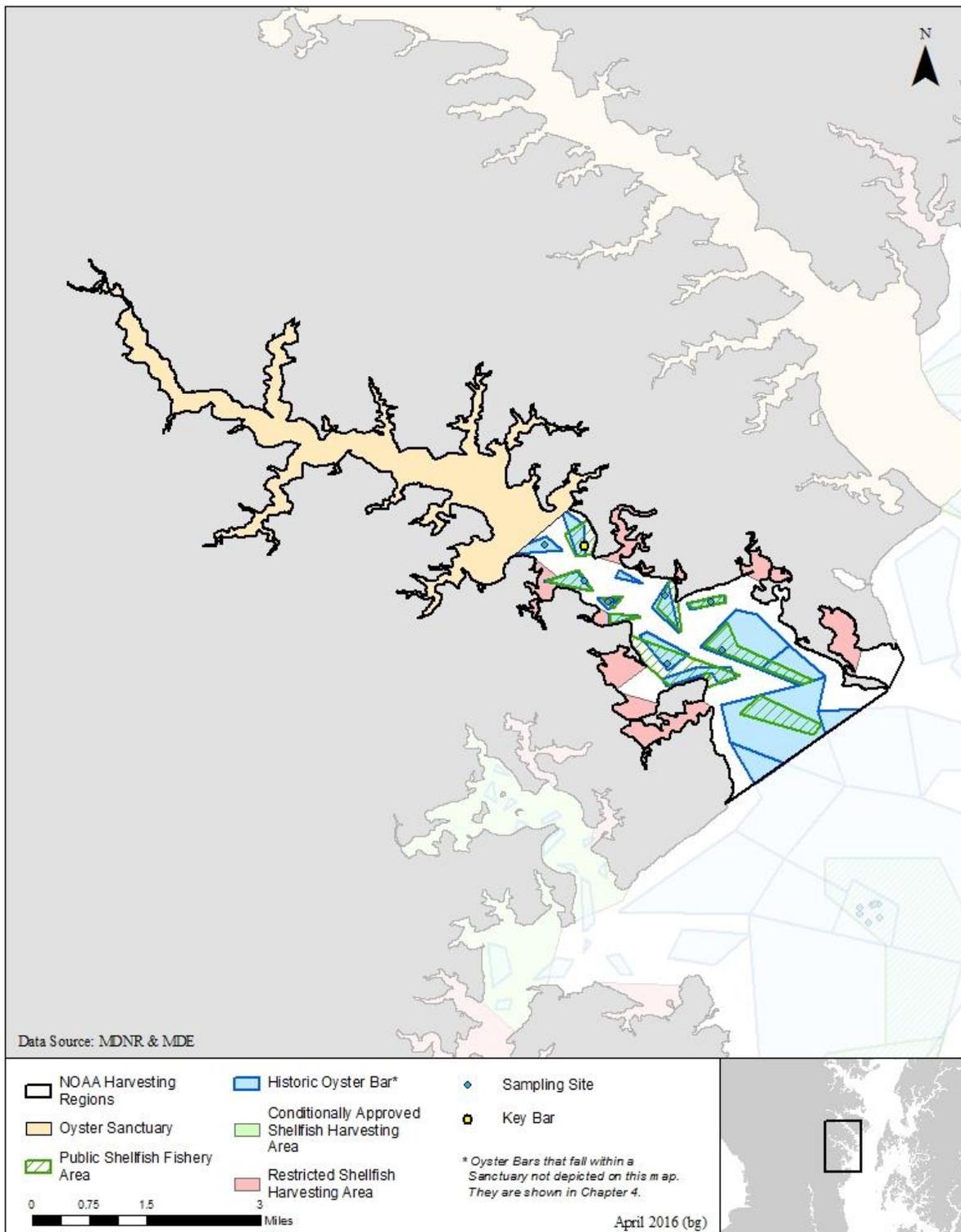


Figure B.16 -1. Map of NOAA Code 088 (South River).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled one to seven oyster bars annually in NOAA Code 088 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 29 to 380 per bushel with an average of 130 (Figure B.16-2). The average number of oysters was similar from 2010 to 2015 than prior to 2010 (Table B.16-2). On average, there were more small-sized oysters annually than market-sized oysters.

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 85	6 / 38
Number of Live Oysters per Bushel	126 \pm 19	141 \pm 21
Number of Live Small-Sized Oysters per Bushel	79 \pm 20	61 \pm 12
Number of Live Market-Sized Oysters per Bushel	45 \pm 6	52 \pm 7
Live Oyster Biomass (g Dry Weight per Bushel)	ND	ND
Mortality (%)	18.9 \pm 2.4	9.1 \pm 2.8

Oyster Size Structure

The Fall Survey has not collected information on oyster shell height in this NOAA Code since 1990.

Biomass

The Fall Survey has not collected information on oyster biomass in this NOAA Code since 1990.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall had ranged from 0 to 121 spat per bushel from 1990 to 2015 (Figure B.16-2). The largest spatfall occurred in four samples collected on recently planted hatchery seed (2007, 2009, 2010, and 2015). Excluding these samples, spatfall averaged 1 per bushel (Figure B.16.3)

Mortality

Mortality ranged from 1% to 47%; since 2007, mortality has been relatively low (Figure B.16-4). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.16-2).

Disease

Disease samples were collected from 1997 to 2015. Dermo prevalence has ranged from 0% to 100% (Figure B.16-5). Dermo prevalence was greater than 80% during 10 of the 19 years disease information was collected. Dermo intensity ranged from 0 to 5.2. Dermo intensity reached lethal levels in 1999 (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence was 0% for the 15 years information was collected.

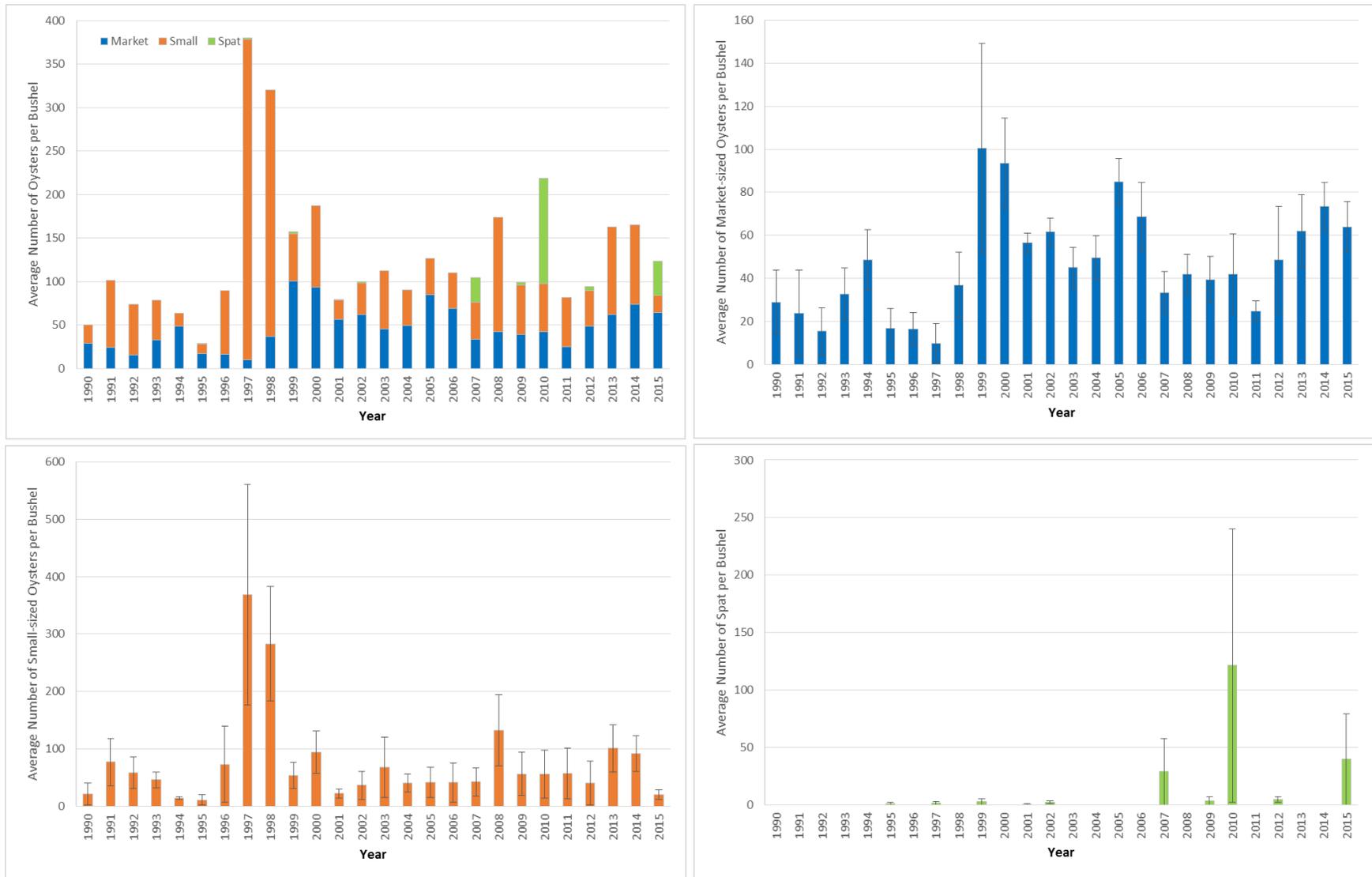


Figure B.16-2. Average number of live oysters per bushel of material by size class in the NOAA Code 088 (South River). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

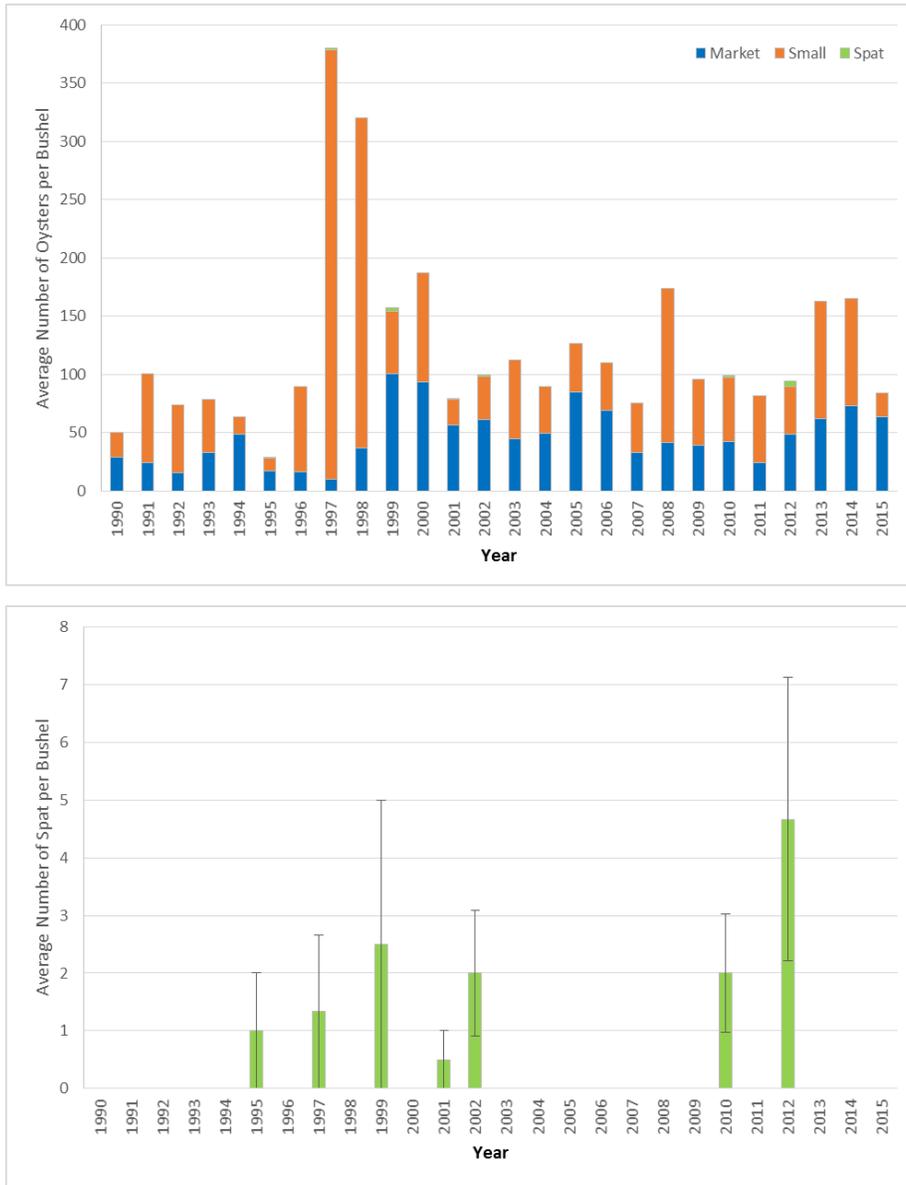


Figure B.16-3. Average number of live oysters per bushel of material by size class in the NOAA Code 088 (South River) excluding samples taken on hatchery seed plantings in 2007, 2009, 2010, and 2015. Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

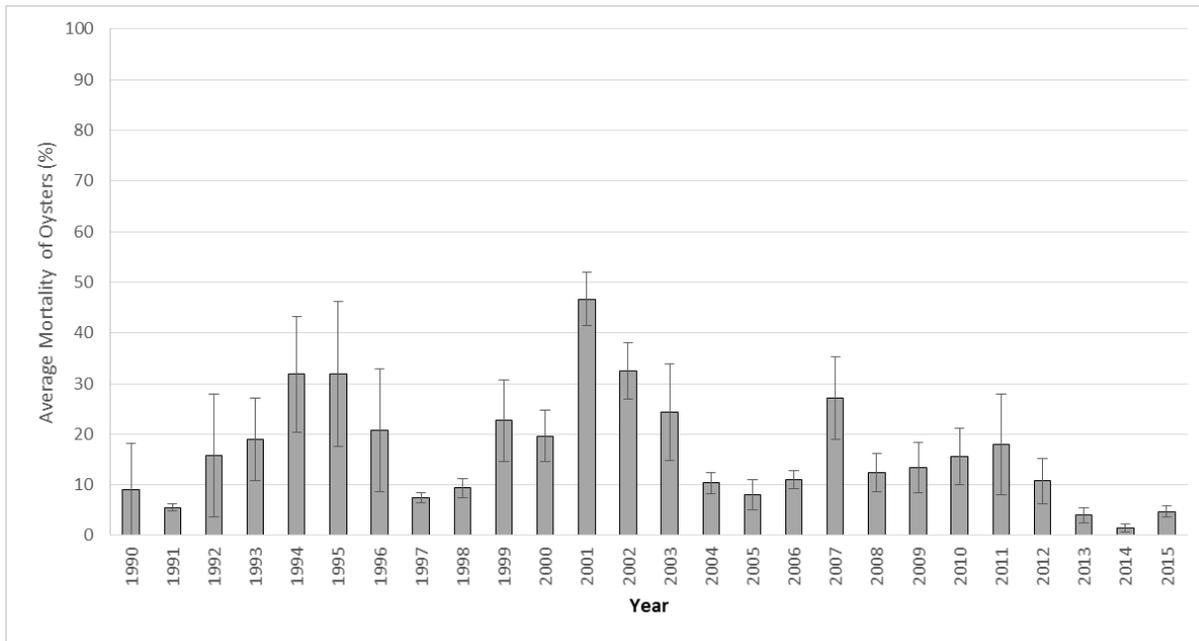


Figure B.16-4. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 088 (South River). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

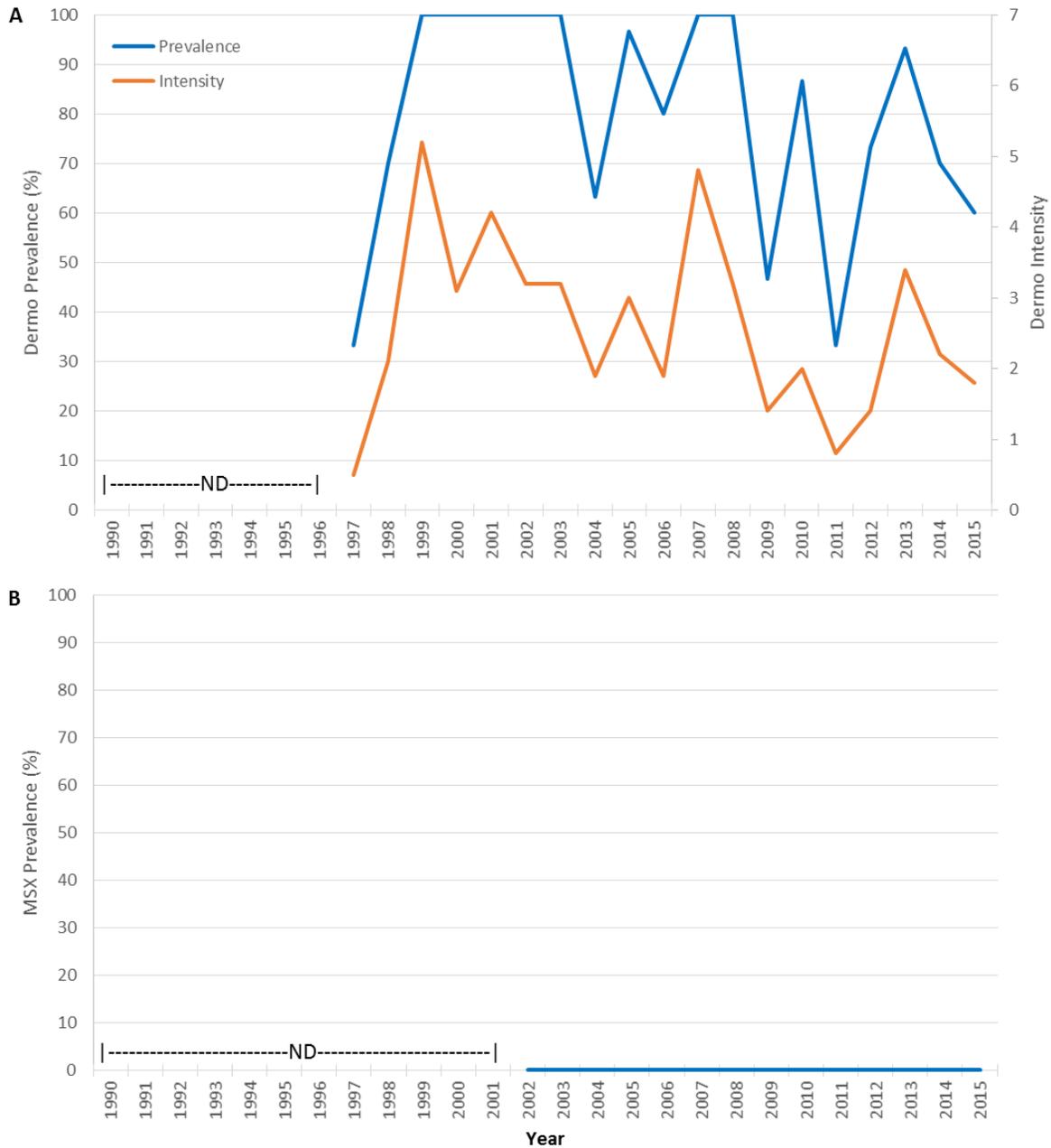


Figure B.16-6. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 088 (South River). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland's Annual Fall Oyster Dredge Survey. ND = No Data.

Harvest

Harvest for the entire NOAA Code 088 since 1990 is presented in Figure B.16-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 38% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in the 1996-1997, 1998-1999 and 2003-2004 seasons to a maximum of approximately 2,700 bushels in the 2013-2014 season. This maximum harvest may be partly attributed to planting 29.1 million hatchery seed was planted in 2010. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Hand tonging accounted for 94% of the harvest, as reported on oyster harvester reports.

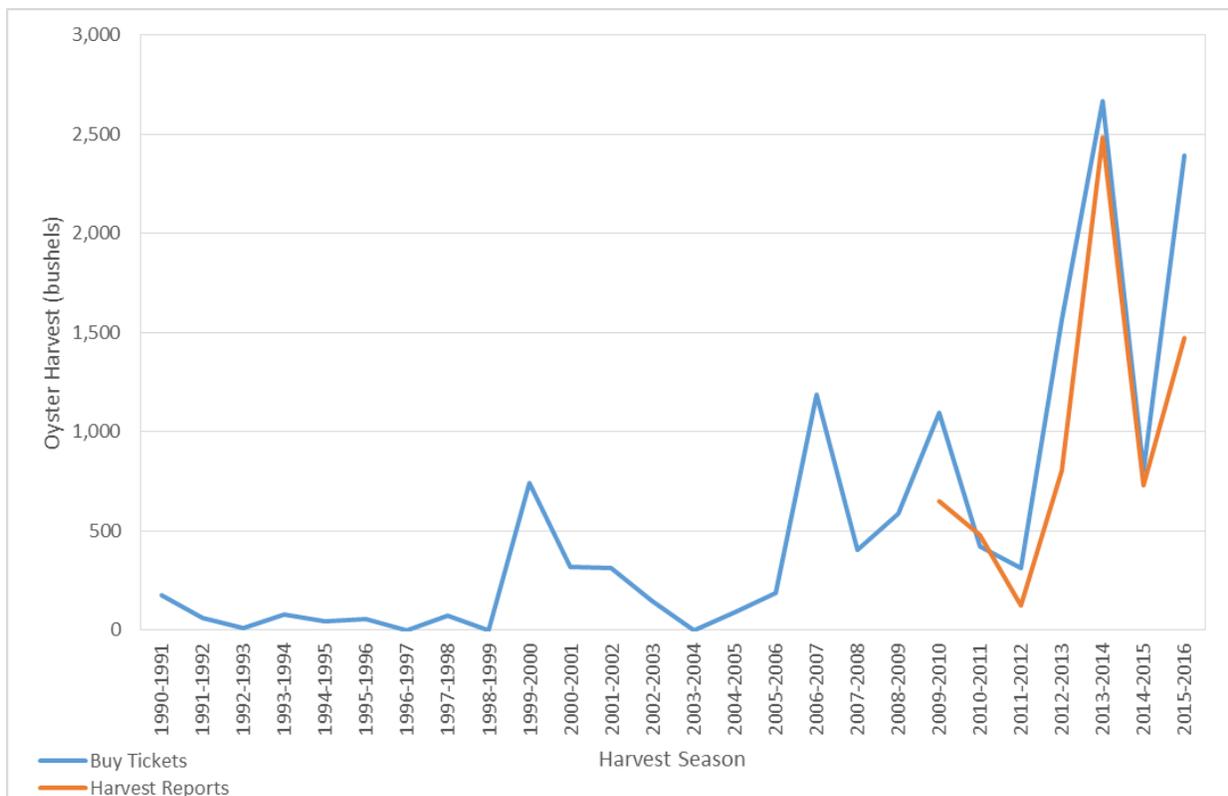


Figure B.16-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 088 (South River). After the 2009-2010 season, 38% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.17: NOAA Code 094 – West River and Rhode River

NOAA Code 094 encompasses Fishing Bay and is located in Maryland's mid-western portion of Chesapeake Bay (Figure B.17-1). The NOAA Code is 3,789 acres and has 17 historic oyster bars²¹. None of the NOAA Code is an oyster sanctuary. There are 367 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code. There are no acres within the NOAA Code designated as a Public Shellfish Fishery Area. This NOAA Code is generally located within Maryland's low salinity zone.

The Fall Survey has not sampled in this NOAA Code since 1990, thus there are no oyster population characterization results. Also, there have not been any replenishment activities in this NOAA Code since 1990.

Harvest

Harvest for the entire NOAA Code 094 since 1990 is presented in Figure B.17-2. Harvest reported by seafood dealers on buy tickets has ranged from no harvest for most seasons to a maximum of approximately 610 bushels in the 1999-2000 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Power dredging accounts for slightly more harvest (54%) than hand tonging (46%), as reported on oyster harvester reports.

²¹ See chart 13 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

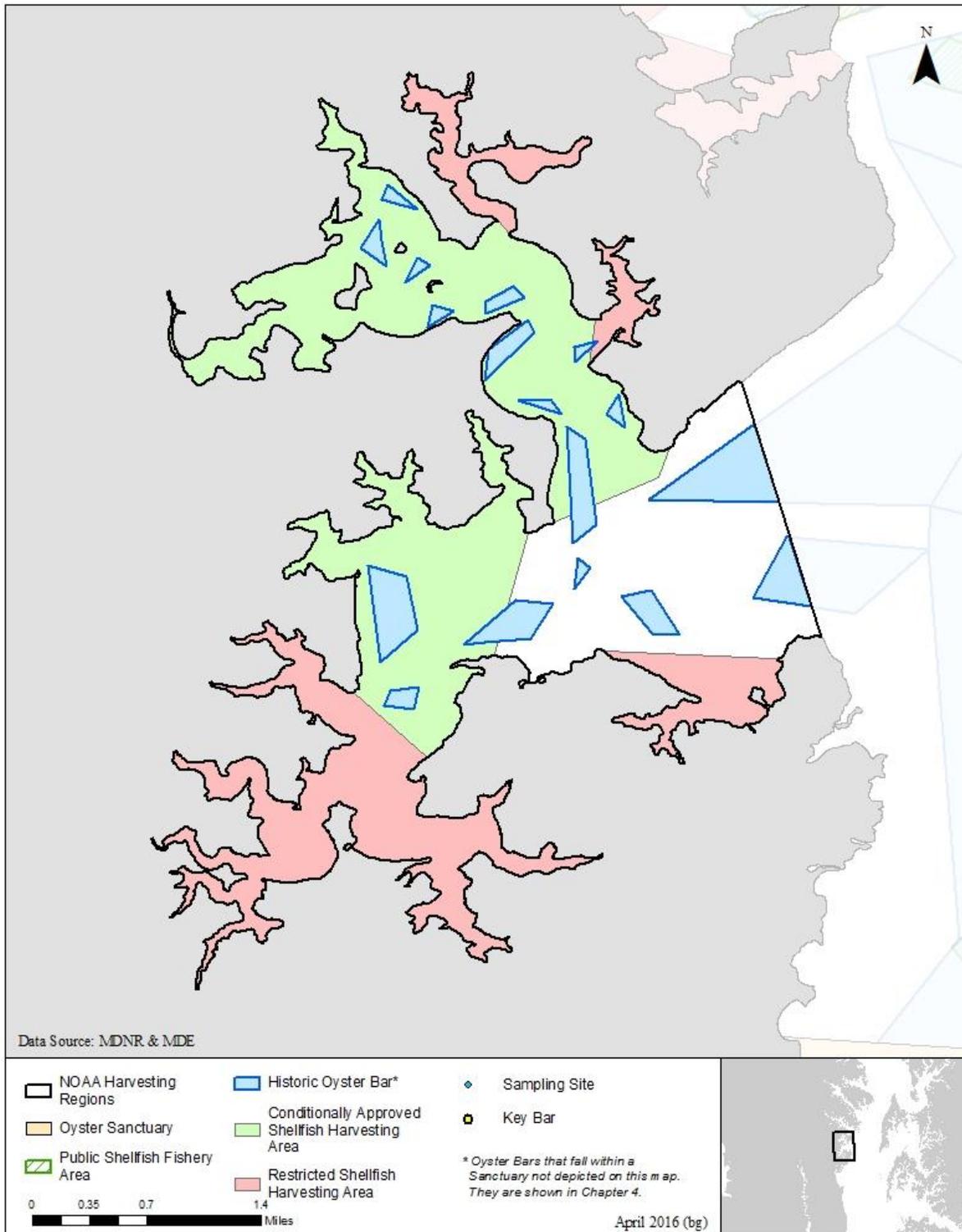


Figure B.17-1. Map of NOAA Code 094 (West River and Rhode River).

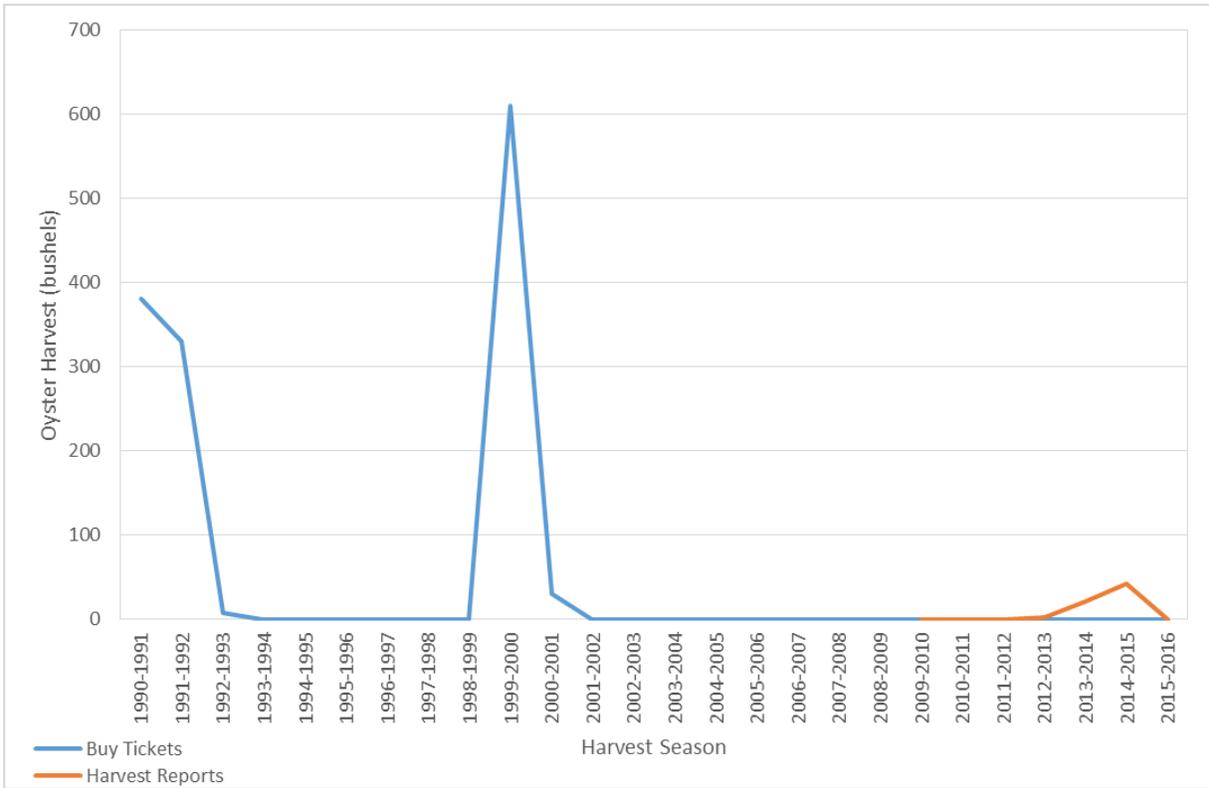


Figure B.17-2. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 094 (West River and Rhode River).

Section B.18: NOAA Code 096 – Wicomico River (East)

NOAA Code 096 encompasses the Wicomico River (East) and is located in Maryland’s lower eastern portion of Chesapeake Bay (Figure B.18-1). The entire NOAA Code is 6,621 acres and has 9 historic oyster bars²². There are no sanctuaries in the NOAA Code. There are 715 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code. In 2010, 772 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s medium salinity zone.

Replenishment Activities

Since 1990, approximately 80,000 bushels of shell, 40,000 bushels of wild seed and 67 million hatchery spat-on-shell have been planted in NOAA Code 096 (Table B.18-1).

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1991	Wild Seed	25.6	14.0	-
1992	Wild Seed	11.3	3.3	-
1995	Wild Seed	11.9	3.3	-
1996	Dredged Shell	26.7	60.2	-
1997	Wild Seed	6.4	2.3	-
1998	Wild Seed	17.7	12.7	-
2001	Wild Seed	10.2	4.2	-
2009	Hatchery Spat-on-Shell	9.9	-	19.8
2011	Hatchery Spat-on-Shell	47.1	-	47.5
2015	Fresh Shell	13.1	20.7	-

²² See chart 31 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

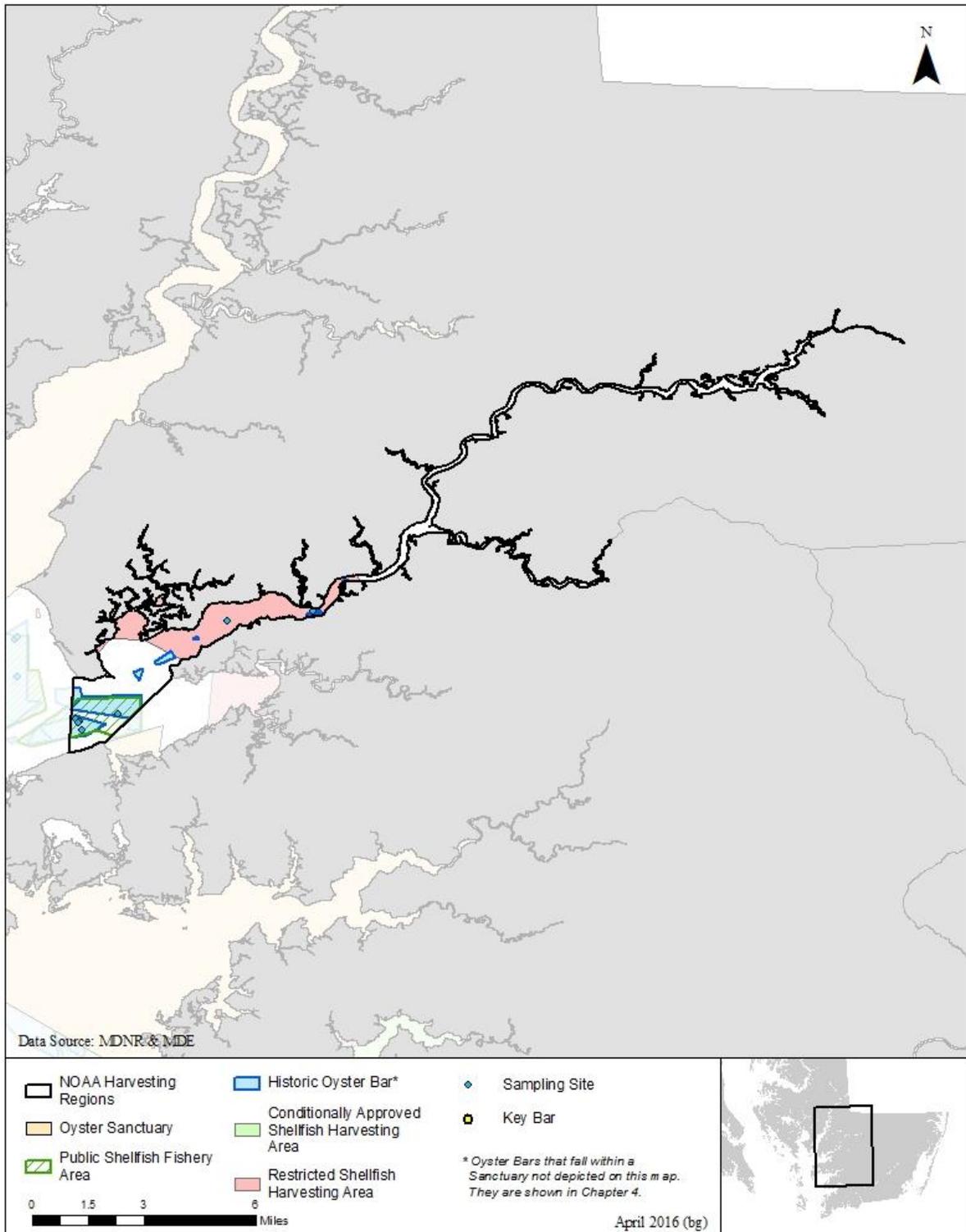


Figure B.18 -1. Map of NOAA Code 096 (Wicomico River - East).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled three oyster bars annually in NOAA Code 096. The average number of total live oysters (market, small, and spat) ranged from 5 to 196 per bushel with an average of 65 (Figure B.18-2). The number of oysters decreased from 1996 to 2009, and then began to increase starting in 2010. Since 2006, there has been a general increase in the number of small-sized and market-sized oysters. The average number of live oysters was greater from 2010 to 2015 than prior to 2010 (Table B.18-2).

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 81	6 / 23
Number of Live Oysters per Bushel	55 \pm 12	95 \pm 18
Number of Live Small-Sized Oysters per Bushel	28 \pm 10	36 \pm 7
Number of Live Market-Sized Oysters per Bushel	22 \pm 3	38 \pm 8
Live Oyster Biomass (g Dry Weight per Bushel)	129 \pm 7	118 \pm 22
Mortality (%)	28.9 \pm 4.6	8.3 \pm 2.8

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Evans and Mount Vernon Wharf bars within NOAA Code 096 (Figure B.18-3). Oysters were not measured from 1998 to 2009. Two percent of oysters were larger than 120 mm. Length frequencies were similar for 1990-2009 and 2010-2015, with 54% of oysters 80 mm or smaller.

Biomass

The Fall Survey measured oyster biomass on Evans and Mount Vernon Wharf bars within NOAA Code 096 from 1990 to 1997 and 2010 to 2015. The annual biomass ranged from 42 to 178 grams of dry weight per bushel and the average is 124 \pm 9.8 (average \pm SE; Figure B.18-4). The average biomass was similar from 1990 to 2010 than prior to 2010 (Table B.18-2). Biomass increased from its lowest in 2010 to a peak in 2015.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 0 to 88 spat per bushel (Figure B.18-2). The largest spatfall occurred in 2012. From 1995 to 2006, there was very little spatfall, averaging 1 per bushel. Since 2007, spatfall has average 16 per bushel.

Mortality

Mortality ranged from 0% to 67%; since 2005, mortality has been relatively low, averaging 10% (Figure B.18-5). The average mortality was lower from 2010 to 2015 than to prior to 2010 (Table B.18-2).

Disease

Since 1990, the Fall Survey has not collected information on oyster disease in this NOAA Code.

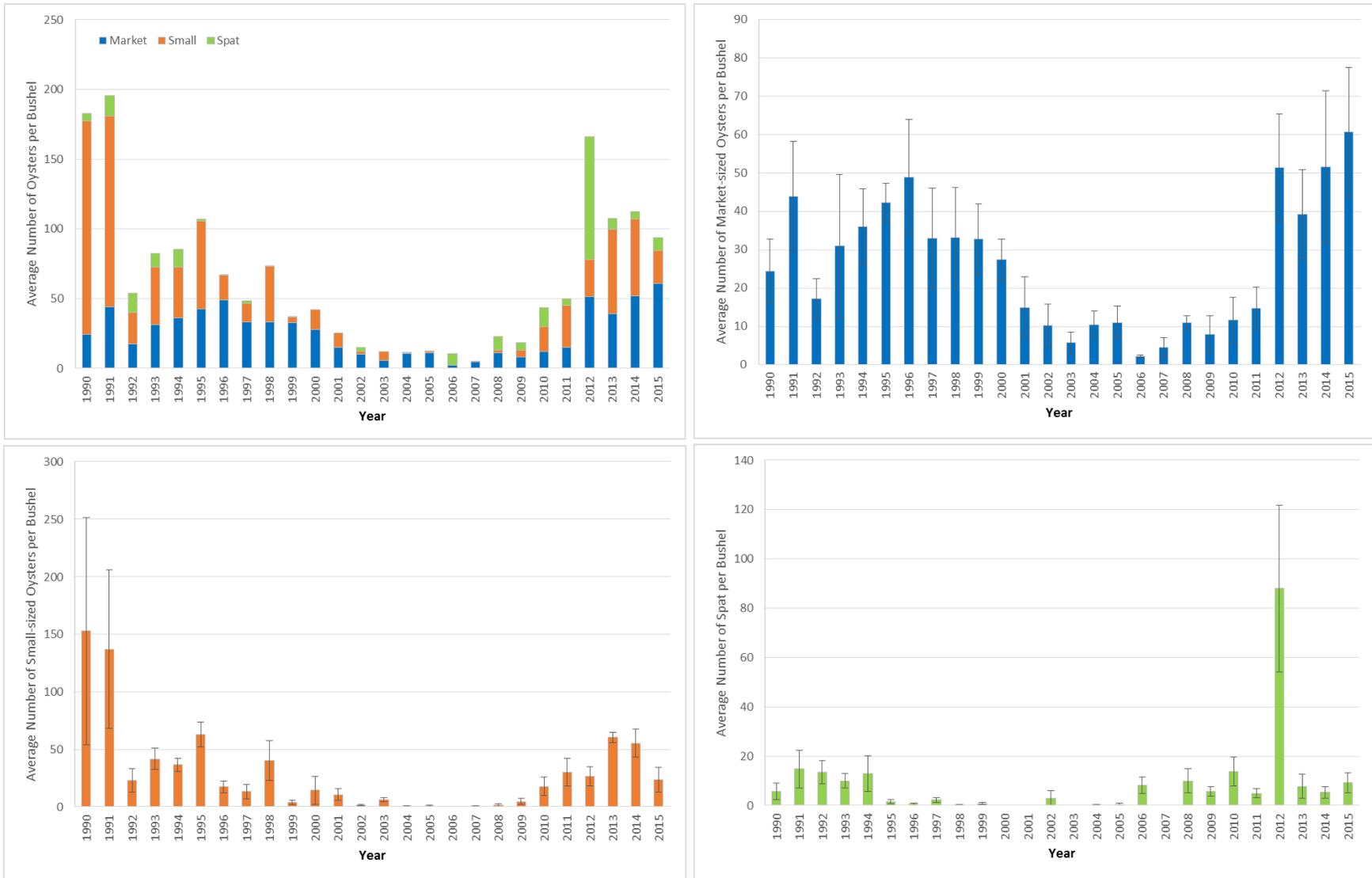
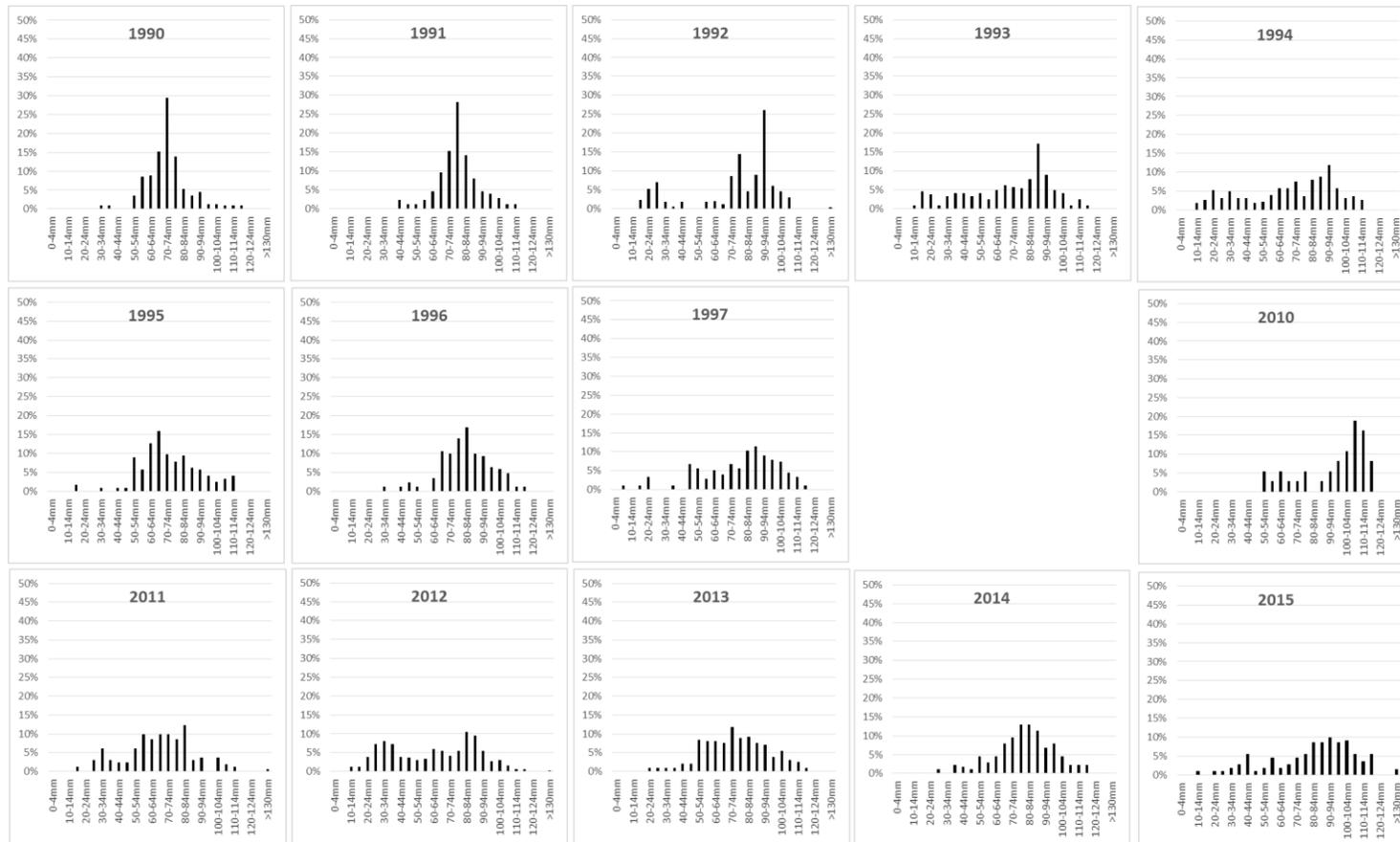


Figure B.18-2. Average number of live oysters per bushel of material by size class in the NOAA 096 (Wicomico River - East). Error bars represent ± 1 standard error. Data from Maryland's Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

Frequency (%)



Shell Heights (mm)

Figure B.18-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 096 (Wicomico River - East). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster shell heights were not recorded from 1998 to 2009.

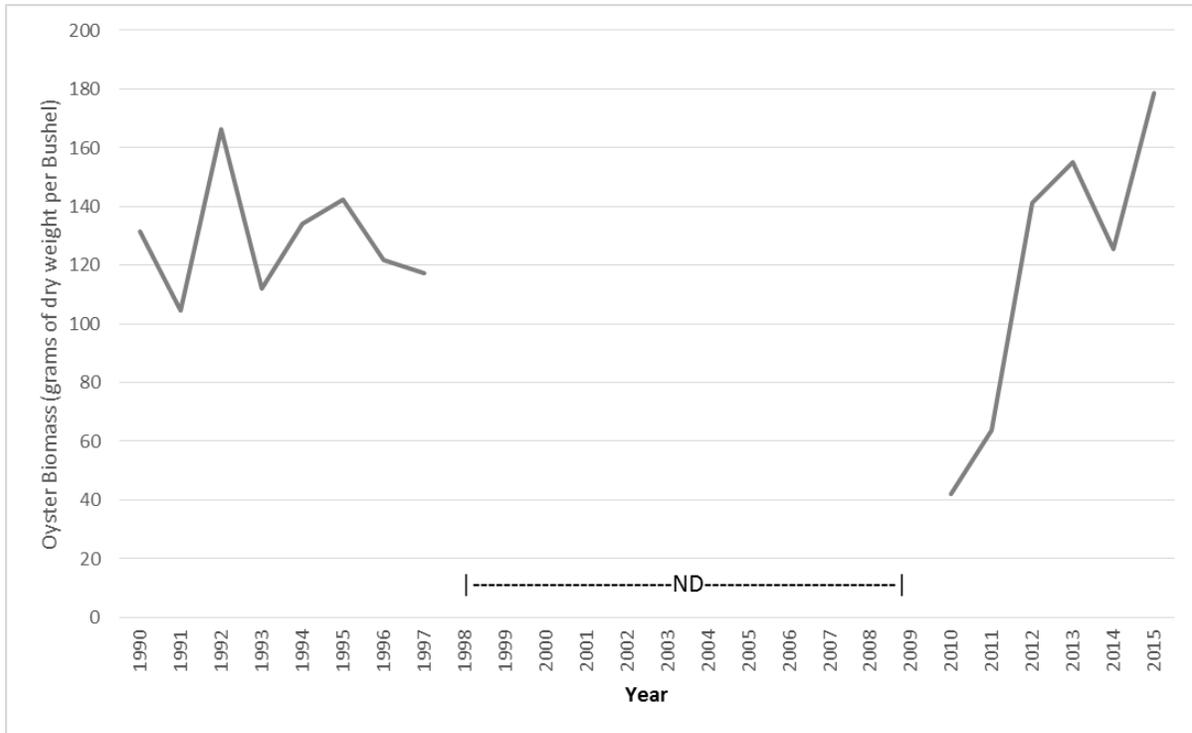


Figure B.18-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 096 (Wicomico River - East). Data from Maryland’s Annual Fall Oyster Dredge Survey. ND = No Data.

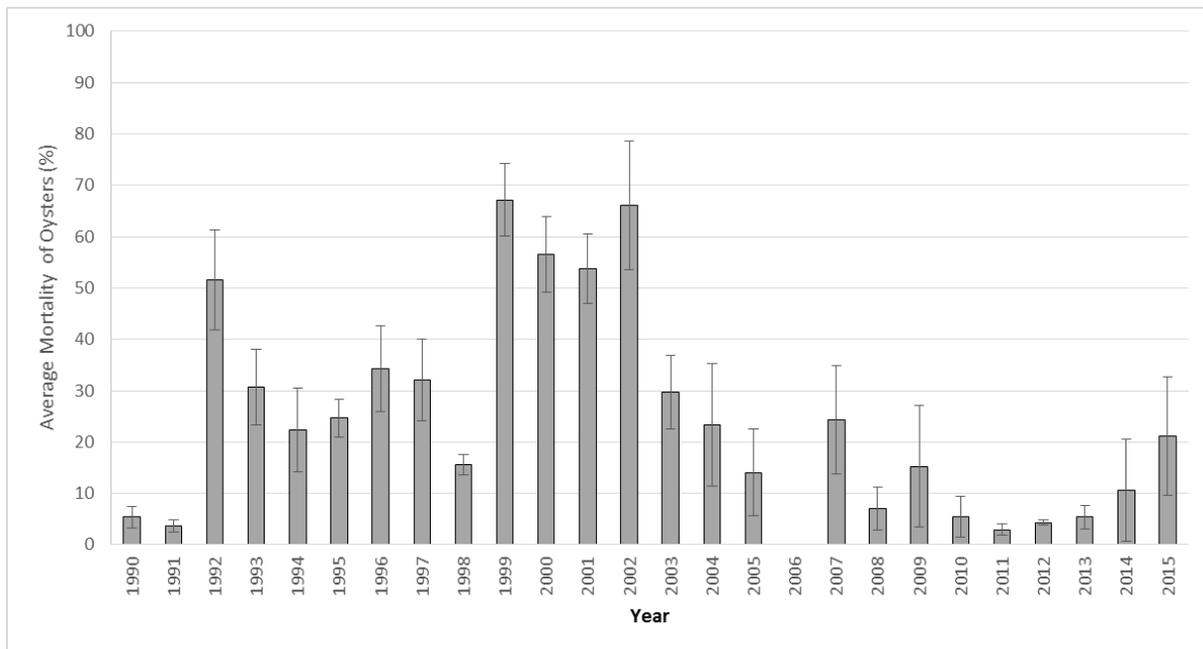


Figure B.18-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 096 (Wicomico River - East). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

Harvest

Harvest for the entire NOAA Code 096 since 1990 is presented in Figure B.18-6. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in the 2003-2004, 2004-2005 and 2005-2006 seasons to a maximum of approximately 9,800 bushels in the 2015-2016 season. This maximum harvest may be partly attributed to planting 47.5 million hatchery seed was planted in 2011. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Power dredging accounts for 87% of the harvest, as reported on oyster harvester reports.

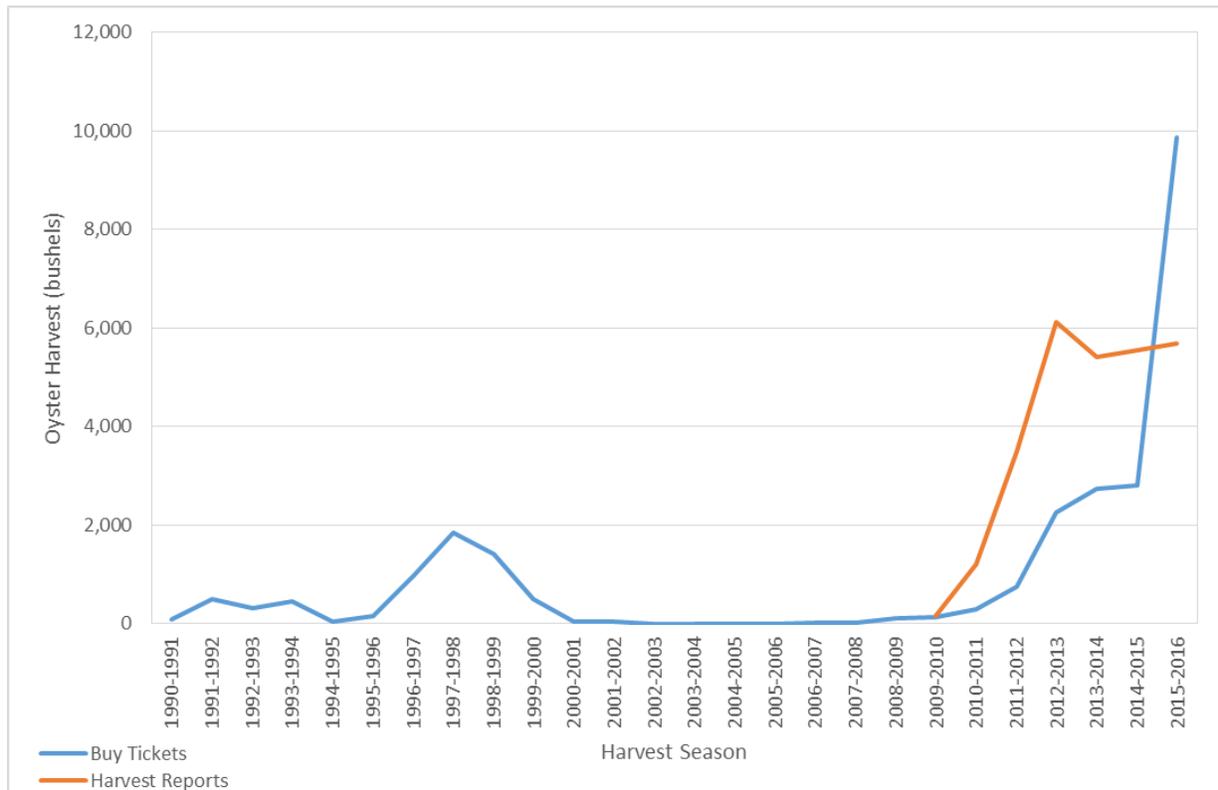


Figure B.18-6. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 096 (Wicomico River - East).

Section B.19: NOAA Code 098 – Monie Bay

NOAA Code 098 encompasses Monie Bay and is located in Maryland's lower eastern portion of Chesapeake Bay (Figure B.19-1). The entire NOAA Code is 3,359 acres and has 2 historic oyster bars²³. The Webster Sanctuary encompasses 16% (554 total acres) of the NOAA Code. This equates to 2,805 acres. There are 59 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010, 142 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland's medium salinity zone.

The Fall Survey has not sampled in this NOAA Code outside of the current sanctuary area since 1990, thus there are no oyster population characterization results. Also, there have not been any replenishment activities in this NOAA Code outside of the current sanctuary area since 1990.

Harvest

Harvest for the entire NOAA Code 098 since 1990 is presented in Figure B.19-2. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. Starting in 1997, 16% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest (12 seasons) to a maximum of approximately 3,300 bushels in the 2012-2013 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Patent tonging accounts for approximately 68% of the harvest, with power dredging accounting for the rest, as reported on oyster harvester reports.

²³ See chart31 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

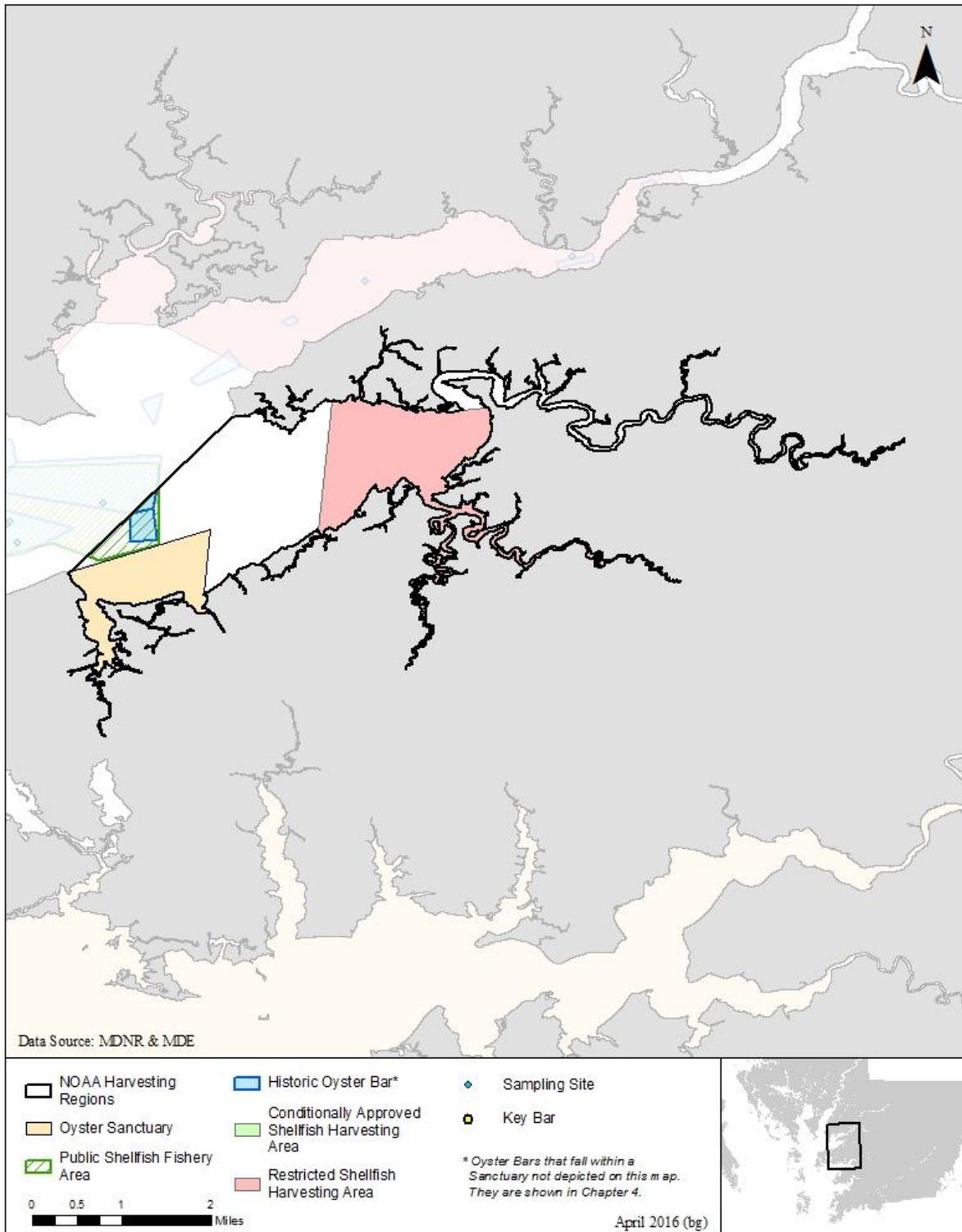


Figure B.19-1. Map of NOAA Code 098 (Monie Bay).

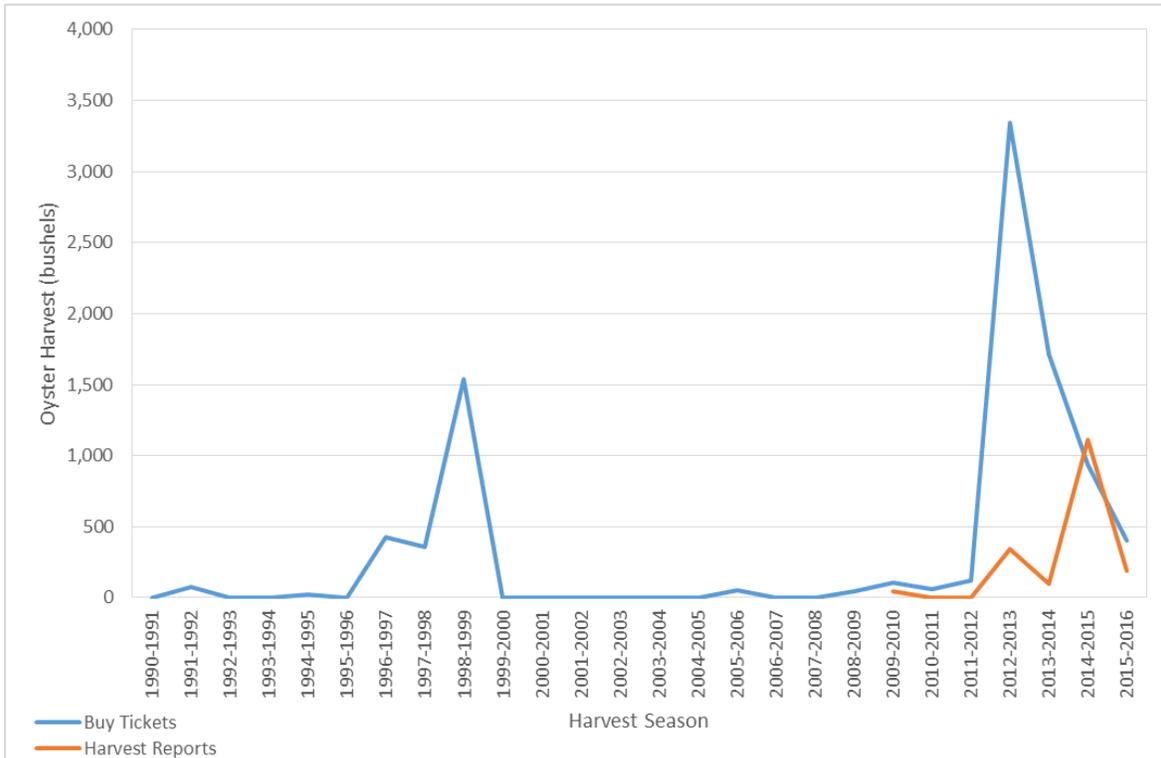


Figure B.19-2. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 098 (Monie Bay). After 1997, 16% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.20: NOAA Code 099 – Wye River

NOAA Code 099 encompasses Wye River (Figure B.20-1). The entire NOAA Code is 6,493 acres and has 23 historic oyster bars. The Wye River Sanctuary encompasses 54% (3,510 total acres) of the NOAA Code. There are 16 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. There are 27 acres within the NOAA Code that is designated as a Public Shellfish Fishery Area in 2010 where aquaculture leasing is prohibited. See Appendix A Section A.51 for more information on the oyster population characteristics.

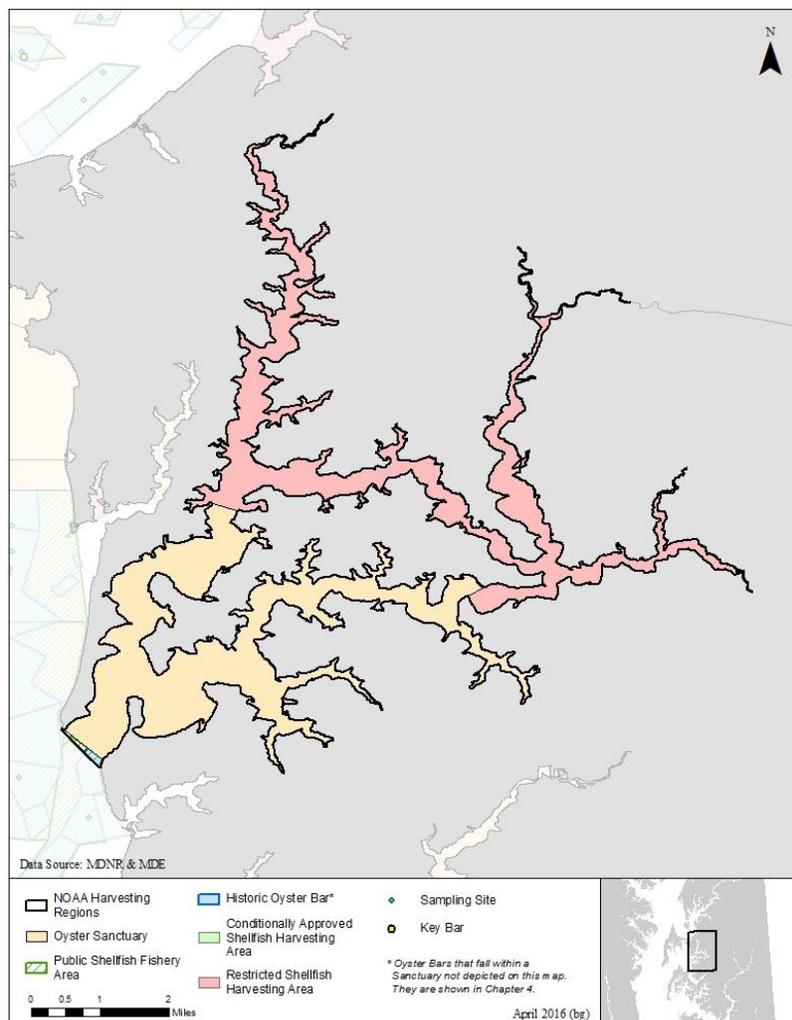


Figure B.20 -1. Map of NOAA Code 099 (Wye River).

Section B.21: NOAA Code 127 – Upper Middle Chesapeake Bay

NOAA Code 127 encompasses Chesapeake Bay south of the Bay Bridge and north of a line from Kent Point to Fairhaven (Figure B.21-1). The entire NOAA Code is 56,902 acres and has 30 historic oyster bars²⁴. The Herring Bay and Severn River sanctuaries encompass 10% (5,623 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 51,279 acres. There are 14,777 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside the sanctuaries. In 2010, 5,708 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland's low salinity zone.

Replenishment Activities

Since 1990, approximately 168,000 bushels of shell, 713,000 bushels of wild seed and 25.3 million hatchery spat-on-shell have been planted in NOAA Code 127 outside of the current sanctuary area (Table B.21-1).

²⁴ See charts 9 and 13 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

Table B.21-1. Replenishment planting activities occurring since 1990 in NOAA Code 127 (Upper Middle Chesapeake Bay). ND = No Data.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Dredged Shell	9.6	119.5	-
1990	Fresh Shell	3.2	4.4	-
1990	Wild Seed	28.3	13.6	-
1991	Fresh Shell	2.8	2.9	-
1991	Wild Seed	58.4	26.6	-
1992	Wild Seed	143.5	115.6	-
1993	Wild Seed	69.8	38.2	-
1994	Wild Seed	132.3	46.4	-
1995	Dredged Shell	7.8	41.9	-
1995	Wild Seed	58.0	43.4	-
1996	Wild Seed	24.7	14.2	-
1997	Wild Seed	101.3	54.9	-
1998	Wild Seed	219.8	95.0	-
1999	Wild Seed	28.5	12.1	-
2000	Wild Seed	63.8	63.3	-
2001	Wild Seed	30.0	31.8	-
2002	Wild Seed	21.7	12.3	-
2003	Wild Seed	35.9	28.8	-
2004	Wild Seed	62.4	55.2	-
2006	Wild Seed	15.7	39.2	-
2007	Wild Seed	88.0	37.5	-
2008	Wild Seed	12.5	8.2	-
2009	Wild Seed	11.4	3.7	-
2011	Wild Seed	3.1	ND	-
2014	Hatchery Spat-on-Shell	3.5	-	8.9
2015	Hatchery Spat-on-Shell	8.4	-	16.5

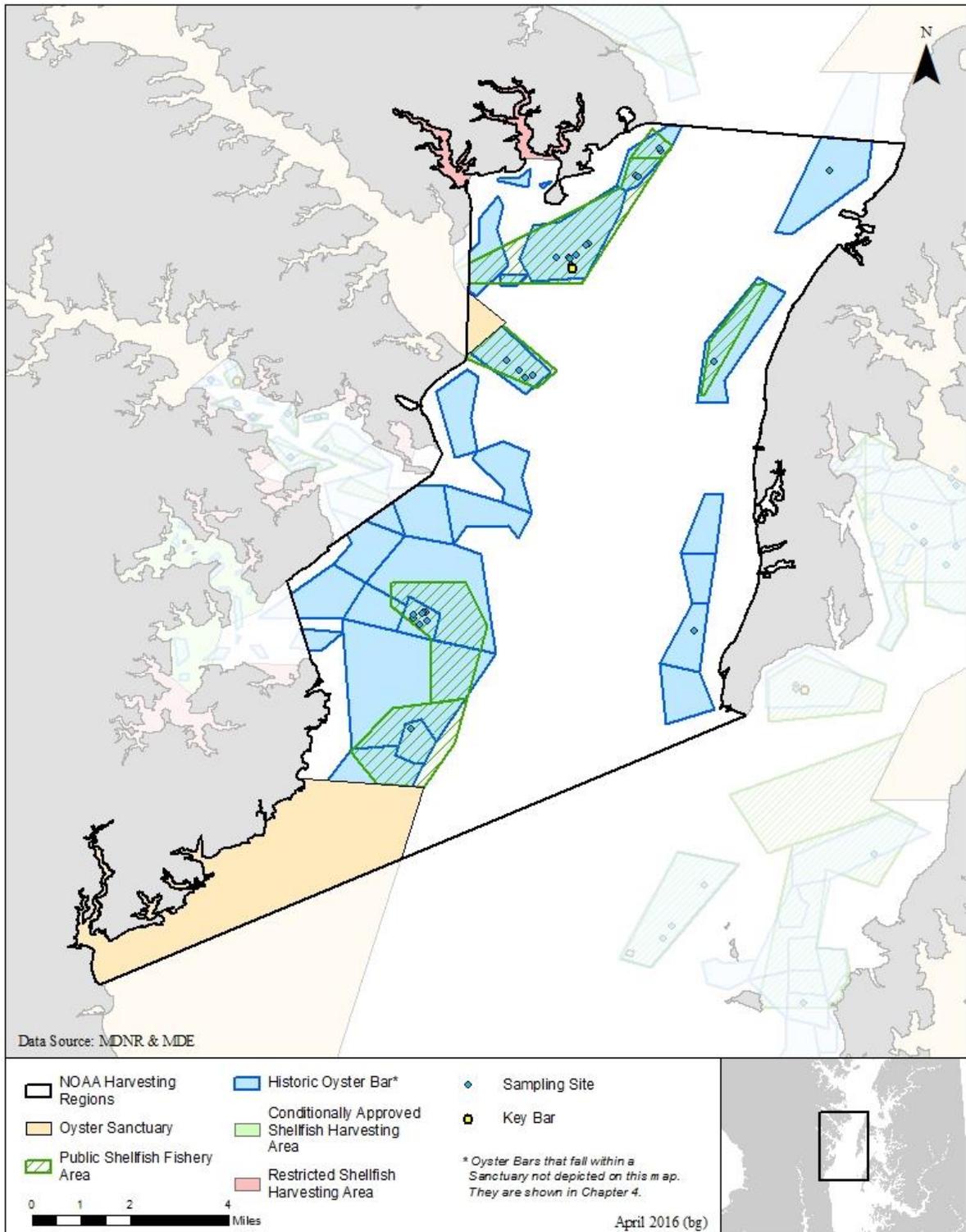


Figure B.21 -1. Map of NOAA Code 127 (Upper Middle Chesapeake Bay).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled 7 to 9 oyster bars annually in NOAA Code 127 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 31 to 137 per bushel with an average of 79 (Figure B.21-2). The average number of total live oysters was lower from 2010 to 2015 than prior to 2010 (Table B.21-2).

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 252	6 / 66
Number of Live Oysters per Bushel	89 \pm 5	44 \pm 4
Number of Live Small-Sized Oysters per Bushel	46 \pm 6	11 \pm 3
Number of Live Market-Sized Oysters per Bushel	41 \pm 3	32 \pm 6
Live Oyster Biomass (g Dry Weight per Bushel)	118 \pm 13	37 \pm 5
Mortality (%)	16 \pm 2.5	5 \pm 1.1

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Hackett Point bar within NOAA Code 127 (Figure B.21-3). From 2010 to 2015, 54% of oysters were greater than 75 mm, compared to 67% of oysters prior to 2009. After 2010, a bi-modal oyster shell height distribution occurred indicating two distinct classes of oysters, with peaks at 50 and 90 mm.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on Hackett Point bar within NOAA Code 127. The annual biomass ranged from 15 to 233 grams of dry weight per bushel and the average is 98.8 \pm 12.2 (average \pm SE; Figure B.21-4). The average biomass was lower in 2010 to 2015 than prior to 2010 (Table B.21-2). Biomass peaked in 1991 and 2004 and has generally declined since then.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 0 to 24 spat per bushel from 1990 to 2015 (Figure B.21-2). The largest spatfall occurred in 2002. In most years, no spat was recorded during the Fall Survey.

Mortality

Mortality ranged from 3% to 52%; since 2006, mortality has been relatively low, averaging 7% (Figure B.21-5). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.21-2).

Disease

From 1990 to 2015, dermo prevalence has ranged from 0% to 100% (Figure B.21-6); it was greater than 80% for 8 of the 26 years disease information was collected. Since 2010, dermo prevalence average 25%. Dermo intensity ranged from 0 to 3.7, never reaching lethal levels (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 13%.

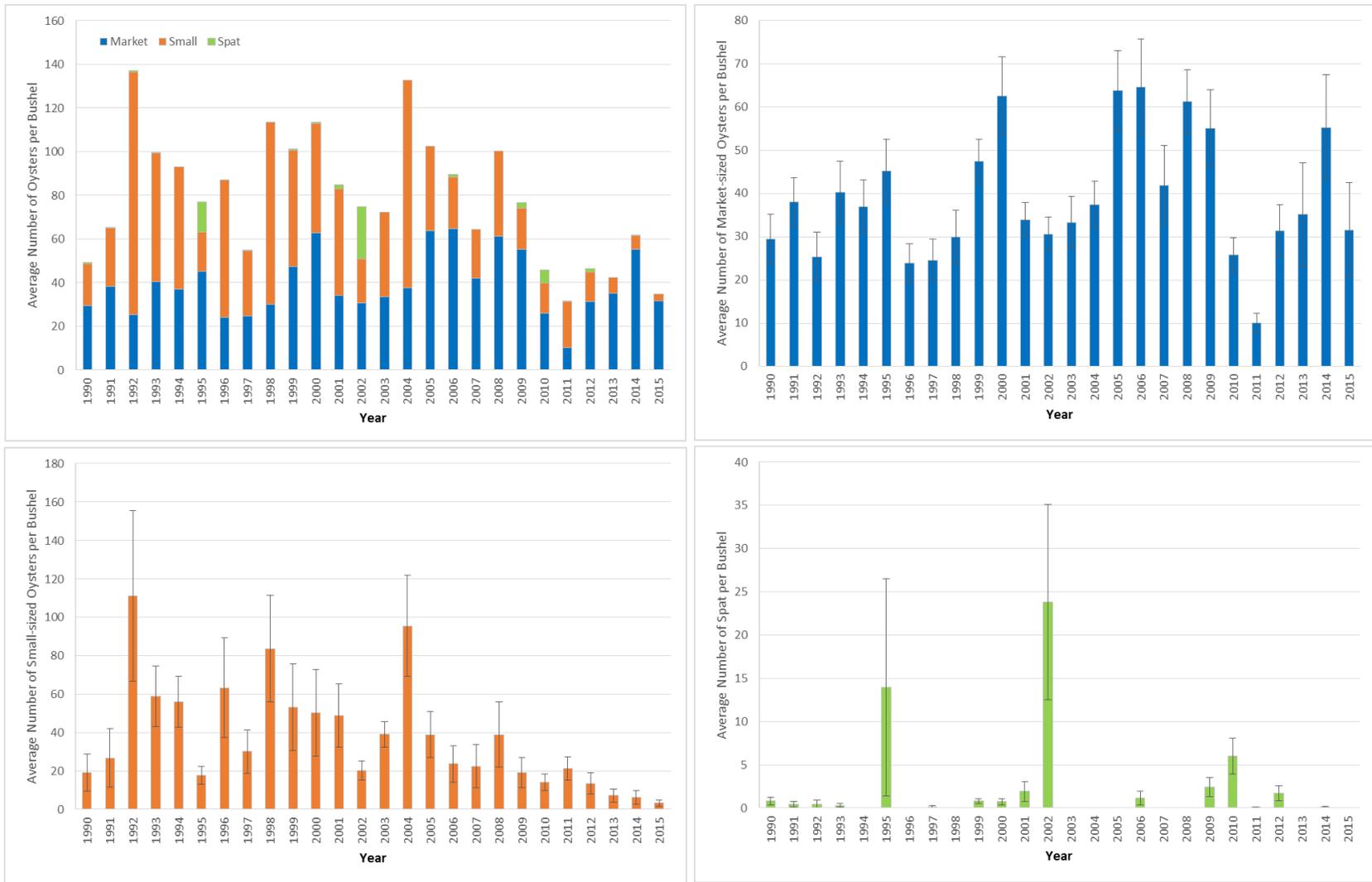


Figure B.21-2. Average number of live oysters per bushel of material by size class in the NOAA Code 127 (Upper Middle Chesapeake Bay). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

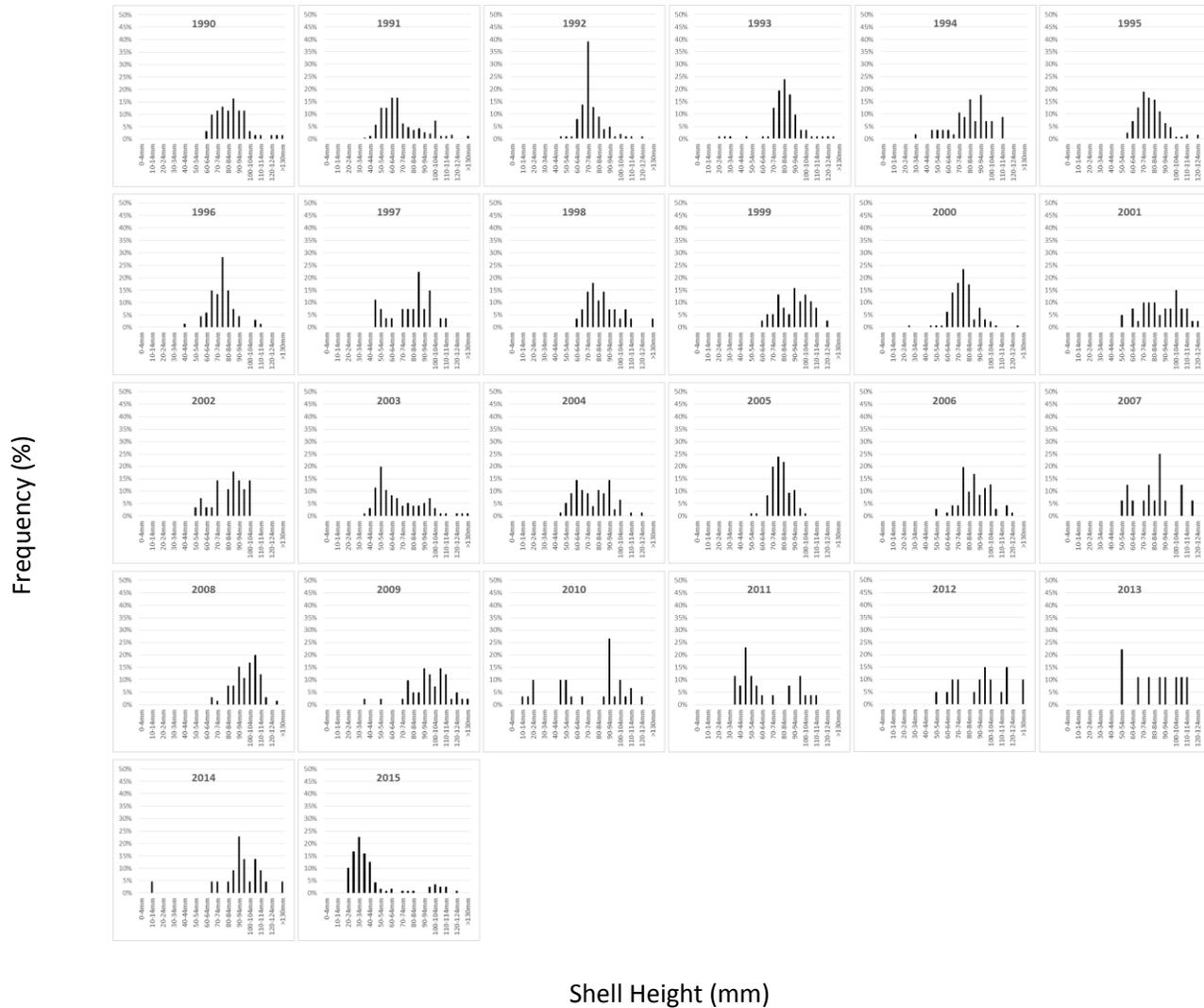


Figure B.21-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 127 (Upper Middle Chesapeake Bay). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

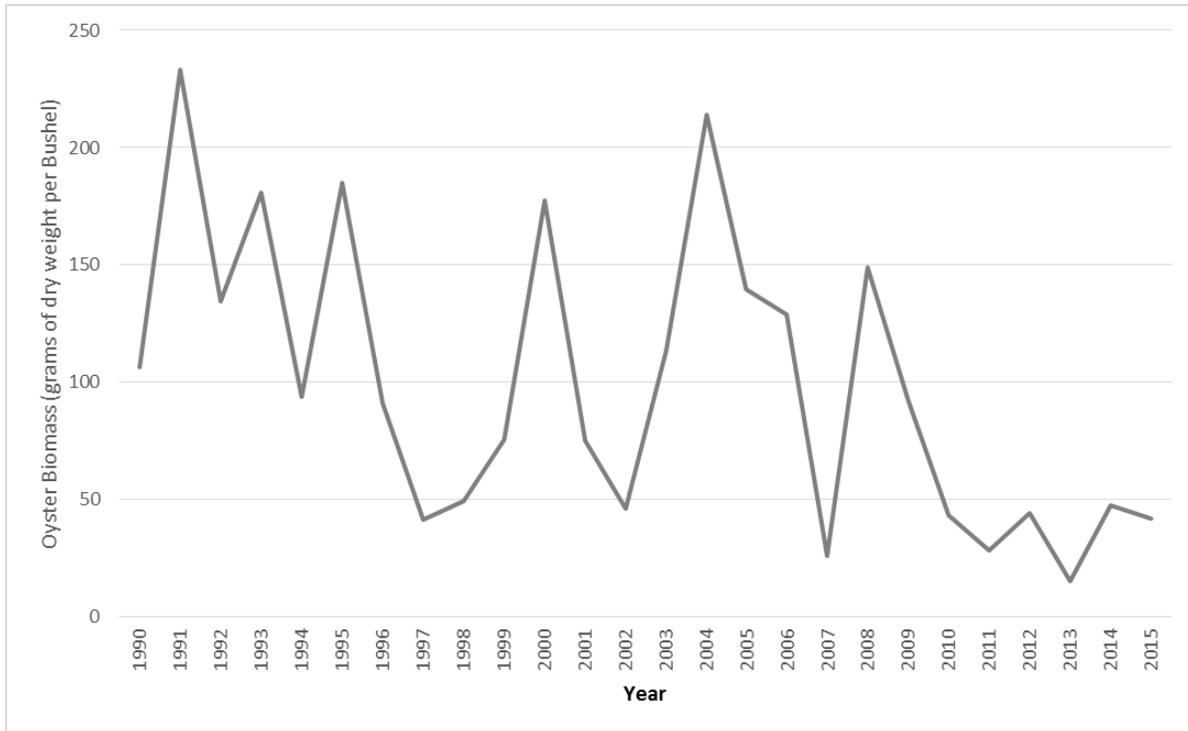


Figure B.21-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 127 (Upper Middle Chesapeake Bay). Data from Maryland’s Annual Fall Oyster Dredge Survey.

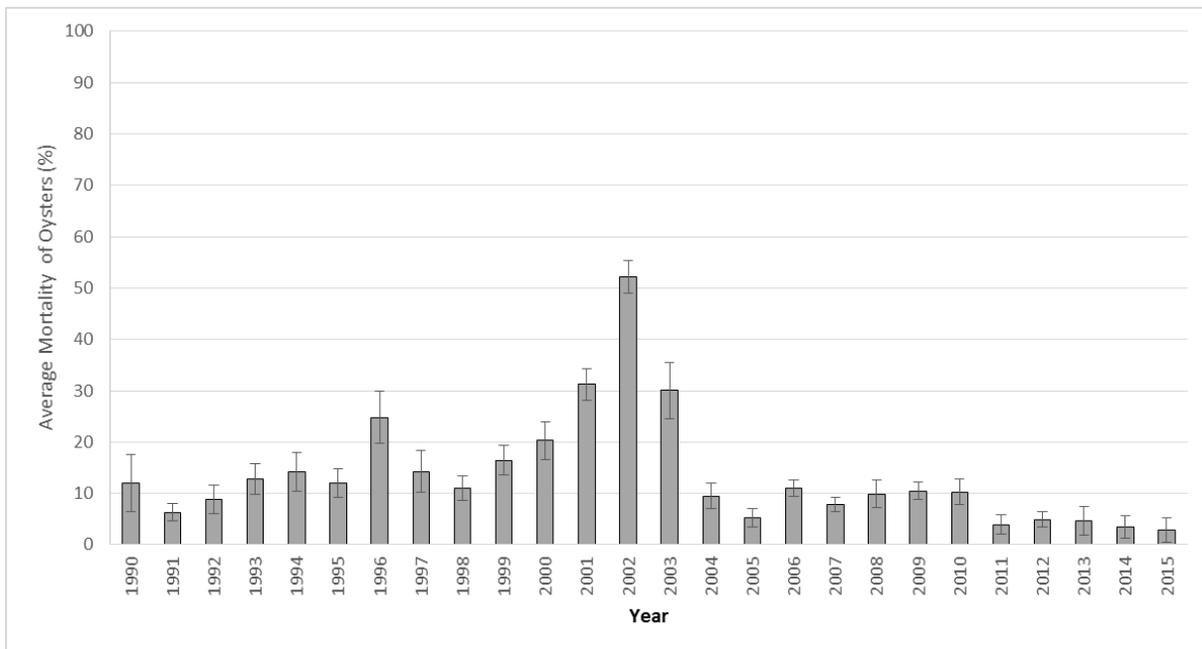


Figure B.21-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 127 (Upper Middle Chesapeake Bay). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

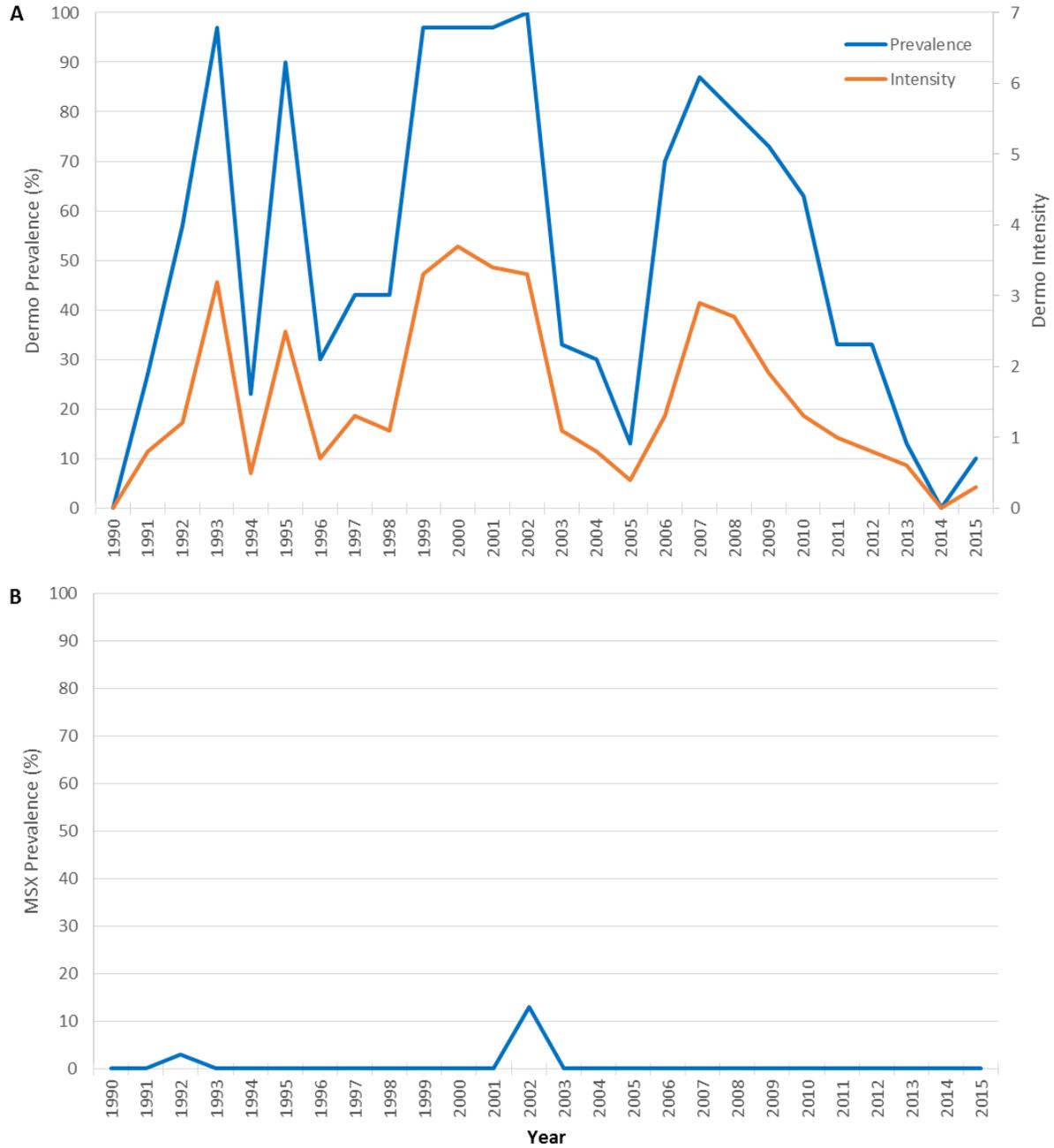


Figure B.21-6. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 127 (Upper Middle Chesapeake Bay). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland’s Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 127 since 1990 is presented in Figure B.21-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 10% of the NOAA Code area was a sanctuary where harvest is prohibited. No harvest data was available prior to the 1998-1999 season because this NOAA Code was lumped into 027 NOAA Code prior to 1998. Harvest reported by seafood dealers on buy tickets has ranged from 11 bushels in the 1998-1999 season to a maximum of approximately 15,000 bushels in the 1999-2000 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Patent tonging accounted for 83% of the harvest, as reported on oyster harvester reports.

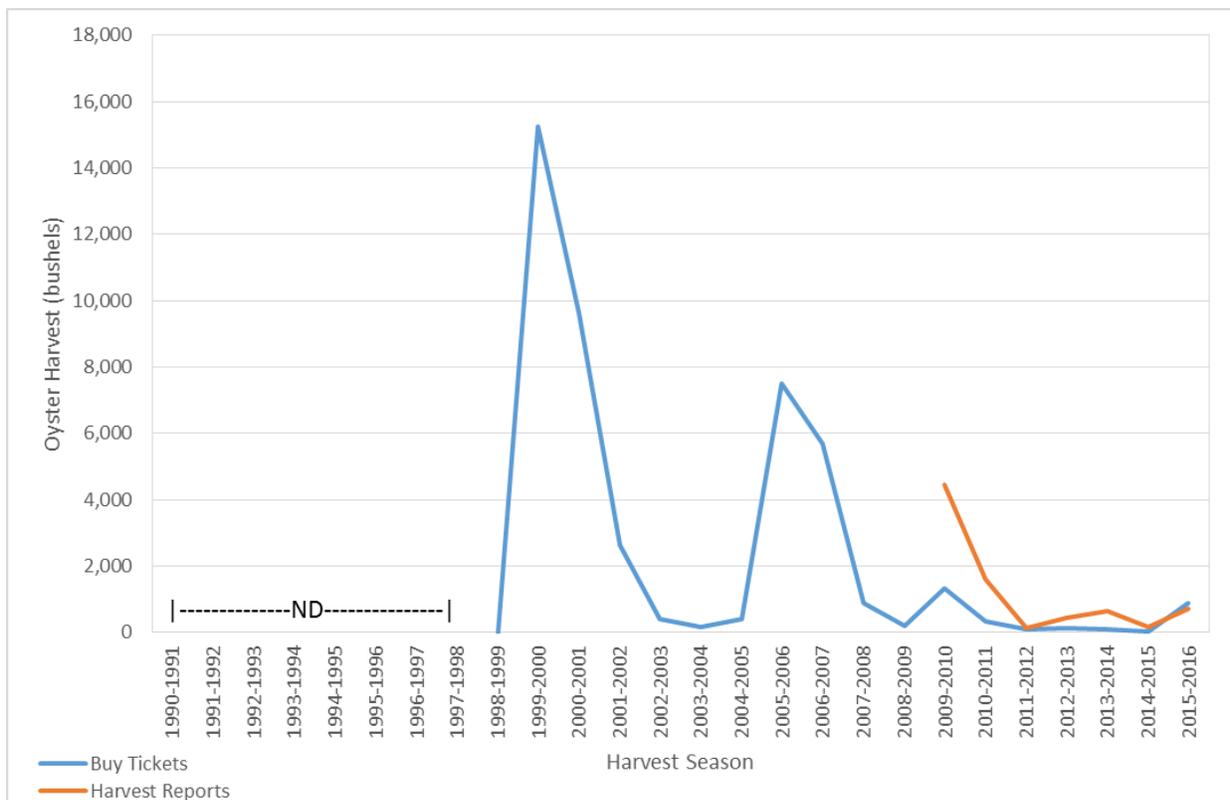


Figure B.21-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 127 (Upper Middle Chesapeake Bay). Harvest from NOAA Code 127 was lumped together with NOAA Code 027 prior to 1998. After the 2009-2010 season, 10% of the NOAA Code area was a sanctuary where harvest is prohibited. ND = No Data.

Section B.22: NOAA Code 129 – Lower East Chesapeake Bay

NOAA Code 129 encompasses Chesapeake Bay south of Cove Point and east of the ship channel and is located in Maryland's lower eastern portion of Chesapeake Bay (Figure B.22-1). The entire NOAA Code is 130,954 acres and has 16 historic oyster bars²⁵. The Lower Mainstem Sanctuary encompasses 24% (31,934 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 99,020 acres. There are 1,359 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. No acres within the NOAA Code were designated as a Public Shellfish Fishery Area in 2010, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland's medium salinity zone.

The Fall Survey has not sampled in this NOAA Code outside of the current sanctuary area since 1990, thus there are no oyster population characterization results. Also, there have not been any replenishment activities in this NOAA Code outside of the current sanctuary area since 1990.

Harvest

Harvest for the entire NOAA Code 129 since 1990 is presented in Figure B.22-2. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 24% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in the 1993-1994 and 2001-2002 seasons to a maximum of approximately 9,600 bushels in the 2009-2010 season. Power dredging accounted for 83% of the harvest, as reported by oyster harvester reports.

²⁵ See chart 28, 29, and 41 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

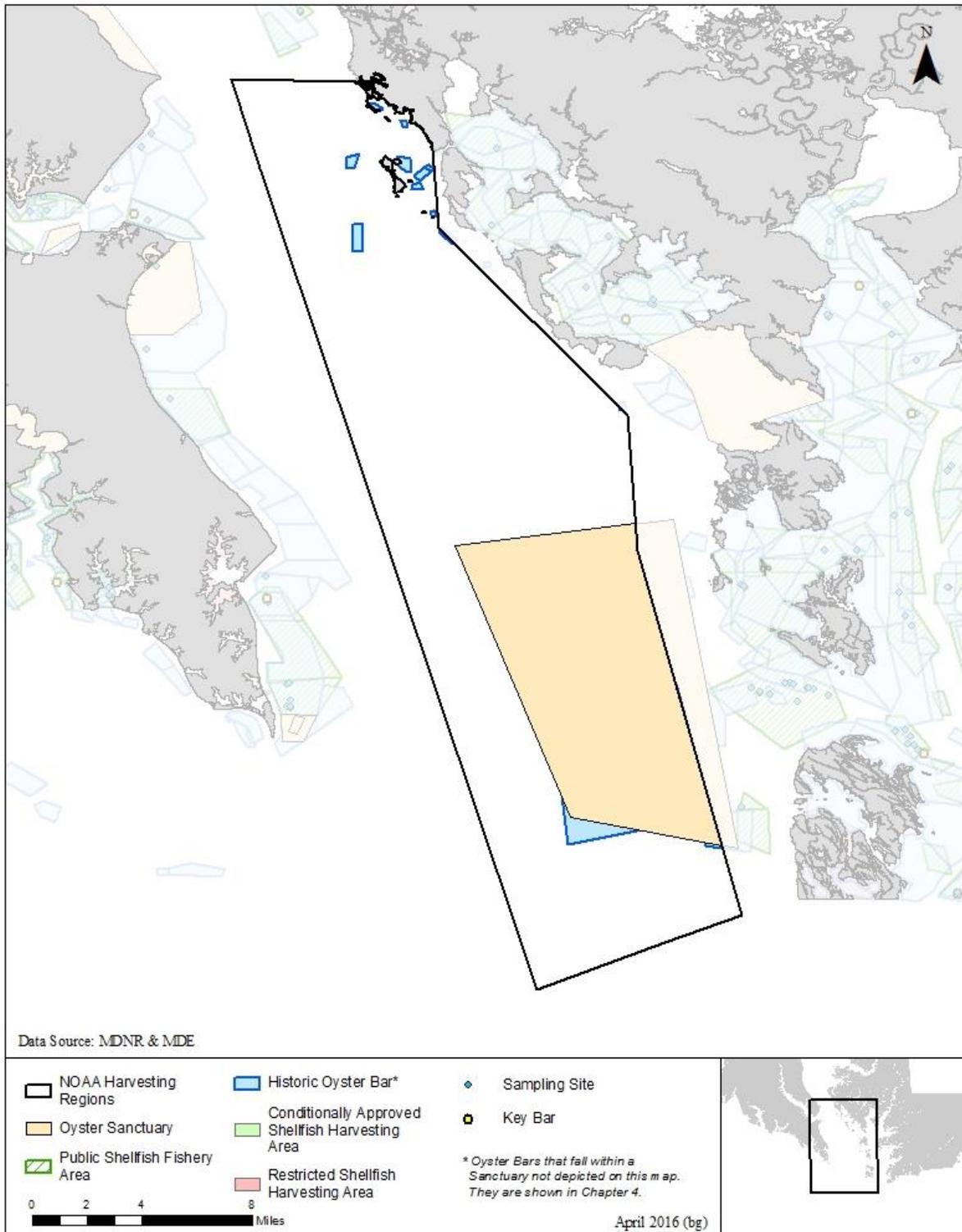


Figure B.22 -1. Map of NOAA Code 129 (Lower West Chesapeake Bay).

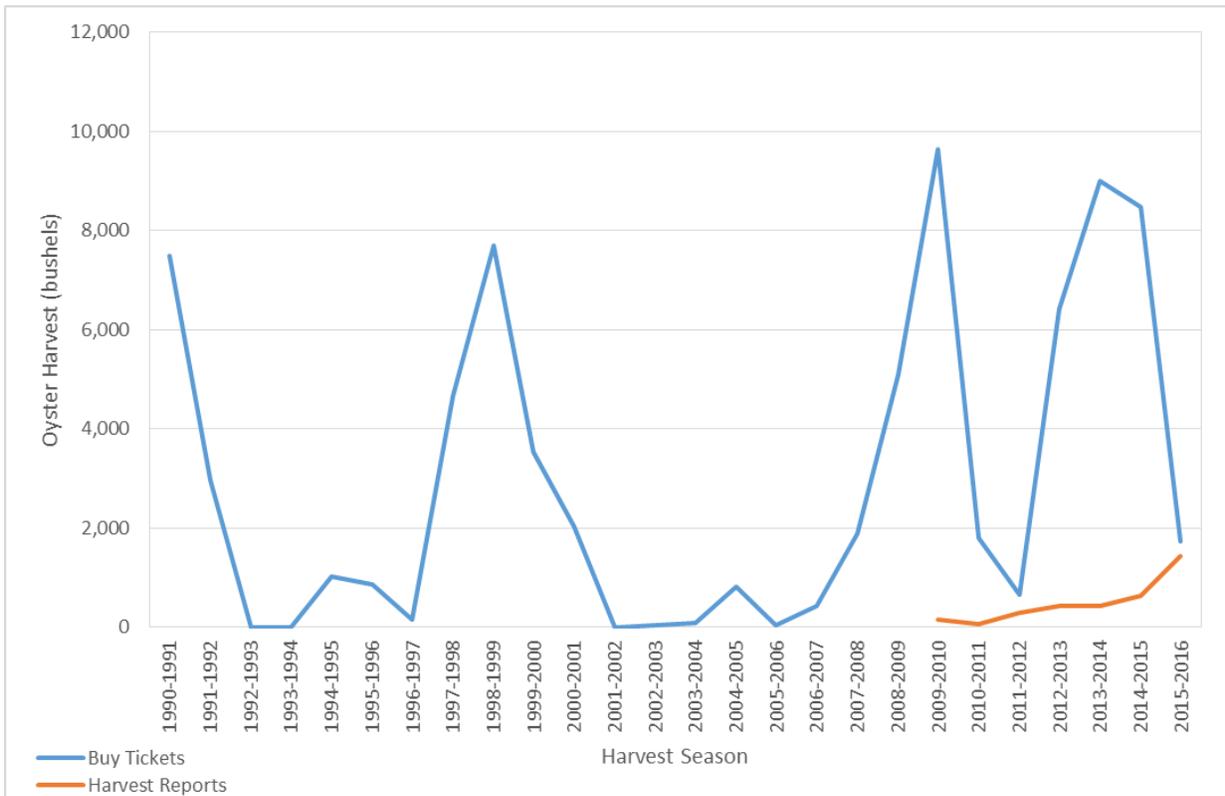


Figure B.22-2. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 129 (Lower West Chesapeake Bay). After the 2009-2010 season, 24% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.23: NOAA Code 131 – Chester River Lower

NOAA Code 131 encompasses the lower portion of the Chester River below Queenstown Creek and is located in Maryland's upper eastern portion of Chesapeake Bay (Figure B.37-1). The entire NOAA Code is 18,183 acres and has 18 historic oyster bars²⁶. The Lower Chester River Sanctuary encompasses 69% (12,591 acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 5,592 acres. There are 986 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside the sanctuary. In 2010, 756 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland's low salinity zone.

Replenishment Activities

Since 1990, approximately 700,000 bushels of shell, 28,000 bushels of wild seed, and 277 million hatchery spat-on-shell have been planted in NOAA Code 131 outside of the current sanctuary area.

²⁶ See chart 7 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

Table B.23-1. Replenishment planting activities occurring since 1990 in NOAA Code 131 (Chester River Lower). ND = No Data.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Wild Seed	15.9	3.1	-
1997	Wild Seed	14.1	7.4	-
1998	Wild Seed	13.6	5.6	-
2000	Wild Seed	10.9	5.7	-
2001	Dredged Shell	9.9	87.9	-
2001	Fresh Shell	1	6.7	-
2001	Wild Seed	13.3	6.9	-
2003	Dredged Shell	24	133	-
2003	Hatchery Spat-on-Shell	23.6	-	3.1
2003	Wild Seed	14.2	ND	-
2004	Dredged Shell	26.5	278.2	-
2004	Hatchery Spat-on-Shell	17.5	-	9.1
2004	Wild Seed	9.4	ND	-
2005	Dredged Shell	26.8	193.2	-
2005	Hatchery Spat-on-Shell	64.1	-	51.7
2006	Hatchery Spat-on-Shell	7.1	-	13.2
2008	Hatchery Spat-on-Shell	18.9	-	21
2009	Hatchery Spat-on-Shell	40.1	-	64.8
2010	Hatchery Spat-on-Shell	26.1	-	34.4
2011	Hatchery Spat-on-Shell	40.6	-	72
2015	Hatchery Spat-on-Shell	5.1	-	7.5

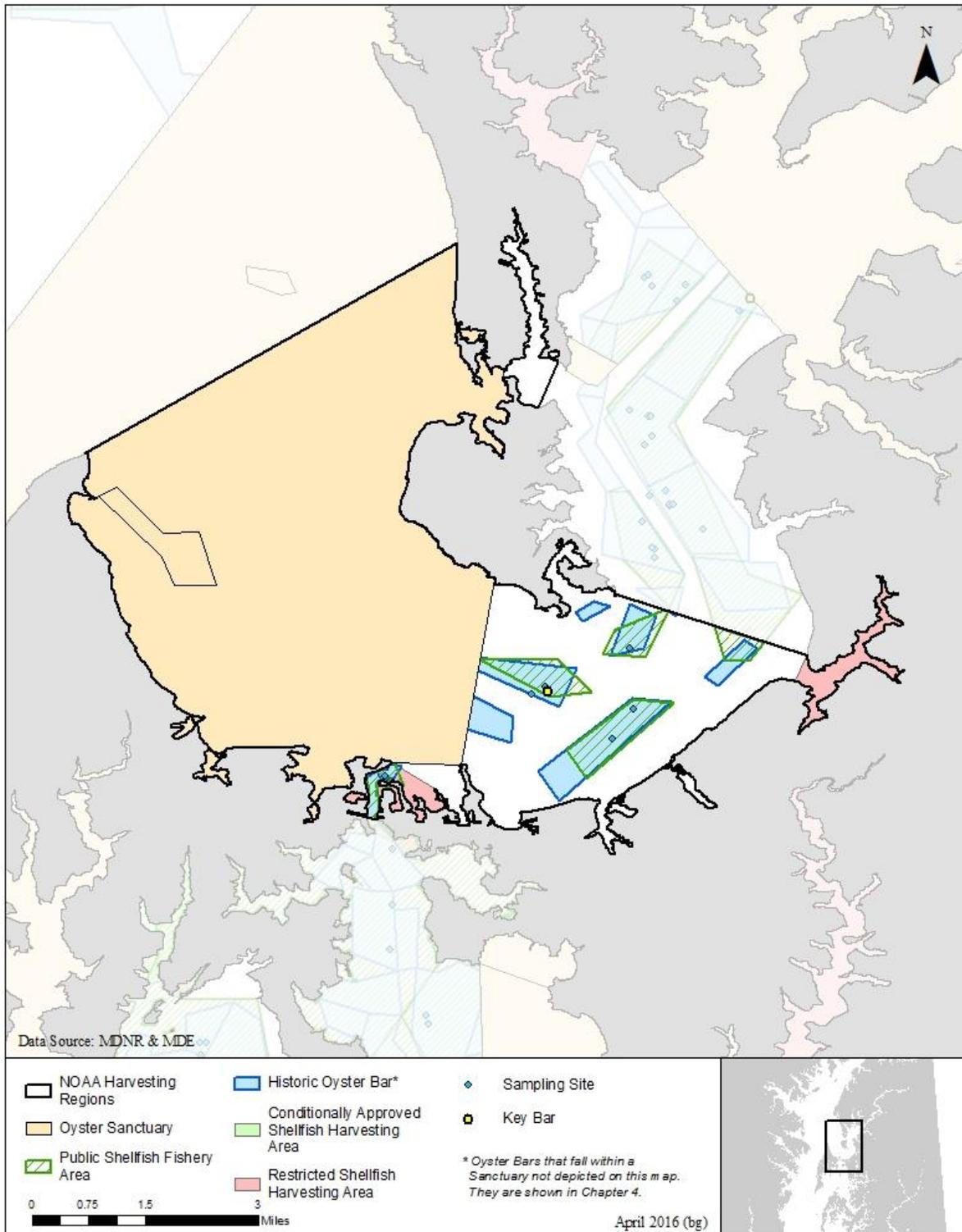


Figure B.23 -1. Map of NOAA Code 131 (Chester River Lower).

Oyster Population Characteristics

Since 1990, The Fall Survey has sampled 1 to 3 oyster bars annually in NOAA Code 131 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 25 to 188 per bushel with an average of 78 (Figure B.23-2). The average number of live oysters was slightly greater from 1990 to 2009 than for 2010 to 2015 (Table B.23-2). On average, there were more market-sized oysters annually than small-sized oysters.

Table B.23-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 131 (Chester River Lower). Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20/48	6/13
Number of Live Oysters per Bushel	84 \pm 9	60 \pm 9
Number of Live Small-Sized Oysters per Bushel	25 \pm 6	19 \pm 6
Number of Live Market-Sized Oysters per Bushel	55 \pm 6	41 \pm 10
Live Oyster Biomass (g Dry Weight per Bushel)	122.8 \pm 17.4	74.3 \pm 13.2
Mortality (%)	20 \pm 3	4 \pm 1

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Buoy Rock bar within NOAA Code 131 (Figure B.23-3). Sizes from 2010-2015 were slightly larger than those from 1990-2009; approximately 80% were 80 mm or larger, with 16% larger than 120 mm. For 1990-2009, 75% were 80 mm or larger, with 10% larger than 120 mm.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on Buoy Rock bar within NOAA Code 131. The annual biomass ranged from 34 to 308 grams of dry weight per bushel and the average is 111.6 \pm 14.2 (average \pm SE; Figure B.23-4). The average biomass was greater from 1990 to 2009 than for 2010 to 2015 (Table B.23-2). Biomass peaked in 1994 and 1999.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall had ranged from 0 to 29 spat per bushel from 1990 to 2015 (Figure B.23-2). The largest spatfall occurred in 2009, but has generally been low and inconsistent, averaging 3 per bushel. Two samples were collected on hatchery seed plantings. Without those samples, spatfall averaged 2 per bushel (Figure B.23-5).

Mortality

Mortality ranged from 2% to 51%; since 2010 mortality has been relatively low, averaging 4% (Figure B.23-6). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.23-2).

Disease

Disease pressure from dermo has fluctuated over the years (Figure B.23-7). Dermo prevalence has ranged from 7% to 100%. Dermo prevalence was greater than 80% for 9 of the 26 years disease information was collected. Dermo intensity ranged from 0.2 to 3.5, never reaching lethal levels (scale of 0 to 7 with values higher than 5 indicating lethal infections). Both prevalence and intensity declined after 2010. MSX prevalence has been 0% for the entire time period.

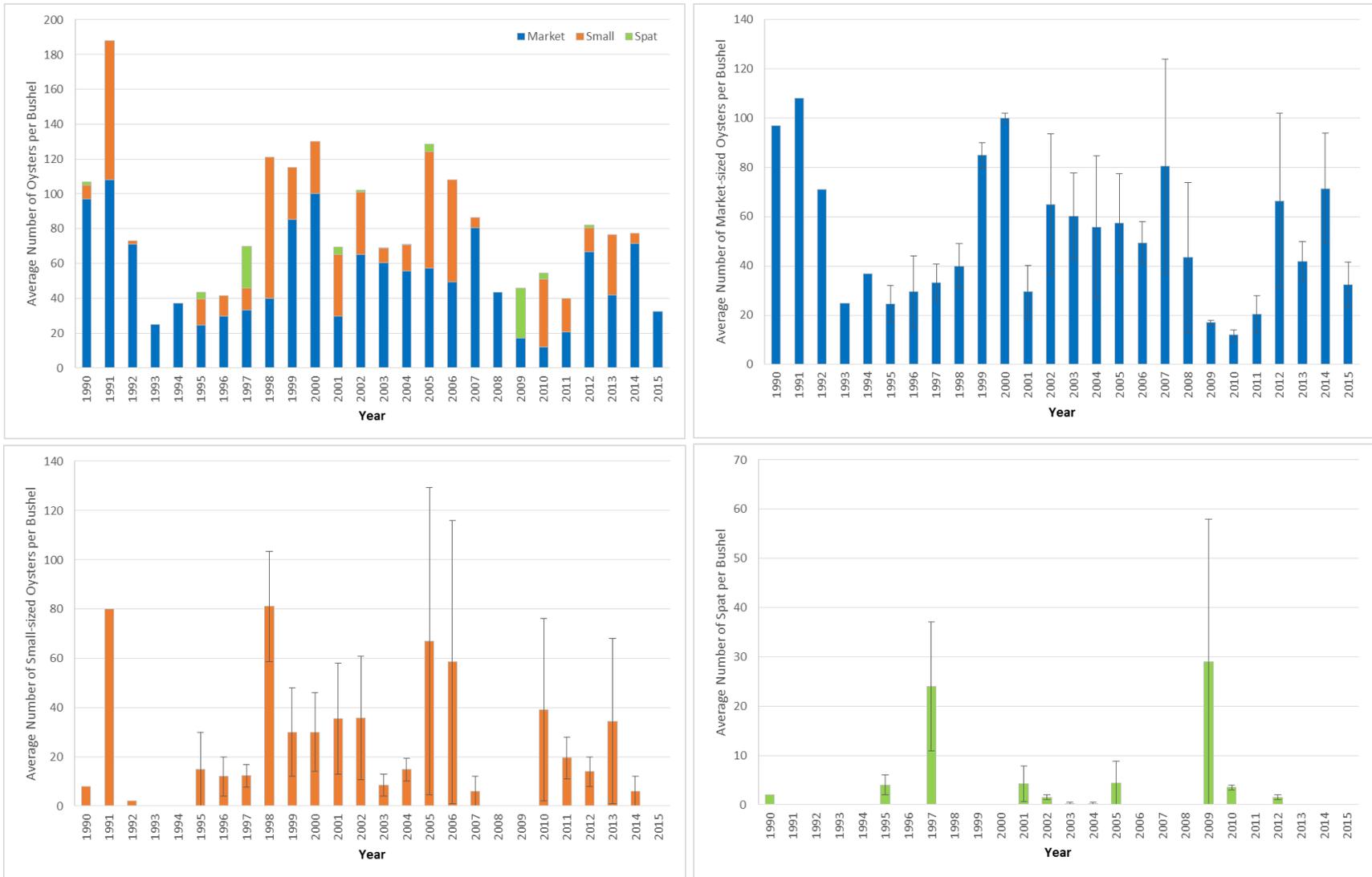
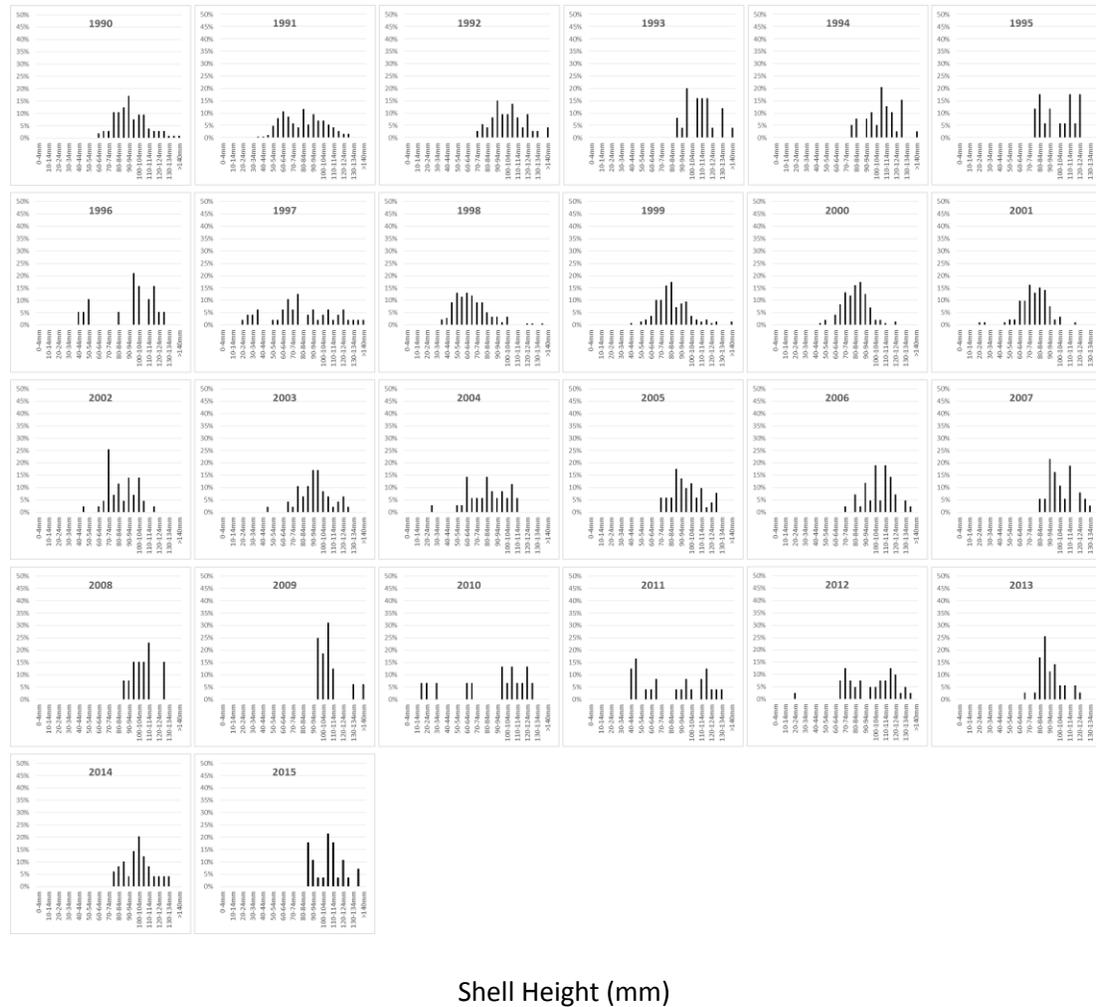


Figure B.23-2. Average number of live oysters per bushel of material by size class in the NOAA Code 131 (Chester River Lower). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

Frequency (%)



Shell Height (mm)

Figure B.23-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 131 (Chester River Lower). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

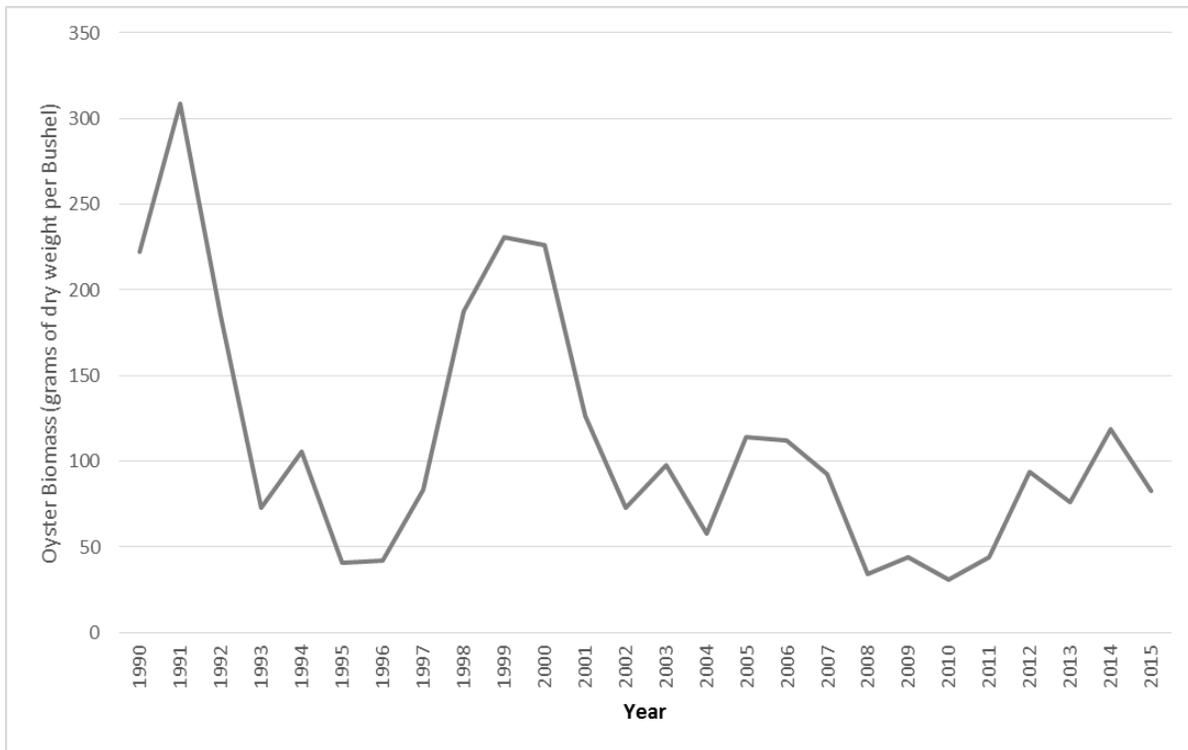


Figure B.23-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 131 (Chester River Lower). Data from Maryland’s Annual Fall Oyster Dredge Survey.

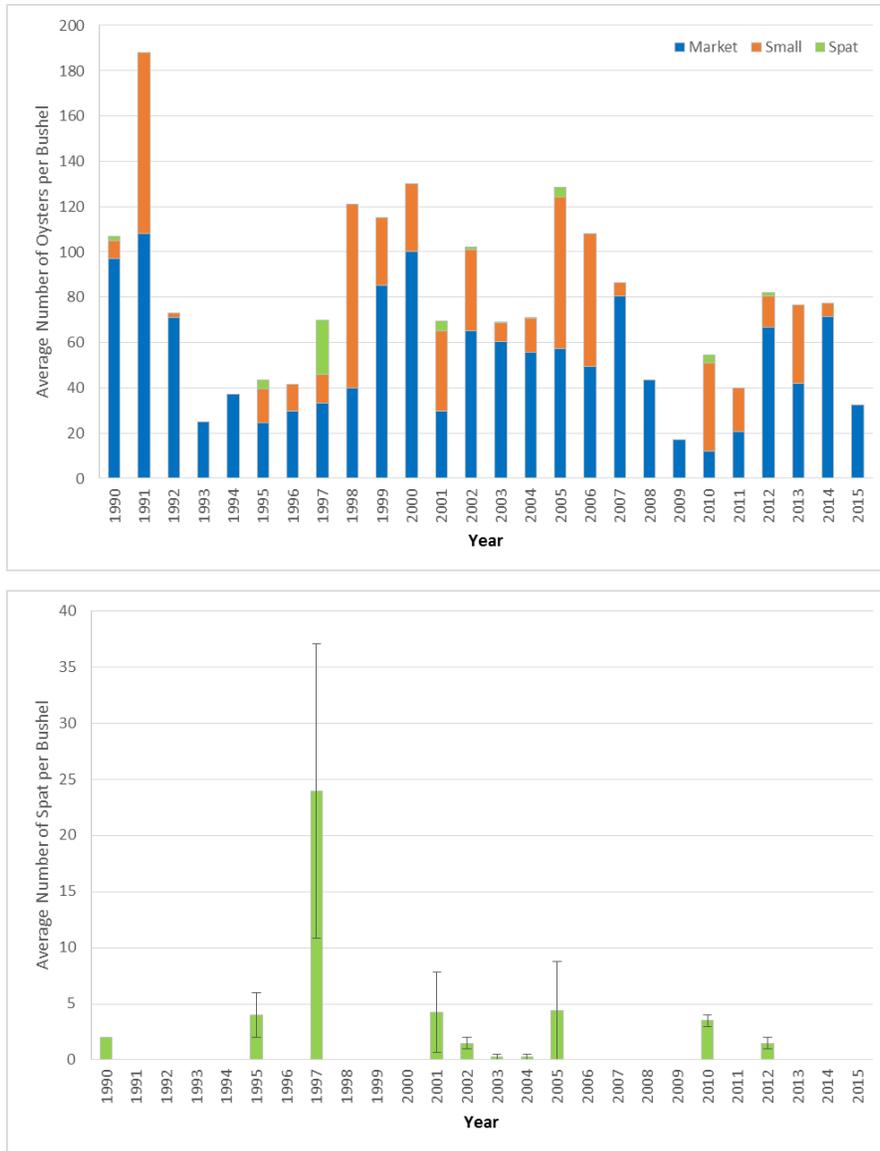


Figure B.23-5. Average number of live oysters per bushel of material by size class in the NOAA Code 131 (Chester River Lower) excluding samples taken on hatchery seed plantings. Error bars represent ± 1 standard error. Data from Maryland's Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

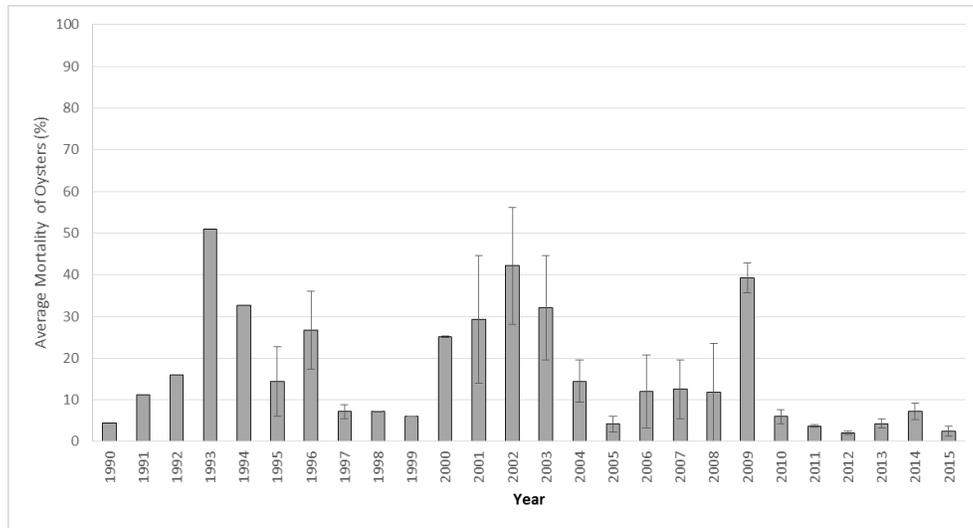


Figure B.23-6. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 131 (Chester River Lower). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

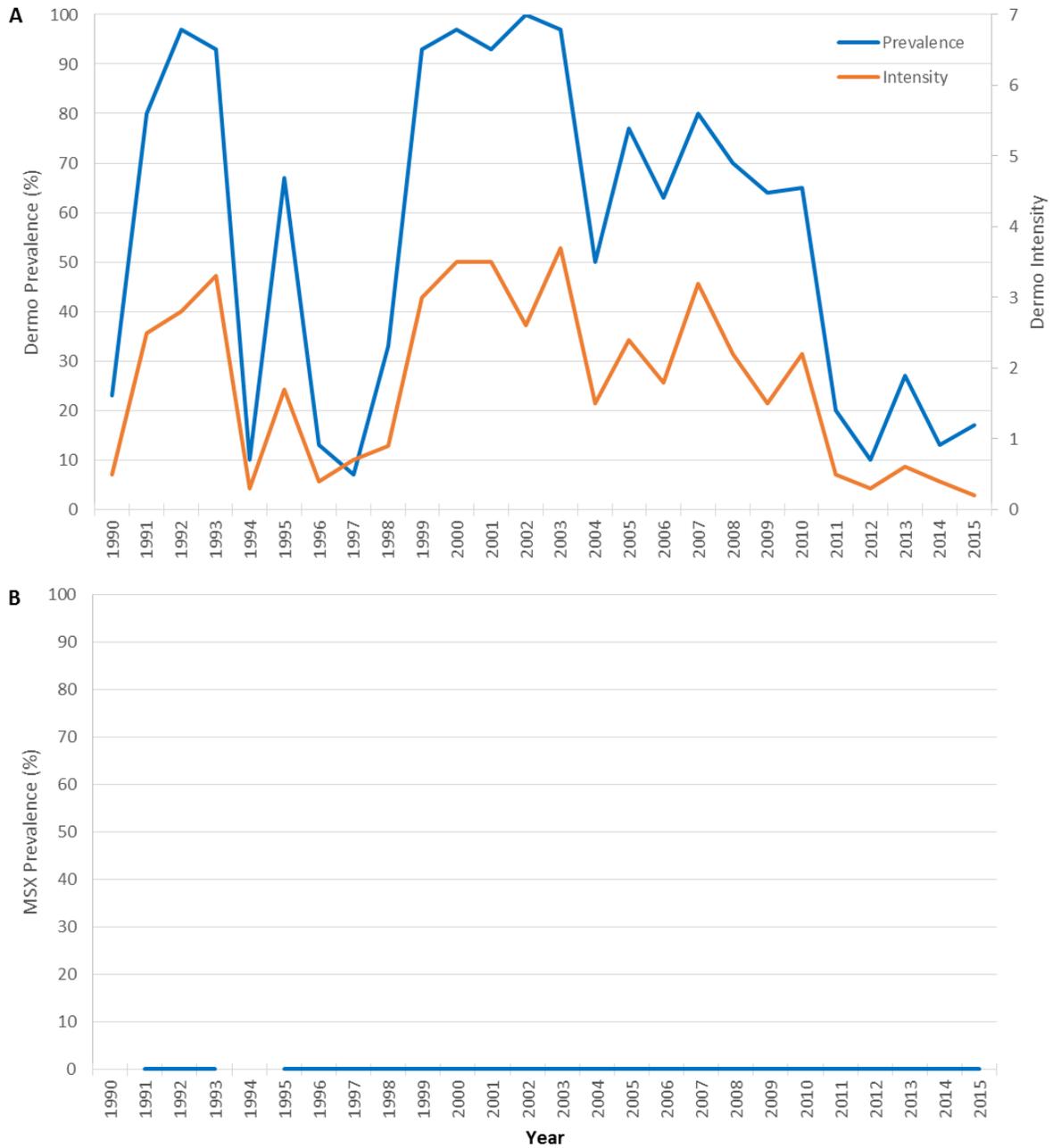


Figure B.23-7. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 131 (Chester River Lower). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland's Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 131 since 1990 is presented in Figure B.23-8. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 69% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from 24 bushels in the 2012-2013 season to a maximum of approximately 32,000 bushels in the 1999-2000 season. Harvest since 2011-2012 has increased annually which may be partly attributed to hatchery seed plantings that are reaching harvest size (approximately three years after the hatchery seed are planted). Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Diving accounted for most of the harvest (84%), followed by hand tonging (16%), as reported on oyster harvester reports.

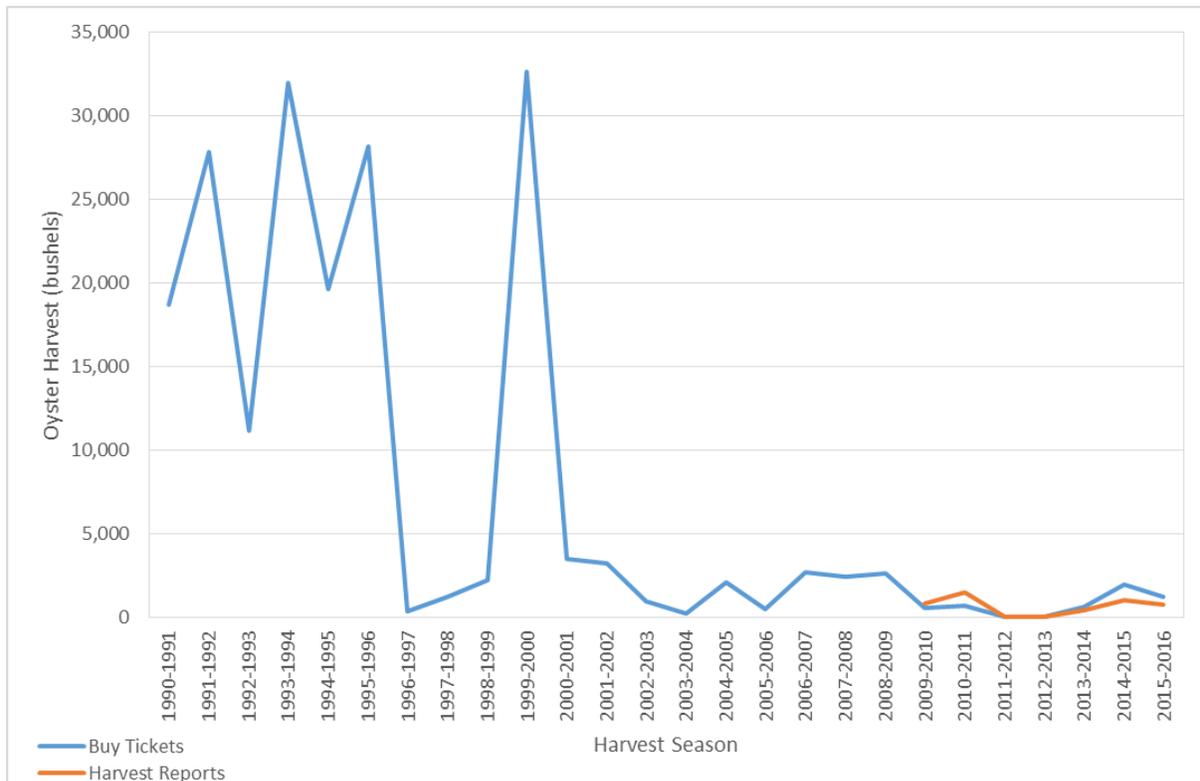


Figure B.23-8. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 131 (Chester River Lower). After the 2009-2010 season, 69% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.24: NOAA Code 137 – Choptank River Lower

NOAA Code 137 encompasses the lower portion of the Choptank River south of Castlehaven and is located in Maryland’s mid-eastern portion of Chesapeake Bay (Figure B.24-1). The entire NOAA Code is 35,040 acres and has 48 historic oyster bars²⁷. Two sanctuaries (Lower Choptank and Cook Point) encompass 14% (4,996 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 30,044 acres. There are 17,314 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010, 17,503 acres within the NOAA Code were designated as a Public Shellfish Fishery Area prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s medium salinity zone.

Replenishment Activities

Since 1990, approximately 1,148,000 bushels of shell and 99,000 bushels of wild seed have been planted in NOAA Code 137 outside of the current sanctuary area (Table B.24-1).

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Dredged Shell	11.3	73.1	-
1990	Wild Seed	146.2	63.4	-
1991	Wild Seed	21.6	10.0	-
1992	Wild Seed	35.8	20.2	-
1993	Fresh Shell	1.3	6.5	-
1994	Fresh Shell	2.6	7.7	-
1997	Dredged Shell	14.6	51.7	-
1998	Dredged Shell	54.5	214.3	-
1999	Dredged Shell	26.4	154.8	-
1999	Wild Seed	14.6	5.5	-
2000	Dredged Shell	45.1	355.1	-
2005	Dredged Shell	41.9	253.4	-
2012	Dredged Shell	84.9	14.5	-
2014	Fresh Shell	10.4	7.6	-
2015	Fresh Shell	5.6	10.1	-

²⁷ See chart 19 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

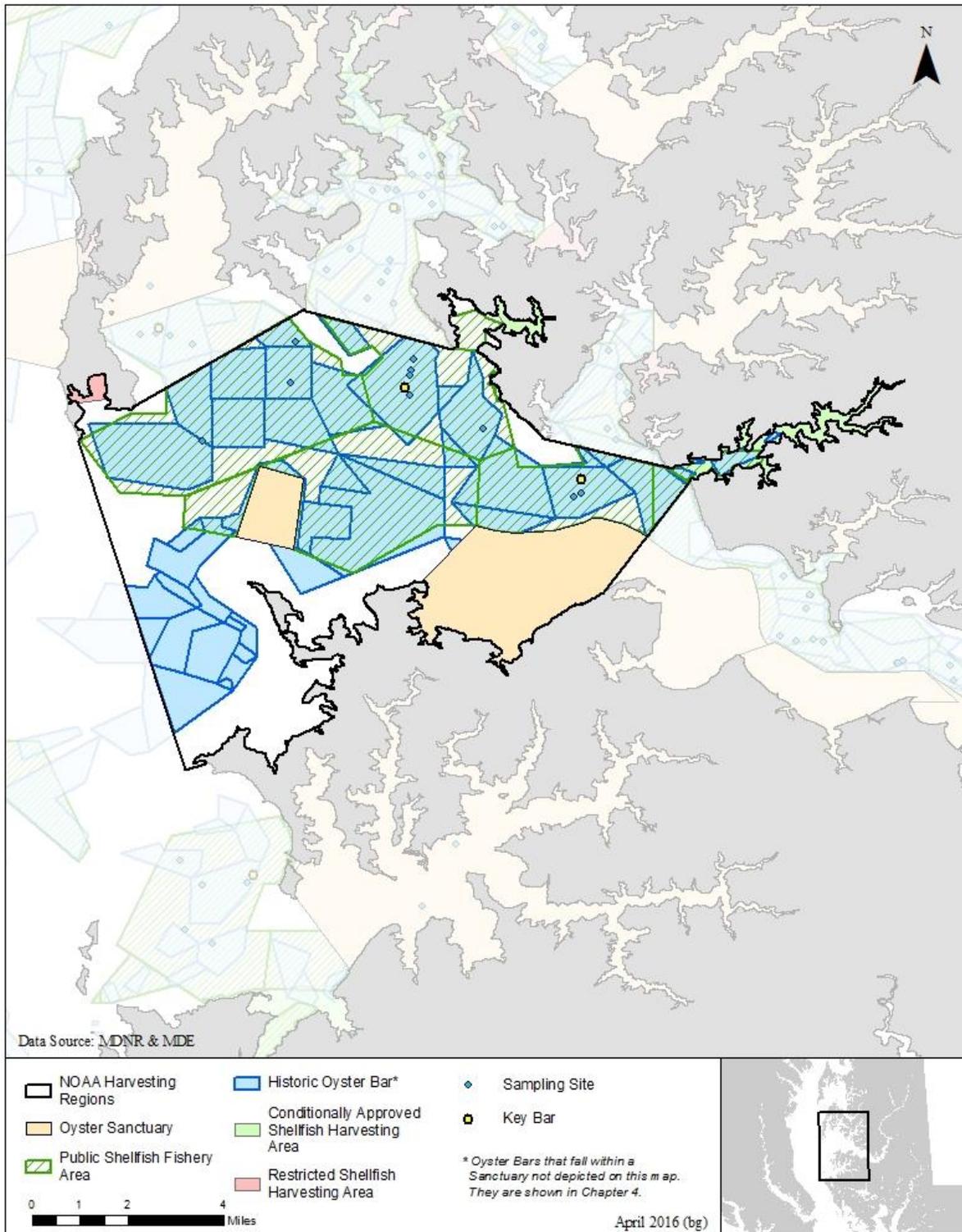


Figure B.24 -1. Map of NOAA Code 137 (Choptank River Lower).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled 4 to 10 oyster bars annually in NOAA Code 137 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 11 to 354 per bushel with an average of 114 (Figure B.24-2). Since 2002, there has been a general increase in the number of oysters. Years 2012 to 2014 had the highest number of market-sized oysters over the 26 year time period. The average number of oysters was greater from 2010 to 2015 than prior to 2010 (Table B.24-2).

Table B.24-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 137 (Choptank River Lower). Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 180	6 / 42
Number of Live Oysters per Bushel	103 \pm 23	153 \pm 22
Number of Live Small-Sized Oysters per Bushel	39 \pm 9	66 \pm 10
Number of Live Market-Sized Oysters per Bushel	25 \pm 4	61 \pm 15
Live Oyster Biomass (g Dry Weight per Bushel)	84 \pm 14	159 \pm 30
Mortality (%)	26 \pm 5.4	3.3 \pm 1

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on two bars (Royston and Lighthouse) within NOAA Code 137 (Figure B.24-3). Sizes from 2010-2015 were similar to those from 1990-2009. Approximately 50% were 70 mm or smaller (51% for 1990-2009 and 47% for 2010-2015). Less than 1% of oysters were larger than 120 mm.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on two bars (Royston and Lighthouse) within NOAA Code 137. The annual biomass ranged from 30 to 268 grams of dry weight per bushel and the average is 88.8 \pm 13.6 (average \pm SE; Figure B.24-4). The average biomass was greater from 2010 to 2015 than prior to 2010 (Table B.24-2). From 2002 to 2009, biomass was lowest, increasing again until 2013.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 0 to 305 spat per bushel (Figure B.37-2). The largest spatfall occurred in 1997. From 1998 to 2005, there was very little spatfall. Since then, spatfall has been inconsistent, though generally increasing.

Mortality

Mortality ranged from 1% to 91%, however, since 2005 mortality has been relatively low (Figure B.24-5). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.24-2).

Disease

From 1990 to 2015, dermo prevalence ranged from 7% to 100% (Figure B.24-6); it was greater than 80% for 8 of the 26 years disease information was collected. After 2002, dermo prevalence decreased sharply. Dermo intensity ranged from 0 to 5.4 from 1990 to 2015. Dermo intensity was below lethal levels for the entire time period (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 64% from 1990 to 2015.

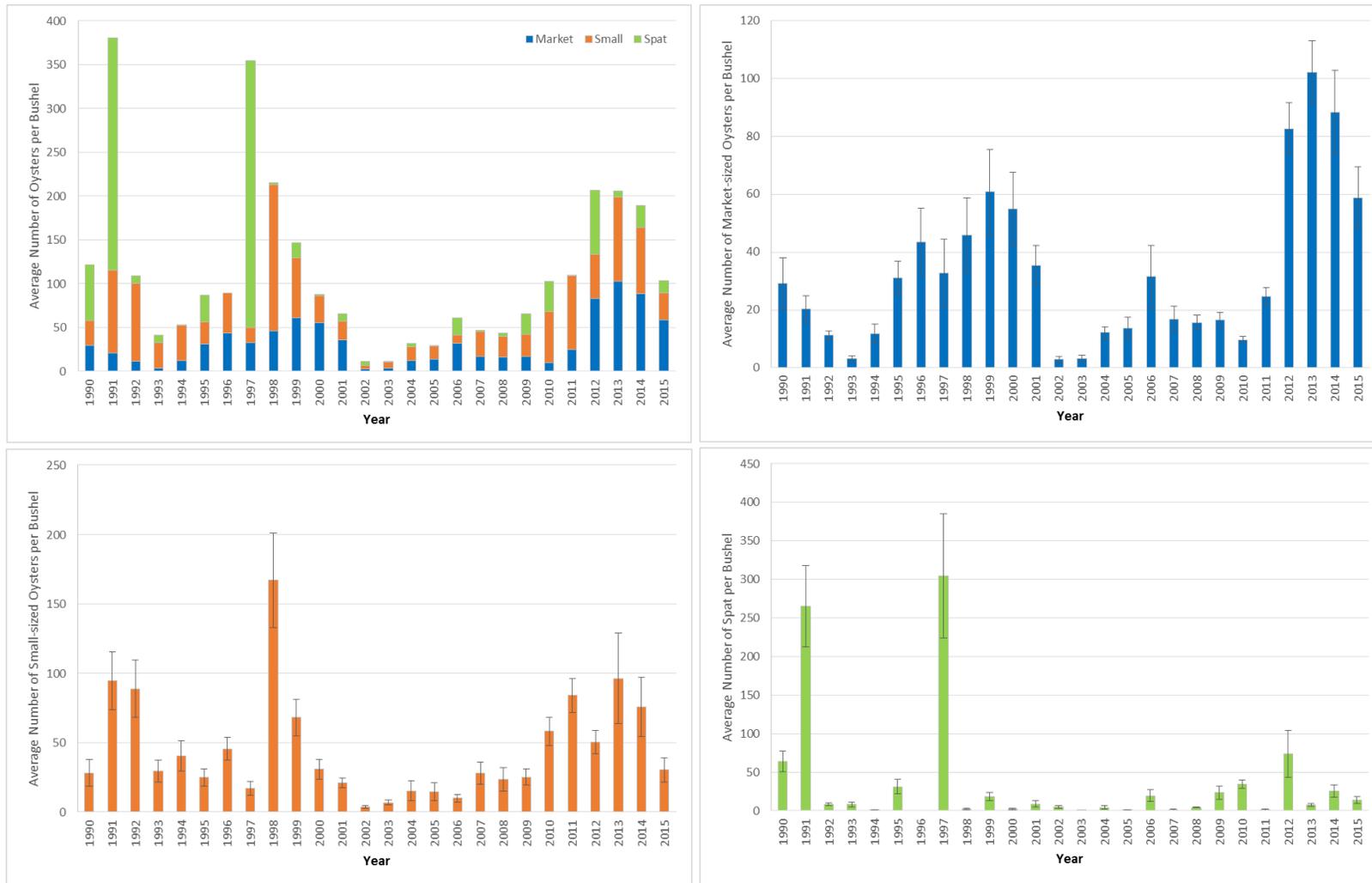


Figure B.24-2. Average number of live oysters per bushel of material by size class in the NOAA Code 137 (Choptank River Lower). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

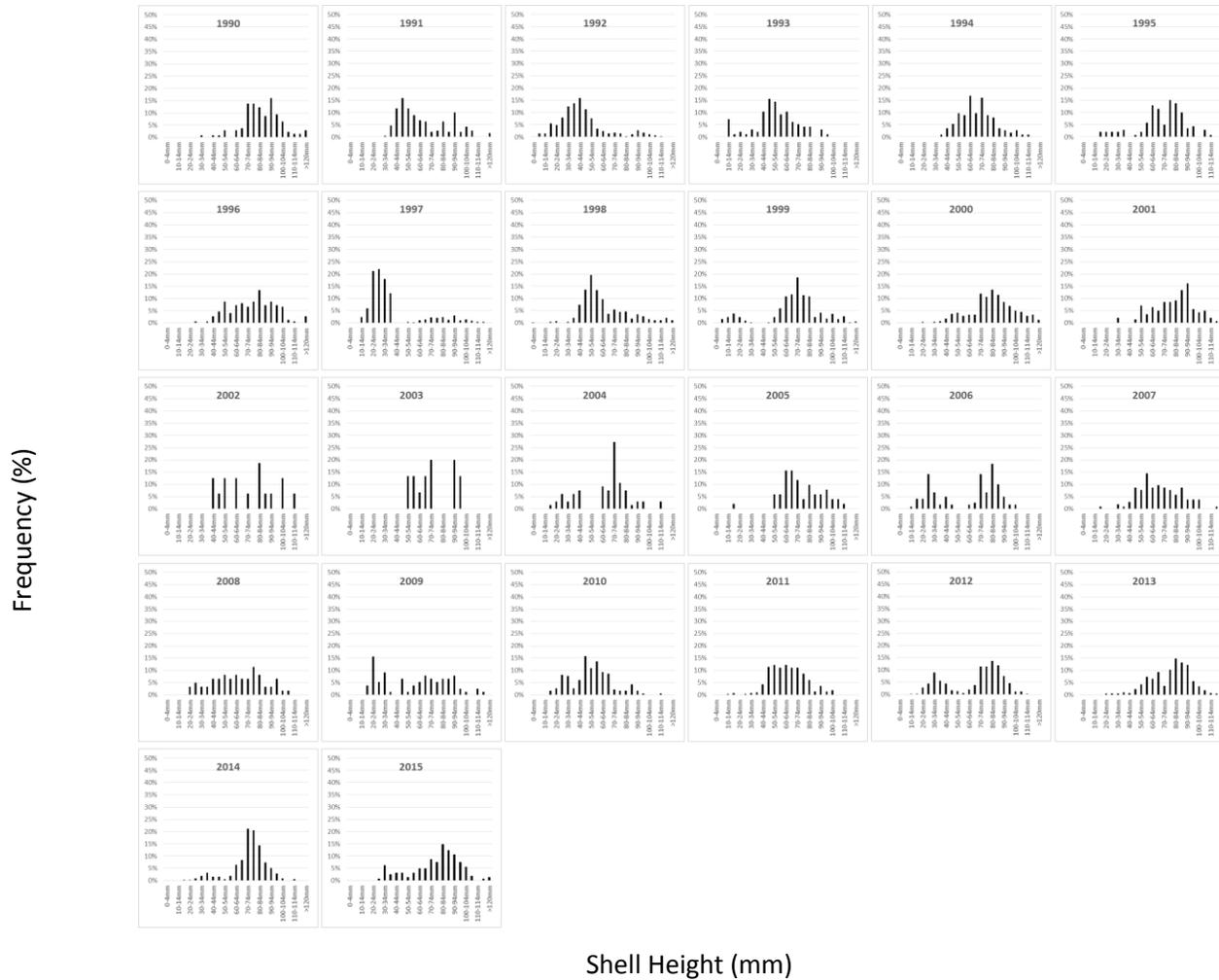


Figure B.24-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 137 (Choptank River Lower). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.



Figure B.24-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 137 (Choptank River Lower). Data from Maryland’s Annual Fall Oyster Dredge Survey.

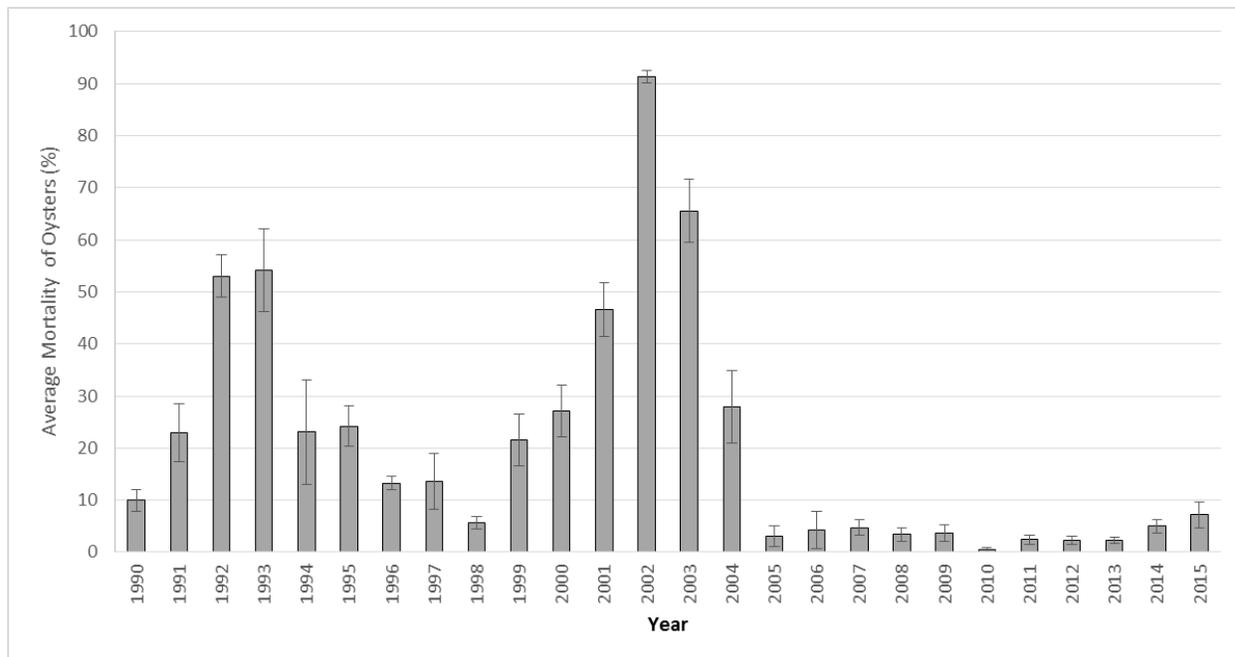


Figure B.24-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 137 (Choptank River Lower). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

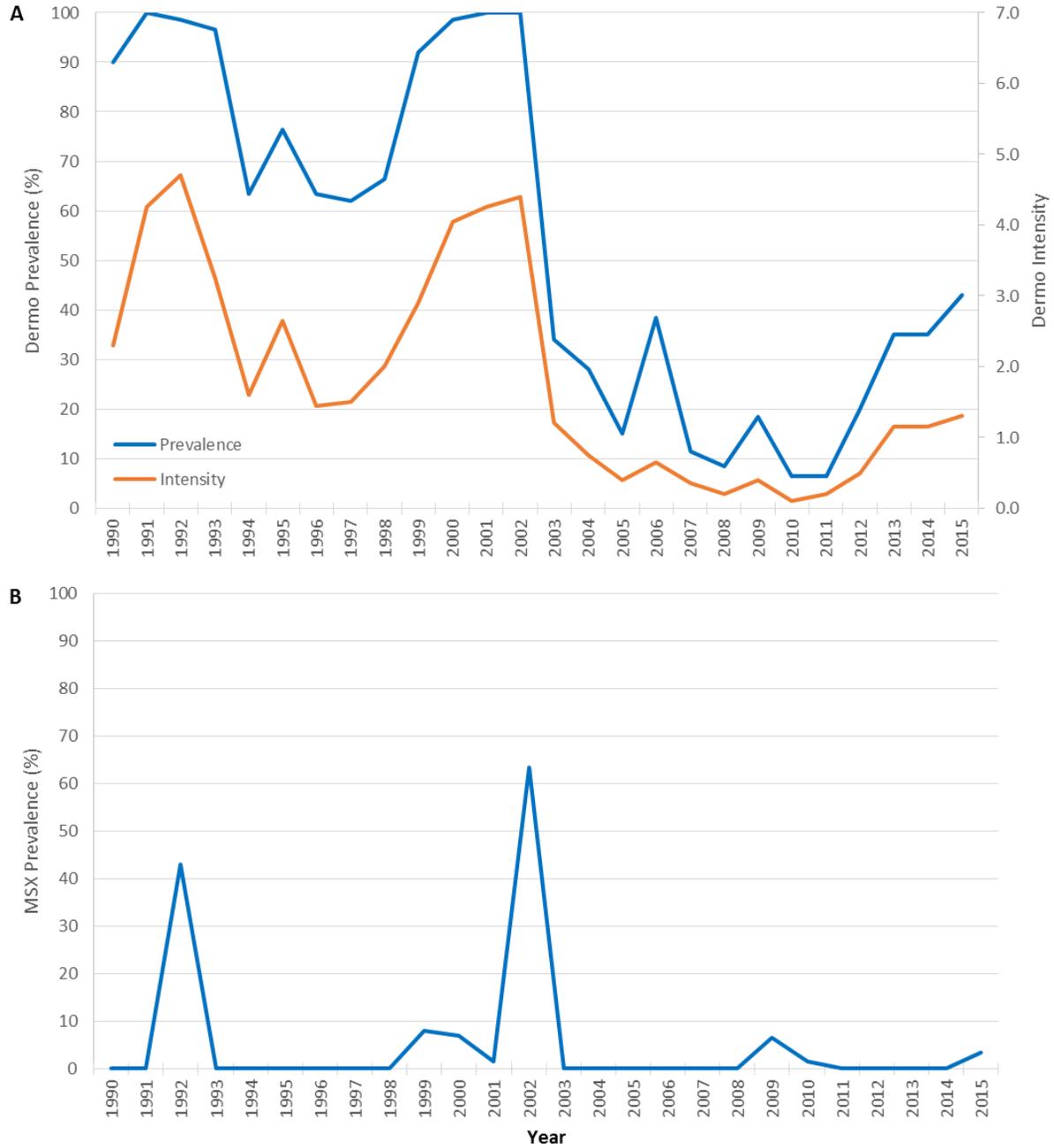


Figure B.24-6. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 137 (Choptank River Lower). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland's Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 137 (Harris Creek) since 1990 is presented in Figure B.24-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 14% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in the 2003-2004 season to a maximum of approximately 28,000 bushels in the 2014-2015 season. The increase in harvest since 2011-2012 season may be partly attributed to the generally increasing spatfall since 2009. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Power dredging accounts for 68% of the harvest, as reported on oyster harvester reports. Sail dredging accounts for another 25% of harvest.

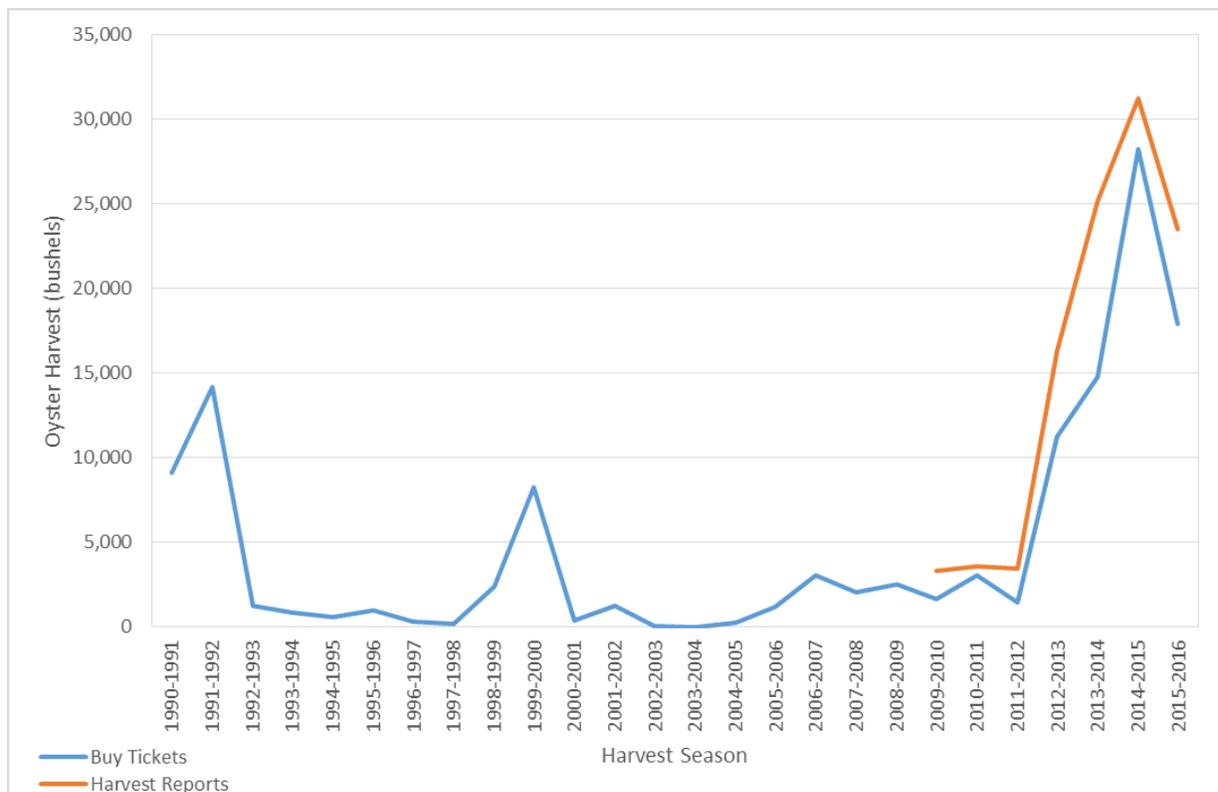


Figure B.24-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 137 (Choptank River Lower). After the 2009-2010 season, 14% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.25: NOAA Code 168 – Patuxent River Lower

NOAA Code 168 encompasses the lower portion of the Patuxent River south of St. Leonard Creek and is located in Maryland's lower eastern portion of Chesapeake Bay (Figure B.25-1). The entire NOAA Code is 8,880 acres and has 22 historic oyster bars²⁸. Two sanctuaries (Solomons Creek and Lower Patuxent) established in 2010 are within the NOAA Code and encompasses 11% (951 acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 7,929 acres. There is 2,231 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and not within a sanctuary. There are 2,981 acres within the NOAA Code that is designated as a Public Shellfish Fishery Area in 2010 where aquaculture leasing is prohibited. This NOAA Code is generally located within Maryland's medium salinity zone.

Replenishment Activities

Since 1990, approximately 185,000 bushels of shell, 75,000 bushels of wild seed, and 32 million hatchery spat-on-shell have been planted in NOAA Code 168 outside of the current sanctuary area (Table B.25-1).

²⁸ See chart 27 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

Table B.25-1. Replenishment planting activities occurring since 1990 in NOAA Code 168 (Patuxent River Lower). ND = No Data.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1995	Wild Seed	1.4	2.5	-
1997	Wild Seed	7.5	4.9	-
1998	Wild Seed	28.0	13.7	-
1999	Fresh Shell	8.7	23.6	-
1999	Wild Seed	6.2	4.0	-
2000	Fresh Shell	18.1	19.5	-
2000	Wild Seed	7.5	6.9	-
2001	Wild Seed	10.6	10.0	-
2002	Fresh Shell	18.1	21.6	-
2002	Wild Seed	7.3	4.3	-
2003	Wild Seed	4.8	6.4	-
2004	Wild Seed	2.0	2.8	-
2006	Dredged Shell	17.6	114.0	-
2007	Wild Seed	11.1	10.1	-
2008	Wild Seed	3.1	4.0	-
2009	Wild Seed	1.5	2.2	-
2010	Hatchery Spat-on-Shell	6.8	-	5.9
2011	Wild Seed	4.9	ND	-
2012	Wild Seed	6.0	ND	-
2013	Hatchery Spat-on-Shell	2.9	-	11.2
2013	Wild Seed	25.1	3.8	-
2015	Fresh Shell	5.9	6.8	-
2015	Hatchery Spat-on-Shell	11.3	-	21.6

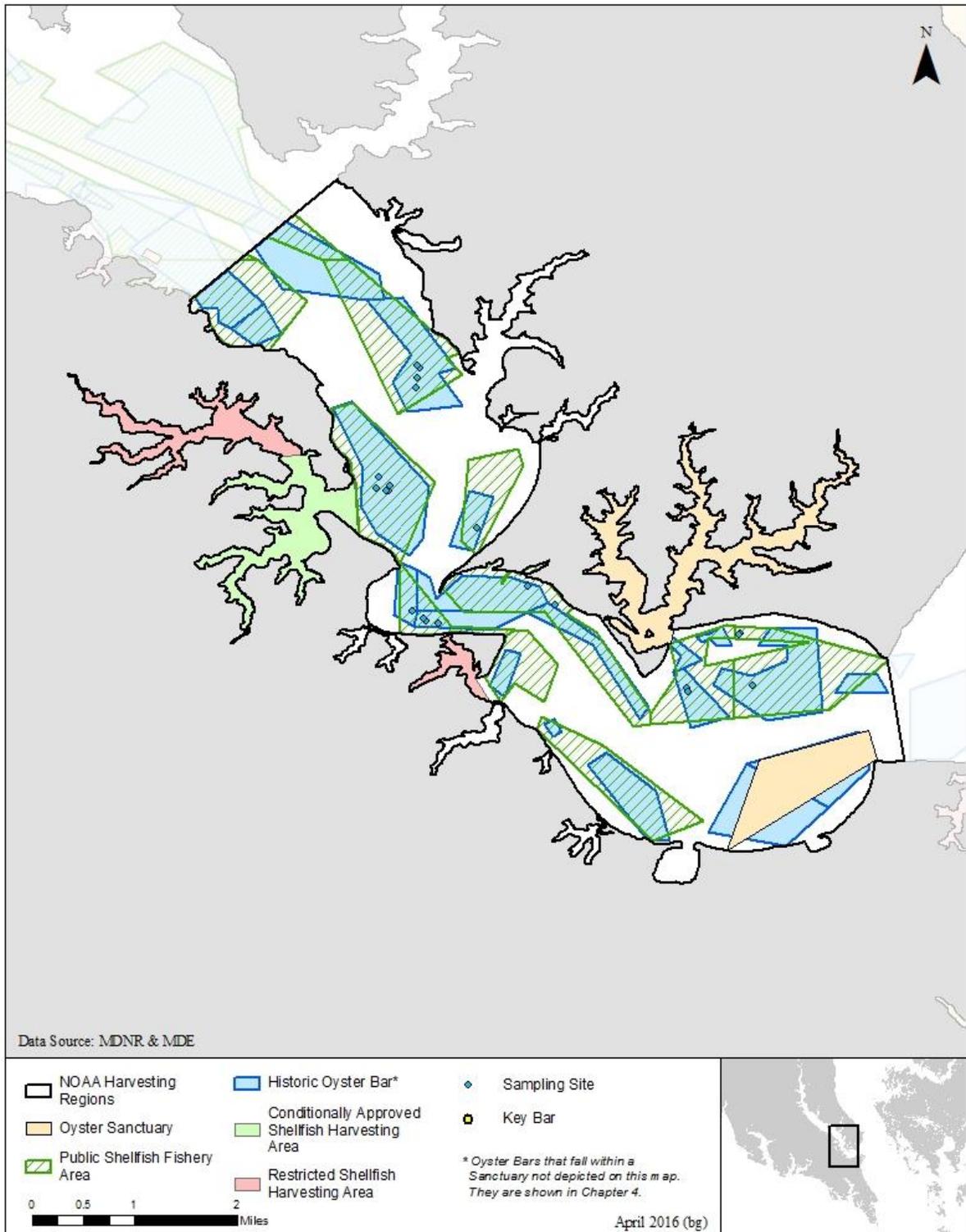


Figure B.25 -1. Map of NOAA Code 168 (Patuxent River Lower).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled 6 to 10 oyster bars annually in NOAA Code 168 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 9 to 206 per bushel with an average of 85 (Figure B.25-2). The number of oysters has generally been increasing since 1990. The average number of oysters was greater from 2010 to 2015 than prior to 2010 (Table B.25-2).

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 170	6 / 55
Number of Live Oysters per Bushel	65 \pm 8	152 \pm 18
Number of Live Small-Sized Oysters per Bushel	35 \pm 5	79 \pm 17
Number of Live Market-Sized Oysters per Bushel	20 \pm 4	43 \pm 6
Live Oyster Biomass (g Dry Weight per Bushel)	49 \pm 10	114 \pm 14
Mortality (%)	37 \pm 5.1	13.8 \pm 2.2

Oyster Size Structure

The Fall Survey measured oyster shell heights on six bars within NOAA Code 168 in 1990, 1992-1997 and 2011-2015 (Figure B.25-3). From 2011-2015, 74% of oysters were less than 80 mm compared to 67% for 1990-1997.

Biomass

The Fall Survey measured oyster biomass on six bars within NOAA Code 168 in 1990, 1992-1997 and 2011-2015. The annual biomass ranged from 23 to 141 grams of dry weight per bushel and the average was 76.3 \pm 13.6 (average \pm SE; Figure B.25-4). The average biomass was greater from 2010 to 2015 than prior to 2010 (Table B.25-2). Biomass was not measured from 1998-2010 but peak biomass occurred in 2012.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 0 to 69 spat per bushel (Figure B.25-2), with an average of 14. The largest spatfall occurred in 1991 and 2010. Excluding two samples on hatchery seed plantings (2010 and 2015), spatfall ranged from 0 to 69 with an average of 13 spat per bushel (Figure B.25-5).

Mortality

Mortality ranged from 7% to 85%, however, since 2006 mortality has been relatively low (Figure B.25-6). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.25-2).

Disease

The Fall Survey has not collected information on oyster disease in this NOAA Code since 1990.

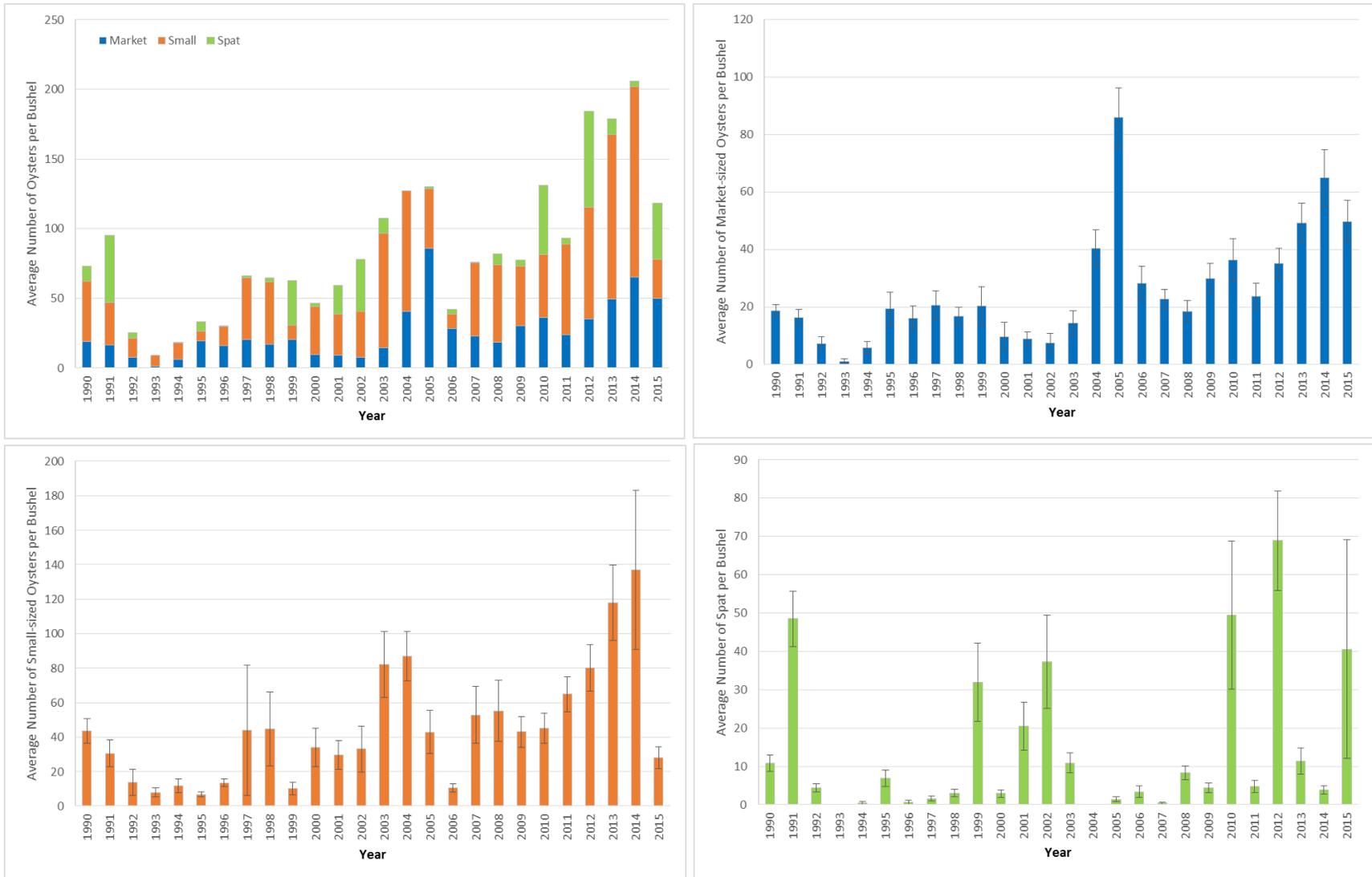
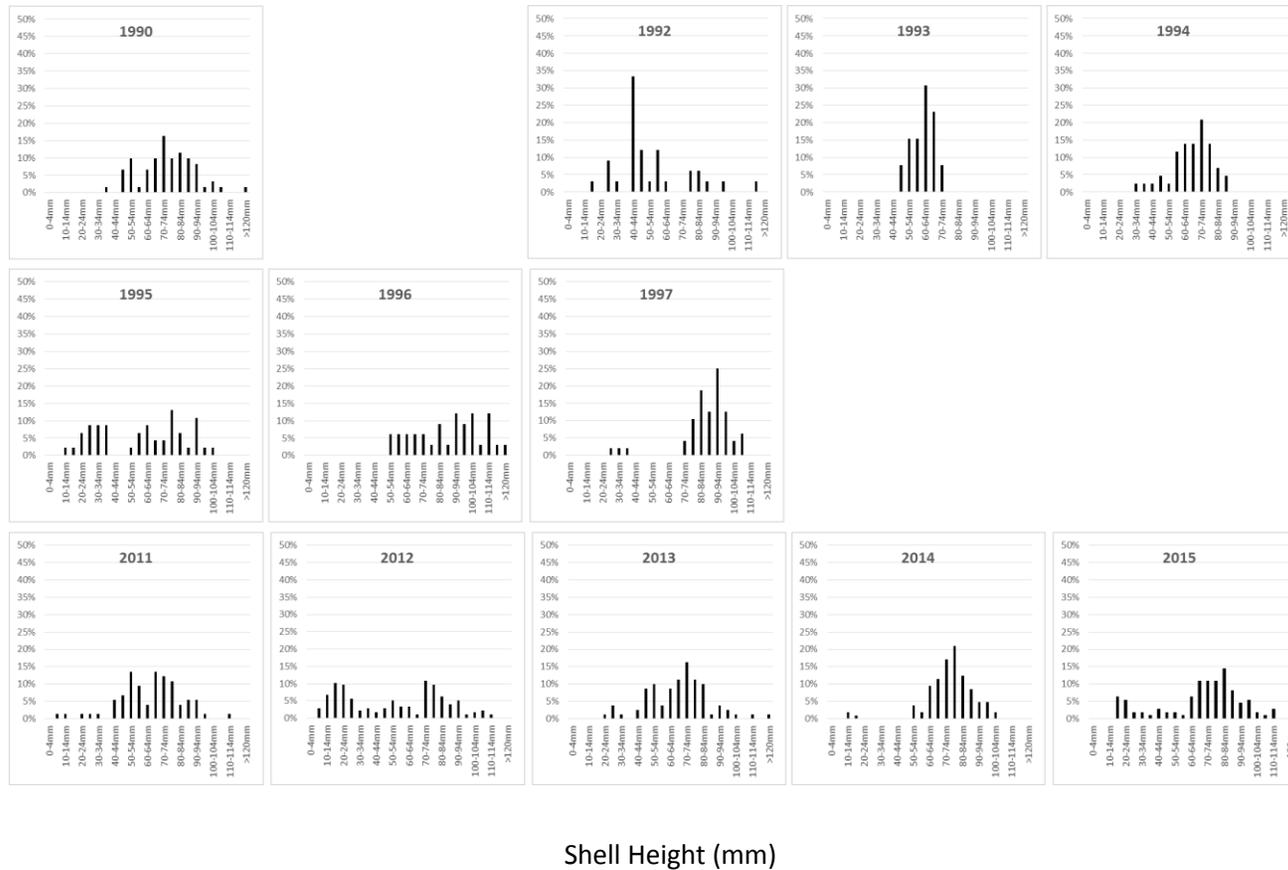


Figure B.25-2. Average number of live oysters per bushel of material by size class in the NOAA Code 168 (Patuxent River Lower). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

Frequency (%)



Shell Height (mm)

Figure B.25-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 168 (Patuxent River Lower). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster shell heights were not measured in 1991 and 1998 to 2010.

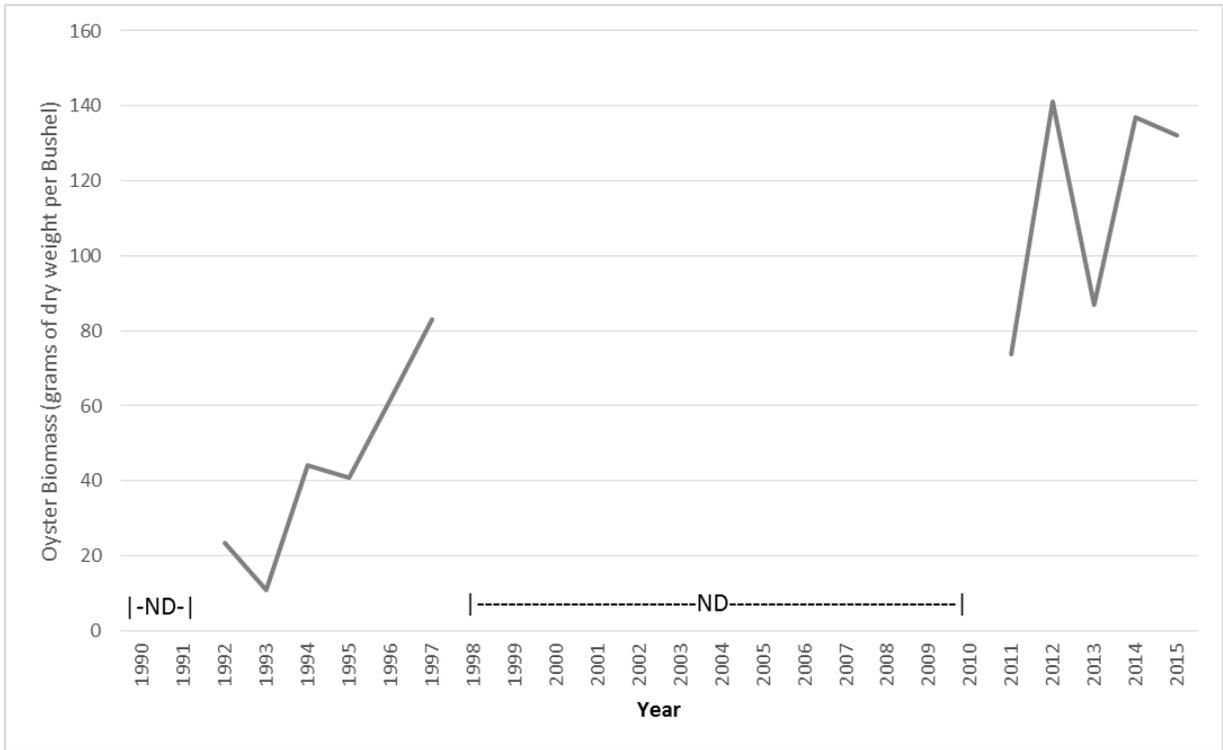


Figure B.25-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 168 (Patuxent River Lower). Data from Maryland’s Annual Fall Oyster Dredge Survey. ND = No Data.

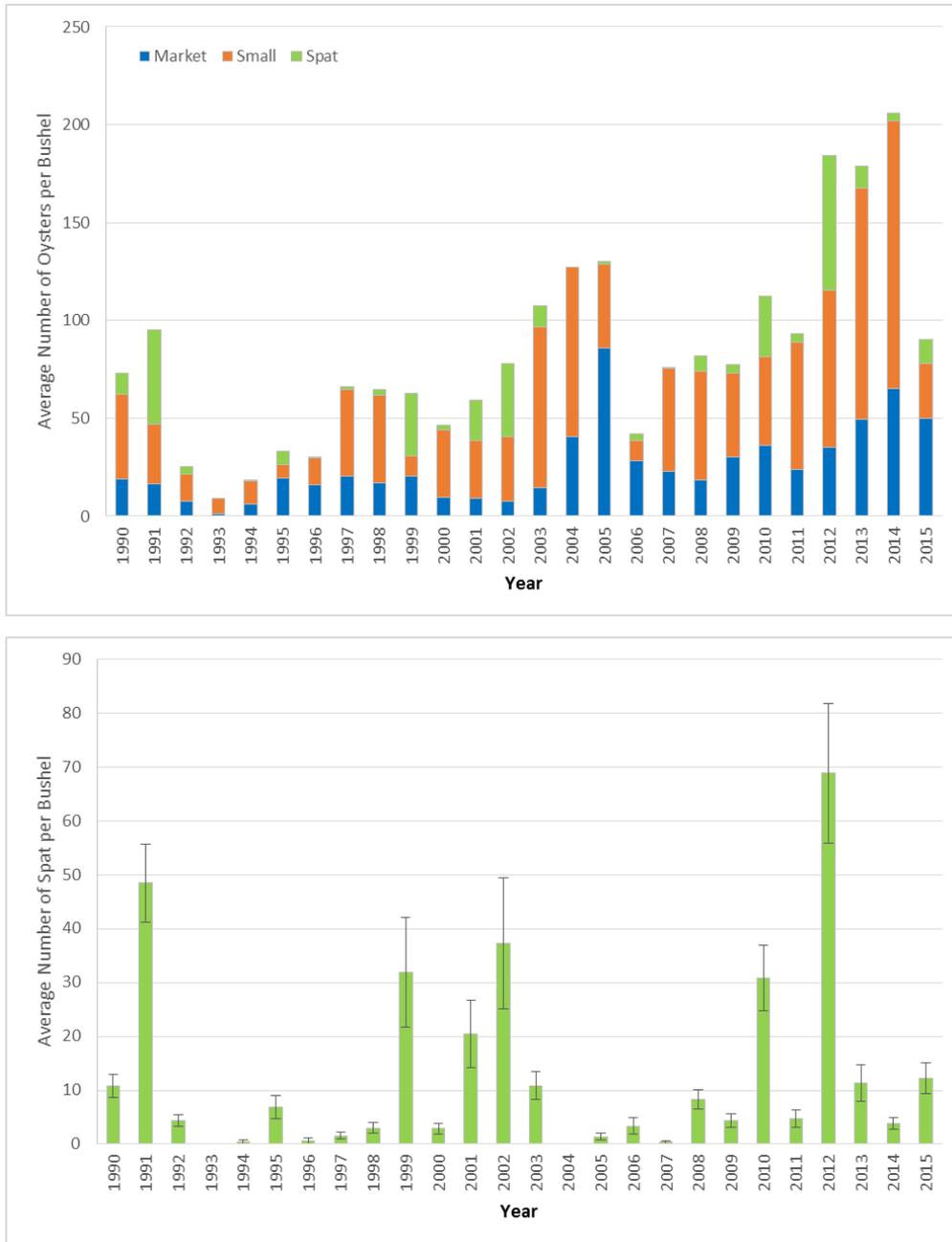


Figure B.25-5. Average number of live oysters per bushel of material by size class in the NOAA Code 168 (Patuxent River Lower) excluding samples taken on hatchery seed plantings. Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

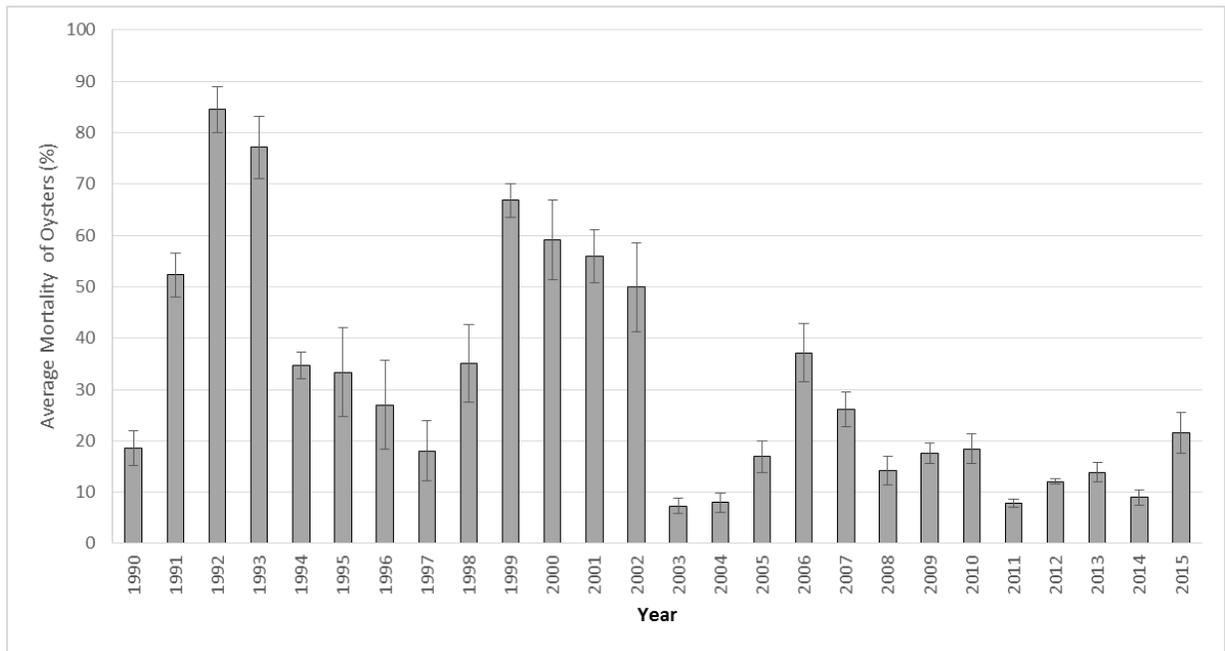


Figure B.25-6. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 168 (Patuxent River Lower). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

Harvest

Harvest for the entire NOAA Code 168 (Harris Creek) since 1990 is presented in Figure B.25-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 11% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest to a maximum of 83 bushels between 1992-1993 and 2003-2004 seasons. Since 2004-2005, the maximum harvest was approximately 39,000 bushels in the 2015-2016 season which is the highest harvest since 1990. The highest spatfall since 1990 that occurred in 2012 may be partly attributed to the increase in harvest. Also, increasing seed plantings may have partly attributed to the increase in harvest. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Patent tongs account for 94% of the harvest, as reported on oyster harvester reports.

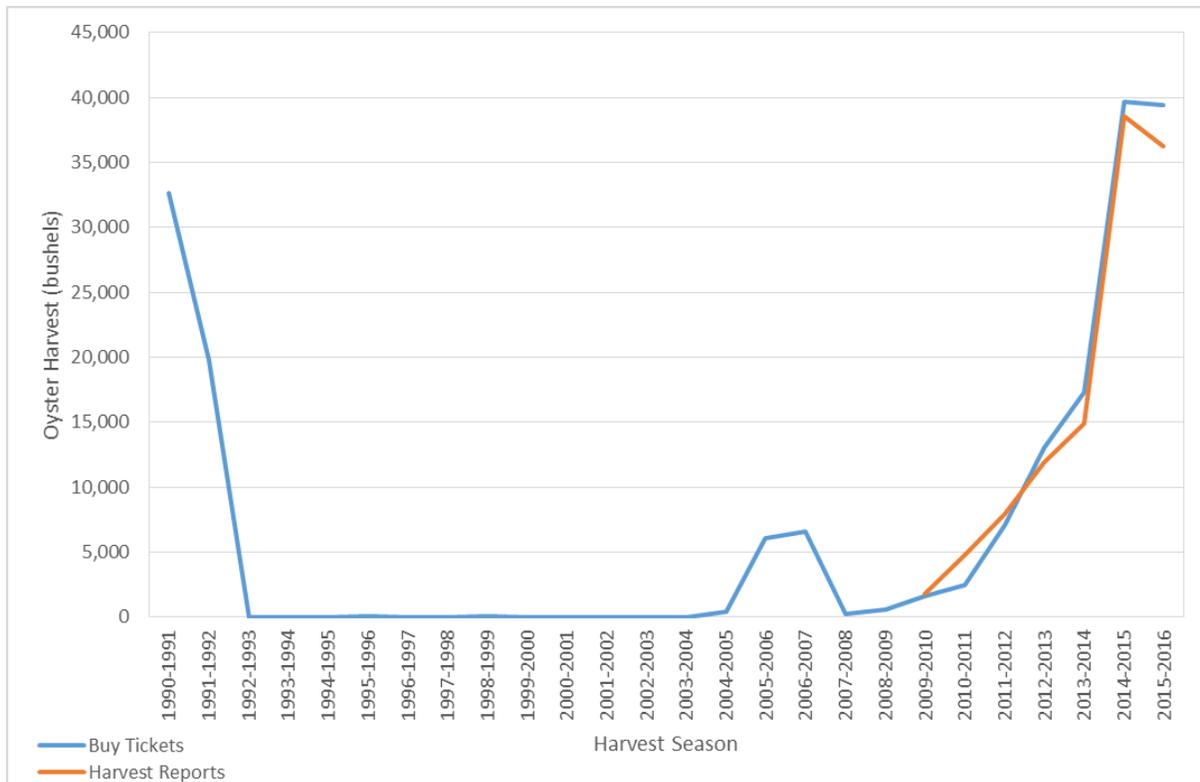


Figure B.25-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 168 (Patuxent River Lower). After the 2009-2010 season, 11% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.26: NOAA Code 174 – St. Clements and Breton Bay

NOAA Code 174 encompasses St. Clements and Breton Bays, tributaries of the Potomac River, located in Maryland’s lower western portion of Chesapeake Bay (Figure B.37-1). The entire NOAA Code is 7,045 acres and has 23 historic oyster bars²⁹. The Breton Bay Sanctuary encompasses 46% (3,212 acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 3,833 acres. There are 1,496 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside the sanctuary. None of the area within the NOAA Code was designated as a Public Shellfish Fishery Area in 2010 prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s low salinity zone.

Replenishment Activities

Since 1990, approximately 13,700 bushels of wild seed have been planted in NOAA Code 174 outside of the current sanctuary area (Table B.26-1). No shell or hatchery spat-on-shell has been planted since 1990.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1991	Wild Seed	4.3	3.2	-
1995	Wild Seed	7.1	4.7	-
1996	Wild Seed	1.7	3.0	-
1997	Wild Seed	1.1	1.3	-
1998	Wild Seed	3.2	1.5	-

²⁹ See chart 34 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

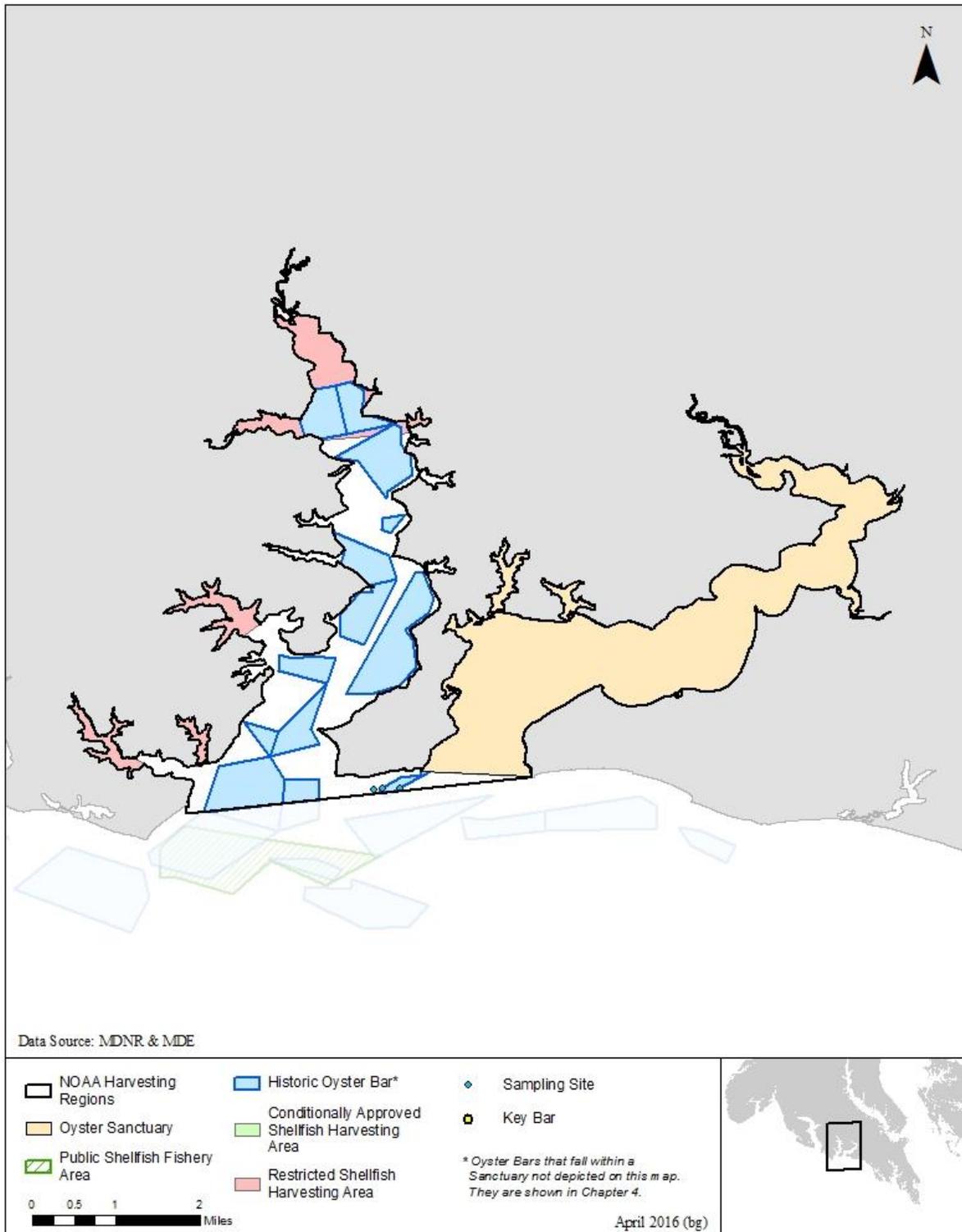


Figure B.26 -1. Map of NOAA Code 174 (St. Clements and Breton Bay).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled 1 to 2 oyster bars annually in NOAA Code 174 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 0 to 380 per bushel with an average of 65 (Figure B.26-2). The number of oysters decreased after 1999 and remained low until 2013. Most of the increase is due to the large number of small oysters in 2013. Years 2013 and 2015 had the highest number of market-sized oysters during the 26 year time period. The average number of total live oysters was slightly greater from 2010 to 2015 than prior to 2010 (Table B.26-2).

Table B.26-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 174 (St. Clements and Breton Bay). Values are given as mean \pm standard error.

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 39	6 / 6
Number of Live Oysters per Bushel	58 \pm 12	91 \pm 62
Number of Live Small-Sized Oysters per Bushel	35 \pm 10	63 \pm 53
Number of Live Market-Sized Oysters per Bushel	21 \pm 3	28 \pm 15
Live Oyster Biomass (g Dry Weight per Bushel)	86 \pm 10	98 \pm 46
Mortality (%)	31.4 \pm 5.4	12.8 \pm 7.9

Oyster Size Structure

The Fall Survey assessed oyster shell heights from 1990 to 1997 and then from 2013 to 2015 on Blue Sow bar within NOAA Code 174 (Figure B.26-3). The percentage of oysters greater than 100 mm was 11% for 1990-1997 and 19% for 2013-2015.

Biomass

The Fall Survey measured oyster biomass on Blue Sow bar within NOAA Code 174 from 1990 to 1997 and from 2013-2015. The annual biomass ranged from 25 to 183 grams of dry weight per bushel and the average was 89.6 \pm 13 (mean \pm SE; Figure B.26-4). The average biomass was similar from 1990 to 1997 than for 2012-2015 (Table B.05-2).

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 0 to 12 spat per bushel (Figure B.26-2), averaging 1 per bushel. There were no spat collected from 2010 to 2015.

Mortality

Mortality ranged from 0% to 80%; since 2006 mortality has been relatively low (Figure B.26-5), with the exception of 2012. The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.37-2).

Disease

The Fall Survey has not collected any information on oyster disease since 1990.

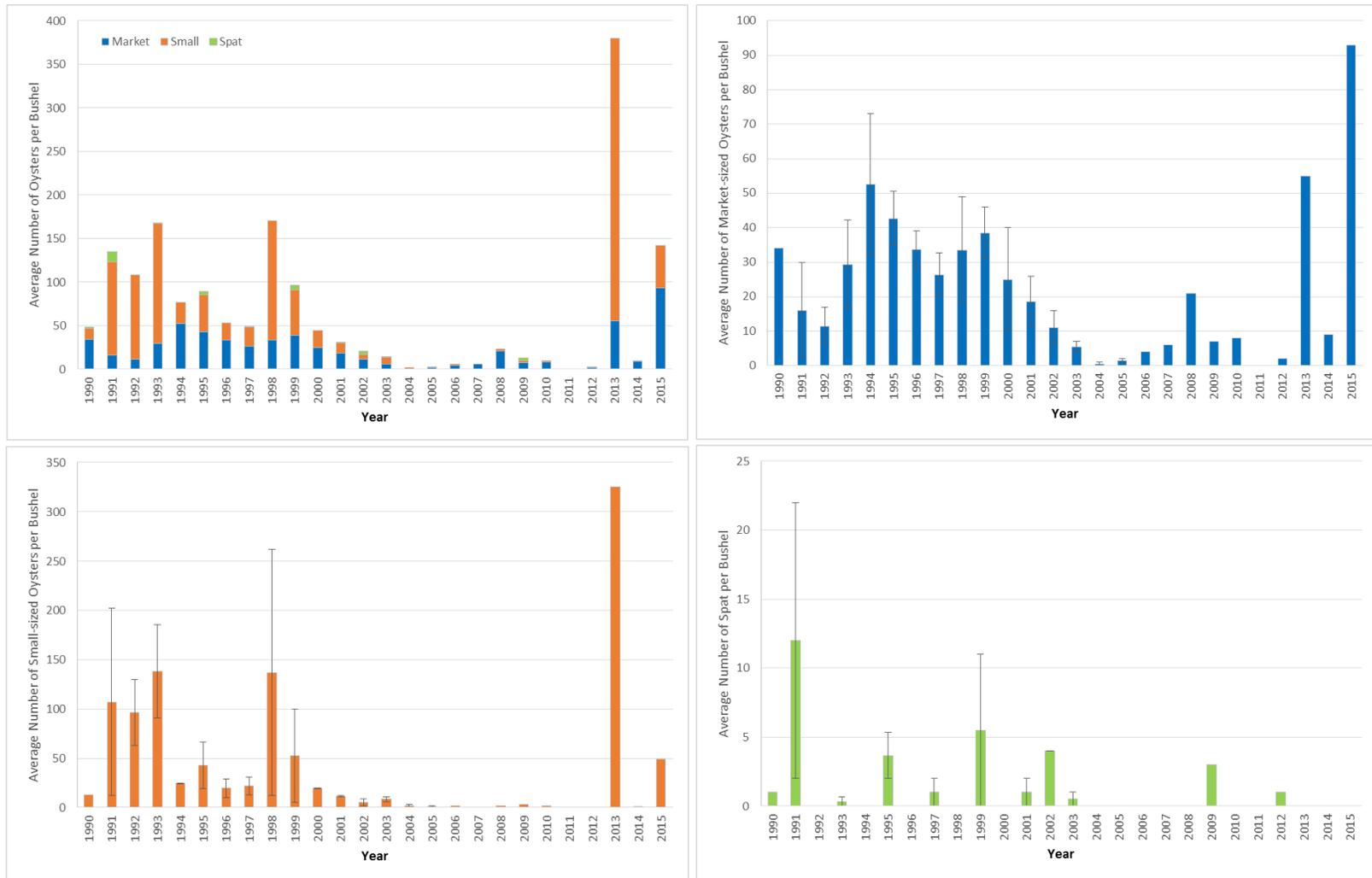


Figure B.26-2. Average number of live oysters per bushel of material by size class in the NOAA Code 174 (St. Clements and Breton Bay). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

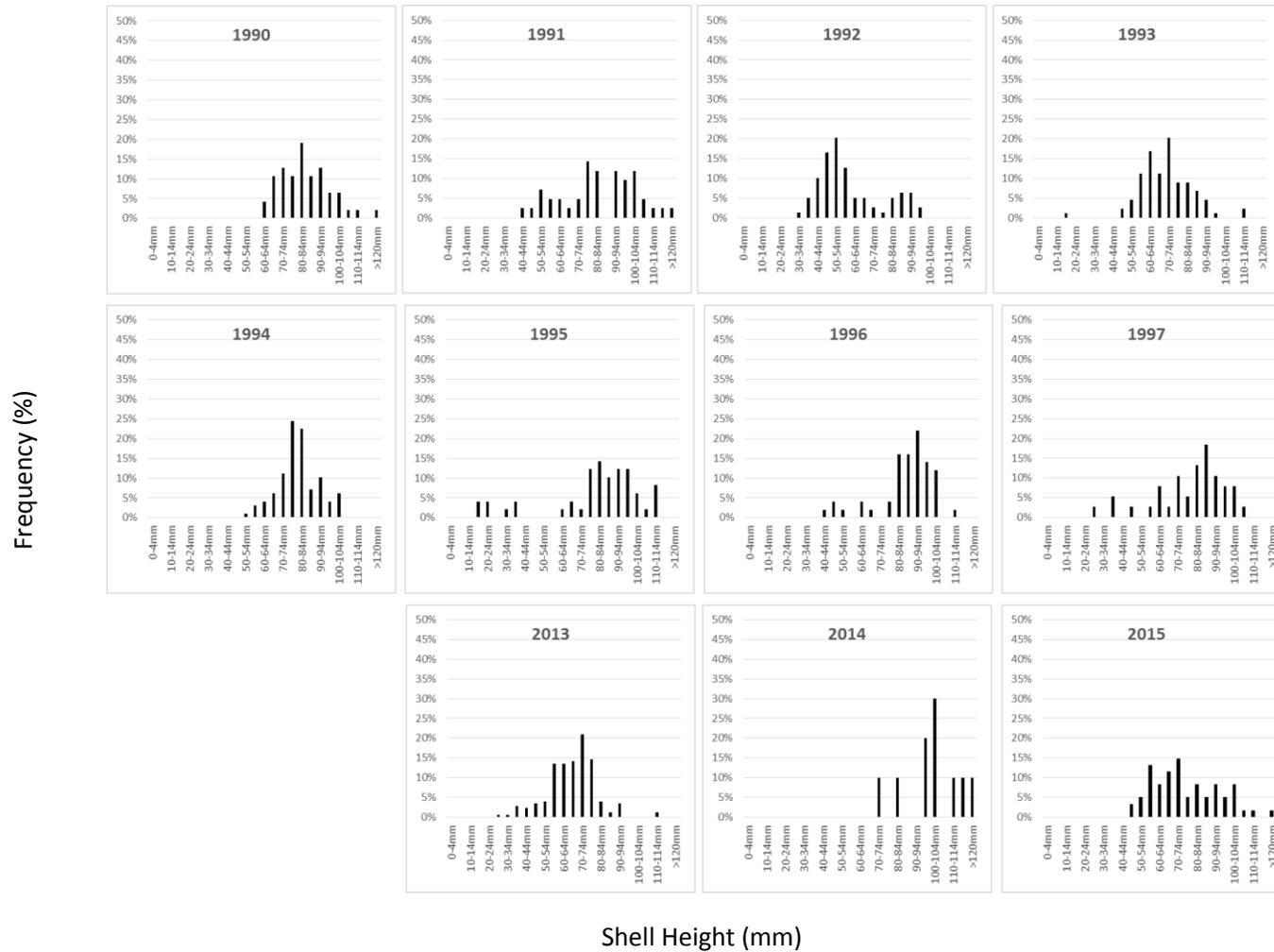


Figure B.26-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 174 (St. Clements and Breton Bay). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster shell heights were not recorded from 1998 to 2012.

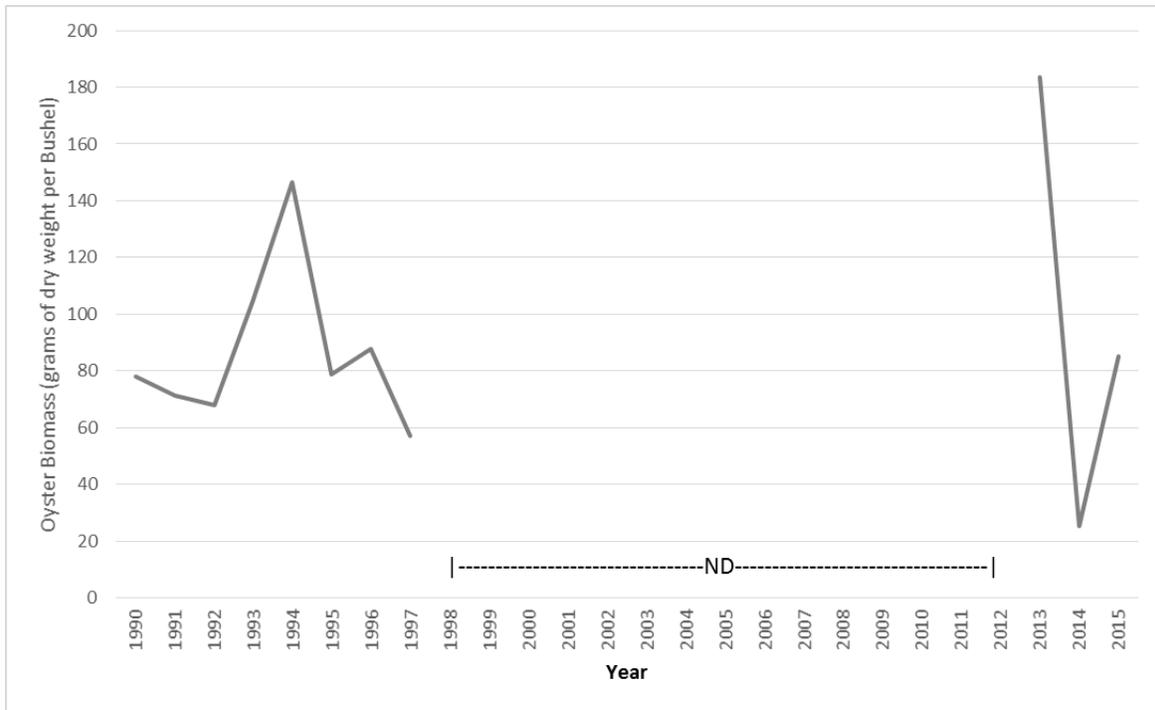


Figure B.26-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 174 (St. Clements and Breton Bay). Data from Maryland’s Annual Fall Oyster Dredge Survey. ND = No Data.

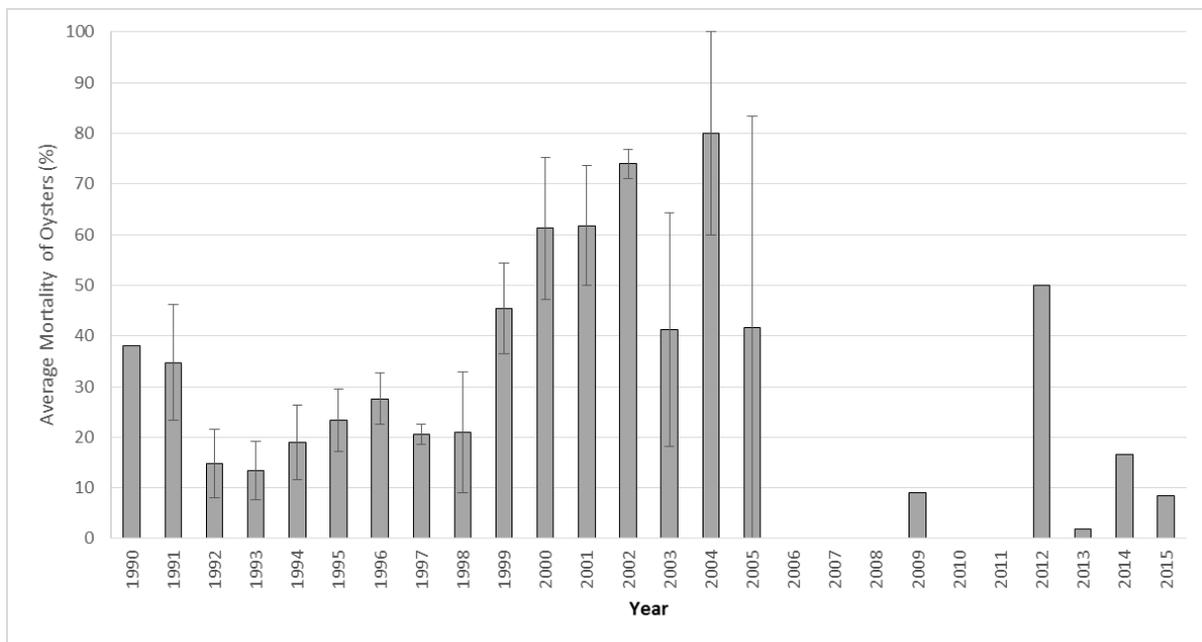


Figure B.26-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 174 (St. Clements and Breton Bay). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

Harvest

Harvest for the entire NOAA Code 174 since 1990 is presented in Figure B.26-6. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 46% of the NOAA Code area was a sanctuary where harvest is prohibited. Very little harvest has been obtained from this NOAA Code with the maximum harvest occurring in 1998-1999 season of approximately 350 bushels. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Hand tonging accounts for majority of the harvest based on the oyster harvester reports.

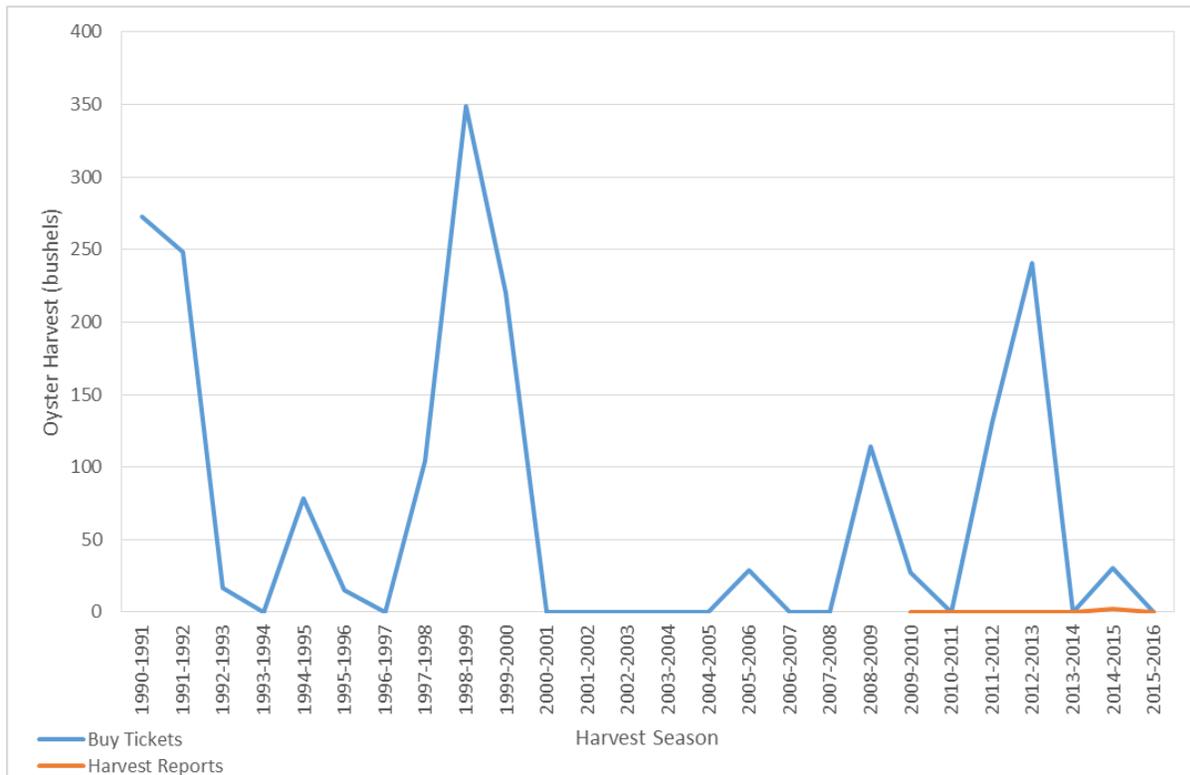


Figure B.26-6. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 174 (St. Clements and Breton Bay). After the 2009-2010 season, 46% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.27: NOAA Code 192 – Tangier Sound South

NOAA Code 192 encompasses the southern portion of Tangier Sound and is located in Maryland’s lower eastern portion of Chesapeake Bay (Figure B.27-1). The entire NOAA Code is 90,266 acres and has 75 historic oyster bars³⁰. There are two sanctuaries within the NOAA Code and they encompass 6% (5,755 acres) of the NOAA Code (Lower Mainstem and Somerset Sanctuaries). With the exception of harvest information, this section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 84,511 acres. There are 37,269 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and not within a sanctuary. In 2010, 29,434 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s high salinity zone.

Replenishment Activities

Since 1990, approximately 12 million bushels of shell, 187,000 bushels of wild seed and 45 million hatchery spat-on-shell have been planted in NOAA Code 192 outside of the current sanctuary area (Table B.27-1).

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Dredged Shell	66.3	487.8	-
1990	Fresh Shell	11.2	41.4	-
1991	Fresh Shell	9.5	30.0	-
1992	Dredged Shell	6.4	40.8	-
1992	Fresh Shell	5.4	36.3	-
1993	Dredged Shell	43.9	631.1	-
1994	Dredged Shell	66.5	617.9	-
1995	Dredged Shell	47.5	325.9	-
1995	Fresh Shell	15.9	51.1	-
1996	Dredged Shell	98.9	1649.9	-
1996	Fresh Shell	50.6	186.8	-
1997	Dredged Shell	130.1	1399.3	-
1997	Fresh Shell	9.8	58.5	-
1998	Dredged Shell	136.1	570.8	-

³⁰ See charts 43, 46, and 47 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

Table B.27-1. Continued				
Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1999	Dredged Shell	65.4	435.1	-
1999	Fresh Shell	16.3	81.8	-
1999	Wild Seed	106.3	ND	-
1999	Wild Seed	8.0	7.8	-
2000	Dredged Shell	113.1	761.8	-
2001	Dredged Shell	45.2	272.6	-
2002	Dredged Shell	97.5	702.1	-
2002	Wild Seed	10.6	ND	-
2002	Wild Seed	14.7	120.2	-
2003	Dredged Shell	96.7	1022.3	-
2003	Fresh Shell	12.7	48.0	-
2003	Wild Seed	67.2	ND	-
2004	Dredged Shell	145.7	1407.8	-
2004	Fresh Shell	25.3	88.6	-
2005	Dredged Shell	76.4	506.8	-
2006	Dredged Shell	110.1	690.5	-
2008	Hatchery Spat-on-Shell	5.2	-	4.5
2008	Wild Seed	11.1	8.3	-
2009	Wild Seed	29.0	51.2	-
2012	Dredged Shell	157.3	125.0	-
2012	Dredged Shell	157.6	ND	-
2013	Fresh Shell	5.6	13.4	-
2013	Hatchery Spat-on-Shell	6.4	-	14.9
2014	Hatchery Spat-on-Shell	3.9	-	26.0
2015	Fresh Shell	16.9	27.3	-

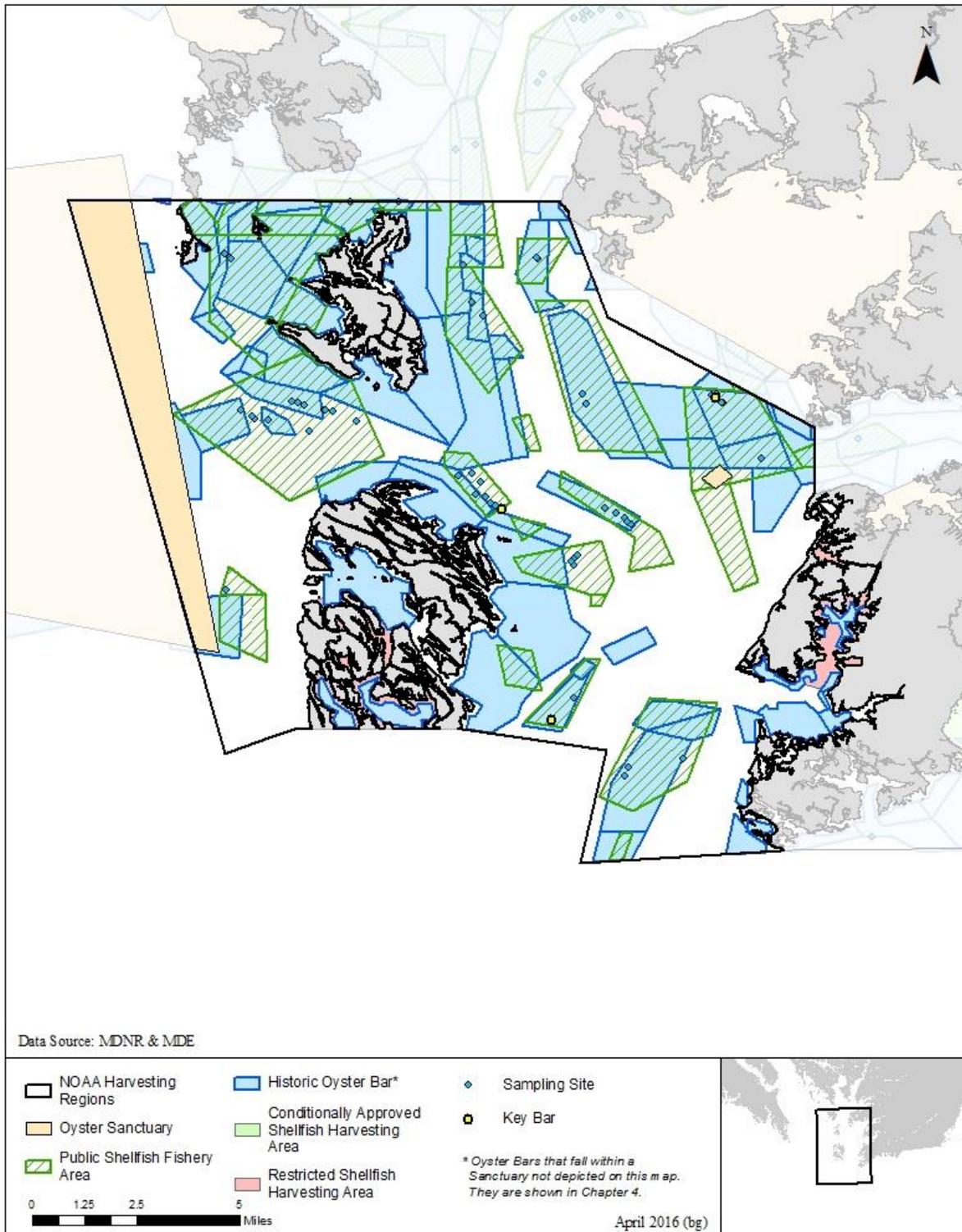


Figure B.27 -1. Map of NOAA Code 192 (Tangier Sound South).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled 10 to 22 oyster bars annually in NOAA Code 192 outside of the current sanctuary area. Because of differences in some oyster population characteristics between bars in the east and west parts of the NOAA Code, each area will be considered separately in this and the following sections. The western part of NOAA Code 192 includes those samples taken west of South Marsh Island and Smith Island and within Holland Straits. The eastern part of NOAA Code 192 consists of samples taken closer to the eastern shore.

For the western area, the average number of live oysters (market, small, and spat) ranged from 103 to 938 per bushel with an average of 292 (Figure B.27-2A). The years 2013 had the highest number of market-sized oysters over the 26 year time period. The average number of live oysters was similar from 2010 to 2015 than prior to 2010 (Table B.27-2A).

For the eastern area, the average number of live oysters (market, small and spat) ranged from 56 to 493 per bushel per bushel, with an average of 205 (Figure B.27-2B). The number of market-sized oysters have generally increased over the 26 year time period. The average number of total live oysters was lower from 2010 to 2015 than prior to 2015 (Table B.27-2B).

Table B.27-2A. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 192 (Tangier Sound Southwest). Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 144	6 / 6
Number of Live Oysters per Bushel	293 \pm 48	288 \pm 47
Number of Live Small-Sized Oysters per Bushel	116 \pm 22	81 \pm 24
Number of Live Market-Sized Oysters per Bushel	28 \pm 4	53 \pm 13
Live Oyster Biomass (g Dry Weight per Bushel)	109 \pm 15	159 \pm 36
Mortality (%)	30.2 \pm 3.5	25.8 \pm 11.2

Table B.27-2B. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 192 (Tangier Sound Southeast). Values are given as mean \pm standard error.

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 373	6 / 110
Number of Live Oysters per Bushel	212 \pm 24	182 \pm 27
Number of Live Small-Sized Oysters per Bushel	81 \pm 12	59 \pm 10
Number of Live Market-Sized Oysters per Bushel	17 \pm 2	29 \pm 2
Live Oyster Biomass (g Dry Weight per Bushel)	99 \pm 11	88 \pm 20
Mortality (%)	32.8 \pm 3.5	19.3 \pm 2.6

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on four bars within NOAA Code 192 (Figure B.27-3A and Figure B.27-3B). For the Holland Straits East bar (located in the western area of NOAA Code 192), oysters were larger from 1990 to 2009, with 24% larger than 80 mm, than after 2010, when 19% were larger than 80 mm. For the other three bars (Back Cove, Old Woman's Leg and Piney Island East), located in the eastern part of the NOAA Code, oysters were larger from 2010 to 2015, with 18% larger than 80 mm, than prior to 2010, when 9% were larger than 80 mm. Oysters were generally smaller on the eastern bars, with 85% less than 75 mm, compared to 72% for the western bar.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on four bars within NOAA Code 192. For the Holland Straits East bar, the annual biomass ranged from 23 to 258 grams of dry weight per bushel and the average was 120.4 \pm 14.4 (average \pm S E; Figure B.27-4A). The average biomass was greater from 2010 to 2015 than prior to 2010 (Table B.27-2A). For the three eastern bars, biomass ranged from 28 to 155 grams of dry weight per bushel and the average was 96.2 \pm 9.2 (average \pm S E; Figure B.27-4B). The average biomass was lower from 2010 to 2015 than prior to 2010 (Table B.27-2B).

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall on western part of Tangier Sound South ranged from 3 to 863 spat per bushel, averaging 150 (Figure B.27-2A). The largest spatfall occurred in 1990. For the bars on the eastern part of Tangier Sound South, spatfall ranged from 16 to 438 per bushel, averaging 110 (Figure B.27-2B). The largest spatfall occurred in 2006.

Mortality

On western part of Tangier Sound South, mortality ranged from 5% to 76%. Since 2006 mortality has been relatively low, with the exception of 2015 (Figure B.27-5A). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.27-2A). For the bars on the eastern part of Tangier Sound South, mortality ranged from 11% to 67% (Figure B.27-5B). Mortality has decreased generally since 2006. Mortality was lower from 2010 to 2015 than prior to 2010.

Disease

On Holland Straits East bar, dermo prevalence ranged from 30% to 100% (Figure B.27-6A). Dermo prevalence was greater than 80% during 13 of the 26 years disease information was collected. Dermo intensity ranged from 0.7 to 4.2, remaining below lethal infection levels (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 73%, with an extended period of prevalence from 1999 to 2002. For the eastern bars, dermo prevalence ranged from 60% to 100% (Figure B.27-6B). Dermo prevalence exceeded 80% for 17 of the 26 years data was collected. Dermo intensity ranged from 1.7 to 4.3, remaining below lethal infection levels. MSX prevalence ranged from 1% to 43%, with an extended period of prevalence from 1998 to 2002.

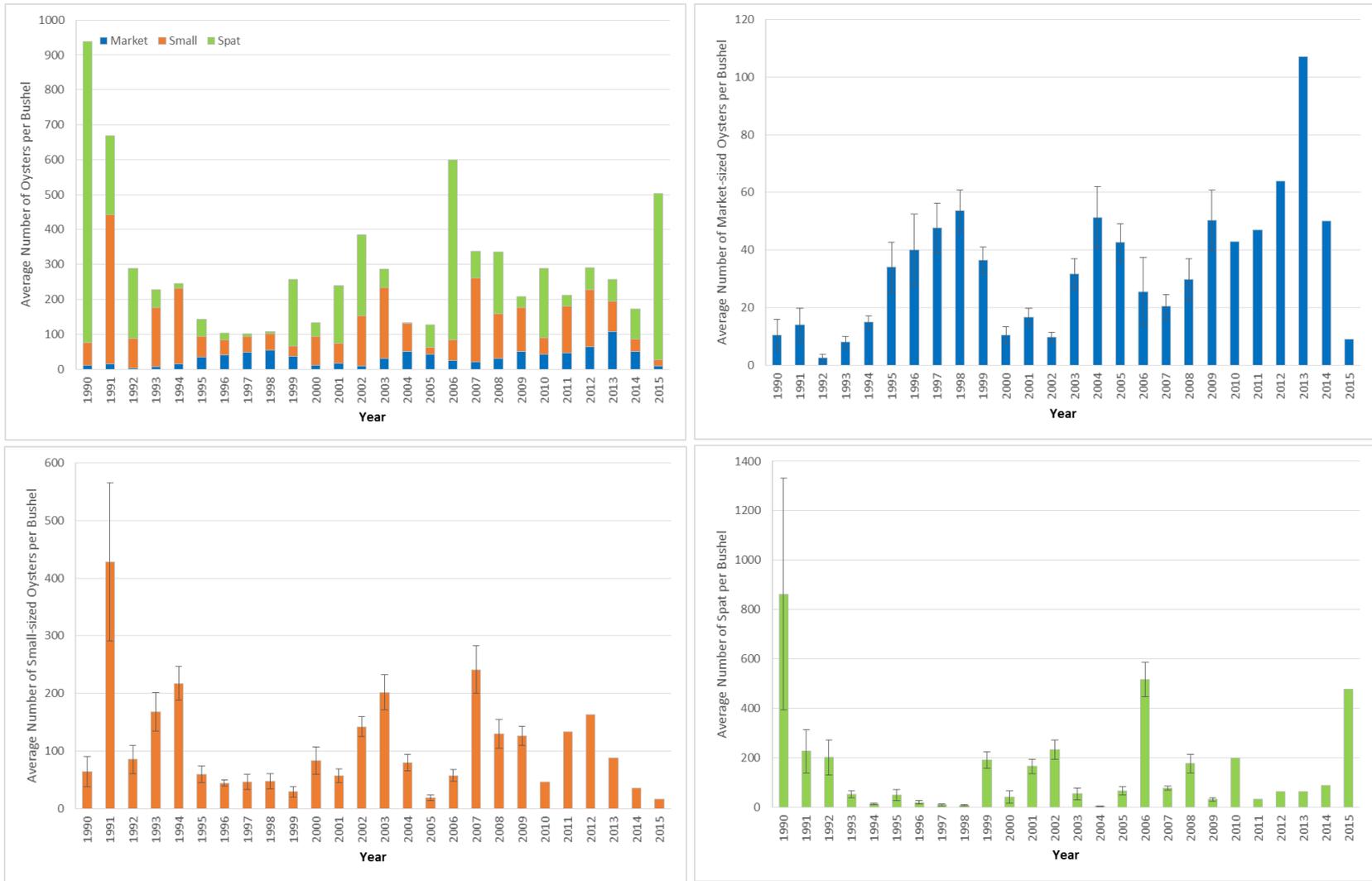


Figure B.27-2A. Average number of live oysters per bushel of material by size class in the western part of NOAA Code 192 (Tangier Sound South). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

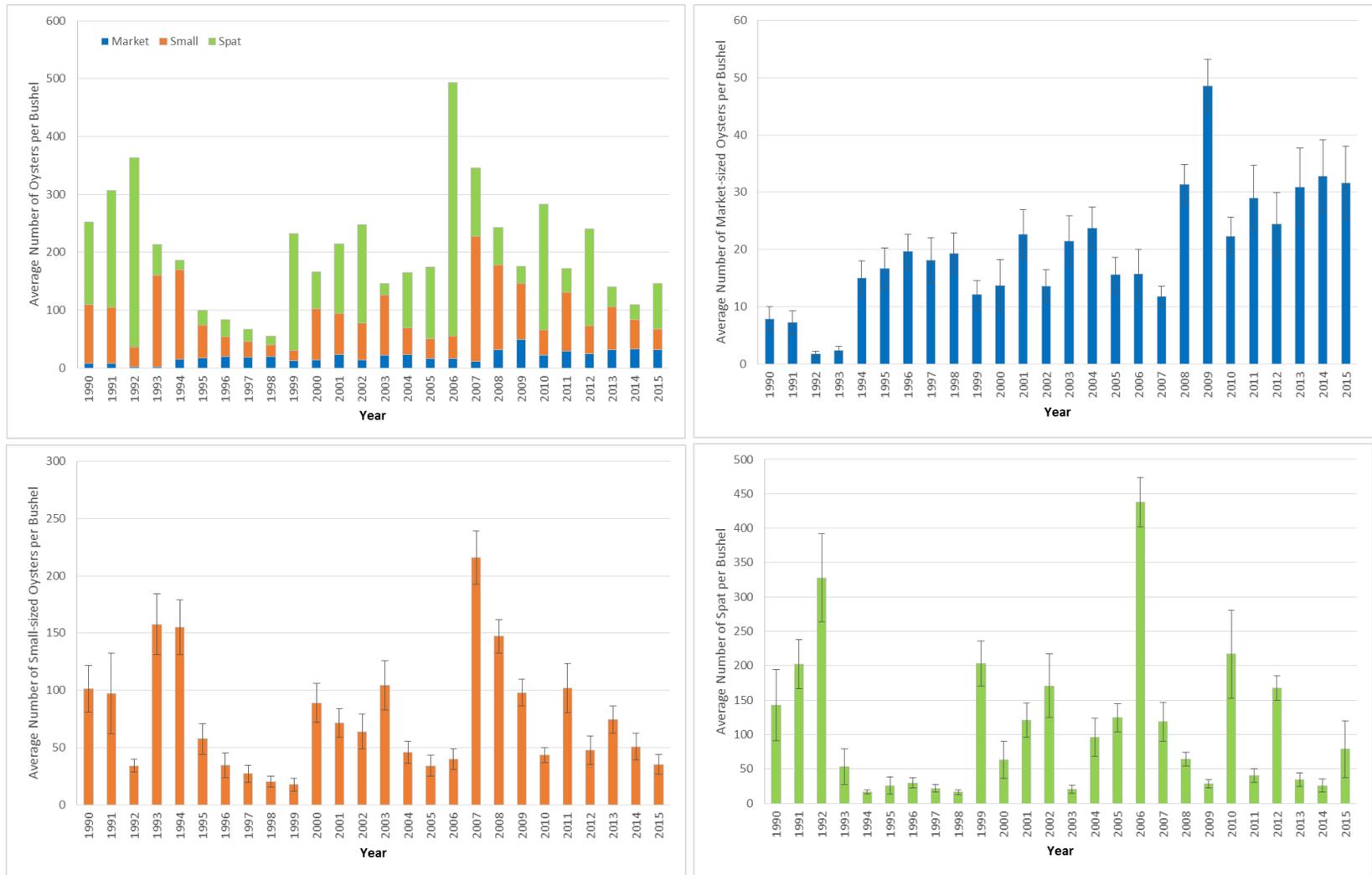
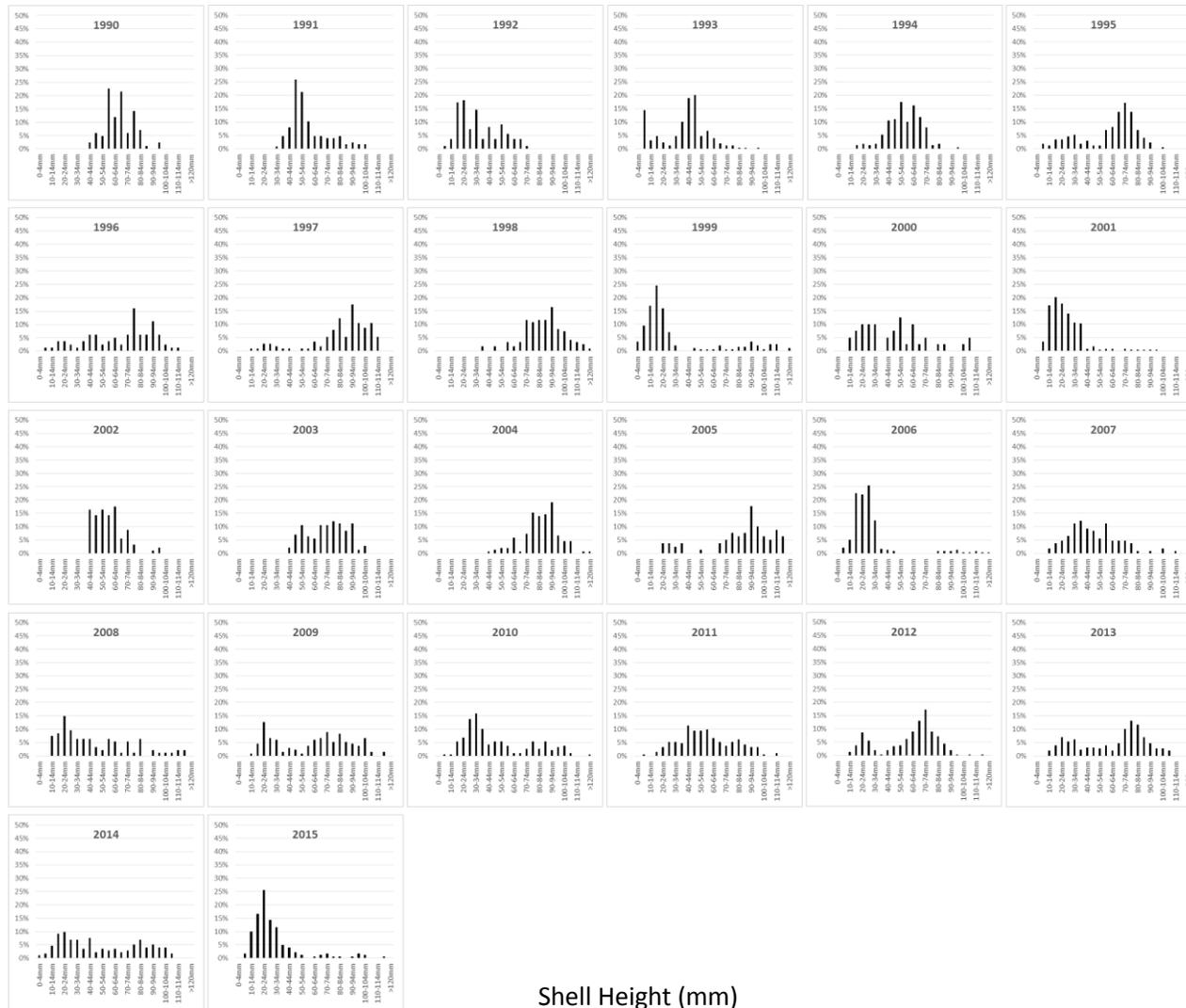


Figure B.27-2B. Average number of live oysters per bushel of material by size class in the eastern part of NOAA Code 192 (Tangier Sound South). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

Frequency (%)



Shell Height (mm)

Figure B.27-3A. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the western part of NOAA Code 192 (Tangier Sound South). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

Frequency (%)

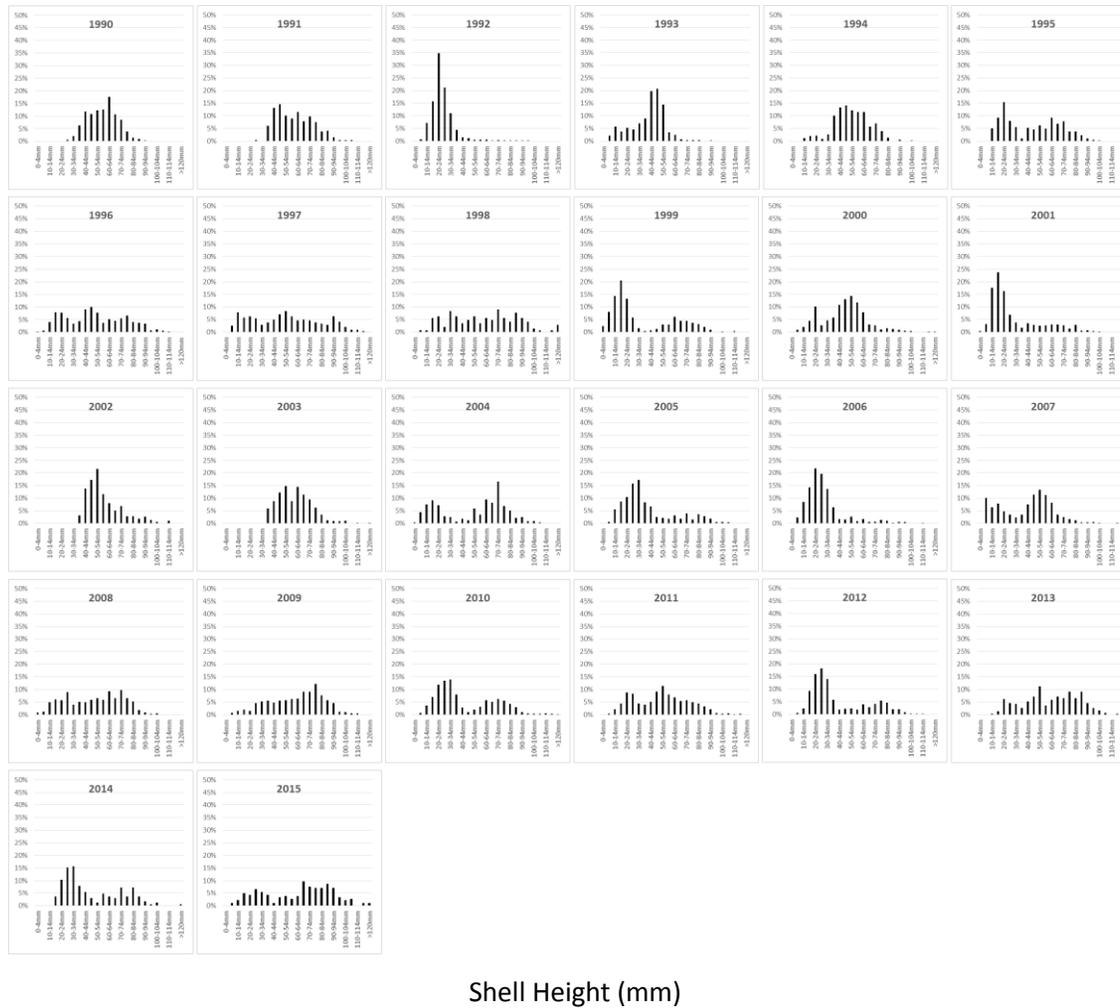


Figure B.27-3B. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the eastern part of NOAA Code 192 (Tangier Sound South). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

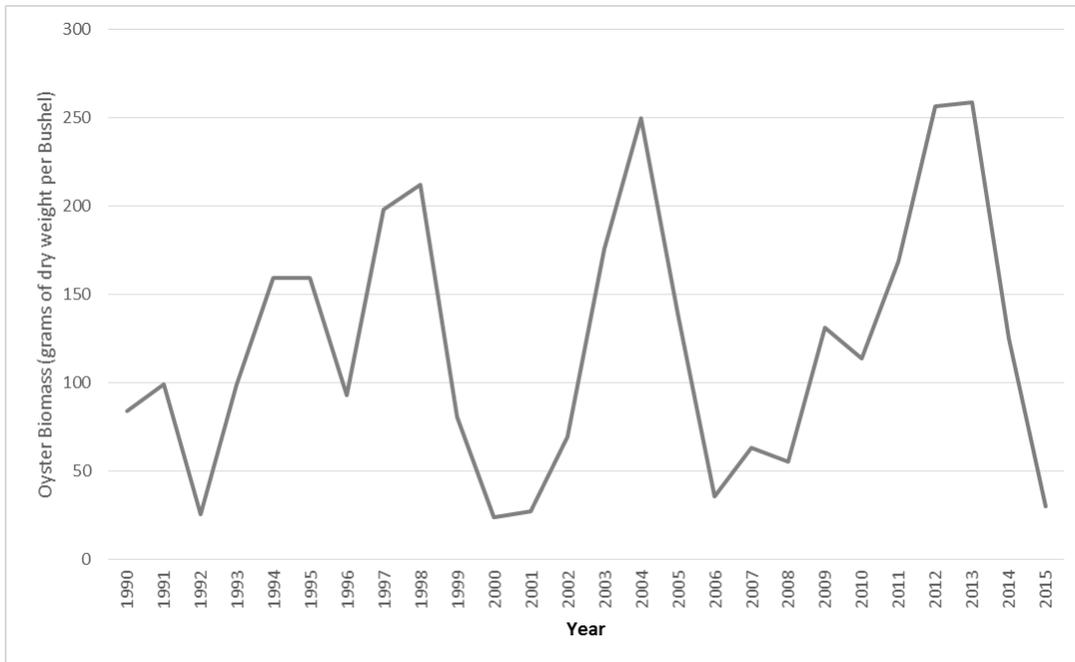


Figure B.27-4A. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the western part of NOAA Code 192 (Tangier Sound South). Data from Maryland’s Annual Fall Oyster Dredge Survey.

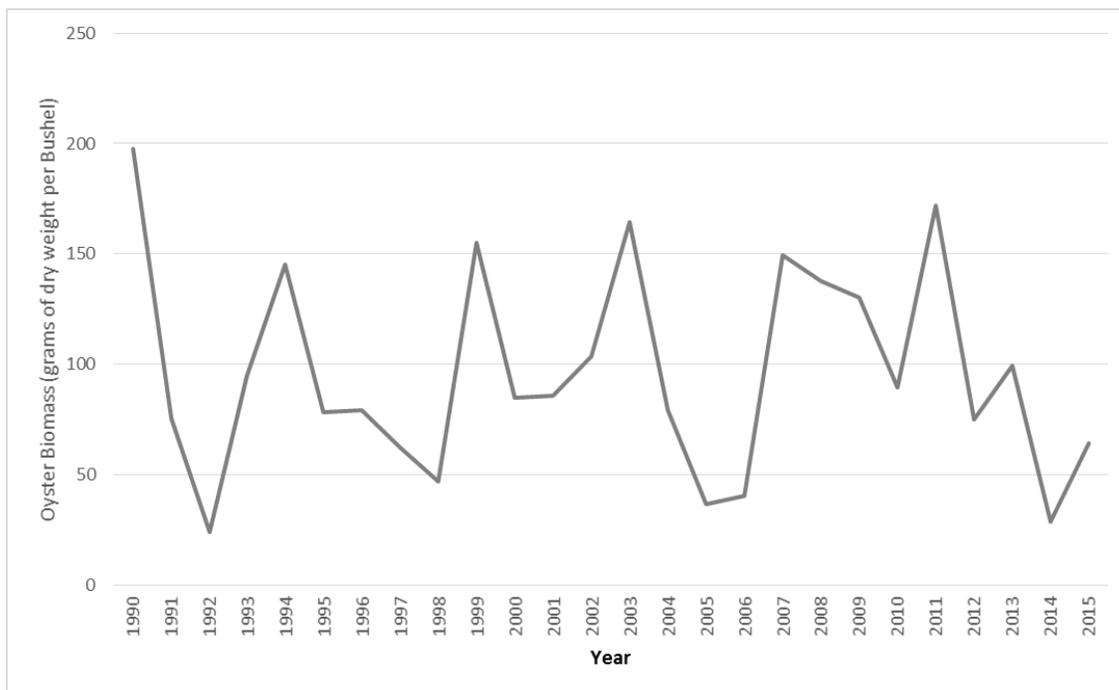


Figure B.27-4B. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the eastern part of NOAA Code 192 (Tangier Sound South). Data from Maryland’s Annual Fall Oyster Dredge Survey.

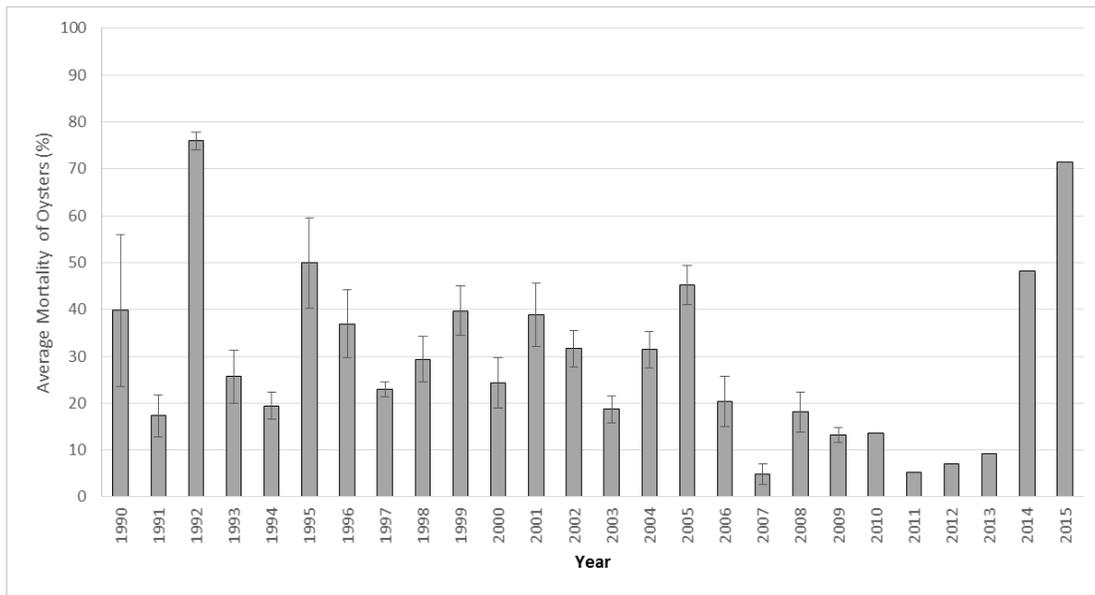


Figure B.27-5A. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in the western part of NOAA Code 192 (Tangier Sound South). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

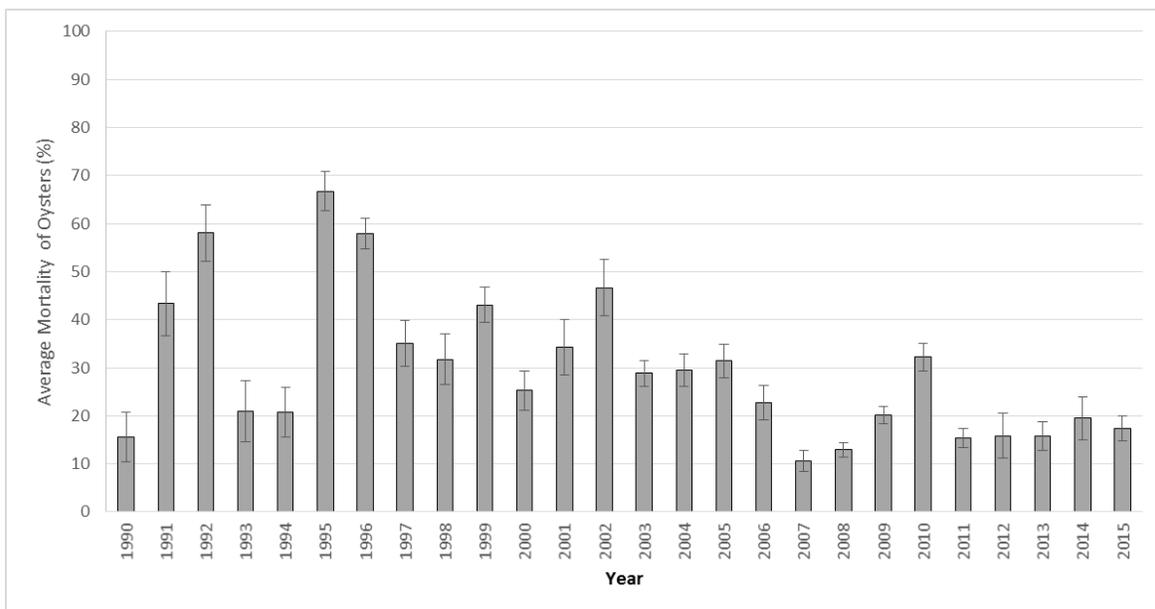


Figure B.27-5B. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in the eastern part of NOAA Code 192 (Tangier Sound South). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

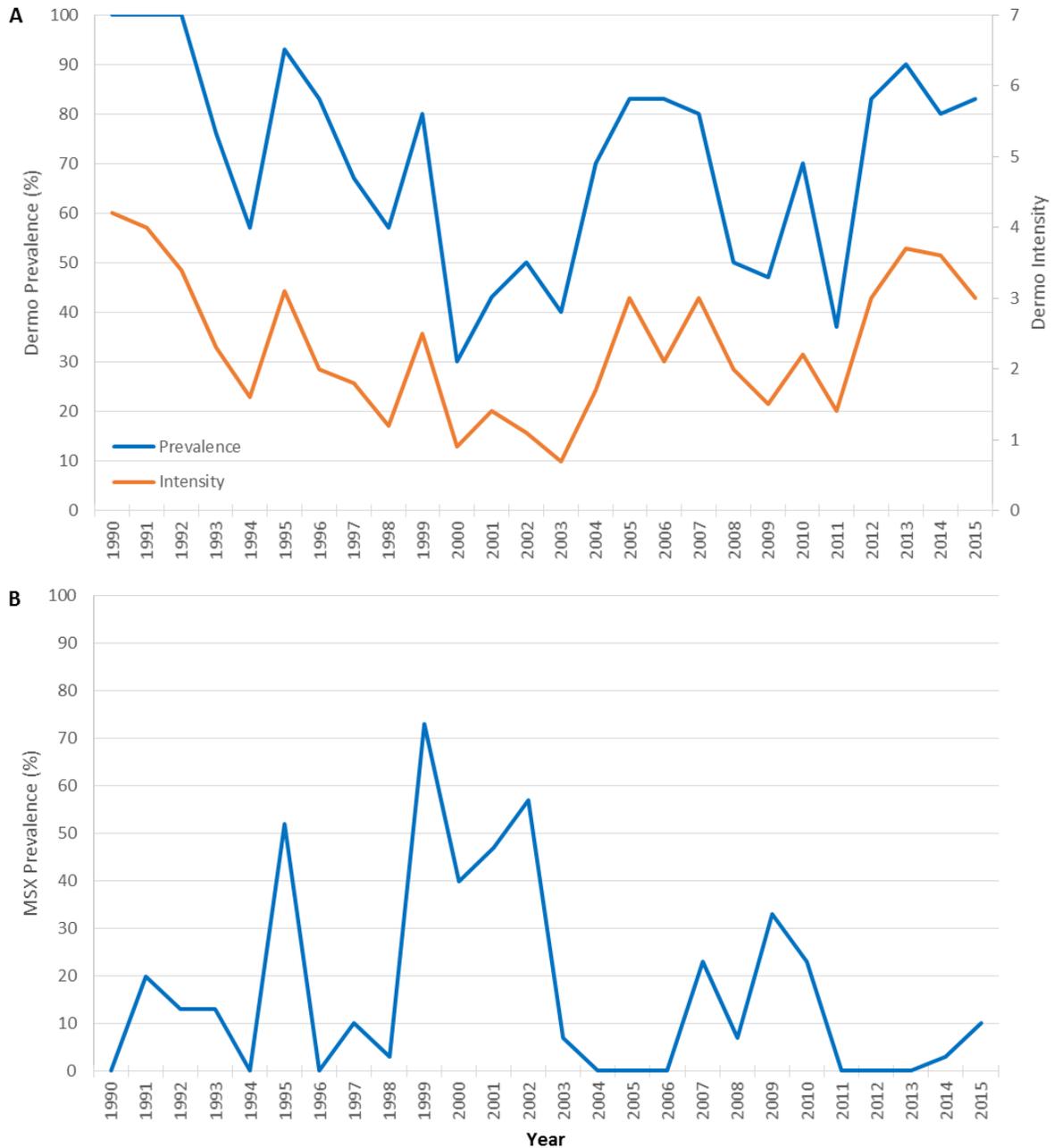


Figure B.27-6A. Oyster disease prevalence and intensity from 1990 to 2015 in the western part of NOAA Code 192 (Tangier Sound South). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland’s Annual Fall Oyster Dredge Survey.

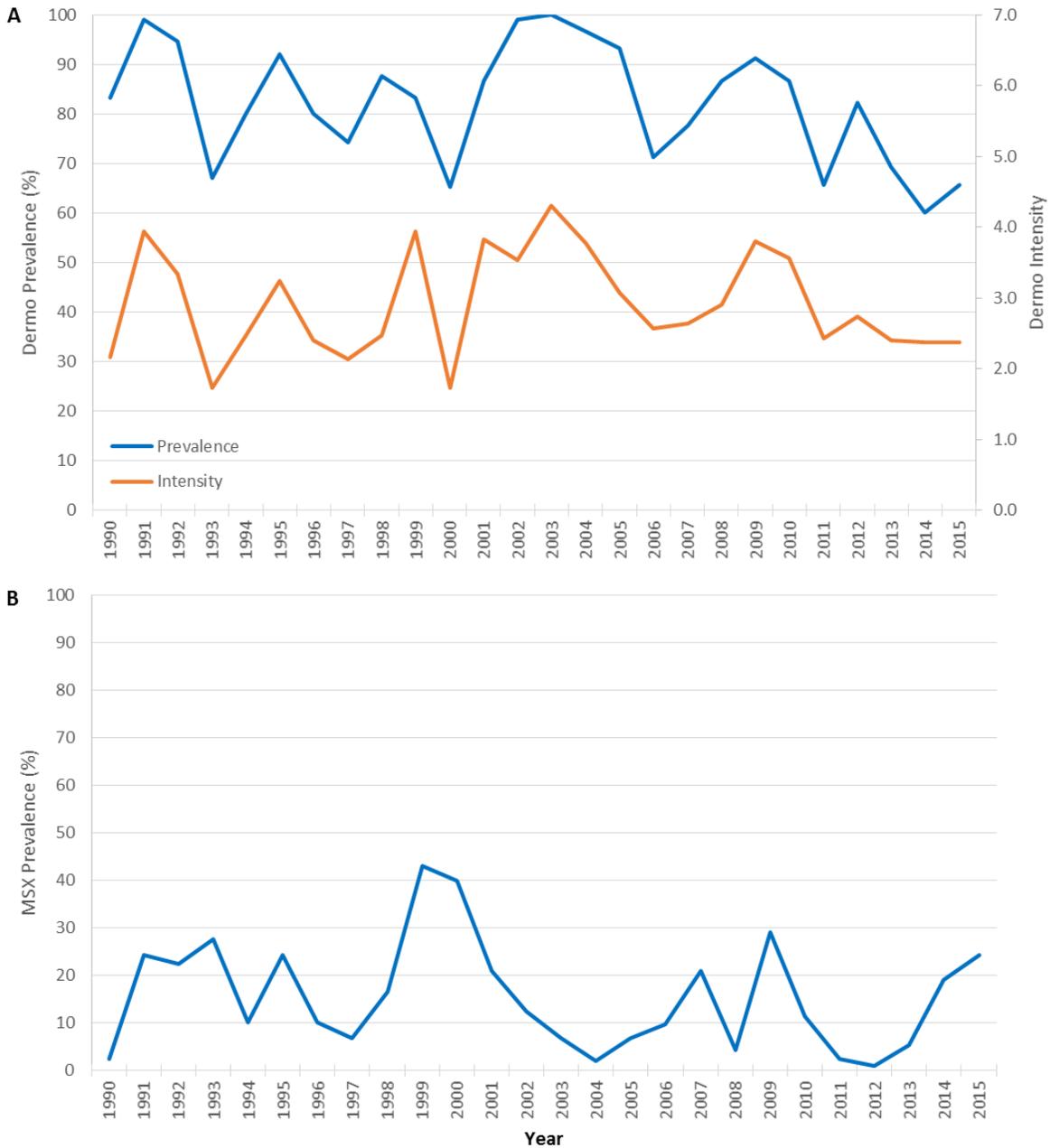


Figure B.27-6B. Oyster disease prevalence and intensity from 1990 to 2015 in the eastern part of NOAA Code 192 (Tangier Sound South). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland’s Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 192 (Tangier Sound South) since 1990 is presented in Figure B.27-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 6% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets ranged from no harvest in 1993-1994 to a maximum of approximately 45,600 bushels in the 2013-2014 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Approximately 64% of harvest in this area as reported on the oyster harvest reports was obtained by power dredging. Harvest is also obtained by patent tonging and sail dredge (approximately 21% and 13%, respectively).

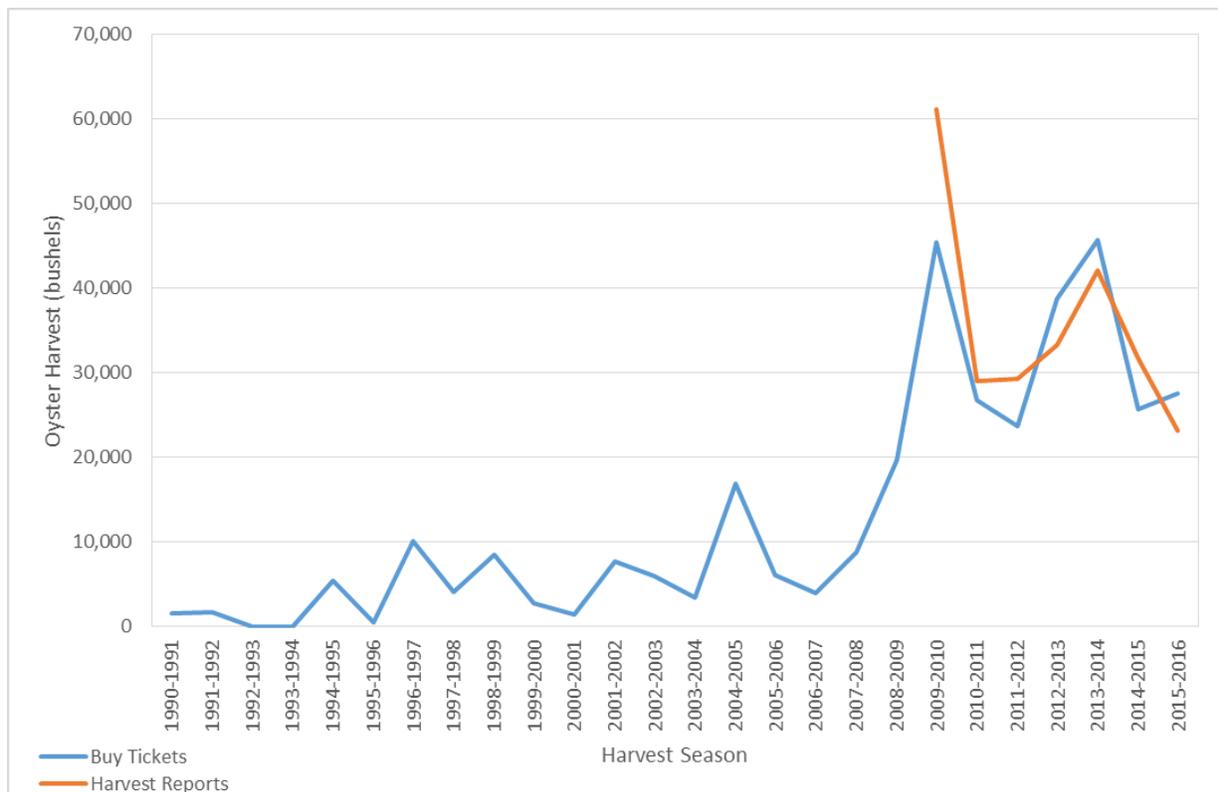


Figure B.27-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 192 (Tangier Sound South). After the 2009-2010 season, 6% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.28: NOAA Code 229 – Lower West Chesapeake Bay

NOAA Code 229 is located in Maryland’s lower western portion of Chesapeake Bay, south of Cove Point and west of the ship channel (Figure B.28-1). The entire NOAA Code is 105,377 acres and has 28 historic oyster bars³¹. Two sanctuaries, both established in 2010, encompass 4% (3,976 total acres) of the NOAA Code (Point Lookout Sanctuary and Cedar Point Sanctuary). This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 101,401 acres. There are 20,262 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010, 6,800 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s medium salinity zone.

Replenishment Activities

Since 1990, approximately 1.8 million bushels of shell and 6,800 bushels of wild seed have been planted in NOAA Code 229 outside of the current sanctuary area (Table B.28-1). No hatchery spat-on-shell has been planted since 1990.

³¹ See chart 35 and 40 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

Table B.28-1. Replenishment planting activities occurring since 1990 in NOAA Code 229 (Lower West Chesapeake Bay). ND = No Data.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1991	Dredged Shell	23.9	151.6	-
1992	Dredged Shell	25.1	159.2	-
1993	Dredged Shell	31.2	229.8	-
1998	Dredged Shell	31.1	51.5	-
1999	Dredged Shell	9.7	ND	-
1999	Wild Seed	113.9	ND	-
2001	Dredged Shell	10.4	489.2	-
2002	Dredged Shell	16.9	130.3	-
2004	Dredged Shell	42.4	441.2	-
2005	Dredged Shell	29.8	190.1	-
2011	Fresh Shell	11.6	10.1	-
2012	Dredged Shell	3.4	ND	-
2012	Wild Seed	6.3	ND	-
2013	Fresh Shell	12.6	11.0	-
2013	Wild Seed	22.8	4.0	-
2014	Fresh Shell	36.9	15.4	-
2014	Wild Seed	39.9	2.8	-
2015	Fresh Shell	32.1	20.2	-

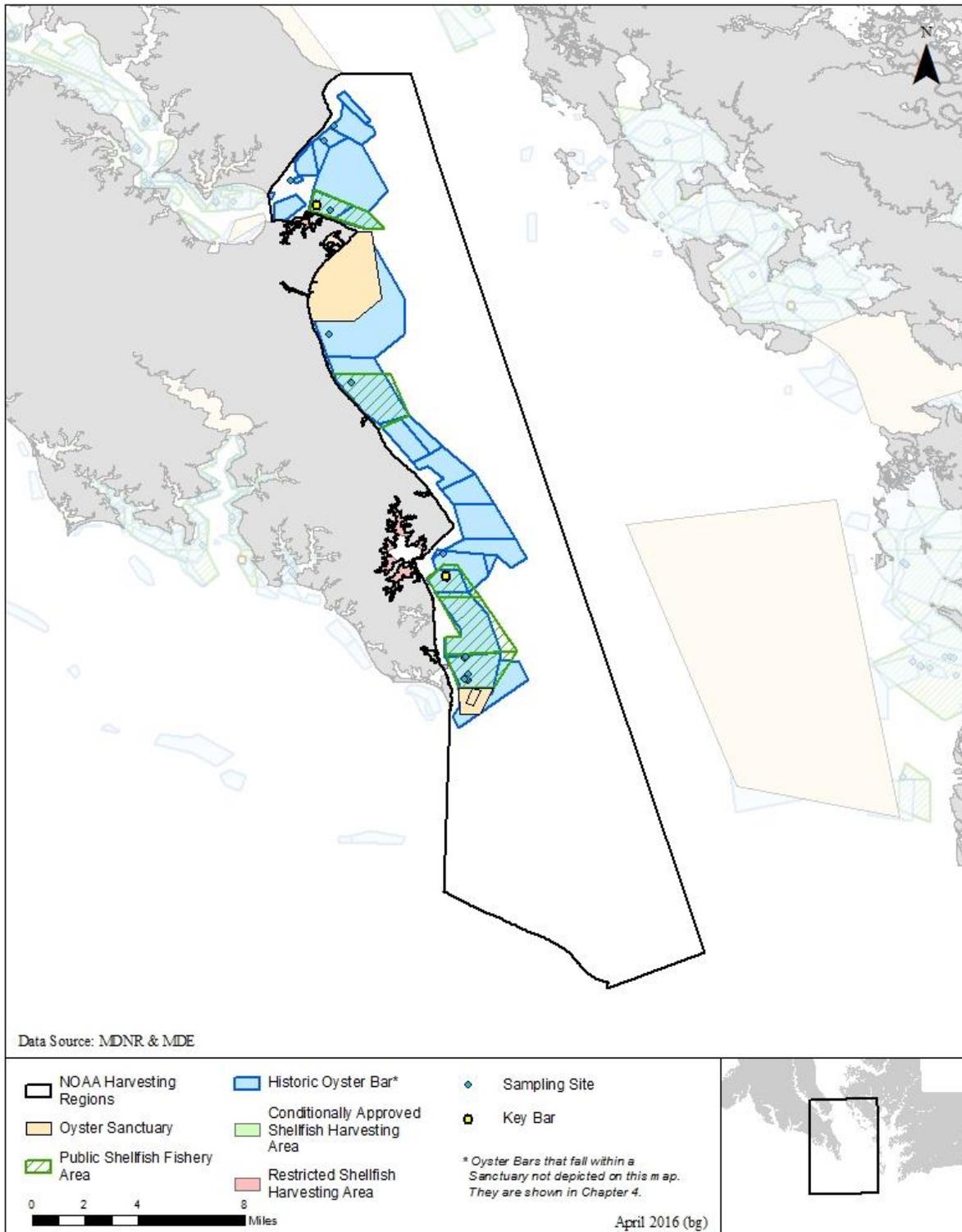


Figure B.28 -1. Map of NOAA Code 229 (Lower West Chesapeake Bay).

Oyster Population Characteristics

The Fall Survey has sampled 5 to 9 oyster bars annually in NOAA Code 229 outside of the current sanctuary area since 1990. The average number of total live oysters (market, small, and spat) ranged from 22 to 439 per bushel with an average of 88 (Figure B.8-2). Years 2013 and 2014 had the highest number of market-sized oysters during the 26 year time period. The average number of live oysters was slightly greater from 2010 to 2015 than prior to 2010 (Table B.28-2).

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 193	6 / 42
Number of Live Oysters per Bushel	84 ± 20	103 ± 14
Number of Live Small-Sized Oysters per Bushel	35 ± 7	34 ± 5
Number of Live Market-Sized Oysters per Bushel	24 ± 3	50 ± 9
Live Oyster Biomass (g Dry Weight per Bushel)	69 ± 12	106 ± 17
Mortality (%)	29.3 ± 4.6	10.4 ± 2.9

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on two bars within NOAA Code 229 (Butler and Hog Island; Figure B.28-3). The largest oysters (greater than 120mm shell height) were collected after 2010 and accounted for 2% of the total number of oysters measured from 2010-2015. Oysters larger than 80 mm accounted for 45% of the oysters measured from 2010-2015, compared to 33% for 1990-2009.

Biomass

Since 1990, the Fall Survey has measured oyster biomass since 1990 on two bars within NOAA Code 229. The annual biomass ranged from 26 to 213 grams of dry weight per bushel and the average is 77.8 ± 10.3 (average ± SE; Figure B.28-4). The average biomass was greater from 2010 to 2015 than prior to 2010 (Table B.28-2). Biomass has increased since 2007, due to the increasing number of market-size oysters.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 0 to 360 spat per bushel from 1990 to 2015 (Figure B.28-2). The largest spatfall occurred in 1991. From 1992 to 2014, there was very little spatfall, averaging 8 per bushel.

Mortality

Mortality has ranged from 4% to 79%, however, since 2003 mortality has been relatively low (Figure B.28-5). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.28-2).

Disease

From 1990 to 2015, dermo prevalence has ranged from 30% to 99% (Figure B.28-6). Dermo prevalence was greater than 80% for 11 of the 26 years disease information was collected. Dermo intensity ranged from 0.8 to 4.4, only reaching lethal levels (scale of 0 to 7 with values higher than 5 indicating lethal infections) on Hog Island bar in 1999. MSX prevalence ranged from 0% to 47% from 1990 to 2015. In 1999 to 2002, there was an extended period of MSX prevalence.

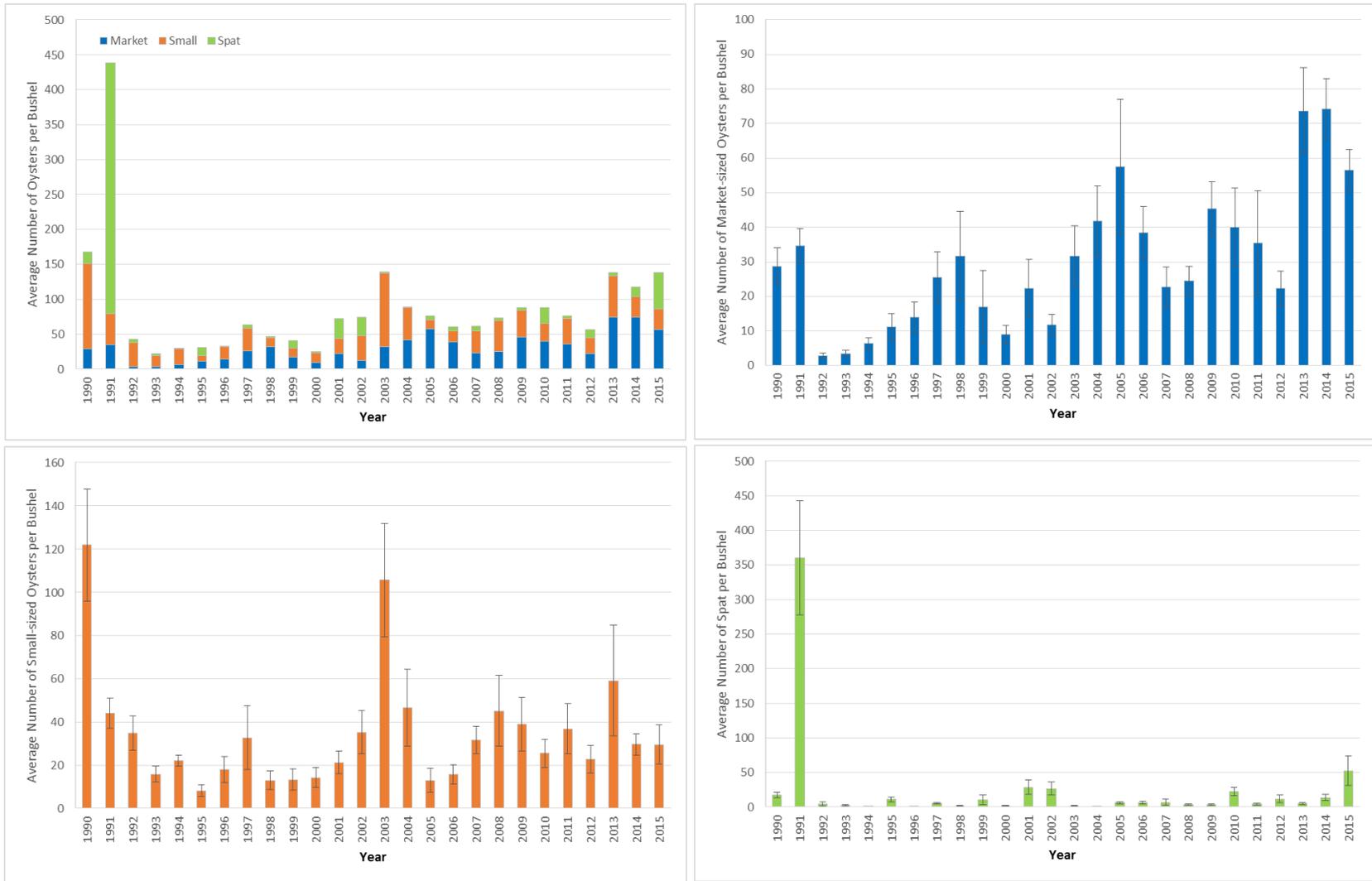


Figure B.28-2. Average number of live oysters per bushel of material by size class in the NOAA Code 229 (Lower West Chesapeake Bay). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

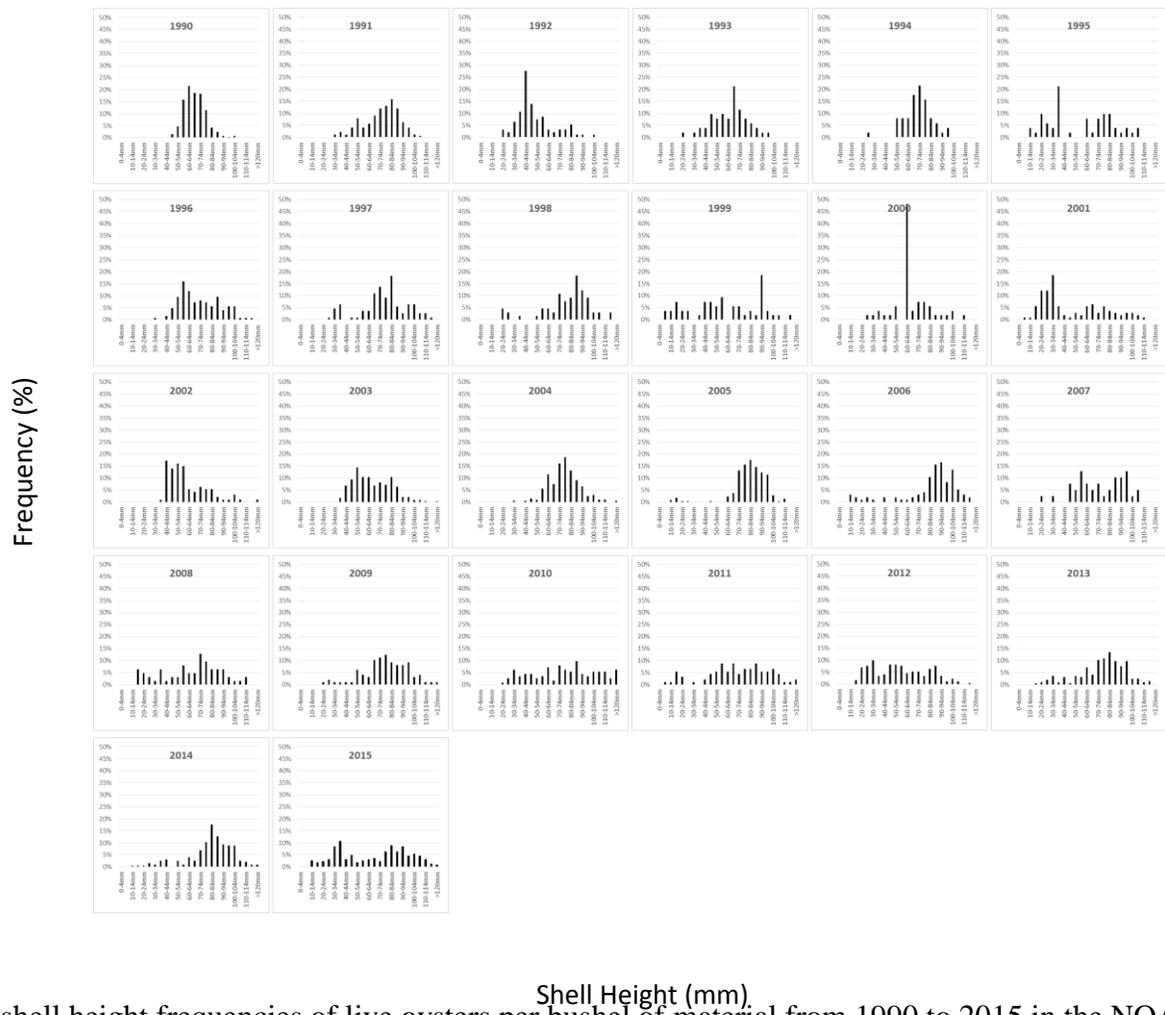


Figure B.28-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 229 (Lower West Chesapeake Bay). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

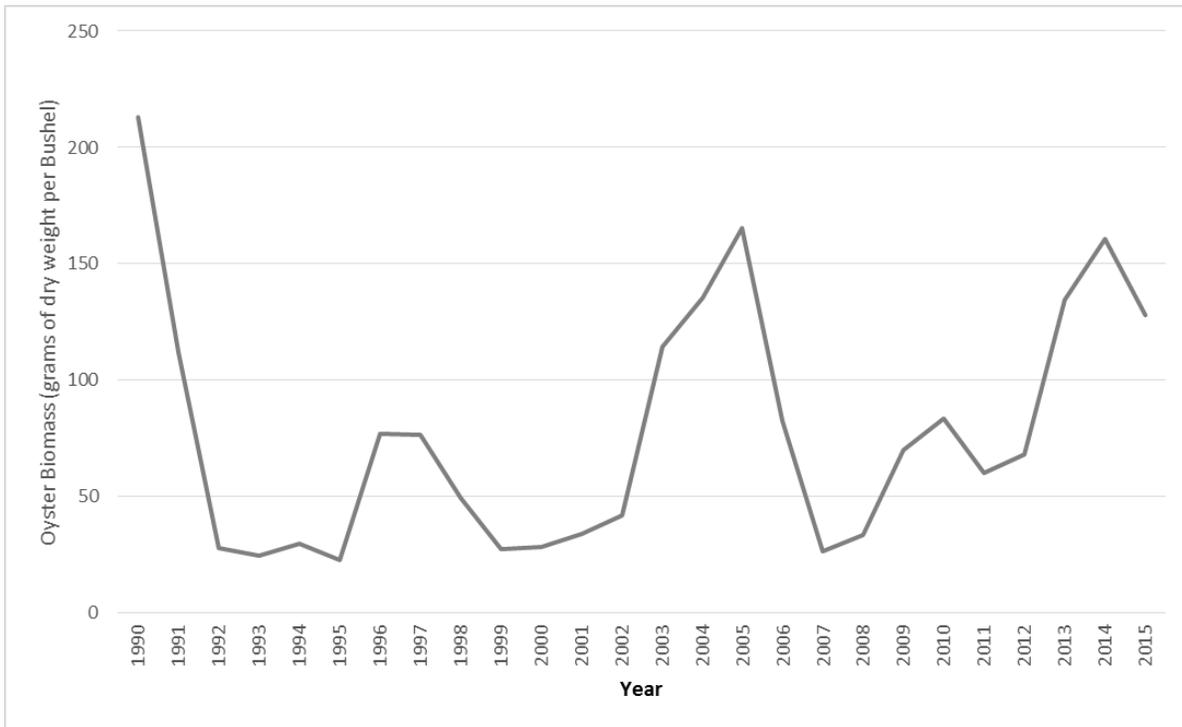


Figure B.28-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 229 (Lower West Chesapeake Bay). Data from Maryland’s Annual Fall Oyster Dredge Survey.

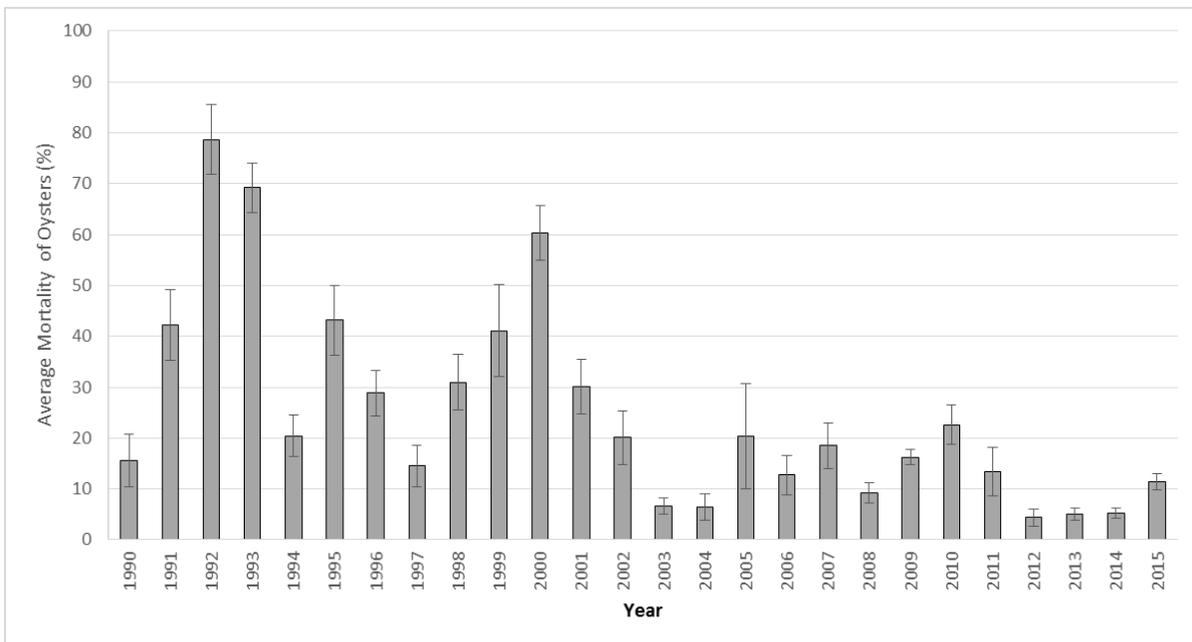


Figure B.28-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 229 (Lower West Chesapeake Bay). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

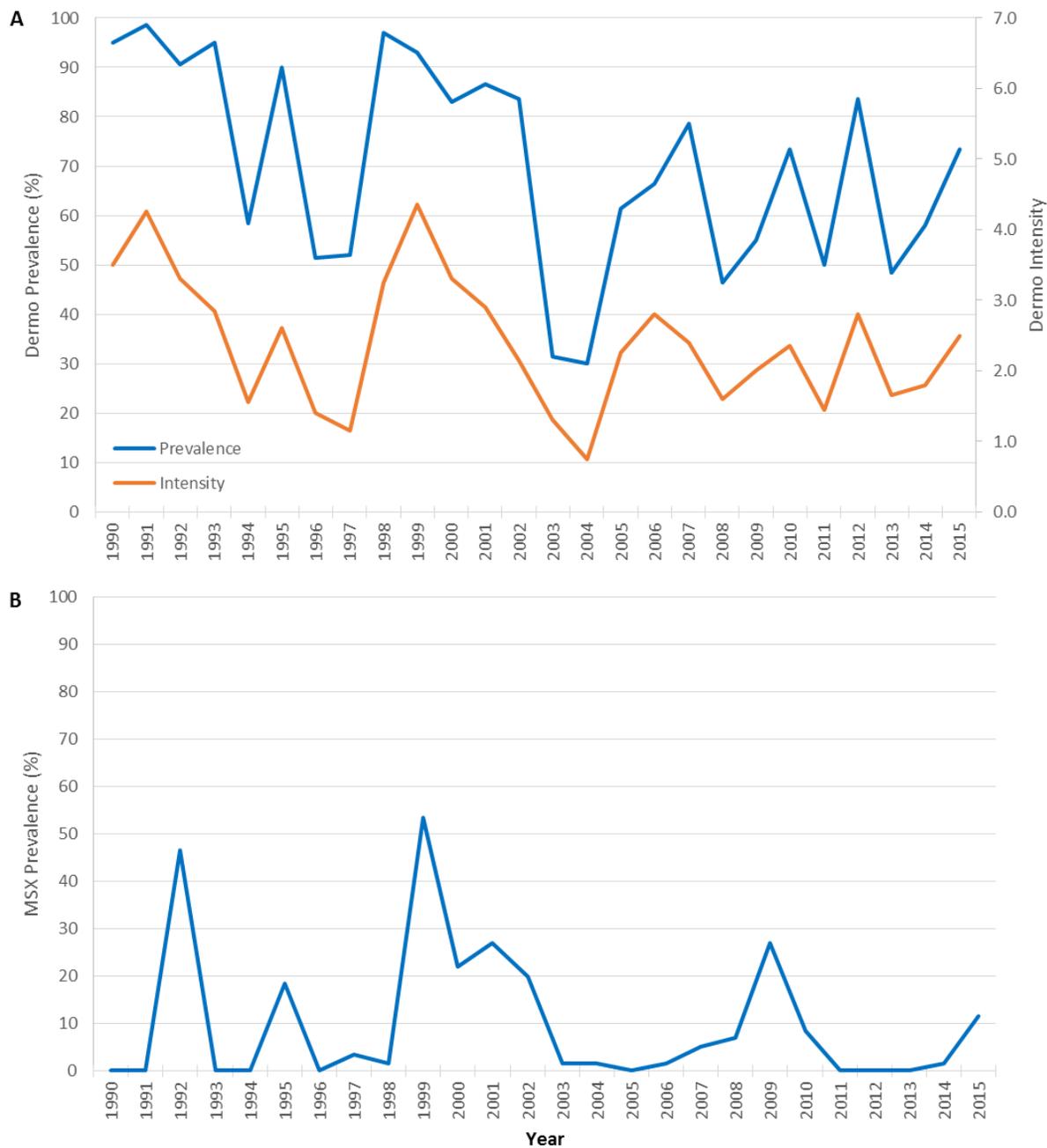


Figure B.28-6. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA 229 (Lower West Chesapeake Bay). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland's Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 229 (Lower West Chesapeake Bay) since 1990 is presented in Figure B.28-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 4% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in 1993-1994, 2000-2001 and 2002-2003 seasons to a maximum of approximately 32,000 bushels in the 1990-1991 season. Harvest started increasing in the 2009-2010 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Power dredging accounts for approximately 70% of harvest as reported on the oyster harvest reports.

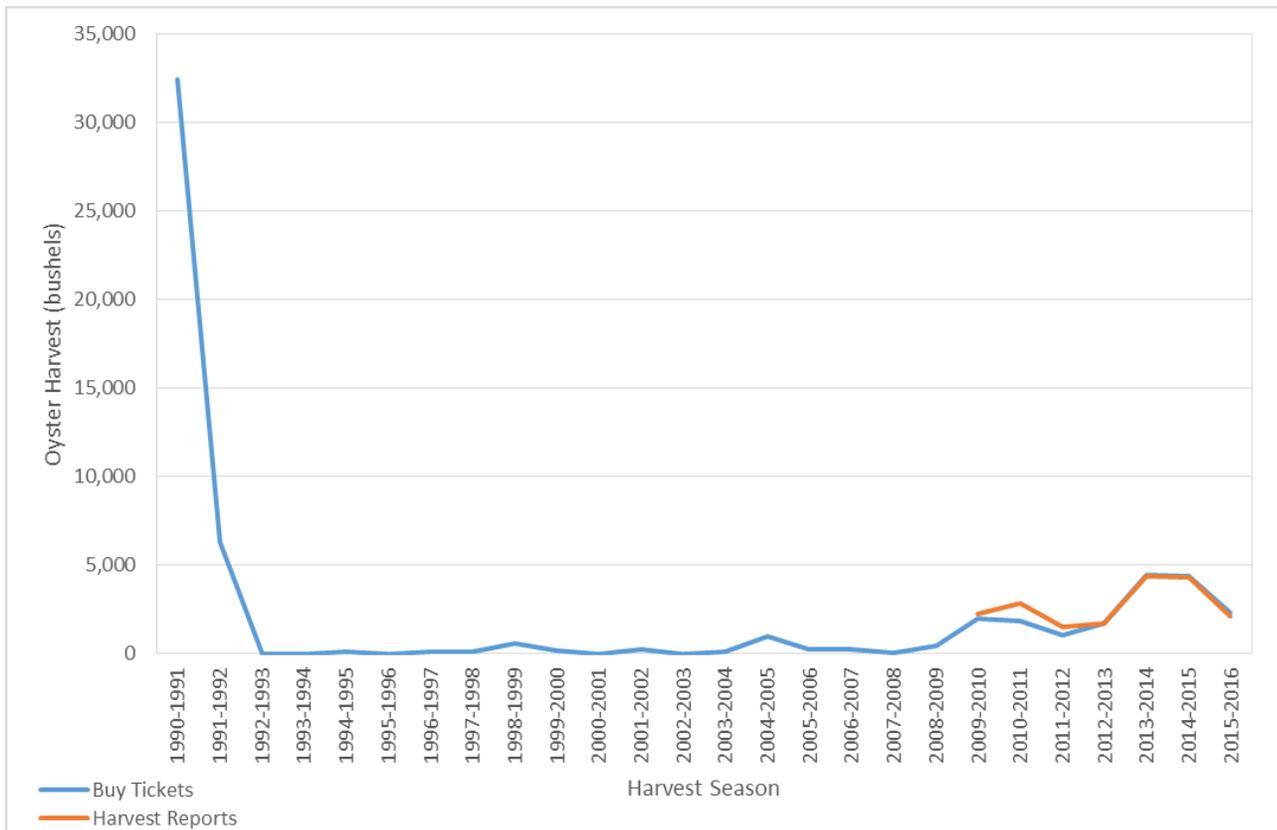


Figure B.28-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 229 (Lower West Chesapeake Bay). After the 2009-2010 season, 4% of the NOAA Code area was a sanctuary where harvest is prohibited,

Section B.29: NOAA Code 231 – Chester River Middle

NOAA Code 231 encompasses the middle section of the Chester River, from Spaniard Point to Queenstown Creek, and is located in Maryland's upper eastern portion of Chesapeake Bay (Figure B.29-1). The entire NOAA Code is 15,437 acres and has 38 historic oyster bars³². There are two sanctuaries in this NOAA Code (Ringgold and Upper Chester River Sanctuaries), encompassing 53% (8,211 acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 7,226 acres. There are 3,220 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside the sanctuaries. In 2010, 2,788 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland's low salinity zone.

Replenishment Activities

Since 1990, approximately 212,000 bushels of shell, 391,000 bushels of wild seed and 155 million hatchery spat-on-shell have been planted in NOAA Code 231 outside of the current sanctuary area (Table B.29-1).

³² See chart 7 and 8 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

Table B.29-1. Replenishment planting activities occurring since 1990 in NOAA Code 231 (Chester River Middle). ND = No Data.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Wild Seed	22.2	8.1	-
1991	Wild Seed	67.3	23.7	-
1992	Wild Seed	124.2	69.4	-
1993	Wild Seed	148.0	32.5	-
1994	Wild Seed	36.9	16.4	-
1995	Wild Seed	57.1	35.1	-
1996	Wild Seed	46.2	20.5	-
1997	Wild Seed	20.9	13.4	-
1998	Dredged Shell	0.8	22.5	-
1998	Wild Seed	143.0	49.5	-
1999	Wild Seed	43.9	23.3	-
2000	Wild Seed	48.0	26.4	-
2001	Wild Seed	23.7	22.3	-
2002	Wild Seed	33.4	19.5	-
2003	Wild Seed	55.0	31.2	-
2005	Hatchery Spat-on-Shell	3.6	-	1.7
2006	Dredged Shell	29.5	190.1	-
2006	Hatchery Spat-on-Shell	54.3	-	39.7
2007	Hatchery Spat-on-Shell	6.8	-	6.8
2008	Hatchery Spat-on-Shell	45.7	-	81.7
2009	Hatchery Spat-on-Shell	7.9	-	16.8
2015	Hatchery Spat-on-Shell	5.0	-	8.8

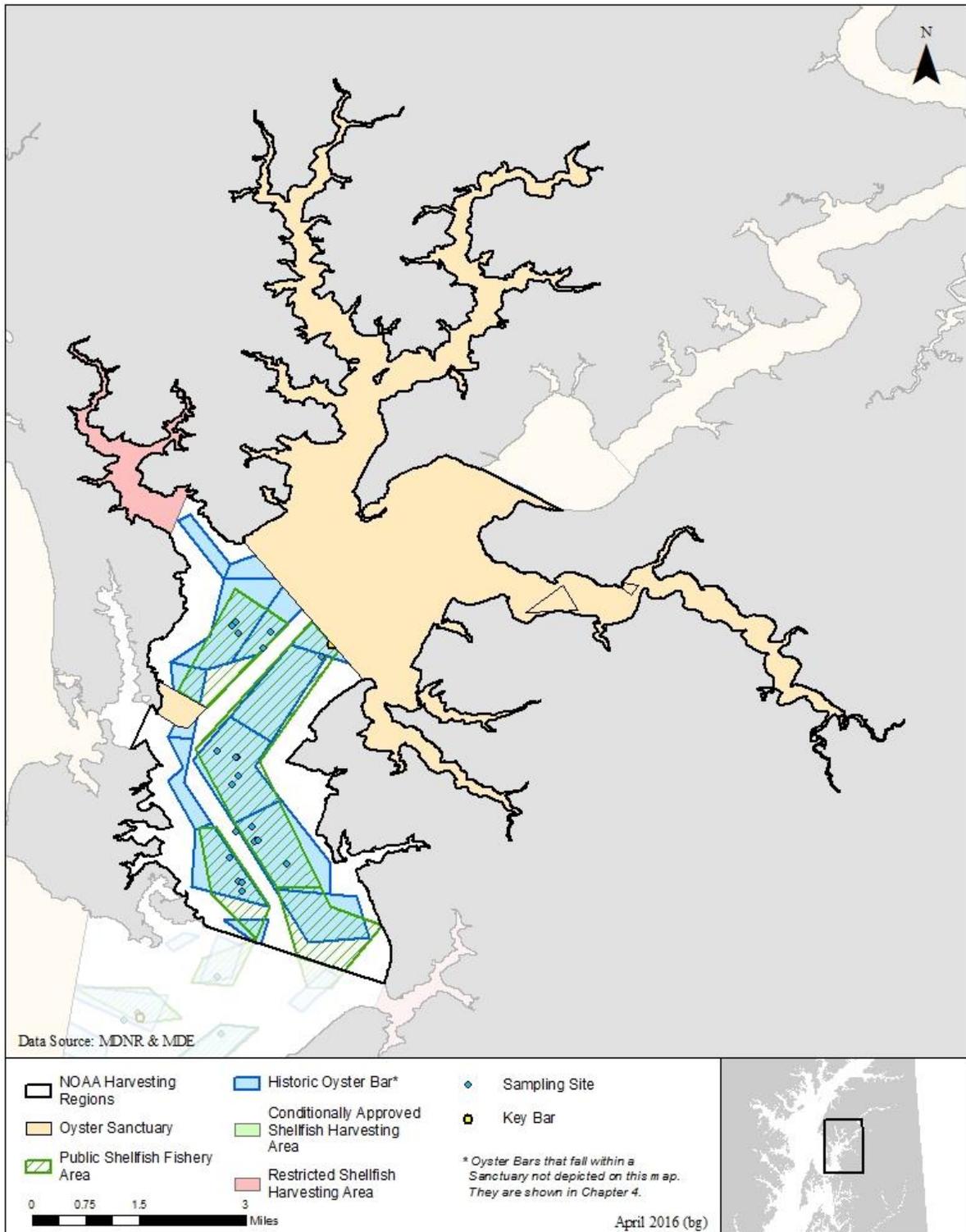


Figure B.29 -1. Map of NOAA Code 231 (Chester River Middle).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled 3 to 7 oyster bars annually in NOAA Code 231 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 13 to 243 with an average of 95 (Figure B.29-2). The number of oysters declined after 2000 and remained low. The average number of oysters was greater from 1990 to 2009 than from 2010 to 2015 (Table B.29-2).

Table B.29-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 231 (Chester River Middle). ND = No Data. Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 157	6 / 36
Number of Live Oysters per Bushel	116 \pm 14	22 \pm 4
Number of Live Small-Sized Oysters per Bushel	49 \pm 11	3 \pm 1
Number of Live Market-Sized Oysters per Bushel	48 \pm 5	20 \pm 4
Live Oyster Biomass (g Dry Weight per Bushel)	ND	ND
Mortality (%)	16.5 \pm 2.6	8.6 \pm 2.8

Oyster Size Structure

The Fall Survey has not collected any information on oyster shell height in this NOAA Code since 1990.

Biomass

The Fall Survey has not collected any information on oyster biomass in this NOAA Code since 1990.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall had ranged from 0 to 205 spat per bushel (Figure B.29-2). Two Fall Survey samples in 2005 and 2006 were taken on hatchery seed plantings. Excluding these samples, spatfall ranged from 0 to 2 (Figure B.29-3).

Mortality

Mortality has varied from 1990 to 2015 ranging from 1% to 46% (Figure B.29-4). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.29-2).

Disease

The Fall Survey has not collected any information on oyster disease in this NOAA Code since 1990.

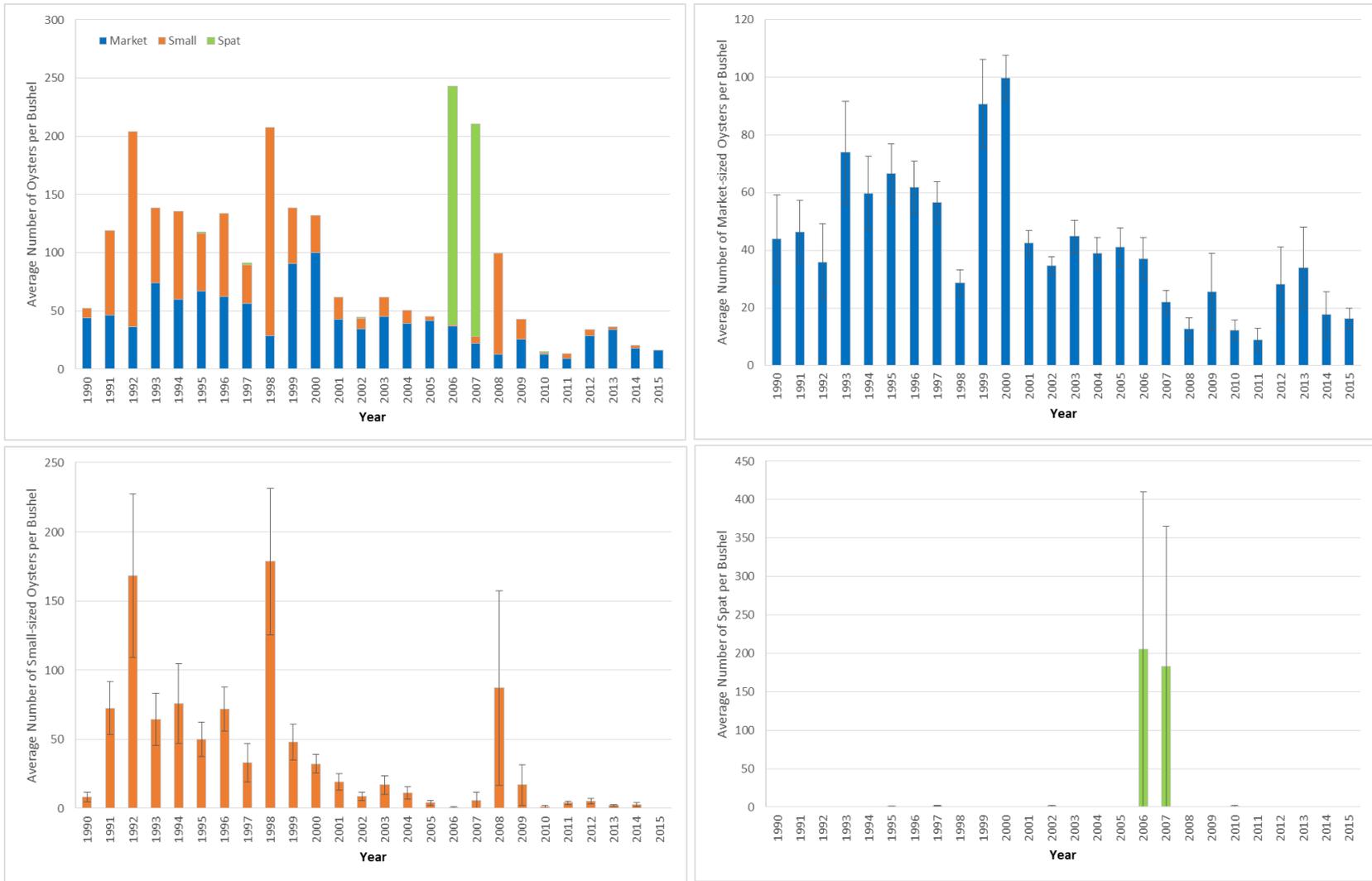


Figure B.29-2. Average number of live oysters per bushel of material by size class in the NOAA Code 231 (Chester River Middle). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

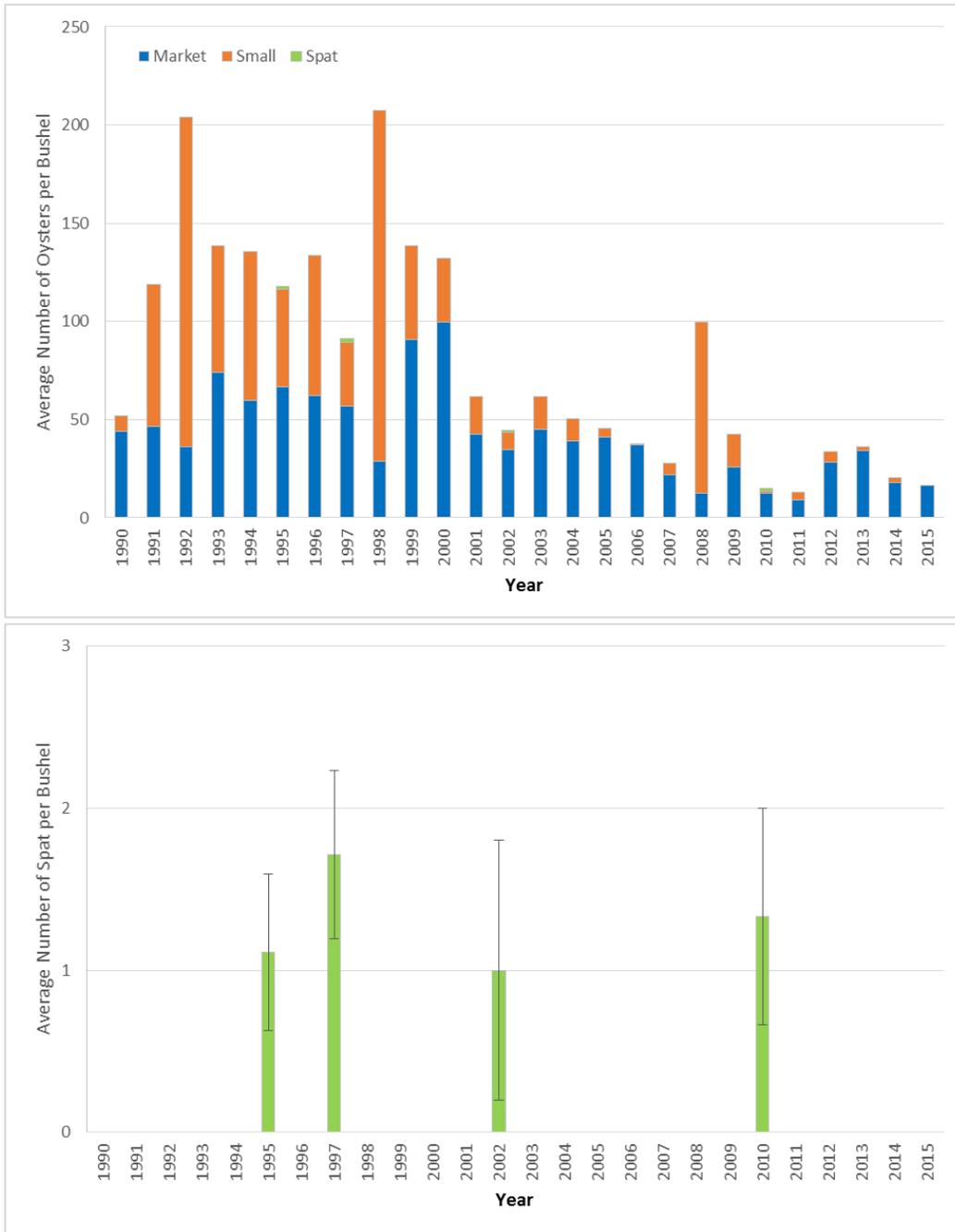


Figure B.29-3. Average number of live oysters per bushel of material by size class in the NOAA Code 231 (Chester River Middle) excluding samples taken on hatchery seed plantings. Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

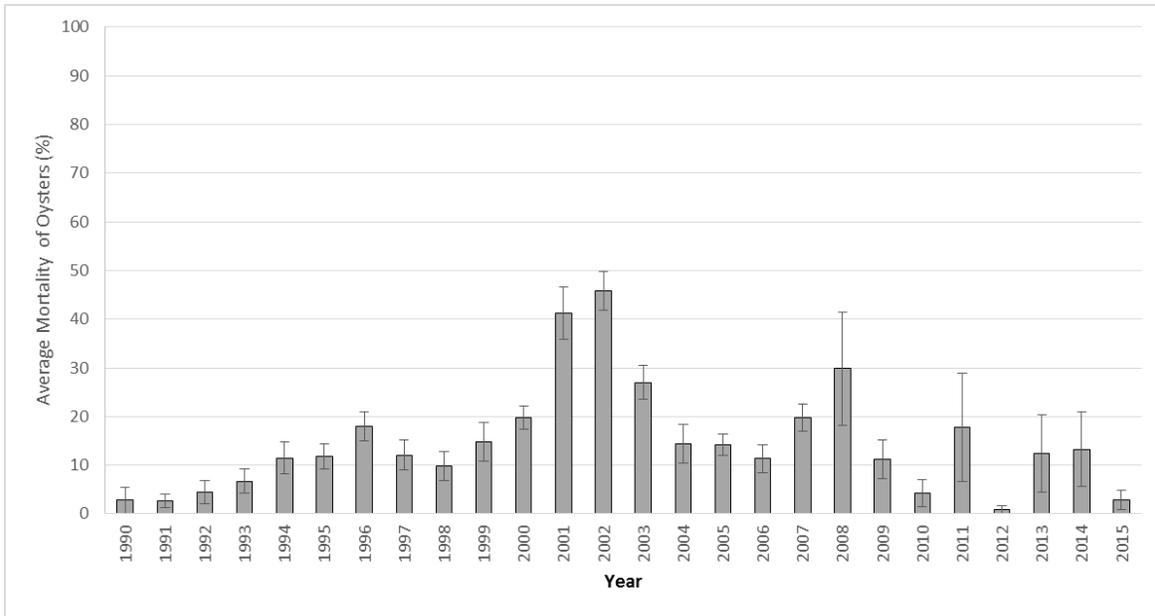


Figure B.29-4. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 231 (Chester River Middle). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

Harvest

Harvest for the entire NOAA Code 231 since 1990 is presented in Figure B.29-5. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 53% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from 30 bushels in the 2013-2014 season to 40,000 bushels in the 1997-1997 season. The high spatfall in 2010 may have partly attributed to the increase in 2014-2015 harvest. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. According to oyster harvester reports, diving and hand tongs each account for approximately 50% of the harvest.

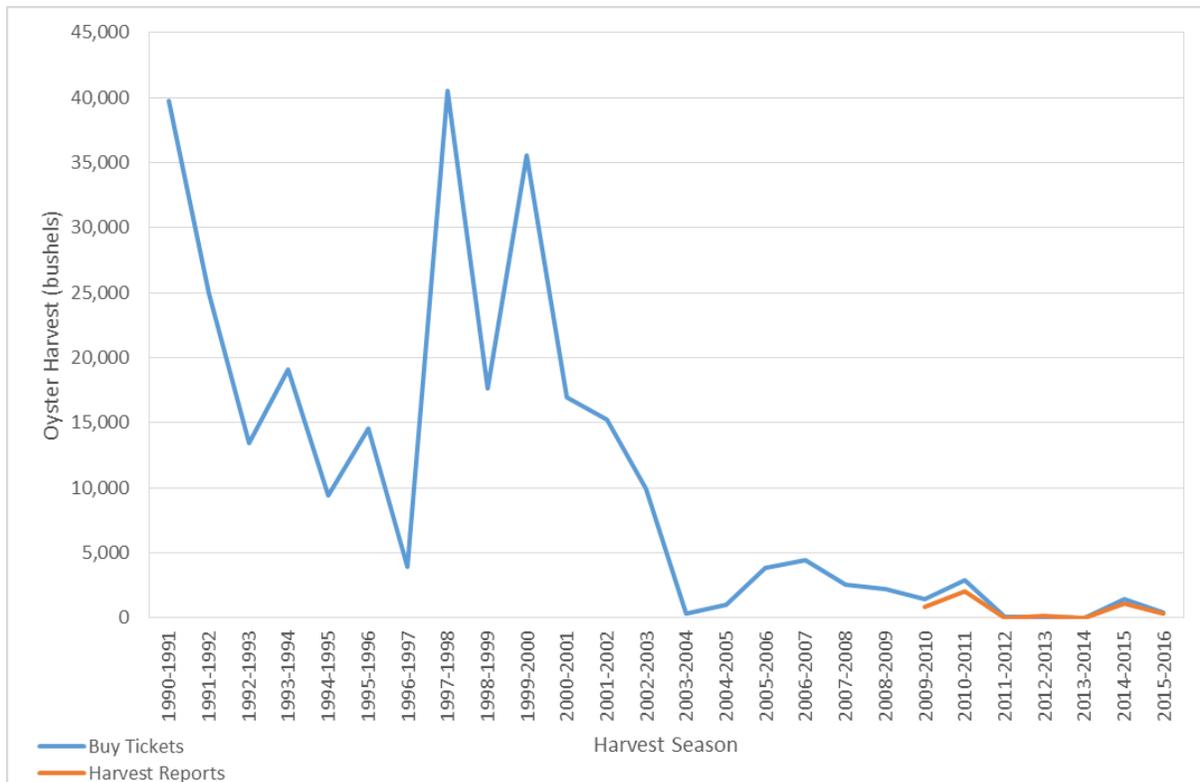


Figure B.29-5. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 231 (Chester River Middle). After the 2009-2010 season, 53% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.30: NOAA Code 237 – Choptank River Middle

NOAA Code 237 encompasses the middle portion of the Choptank River and is located in Maryland’s mid-eastern portion of Chesapeake Bay (Figure B.30-1). The entire NOAA Code is 11,934 acres and has 37 historic oyster bars³³. There are 5 sanctuaries partially or completely within the NOAA Code: Sandy Hill, La Trappe Creek, Howell Point – Beacon, Upper Choptank River, and Lower Choptank River (Total of 6,221 sanctuary acres, 52% of the NOAA Code). This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 5,713 acres. There is 3,605 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside of a sanctuary. In 2010, 3,434 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s low salinity zone.

Replenishment Activities

Since 1990, approximately 54,000 bushels of shell, 148,000 bushels of wild seed and 111 million hatchery spat-on-shell has been planted in NOAA Code 237 outside of the current sanctuary area (Table B.37-1).

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Wild Seed	17.6	22.3	-
1991	Wild Seed	59.3	26.8	-
1992	Wild Seed	16.1	3.7	-
1997	Dredged Shell	10.5	54.0	-
1997	Wild Seed	22.2	6.5	-
1999	Wild Seed	16.0	12.7	-
2000	Wild Seed	5.0	3.6	-
2003	Wild Seed	8.4	19.3	-
2006	Hatchery Spat-on-Shell	1.5	-	1.2
2009	Hatchery Spat-on-Shell	19.0	-	33.6
2011	Hatchery Spat-on-Shell	29.0	-	45.9
2012	Hatchery Spat-on-Shell	4.9	-	1.4
2013	Hatchery Spat-on-Shell	4.3	-	18.8
2014	Hatchery Spat-on-Shell	5.0	-	11.0

³³ See chart 20 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

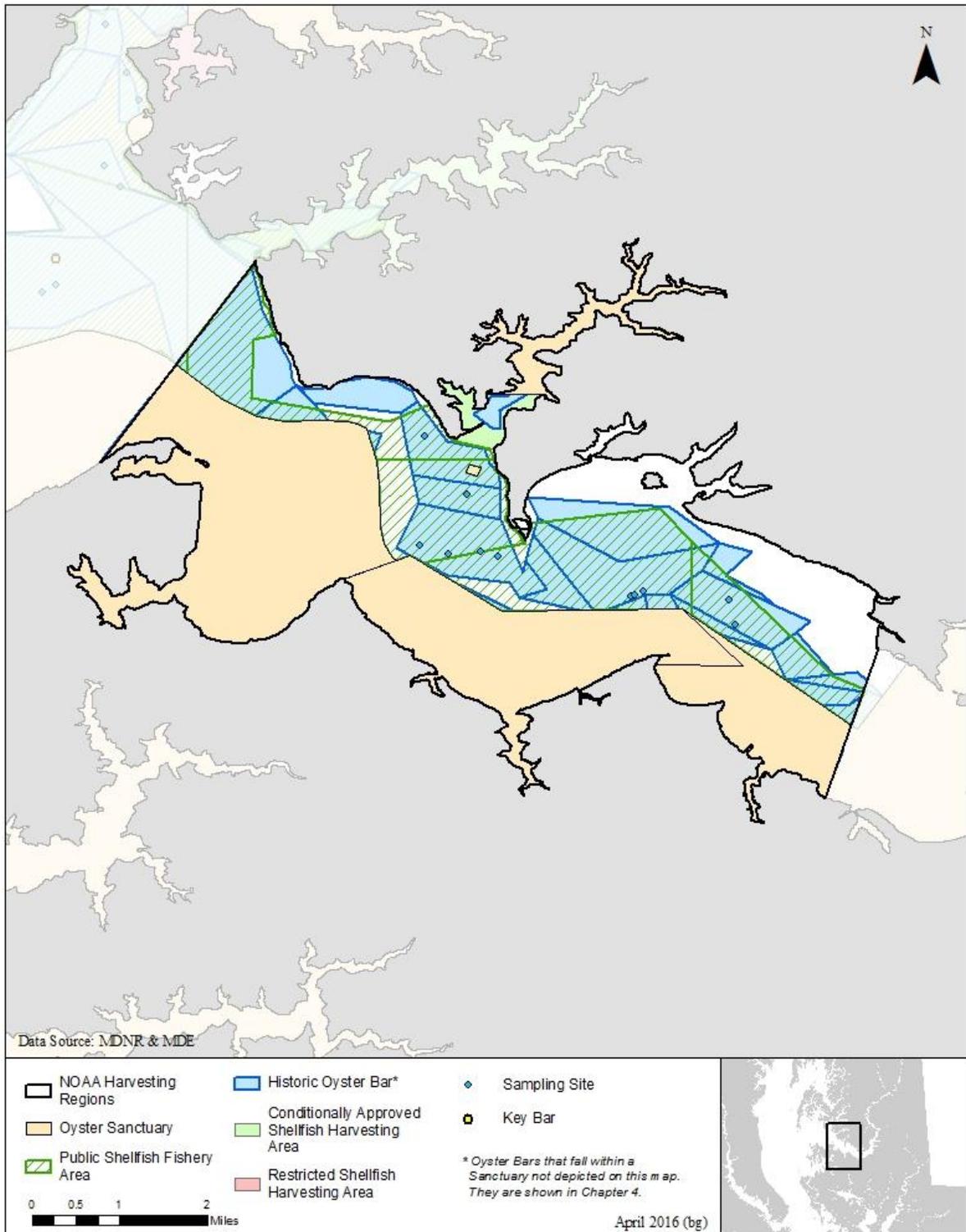


Figure B.30 -1. Map of NOAA Code 237 (Choptank River Middle).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled 4 to 6 oyster bars annually in NOAA Code 237 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 26 to 209 per bushel with an average of 77 (Figure B.30-2). The number of oysters decreased from 1999 to 2004, and then began to increase starting in 2005. Years 2012 to 2015 had the highest number of market-sized oysters during the entire 26 year time period. The average number of total live oysters was greater from 2010 to 2015 than prior to 2010 (Table B.30-2).

Table B.30-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the Public Shellfish Fishery Areas in 2010 within NOAA Code 237 (Choptank River Middle). ND = No Data. Values are given as mean \pm standard error.

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 124	6 / 37
Number of Live Oysters per Bushel	68 \pm 9	109 \pm 8
Number of Live Small-Sized Oysters per Bushel	28 \pm 5	31 \pm 5
Number of Live Market-Sized Oysters per Bushel	28 \pm 3	66 \pm 7
Live Oyster Biomass (g Dry Weight per Bushel)	ND	ND
Mortality (%)	24.6 \pm 4.5	6.5 \pm 1.1

Oyster Size Structure

Since 1990, the Fall Survey has not collected information on oyster shell height.

Biomass

Since 1990, the Fall Survey has not collected information on oyster biomass.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall had ranged from 0 to 98 spat per bushel (Figure B.30-2). The largest spatfall occurred in 1991. From 1993 to 2005, there was very little spatfall, with only one year (1997) averaging more than 10 spat per bushel. Two Fall Survey samples were taken on newly planted hatchery seed in 2006 and 2012. Excluding these samples, spatfall ranged from 0 to 38 with an average of 10 spat per bushel (Figure B.30-3).

Mortality

Mortality ranged from 3% to 62%, however, since 2005 mortality has been relatively low (Figure B.30-4). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.30-2).

Disease

Since 1990, the Fall Survey has not collected information on oyster disease.

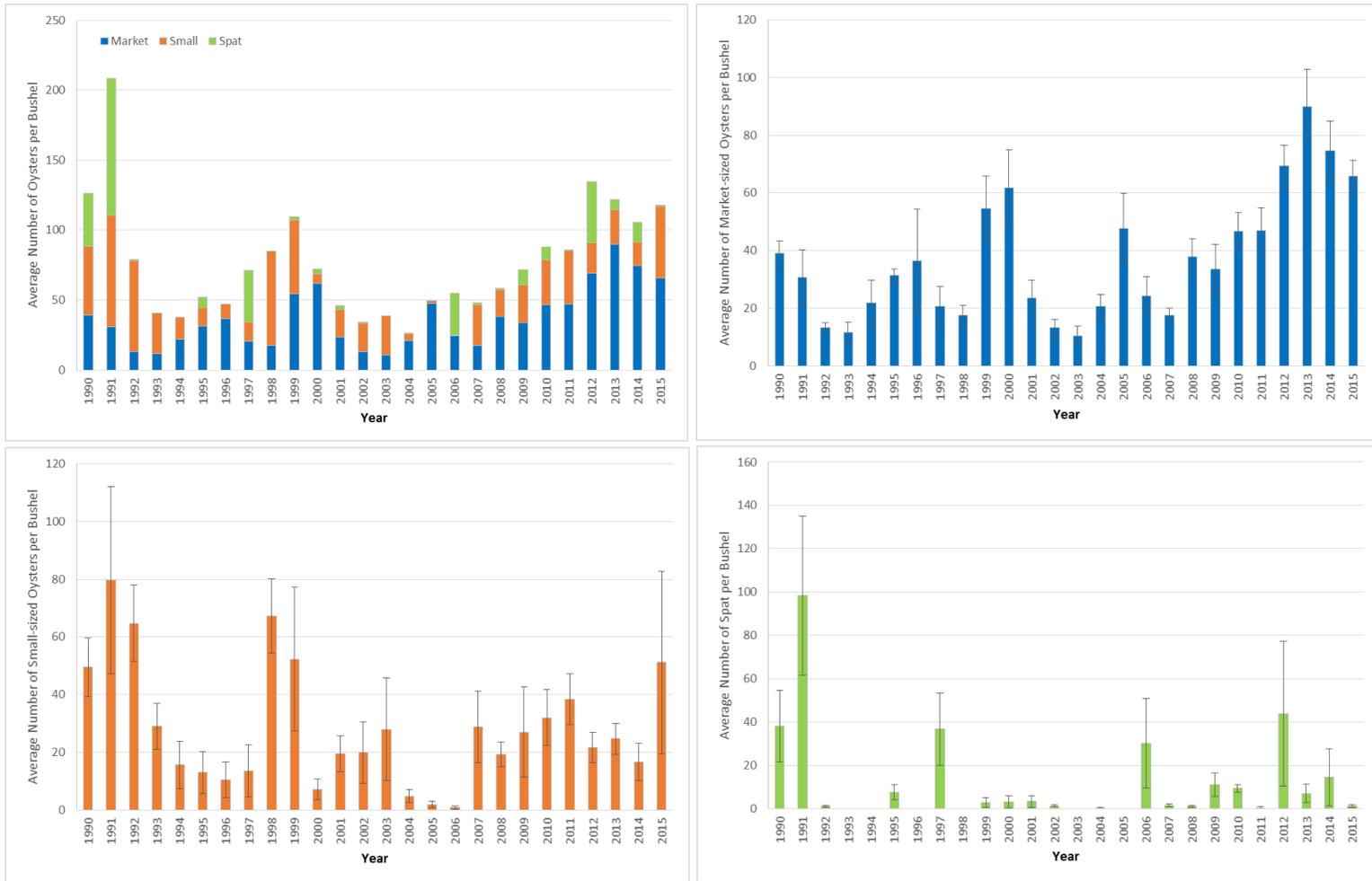


Figure B.30-2. Average number of live oysters per bushel of material by size class in the NOAA Code 237 (Choptank River Middle). Error bars represent ± 1 standard error. Data from Maryland's Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

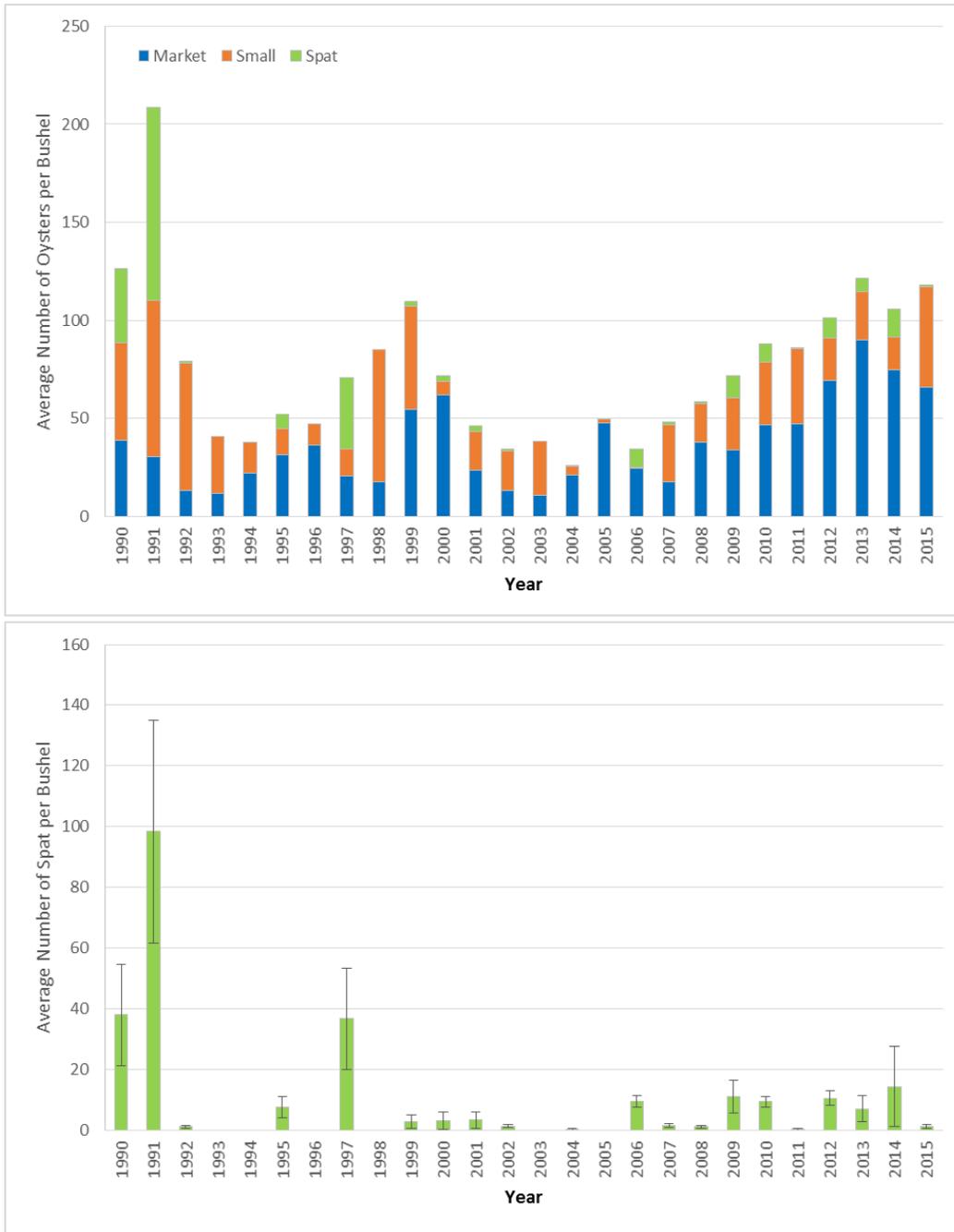


Figure B.30-4. Average number of live oysters per bushel of material by size class in the NOAA Code 237 (Choptank River Middle) excluding the Fall Survey samples taken on hatchery seed plantings. Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

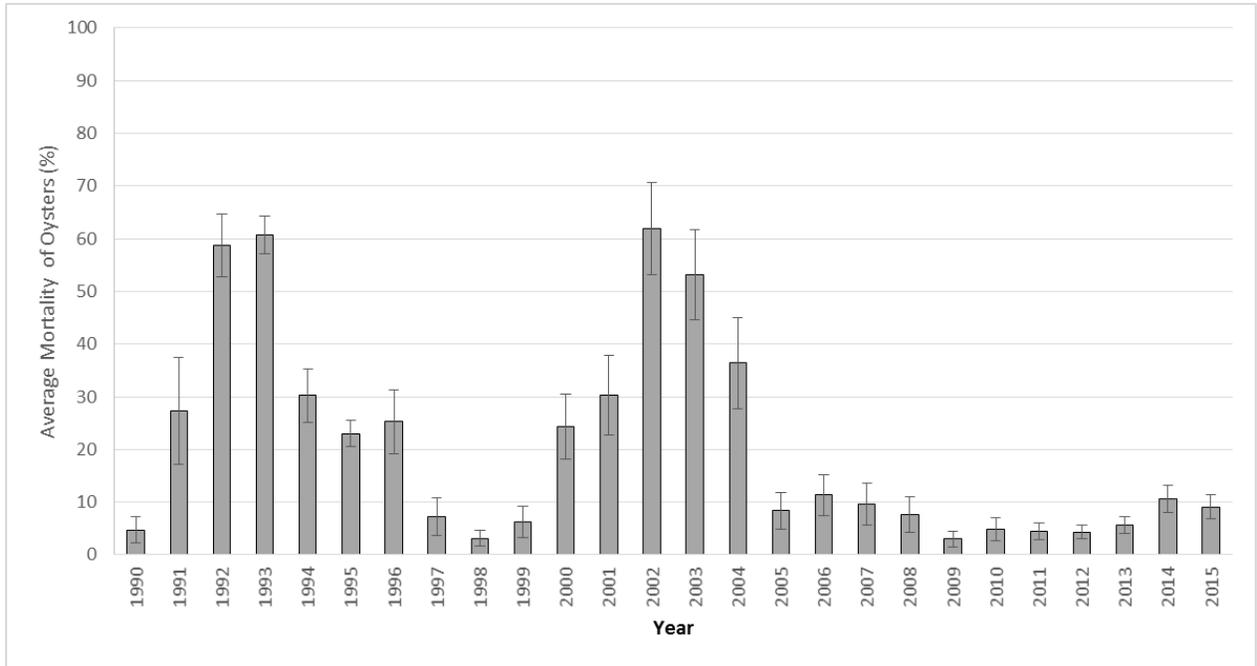


Figure B.30-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 237 (Choptank River Middle). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

Harvest

Harvest for the entire NOAA Code 237 since 1990 is presented in Figure B.30-6. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 52% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from 30 bushels in the 2003-2004 season to a maximum of approximately 16,000 bushels in the 1995-1996 season. Harvest in 2015-2016 was the highest since the 2001-2002 season. This could be partly

attributed to the consistent spatfall in recent years as well as the 2011 hatchery seed planting. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. According to oyster harvester reports, approximately 40% of the harvest was by sail dredge, approximately 35% by hand tong and approximately 20% by diving.

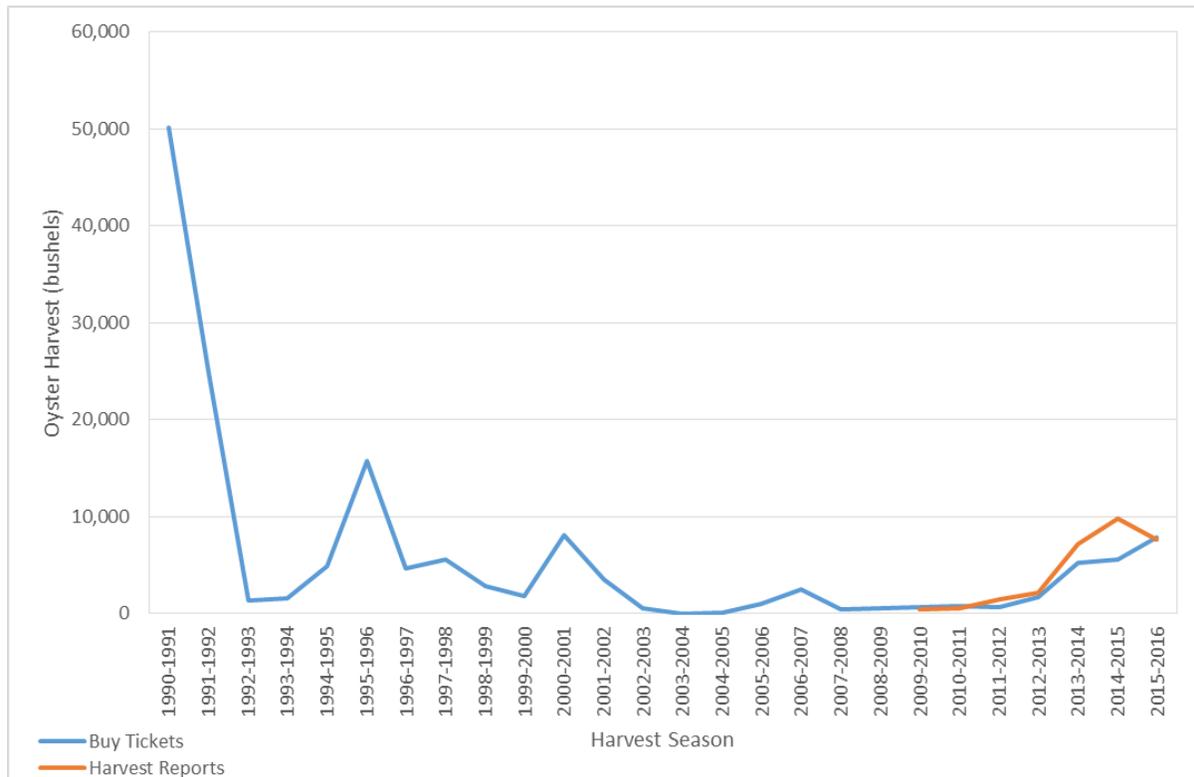


Figure B.30-6. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 237 (Choptank River Middle). After the 2009-2010 season, 52% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.31: NOAA Code 268 – Patuxent River Middle

NOAA Code 268 encompasses the middle portion of the Patuxent River between Broomes Island and St. Leonard Creek and is located in Maryland’s lower western portion of Chesapeake Bay (Figure B.31-1). The entire NOAA Code is 4,573 acres and has 7 historic oyster bars³⁴. The Neal Addition Sanctuary was established in 2001 and encompasses less than 1% (6.7 acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 4,566 acres. There are 1,223 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010, 1,777 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s medium salinity zone.

Replenishment Activities

Since 1990, approximately 36,000 bushels of shell, 3,500 bushels of wild seed and 10.9 million hatchery spat-on-shell have been planted in NOAA Code 268 outside of the current sanctuary area (Table B.31-1).

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Fresh Shell	9.6	12.9	-
1999	Dredged Shell	2.9	24.0	-
1999	Wild Seed	6.1	3.5	-
2008	Hatchery Spat-on-Shell	5.0	-	10.2

³⁴ See chart 26 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

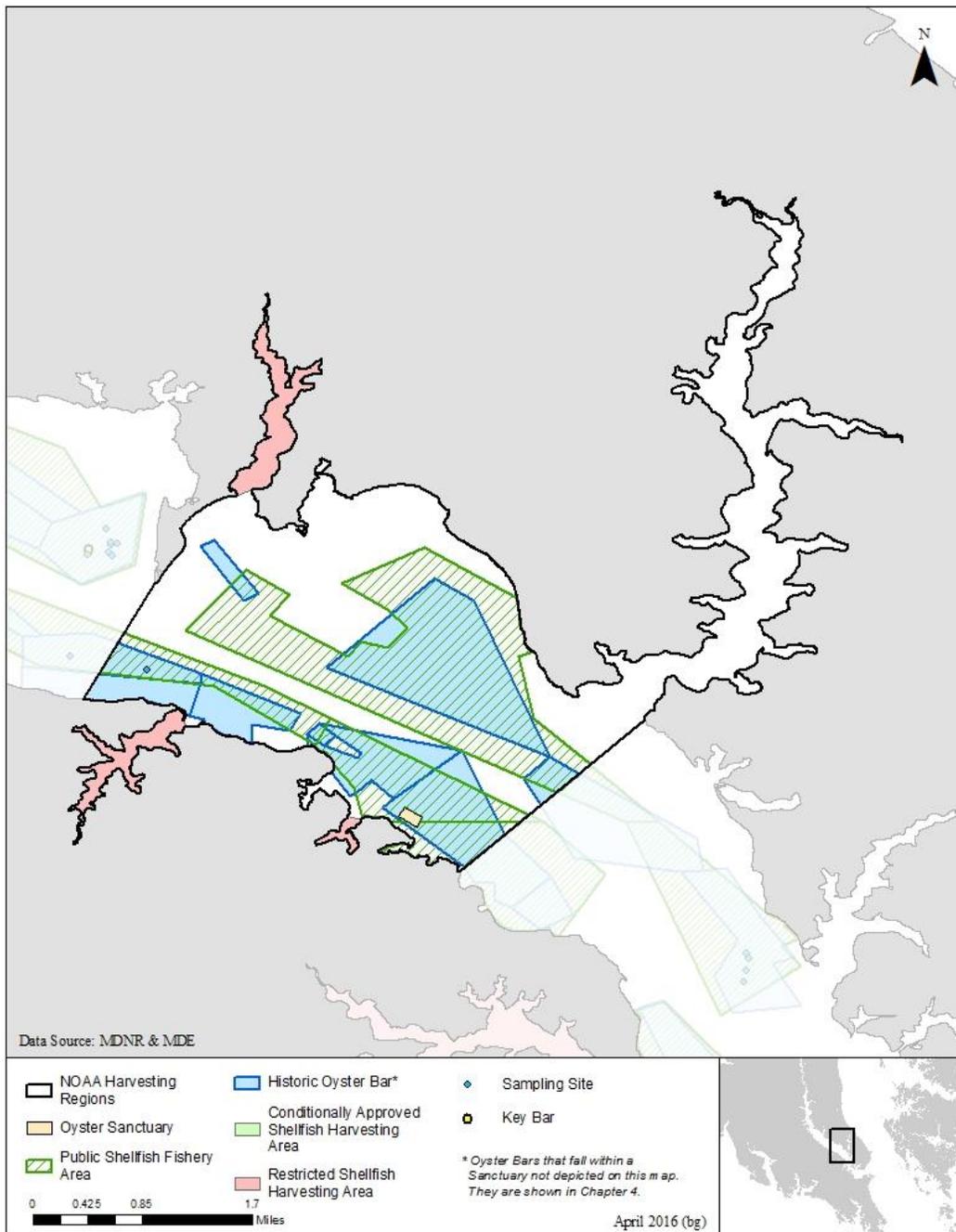


Figure B.31 -1. Map of NOAA Code 268 (Patuxent River Middle).

Oyster Population Characteristics

The Fall Survey sampled one oyster bar between 1990 and 1992 in this NOAA Code but outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) from ranged from 0 to 52 with an average of 25 (Figure B.31-2). No data were collected for the years 2010-2015 (Table B.31-2).

Table B.31-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 268 (Patuxent River Middle). ND = No Data. Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	3 / 4	ND
Number of Live Oysters per Bushel	25 \pm 15	ND
Number of Live Small-Sized Oysters per Bushel	5 \pm 3	ND
Number of Live Market-Sized Oysters per Bushel	17 \pm 12	ND
Live Oyster Biomass (g Dry Weight per Bushel)	ND	ND
Mortality (%)	54 \pm 25	ND

Oyster Size Structure

Since 1990, the Fall Survey has not collected data on oyster shell heights.

Biomass

Since 1990, the Fall Survey has not collected data on oyster biomass.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 0 to 6 spat per bushel, averaging 3 (Figure B.31-2).

Mortality

Mortality has ranged from 14% to 100%, averaging 54% (Figure B.31-3).

Disease

Since 1990, the Fall Survey has not collected data on oyster disease.

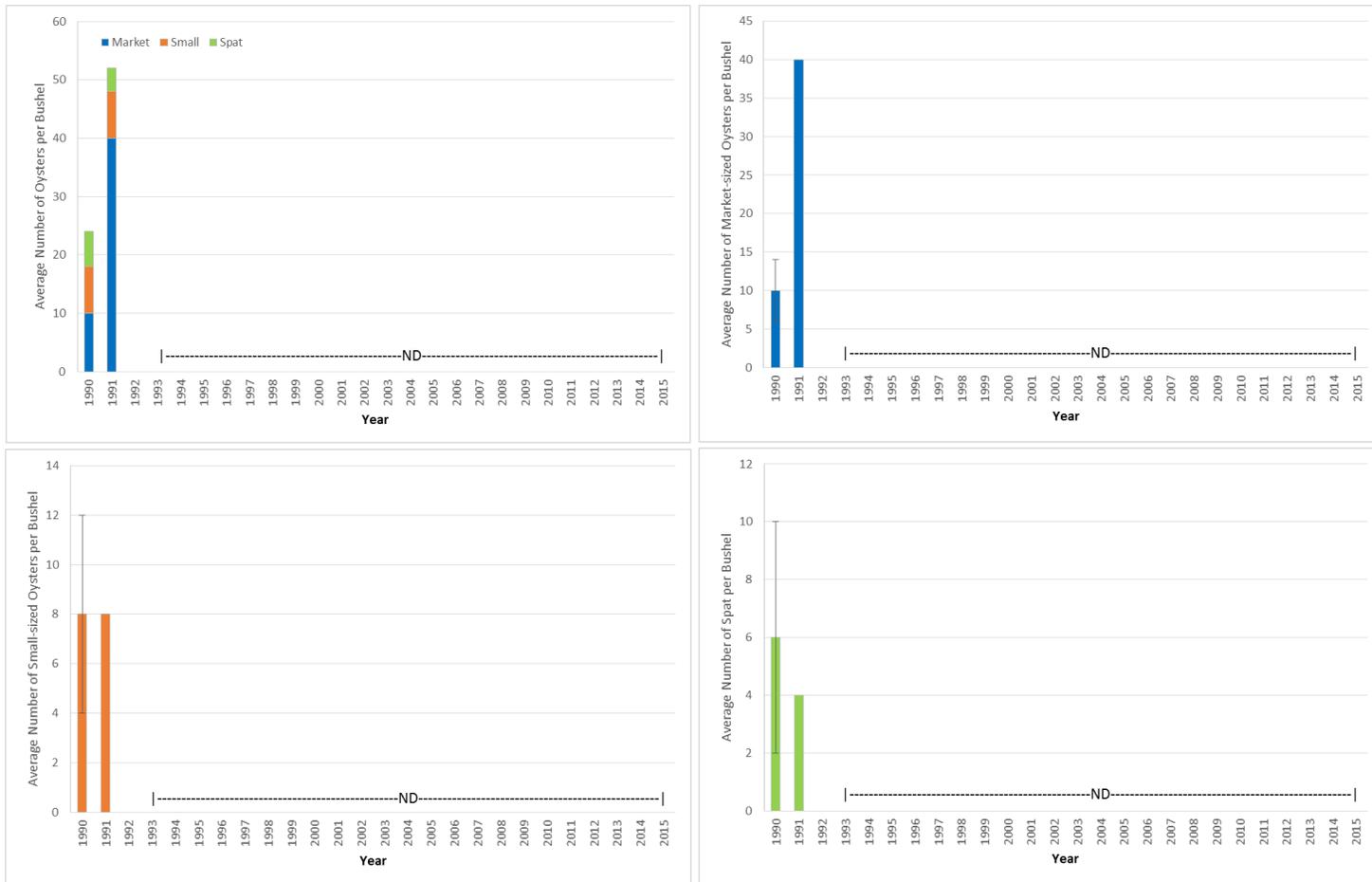


Figure B.31-2. Average number of live oysters per bushel of material by size class in the NOAA Code 268 (Patuxent River Middle). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales. ND = No Data.

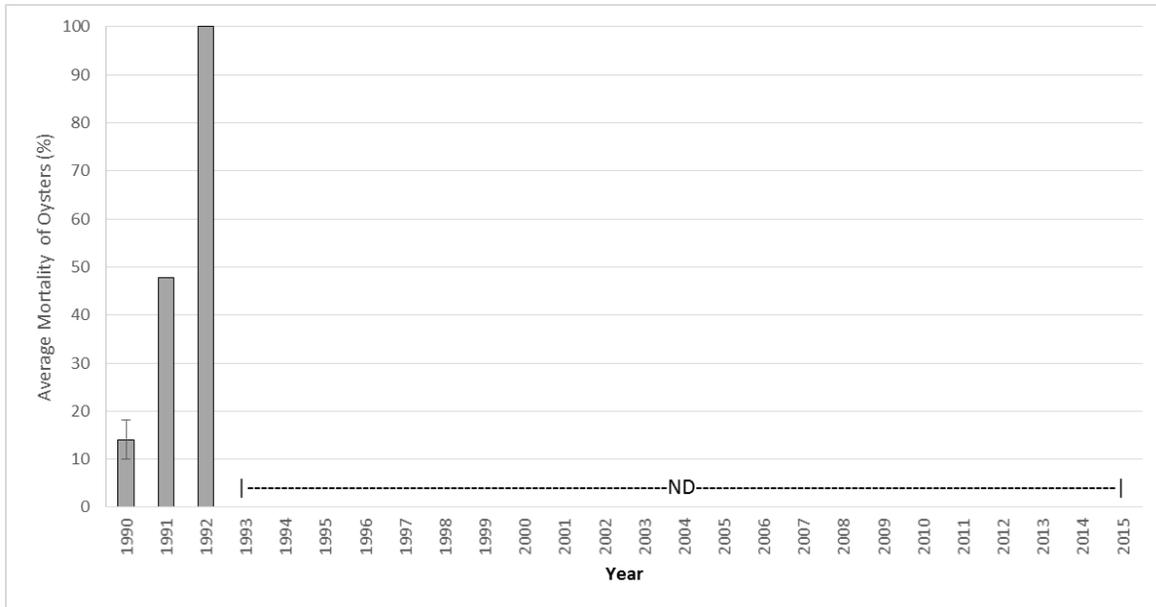


Figure B.31-3. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 268 (Patuxent River Middle). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error. ND = No Data.

Harvest

Harvest for the entire NOAA Code 268 (Patuxent River Middle) since 1990 is presented in Figure B.31-4. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2000-2001 season, less than 1% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest (several seasons) to a maximum of approximately 12,000 bushels in the 2005-2006 season. Harvest has increased in recent years and was the third highest in 2015-2016. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. The majority of harvest (approximately 78%) in this area as reported on the oyster harvest reports is obtained by diving. Approximately 20% of the harvest is obtained by patent tonging.

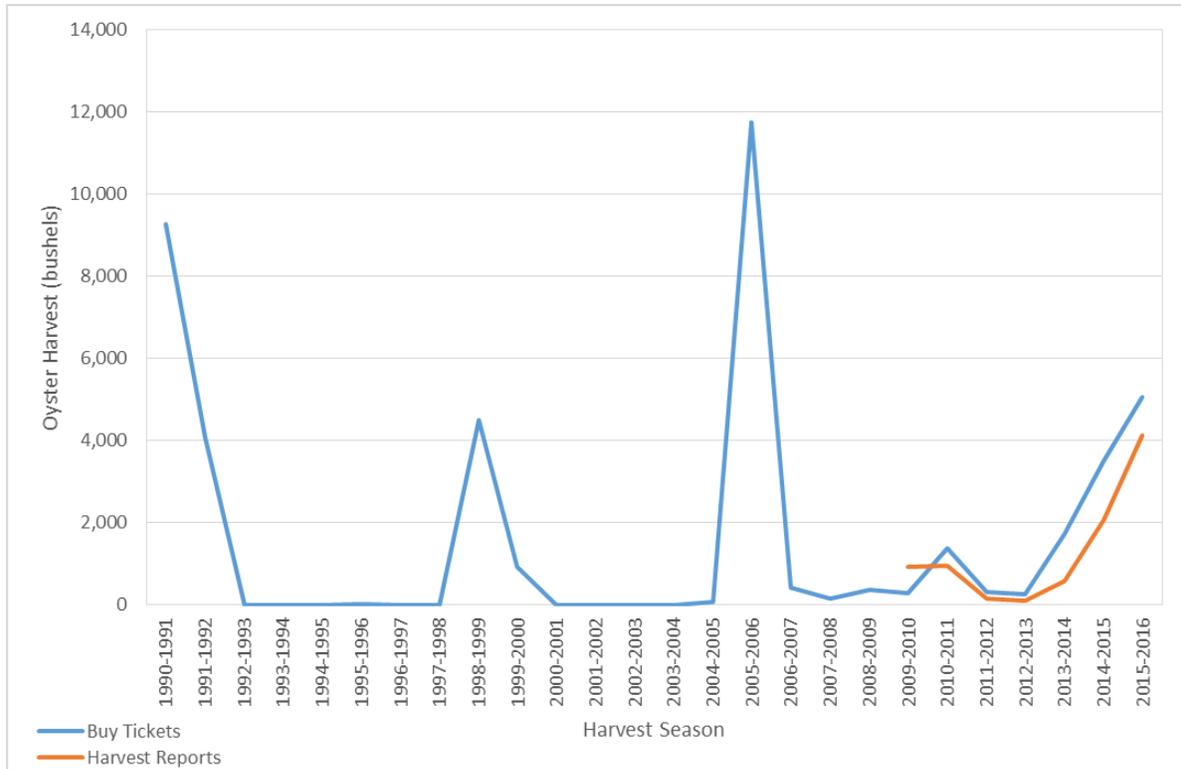


Figure B.31-4. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 268 (Patuxent River Middle).

Section B.32: NOAA Code 274 – Wicomico River West

NOAA Code 274 encompasses the Wicomico River (West), a tributary of the Potomac River and is located in Maryland's lower western portion of Chesapeake Bay (Figure B.32-1). The entire NOAA Code is 11,953 acres and has 24 historic oyster bars³⁵. The Wicomico River Sanctuary was established in 2010 and encompasses 4% (450 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 11,504 acres. There are 4,128 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and not in a sanctuary. In 2010, 6,039 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture. This NOAA Code is generally located within Maryland's low salinity zone.

Replenishment Activities

Since 1990, 72,000 bushels of shell, 272,900 bushels of wild seed and 112.7 million hatchery spat-on-shell have been planted in NOAA Code 274 (Wicomico River West) outside of the current sanctuary area.

³⁵ See chart 33 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

Table B.32-1. Replenishment planting activities occurring since 1990 in NOAA Code 274 (Wicomico River West). ND = No Data.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Wild Seed	41.2	35.2	-
1991	Wild Seed	30.1	11.5	-
1992	Fresh Shell	4.2	14.0	-
1992	Wild Seed	28.7	15.5	-
1993	Fresh Shell	3.0	11.1	-
1993	Wild Seed	2.9	3.8	-
1994	Fresh Shell	2.3	9.2	-
1994	Wild Seed	10.2	5.9	-
1995	Fresh Shell	3.3	23.0	-
1995	Wild Seed	19.6	15.8	-
1996	Fresh Shell	1.7	17.9	-
1996	Wild Seed	6.4	5.5	-
1997	Wild Seed	18.6	13.4	-
1998	Wild Seed	41.5	21.4	-
1999	Wild Seed	14.9	11.6	-
2000	Wild Seed	31.3	37.1	-
2001	Wild Seed	10.3	10.7	-
2002	Wild Seed	31.0	19.0	-
2003	Wild Seed	35.8	30.5	-
2004	Wild Seed	20.0	23.1	-
2006	Hatchery Spat-on-Shell	2.0	-	2.4
2007	Hatchery Spat-on-Shell	1.9	-	3.4
2007	Wild Seed	5.2	8.8	-
2008	Hatchery Spat-on-Shell	4.4	-	6.8
2008	Wild Seed	5.4	4.4	-
2009	Hatchery Spat-on-Shell	4.0	-	19.5
2010	Hatchery Spat-on-Shell	7.8	-	12.0
2011	Wild Seed	19.2	ND	-
2012	Hatchery Spat-on-Shell	7.1	-	17.3
2014	Hatchery Spat-on-Shell	16.2	-	21.4
2015	Hatchery Spat-on-Shell	11.7	-	29.8

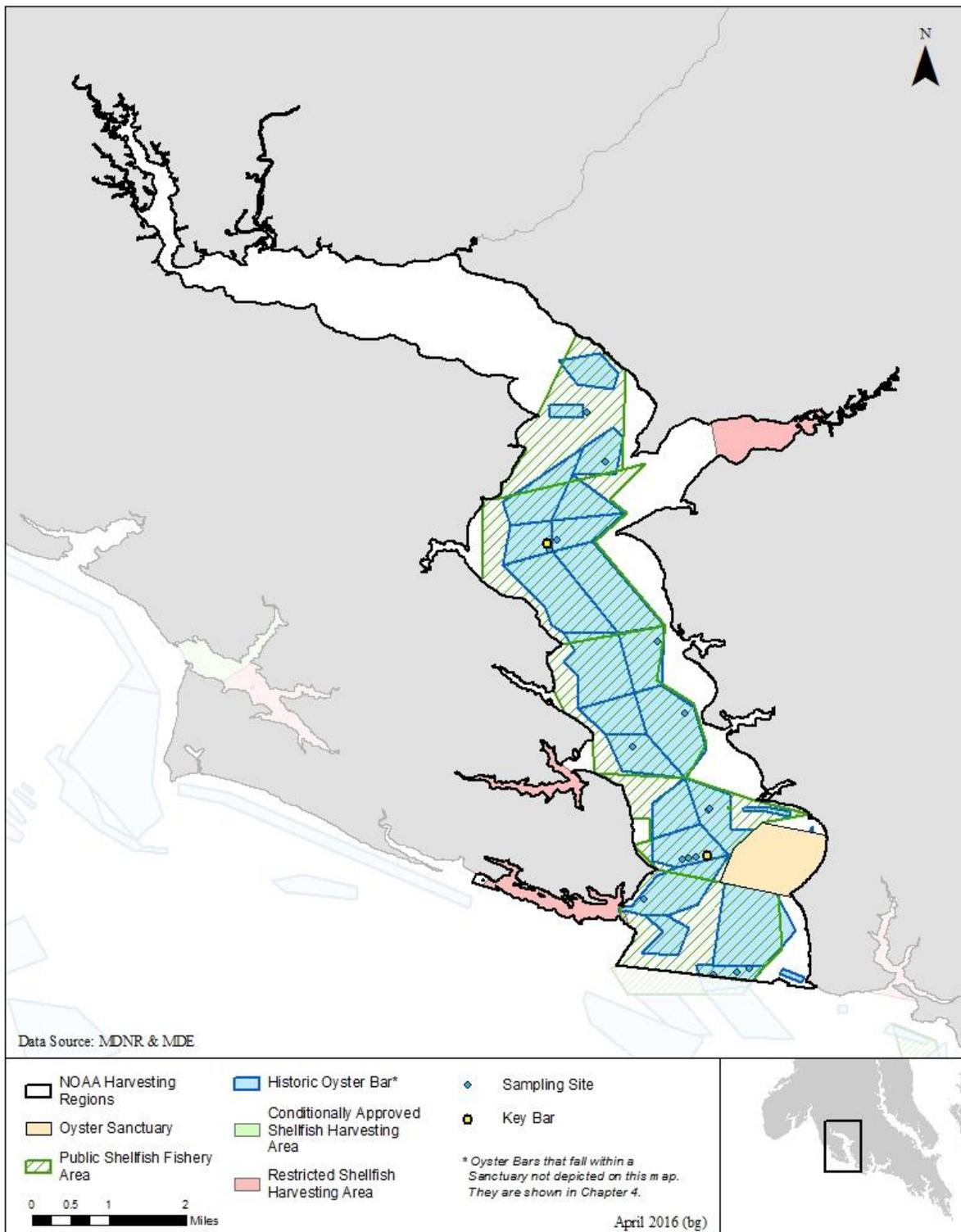


Figure B.32 -1. Map of NOAA Code 274 (Wicomico River West).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled 6 to 10 oyster bars annually in NOAA Code 274 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 25 to 229 per bushel with an average of 100 (Figure B.32-2). The average number of oysters was greater from 1990 to 2009 than from 2010 to 2015 (Table B.32-2).

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 206	6 / 60
Number of Live Oysters per Bushel	104 ± 10	86 ± 30
Number of Live Small-Sized Oysters per Bushel	60 ± 8	24 ± 11
Number of Live Market-Sized Oysters per Bushel	42 ± 3	26 ± 4
Live Oyster Biomass (g Dry Weight per Bushel)	101 ± 16	50 ± 9
Mortality (%)	18.7 ± 2.8	6.6 ± 1.2

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Lancaster and Mills West bars within NOAA Code 274 (Figure B.32-3). The majority of oysters (52%) were between 75 and 100 mm. The largest oysters (greater than 120mm shell height) were collected from 2009 to 2015 and made up three percent of the total measured. The percentage of oysters over 100 mm was higher from 2010 to 2015 (31%) than prior to 2009 (13%).

Biomass

Since 1990, the Fall Survey has measured oyster biomass on Lancaster and Mills West bars within NOAA Code 274. The annual biomass has varied over the years from 31 to 238 grams of dry weight per bushel and the average is 89.6 ± 13.4 (average ± SE; Figure B.32-4). The average biomass was greater from 1990 to 2009 than from 2010 to 2015 (Table B.32-2). Biomass was highest in 1994 but declined to a low in 2007.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall had ranged from 0 to 211 spat per bushel from 1990 to 2015 (Figure B.32-2). In 2013, two Fall Survey samples occurred in the hatchery seed planting. Excluding these samples, spatfall ranged from 0 to 32 spat per bushel with the average being 3 (Figure B.32-5). For 22 of 26 years, spatfall was 0.

Mortality

Mortality has varied from 1990 to 2015 ranging from 3% to 65%, however, since 2007 mortality has been relatively low (Figure B.32-6). The average mortality was lower from 2010 to 2015, than prior to 2010 (Table B.32-2).

Disease

From 1990 to 2015, dermo prevalence has ranged from 20% to 100% (Figure B.32-7). Dermo prevalence was below 80% for 20 of the 26 years disease information was collected. Dermo intensity ranged from 0.2 to 4.7. Throughout the time period intensity never reached lethal levels (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 27%. The highest MSX prevalence occurred in 2002.

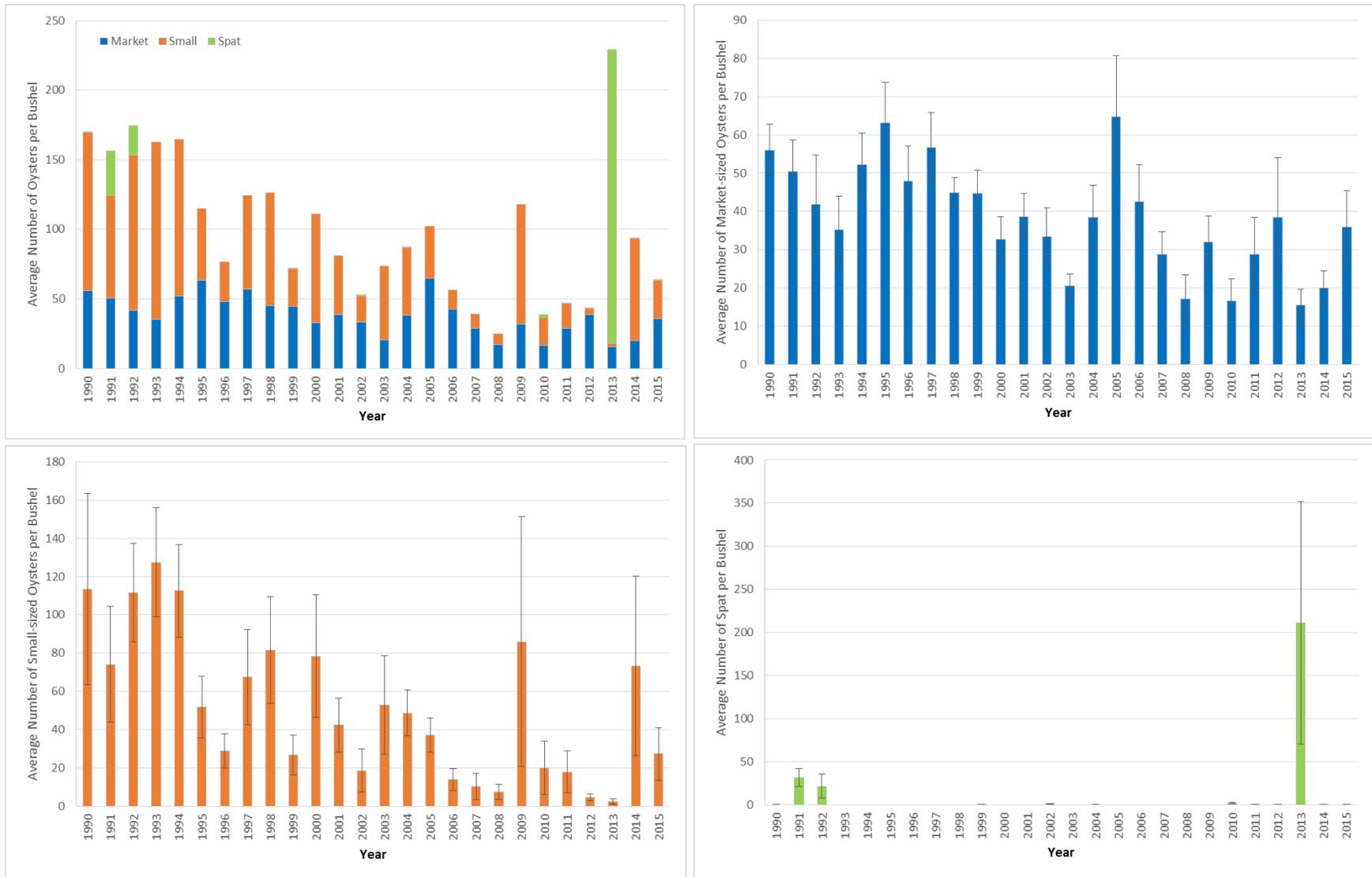
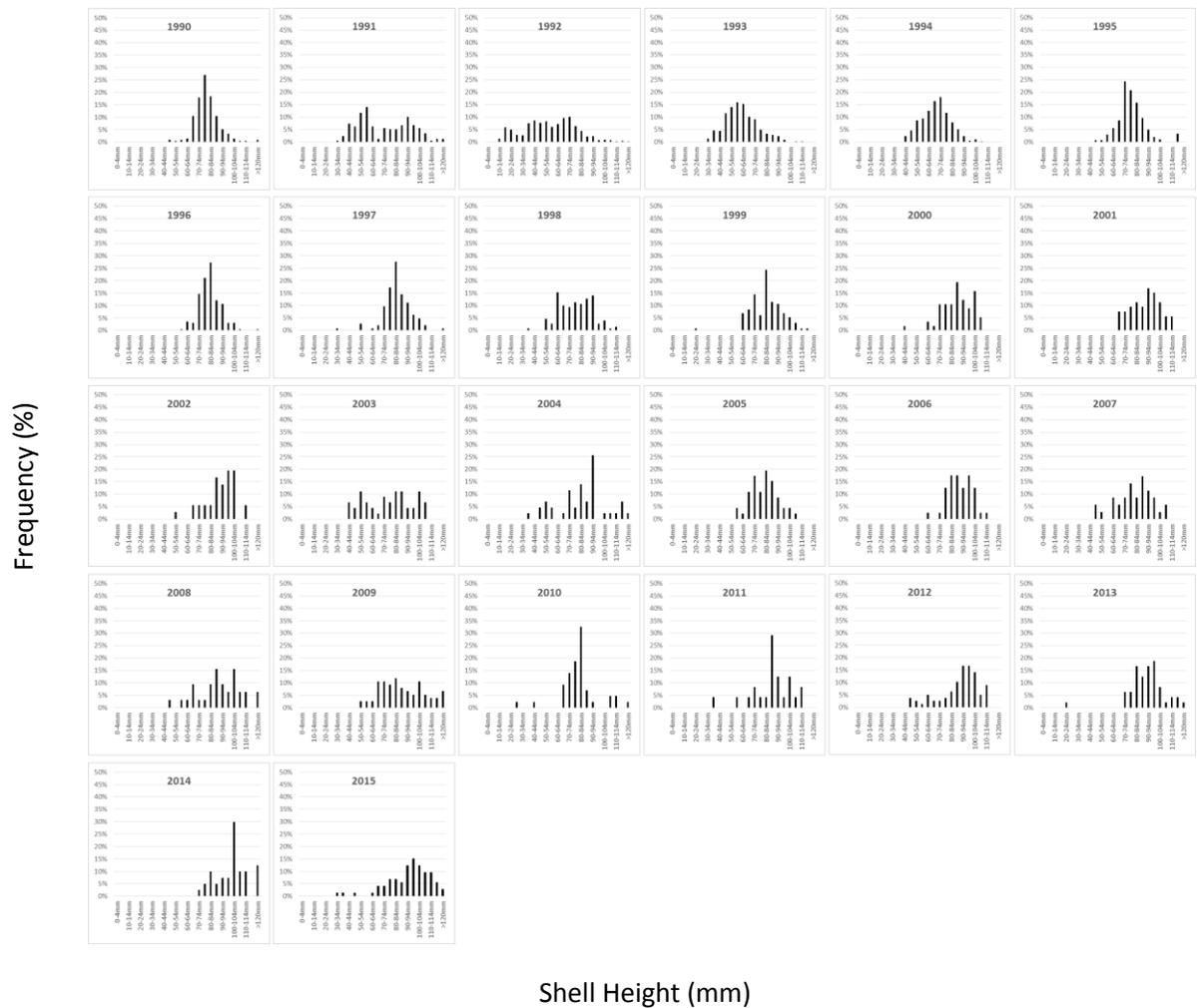


Figure B.32-2. Average number of live oysters per bushel of material by size class in the NOAA Code 274 (Wicomico River West). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.



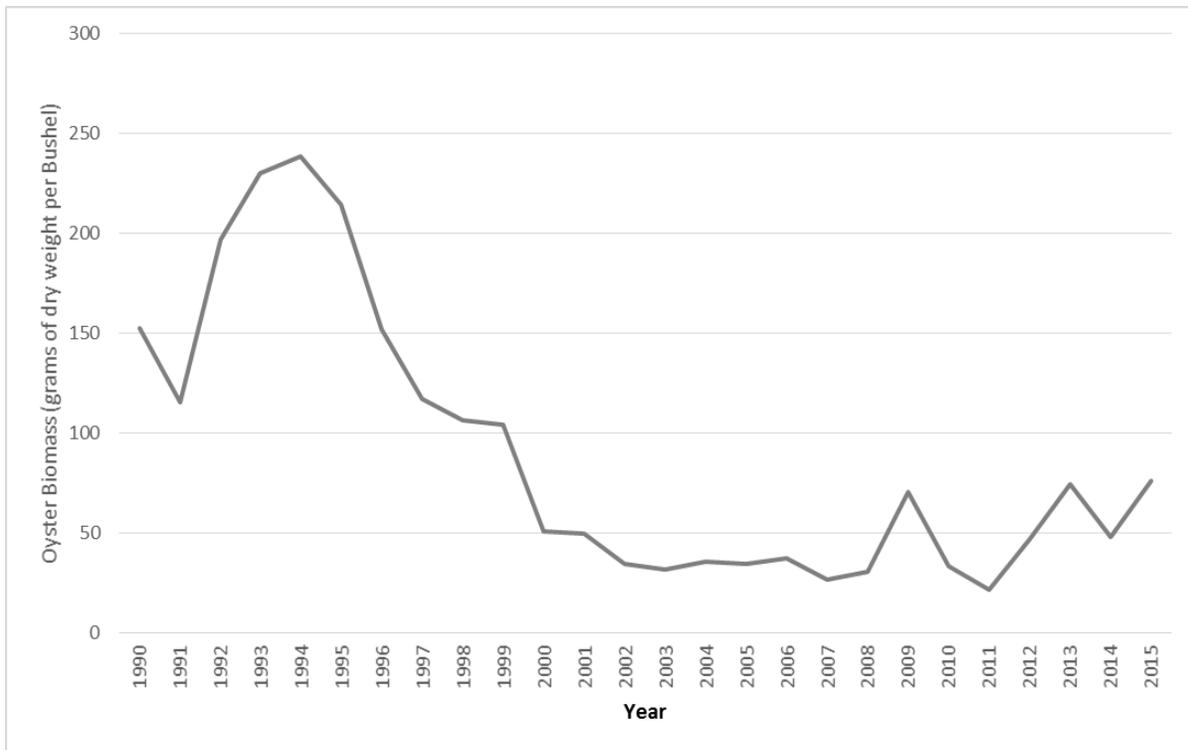


Figure B.32-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 274 (Wicomico River West). Data from Maryland’s Annual Fall Oyster Dredge Survey.

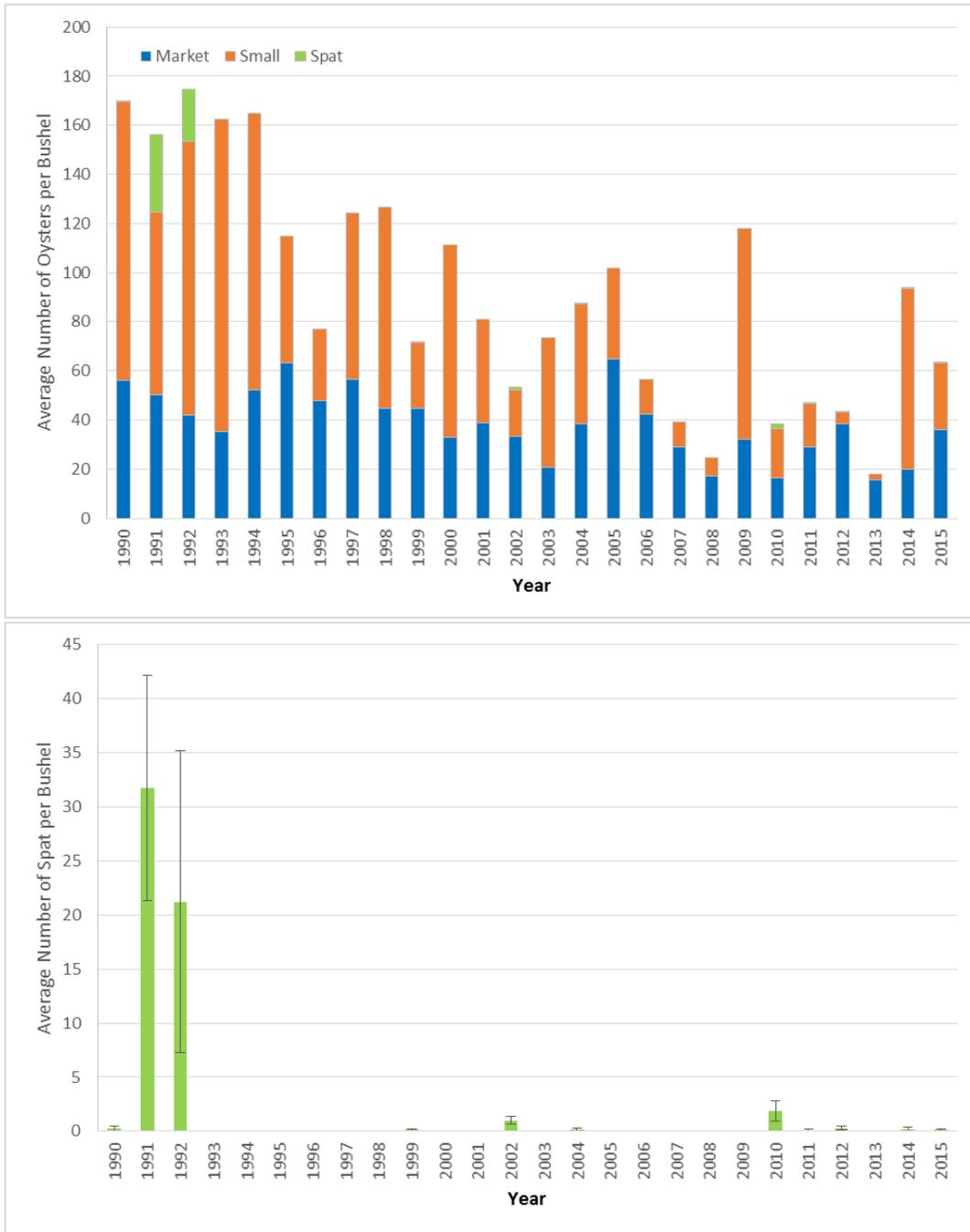


Figure B.32-5. Average number of live oysters per bushel of material by size class in the NOAA Code 274 (Wicomico River West) excluding the samples taken on hatchery seed plantings. Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

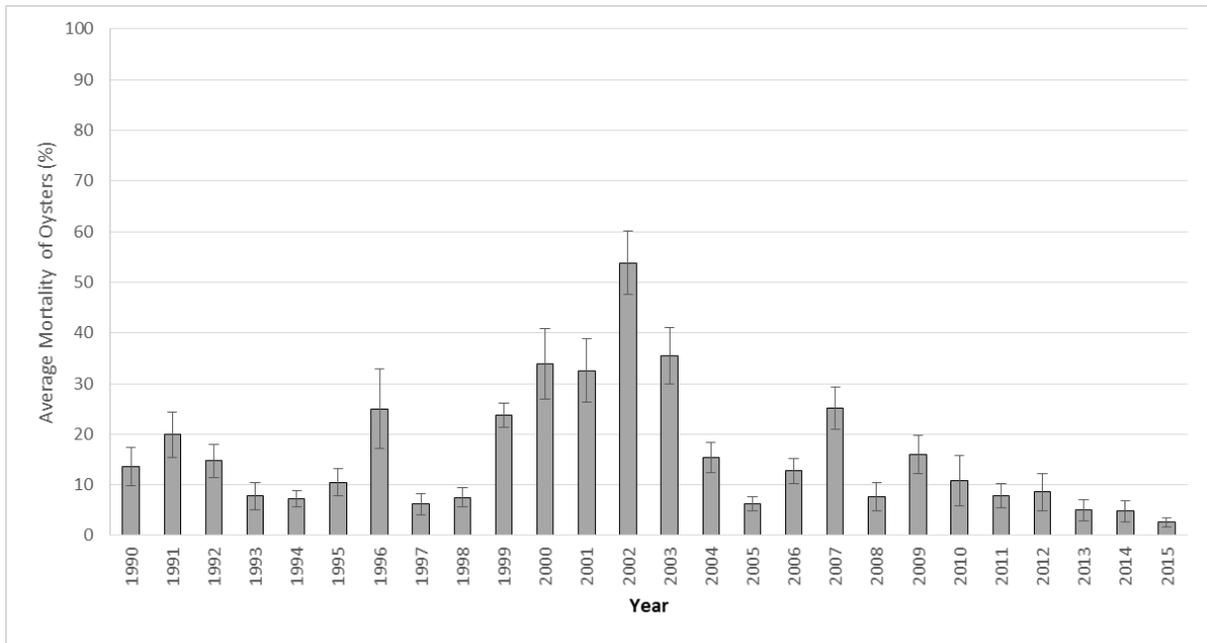


Figure B.32-6. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 274 (Wicomico River West). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

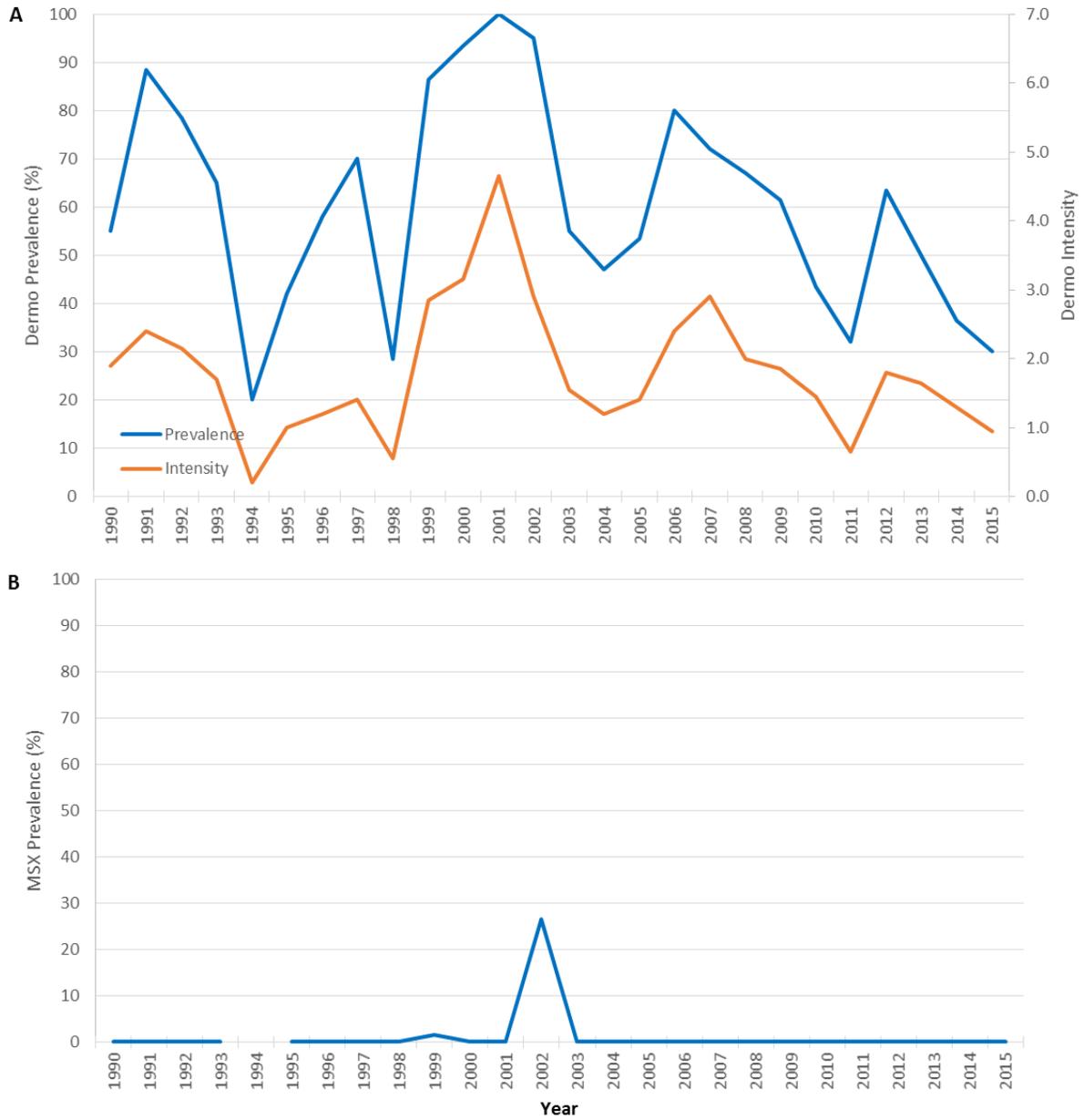


Figure B.32-7. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 274 (Wicomico River West). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland's Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 274 (Wicomico River West) since 1990 is presented in Figure B.32-8. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 4% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from 13 bushels in 2003-2004 season to a maximum of approximately 30,000 bushels in the 1995-1996 season. Harvest has been increasing since 2011-2012. This may be partly attributed to the seed plantings. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. The majority of harvest in this area as reported on the oyster harvest reports was obtained by hand tonging.

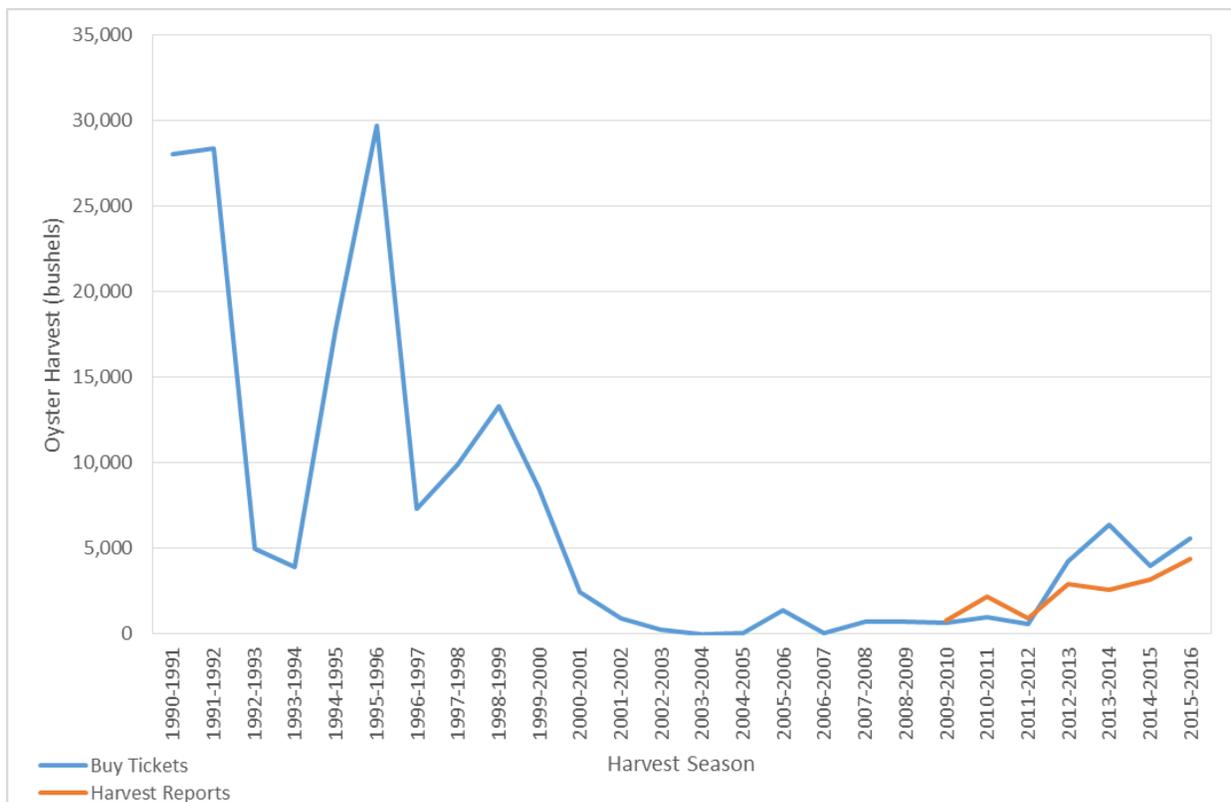


Figure B.32-8. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 274 (Wicomico River West). After the 2009-2010 season, 4% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.33: NOAA Code 292 – Tangier Sound North

NOAA Code 292 encompasses the northern portion of Tangier Sound and is located in Maryland's lower eastern portion of Chesapeake Bay (Figure B.33-1). The entire NOAA Code is 36,250 acres and has 53 historic oyster bars³⁶. Two sanctuaries (Lower Mainstem and Hooper Straits) are partially located within the NOAA Code and contain 8% (2,924 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 33,326 acres. There are 17,401 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside a sanctuary. In 2010, 9,768 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland's medium salinity zone.

Replenishment Activities

Since 1990, approximately 977,286 bushels of shell, 52,000 bushels of wild seed and 91 million hatchery spat-on-shell have been planted in NOAA Code 292 outside of the current sanctuary area (Table B.33-1).

³⁶ See chart 37 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

Table B.33-1. Replenishment planting activities occurring since 1990 in NOAA Code 292 (Tangier Sound North).

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Fresh Shell	8.2	30.1	-
1991	Fresh Shell	10.8	40.0	-
1991	Wild Seed	25.6	14.0	-
1992	Fresh Shell	2.1	5.9	-
1993	Fresh Shell	3.8	6.5	-
1994	Fresh Shell	3.3	2.4	-
1995	Dredged Shell	47.5	95.9	-
1995	Dredged Shell	32.2	ND	-
1997	Dredged Shell	22.1	139.9	-
1998	Dredged Shell	40.5	55.3	-
1998	Fresh Shell	10.1	23.9	-
1998	Wild Seed	39.9	4.2	-
1999	Wild Seed	46.8	7.8	-
2005	Dredged Shell	32.9	215.4	-
2006	Dredged Shell	44.5	285.1	-
2007	Wild Seed	63.1	1.9	-
2008	Wild Seed	6.6	4.0	-
2009	Wild Seed	58.4	20.2	-
2011	Hatchery Spat-on-Shell	11.8	-	26.0
2012	Dredged Shell	126.1	34.4	-
2013	Fresh Shell	4.5	14.0	-
2013	Hatchery Spat-on-Shell	7.3	-	15.0
2014	Fresh Shell	13.1	15.6	-
2014	Hatchery Spat-on-Shell	35.3	-	45.3
2015	Fresh Shell	29.0	13.1	-
2015	Hatchery Spat-on-Shell	7.8	-	4.7

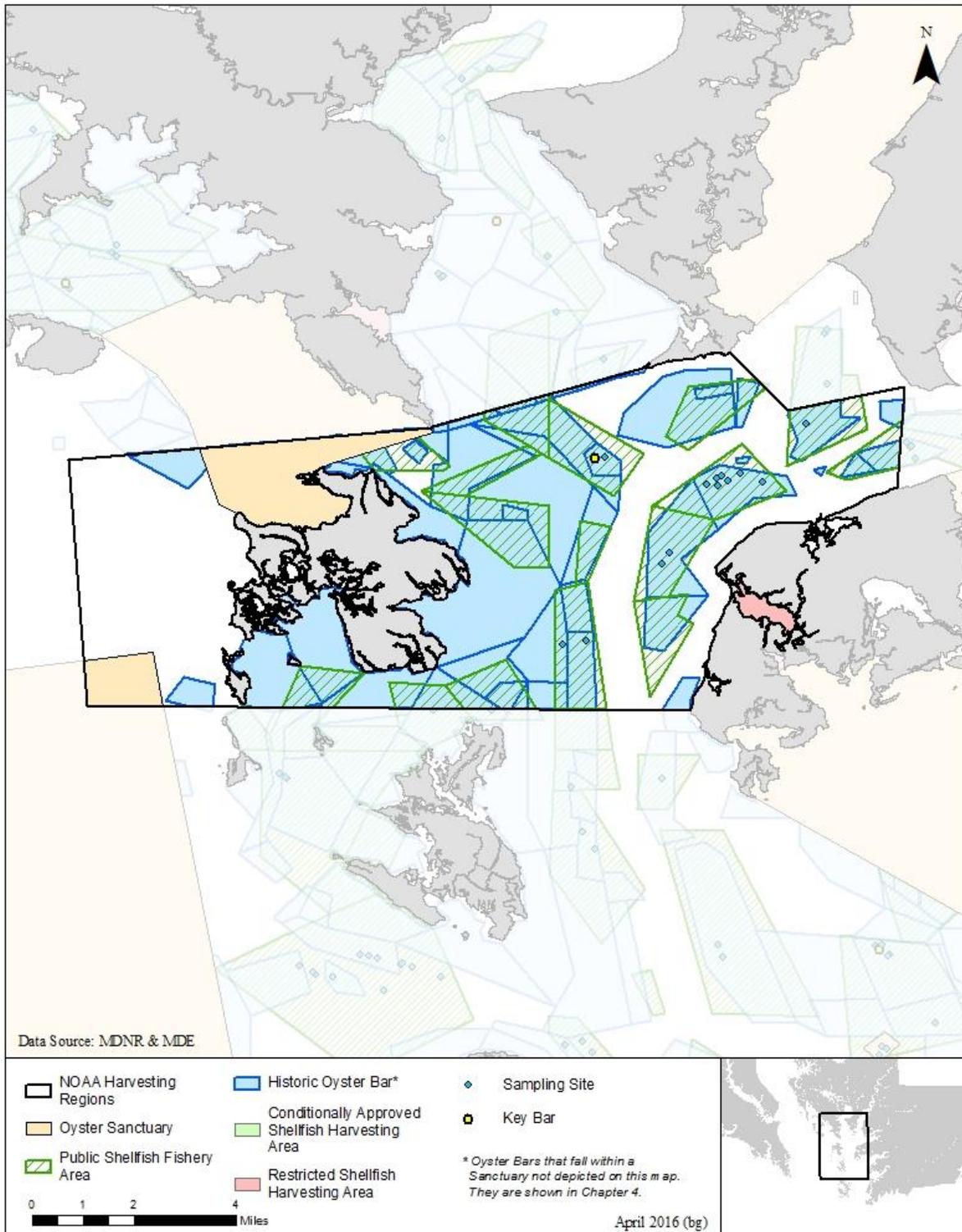


Figure B.33 -1. Map of NOAA Code 292 (Tangier Sound North).

Oyster Population Characteristics

Since 1990 the Fall Survey has sampled 5 to 6 oyster bars annually in NOAA Code 292 outside of the current sanctuary area. The average number of live oysters per bushel (market, small, and spat) ranged from 19 to 250 per bushel with an average of 103 (Figure B.33-2). The number of oysters were low from 1996 to 2005, and then began to increase starting in 2006. Years 2012, 2013, and 2014 had the highest number of market-sized oysters in the 26 year time period. The average number of oysters was greater for the years 2010 to 2015 than prior to 2010 (Table B.33-2).

Table B.33-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 292 (Tangier Sound North). Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 143	6 / 44
Number of Live Oysters per Bushel	86 \pm 10	158 \pm 21
Number of Live Small-Sized Oysters per Bushel	42 \pm 8	65 \pm 11
Number of Live Market-Sized Oysters per Bushel	18 \pm 2	39 \pm 8
Live Oyster Biomass (g Dry Weight per Bushel)	68 \pm 10	146 \pm 35
Mortality (%)	33.7 \pm 4.1	16.2 \pm 2.3

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Sharkfin Shoal and Middleground bars within NOAA Code 292 (Figure B.33-3). The largest oysters (greater than 120mm shell height) were collected from 1998 to 2001, which were also years with the fewest oysters per bushel. For the years 1990-2010, 69% of oysters were 80 mm or less; from 2010-2015, 86% of oysters were less than 80 mm.

Biomass

The Fall Survey has measured oyster biomass on Sharkfin Shoal and Middleground bars within NOAA Code 292 since 1990. The annual biomass has varied over the years from 15 to 255 grams of dry weight per bushel and the average is 86 \pm 13.6 (average \pm SE; Figure B.33-4). The average biomass was greater for the years 2010 to 2015 than prior to 2010 (Table B.33-2). During 1999 to 2006, biomass was the lowest (averaging 38 grams of dry weight per bushel). In 2014 and 2015, biomass began to decrease from the peak in 2013.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 0 to 116 spat per bushel (Figure B.33-2). The largest spatfall occurred in 2010. From 1996 to 2010, spatfall averaged 19 per bushel. From 2010 to 2015, spatfall was higher (averaging 55 per bushel) but inconsistent.

Mortality

Mortality has ranged from 10% to 64%; however, since 2007 mortality has been relatively low (Figure B.33-5). The average mortality was lower from 2010 to 2015 than prior to 2010 (Table B.33-2).

Disease

From 1990 to 2015, dermo prevalence has ranged from 23% to 100% (Figure B.33-6). Dermo prevalence was greater than 80% for 18 of the 26 years disease information was collected. Dermo intensity ranged from 0.3 to 4.4. Throughout the time period intensity never reached lethal levels (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 53%; since 2010, it has averaged 5%.

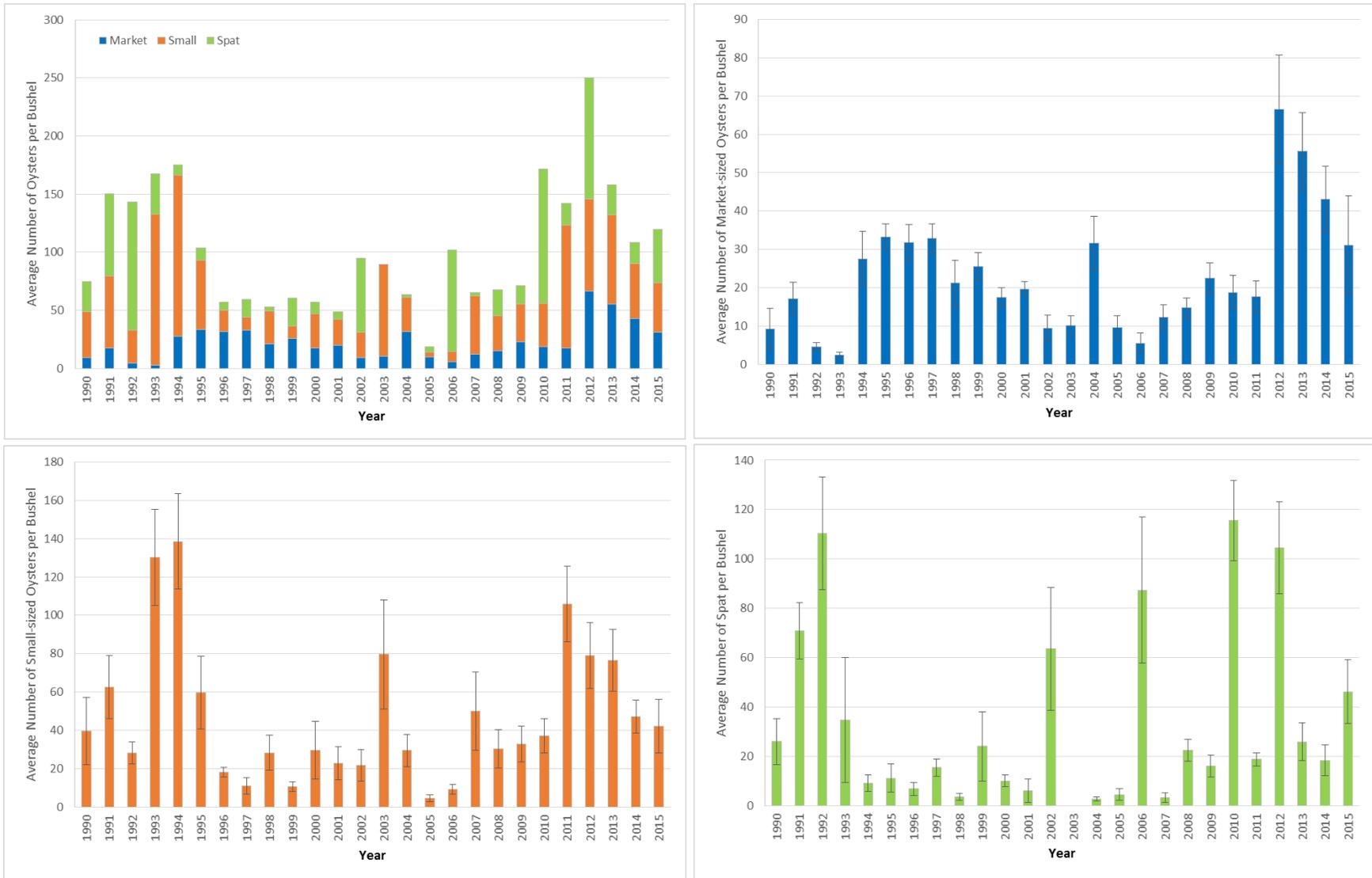
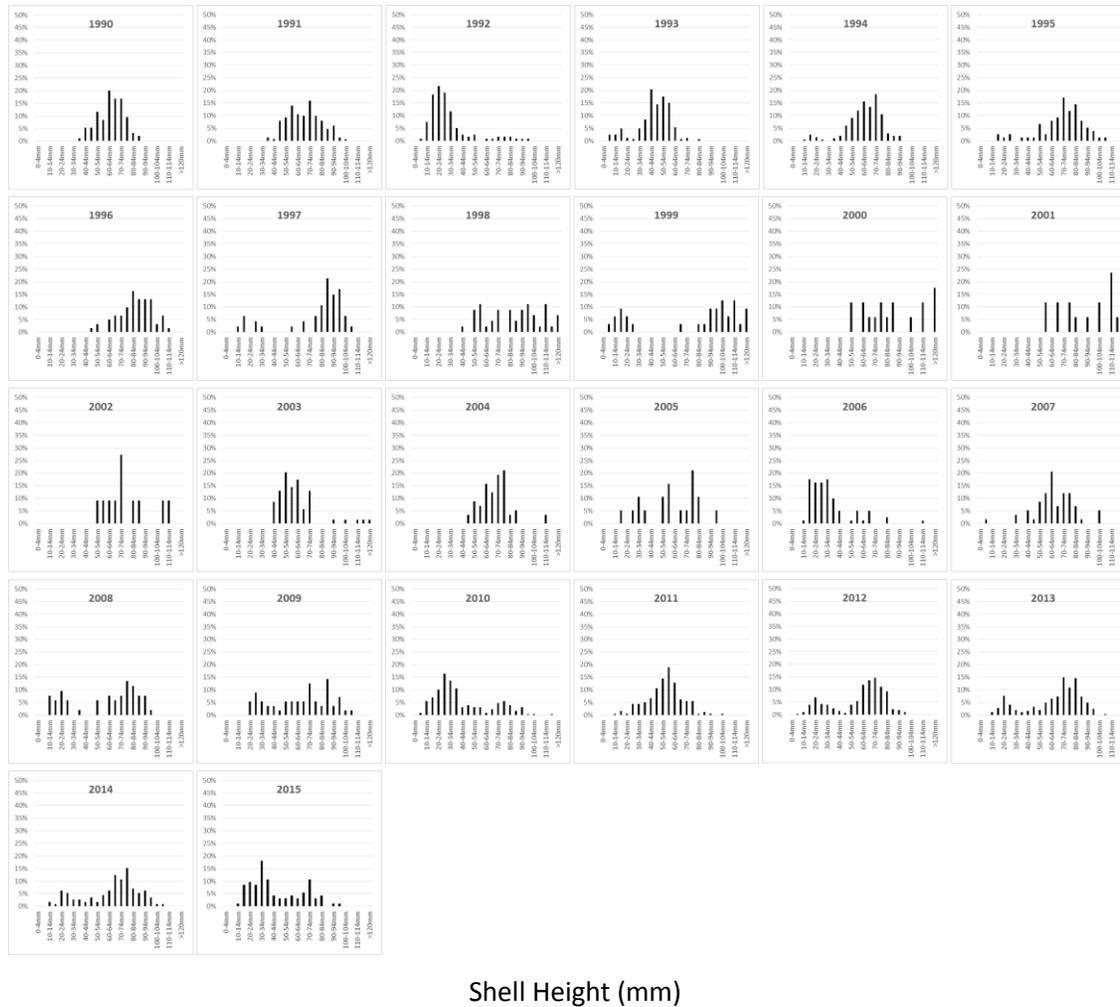


Figure B.33-2. Average number of live oysters per bushel of material by size class in the NOAA Code 292 (Tangier Sound North). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

Frequency (%)



Shell Height (mm)

Figure B.33-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 292 (Tangier Sound North). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.



Figure B.33-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 292 (Tangier Sound North). Data from Maryland’s Annual Fall Oyster Dredge Survey.

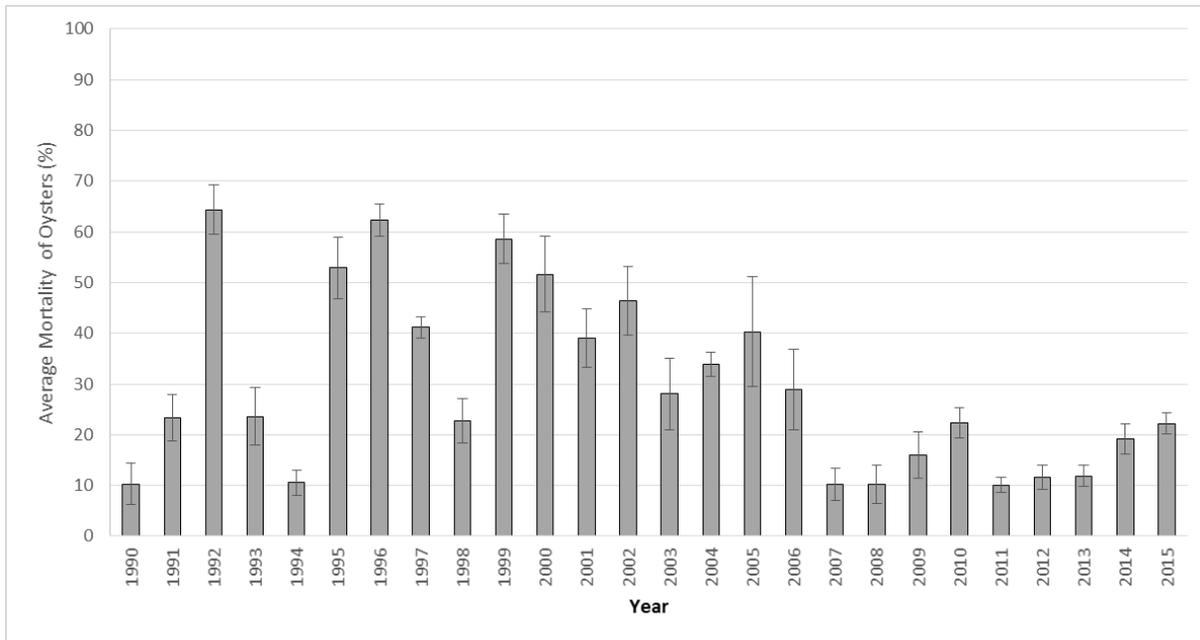


Figure B.33-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 292 (Tangier Sound North). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

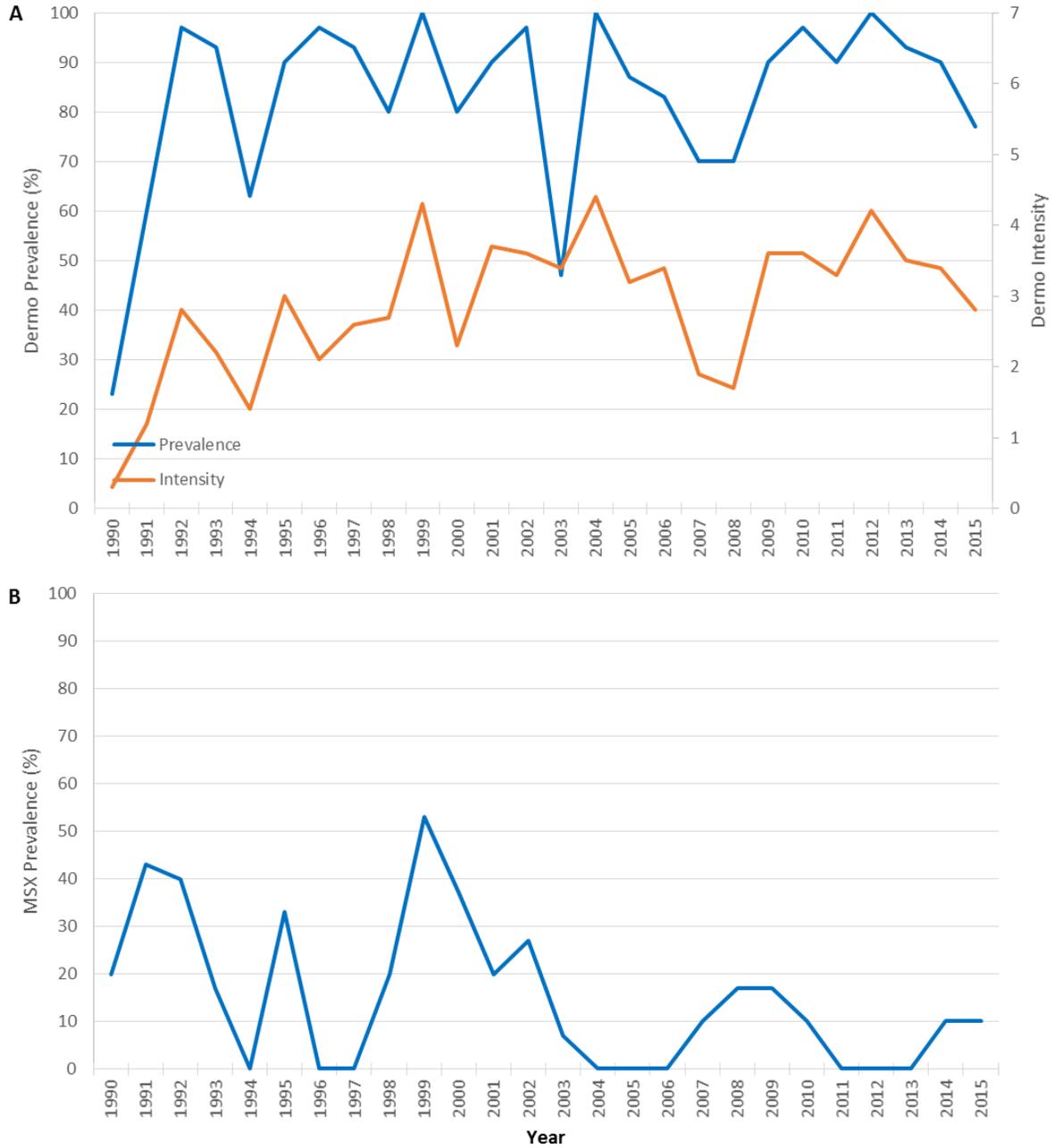


Figure B.33-6. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 292 (Tangier Sound North). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland’s Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 292 (Tangier Sound North) since 1990 is presented in Figure B.33-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 8% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in 1993-1994 season to a maximum of approximately 61,000 bushels in the 2015-2016 season. Harvest has been increasing since the 2005-2006 season. This could be partly attributed to the recent hatchery seed plantings and the high spatfall events in recent years. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Approximately 53% of the harvest in this area as reported on the oyster harvest reports was obtained by patent tonging. Other main gear types of harvest include power dredging (approximately 26% of harvest) and sail dredging (approximately 20% of the harvest).

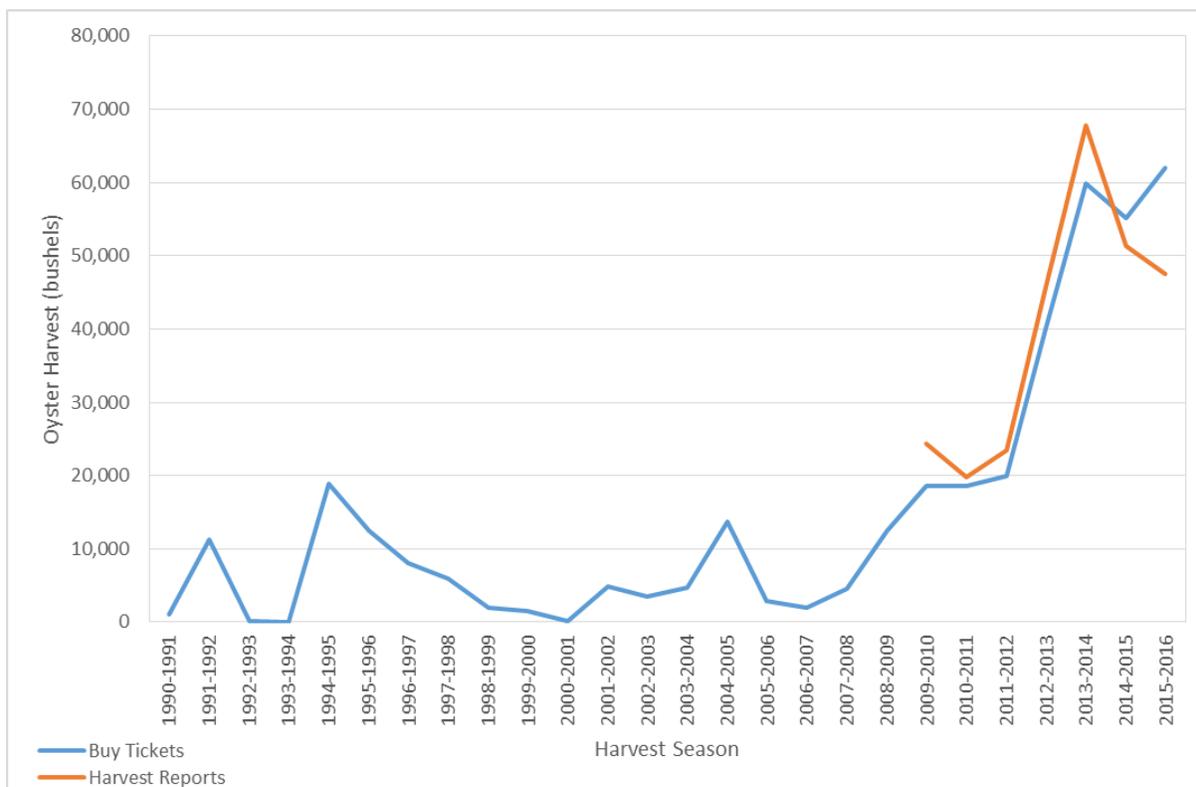


Figure B.33-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 292 (Tangier Sound North). After the 2009-2010 season, 8% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.34: NOAA Code 331 - Chester River Upper

NOAA Code 331 (Chester River Upper) is 7,204 acres; all of the area is within a current sanctuary boundary. The two sanctuaries are Chester River ORA Zone A (established in 1996) and Upper Chester River (established in 2010). See Appendix A Section A.05 and A.46 for more information on the oyster population characteristics.

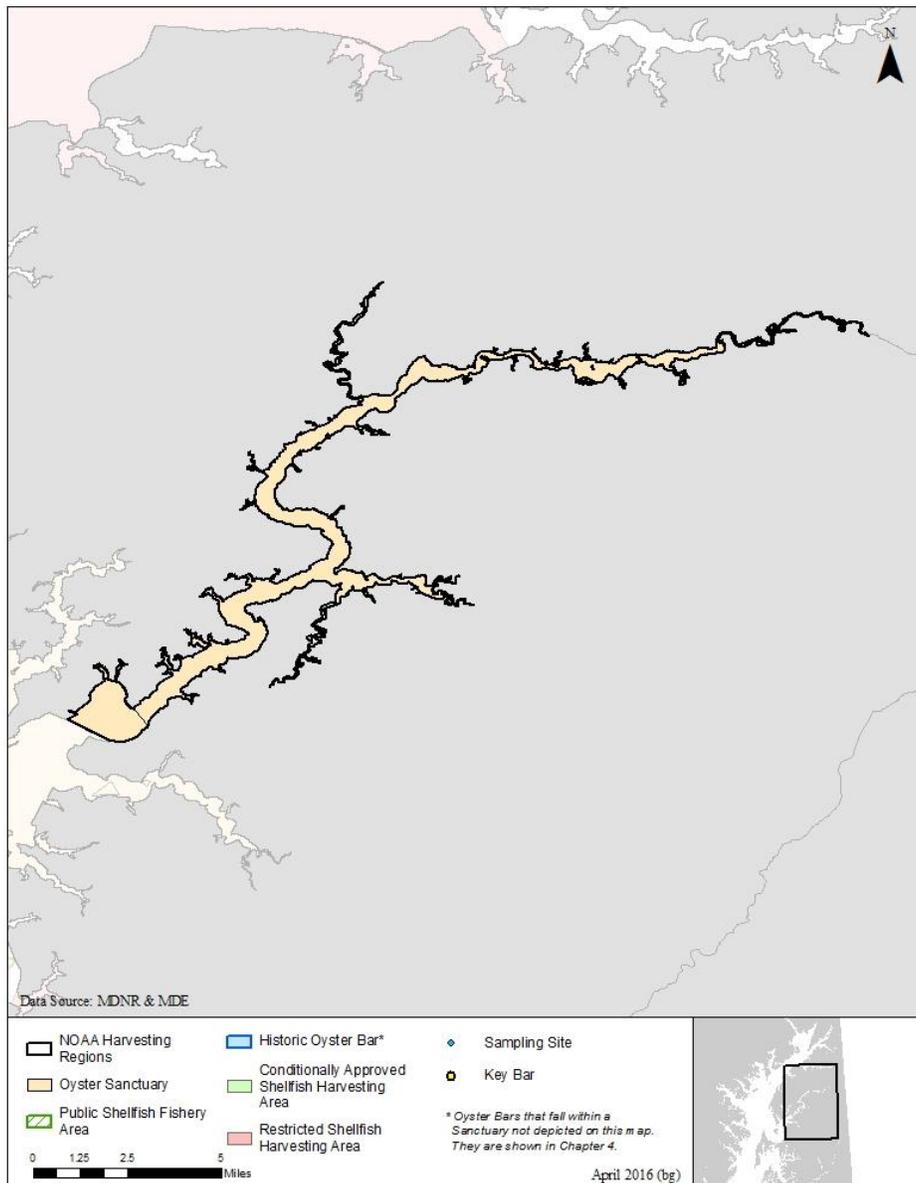


Figure B.34 -1. Map of NOAA Code 331 (Chester River Upper).

Section B.35: NOAA Code 337 - Choptank River Upper

NOAA Code 337 (Choptank River Upper) is 14,142 acres; all but 105 acres of the area is within a current sanctuary boundary. The two sanctuaries are Choptank River ORA Zone A (established in 1996) and Upper Choptank River (established in 2010). In 2010, 33 acres within the NOAA Code were designated as a Public Shellfish Fishery Area, prohibiting aquaculture leasing. See Appendix A Section A.06 and A.47 for more information on the oyster population characteristics.

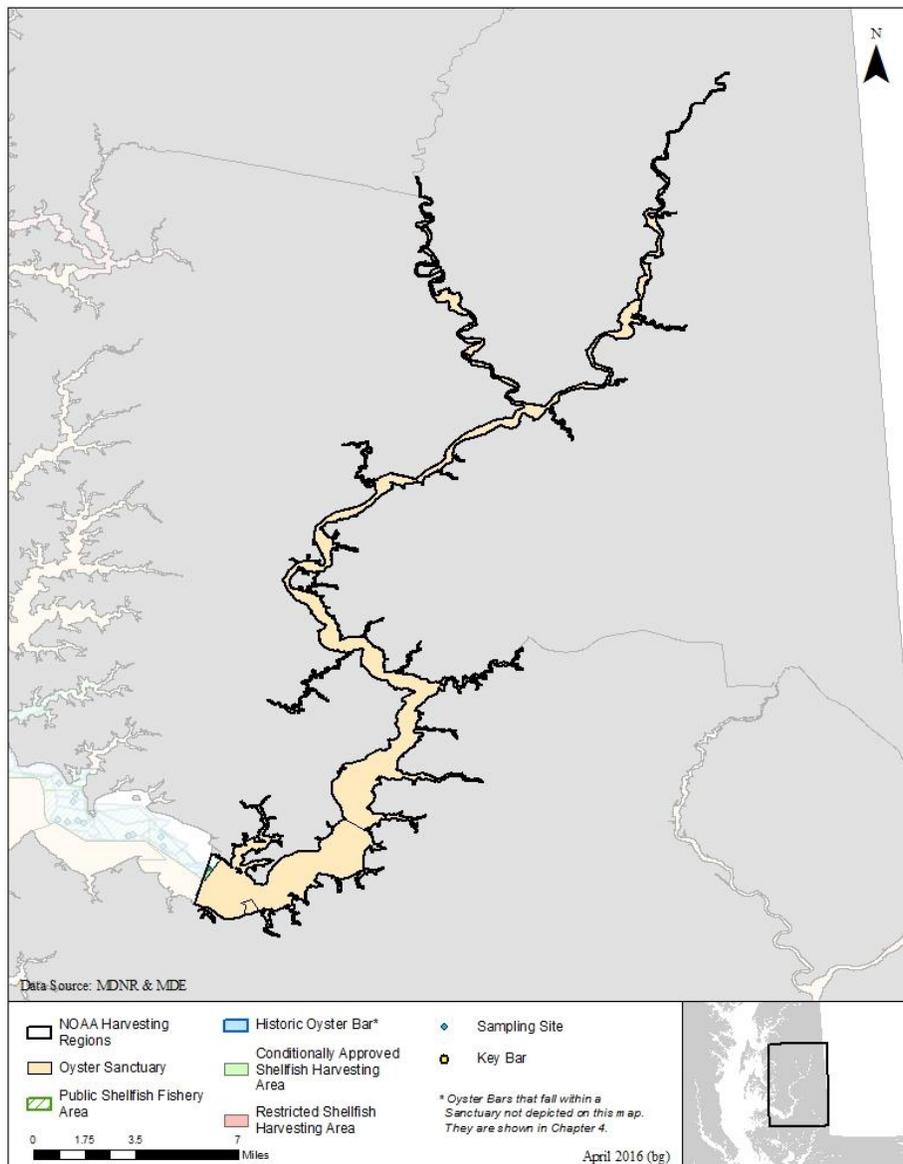


Figure B.35 -1. Map of NOAA Code 337 (Choptank River Upper).

Section B.36: NOAA Code 368 – Patuxent River Upper

NOAA Code 368 consists of the Patuxent River north of Broomes Island and is located in Maryland’s mid-western portion of Chesapeake Bay (Figure B.36-1). The entire NOAA Code is 18,905 acres and has 41 historic oyster bars³⁷. The Upper Patuxent River Sanctuary encompasses 76% (14,461 total acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 4,444 acres. There are 1,769 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and not within a sanctuary. Within NOAA Code 368, 2,043 acres were designated as a Public Shellfish Fishery Area in 2010, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s low salinity zone.

Replenishment Activities

Since 1990, approximately 34,800 bushels of fresh shell and 40,000 bushels of wild seed have been planted in NOAA Code 368 outside of the current sanctuary area (Table B.36-1). No dredged shell or hatchery spat-on-shell plantings have occurred since 1990.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Wild Seed	18.5	11.7	-
1991	Wild Seed	9.0	3.7	-
1995	Fresh Shell	6.0	10.4	-
1997	Fresh Shell	7.7	24.5	-
1997	Wild Seed	5.0	5.3	-
1998	Wild Seed	10.1	7.6	-
2000	Wild Seed	14.5	6.7	-
2003	Wild Seed	8.2	2.9	-
2004	Wild Seed	3.7	2.1	-

³⁷ See chart 22 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

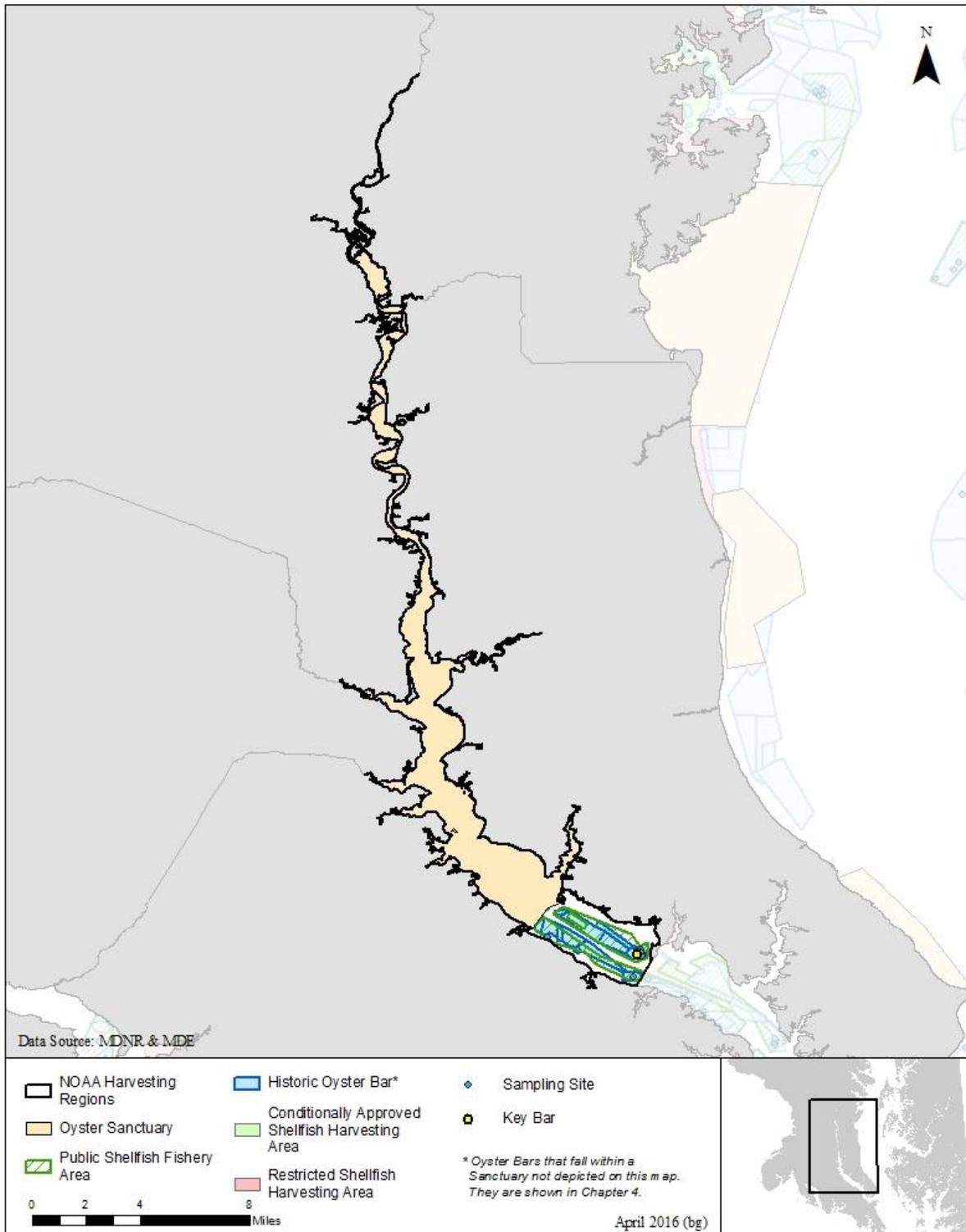


Figure B.36 -1. Map of NOAA Code 368 (Patuxent River Upper).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled between 1 to 3 oyster bars annually in NOAA Code 368 outside of the current sanctuary area. The average number of live oysters (market, small, and spat) ranged from 12 to 188 per bushel with an average of 71 (Figure B.36-2). The number of market-sized oyster was the highest in 2013, 2014, and 2015 during the 26 year time period. The average number of total live oysters was greater for the years 2010 to 2015 than prior to 2010 (Table B.36-2).

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 63	6 / 9
Number of Live Oysters per Bushel	58 \pm 9	114 \pm 23
Number of Live Small-Sized Oysters per Bushel	27 \pm 7	39 \pm 10
Number of Live Market-Sized Oysters per Bushel	26 \pm 4	67 \pm 18
Live Oyster Biomass (g Dry Weight per Bushel)	65 \pm 10	157 \pm 42
Mortality (%)	29.2 \pm 4.5	9.7 \pm 2.3

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Broome Island bar within NOAA Code 368 (Figure B.36-3). The largest oysters (greater than 120mm shell height) were collected from 1997 to 2000. For the years 2010 to 2015, 12% of oysters were larger than 100mm, compared to 20% for the years prior to 2010.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on Broome Island bar within NOAA Code 368. The annual biomass has ranged from 3 to 256 grams of dry weight per bushel and the average is 86 \pm 14.3 (average \pm SE; Figure B.36-4). The average biomass was greater for the years 2010 to 2015 than prior to 2010 (Table B.36-2). From 2001 to 2007, biomass was at its lowest before increasing to its highest level in 2014. The increasing biomass is likely due to larger numbers of market-sized oysters.

Recruitment (Spatfall)

From 1990 to 2015, spatfall ranged from 0 to 46 spat per bushel (Figure B.36-2). The largest spatfall occurred in 1995, with another peak in 2010. From 1996 to 2009 there was very little spatfall, averaging just three spat per bushel.

Mortality

Since 1990, mortality has ranged from 5% to 65% (Figure B.36-5). The average mortality was greater for the years 1990 to 2009 than for 2010 to 2015 (Table B.36-2).

Disease

Disease pressure from dermo has fluctuated over the years with prevalence ranging from 17% to 100% (Figure B.36-6). Dermo prevalence was greater than 80% for 16 of the 26 years disease information was collected. Dermo intensity ranged from 0.4 to 4.8 from 1990 to 2015. Dermo intensity has remained below lethal levels (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 20%, reaching its highest levels in 2000 and 2002 (10% and 13%, respectively).

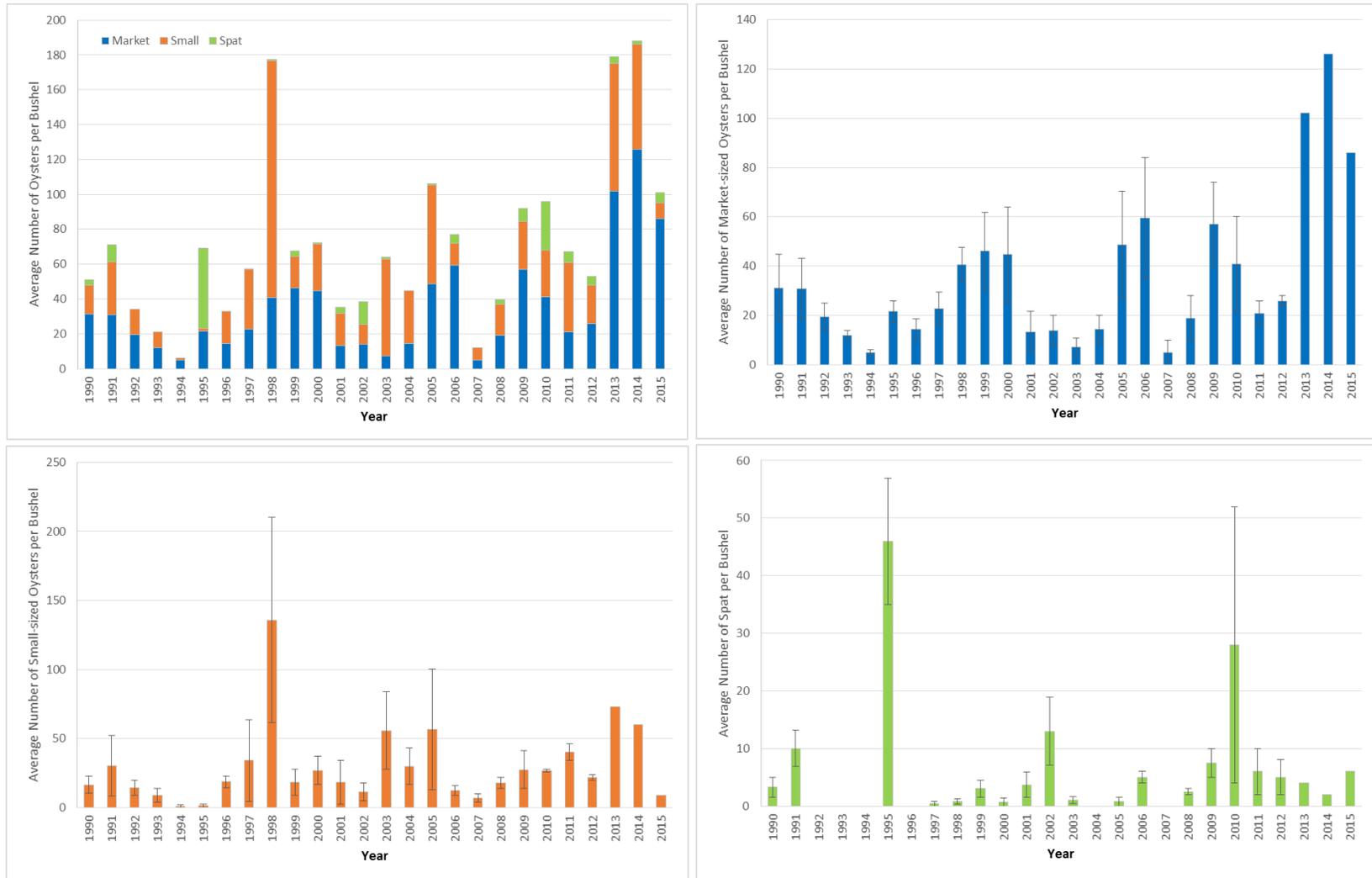
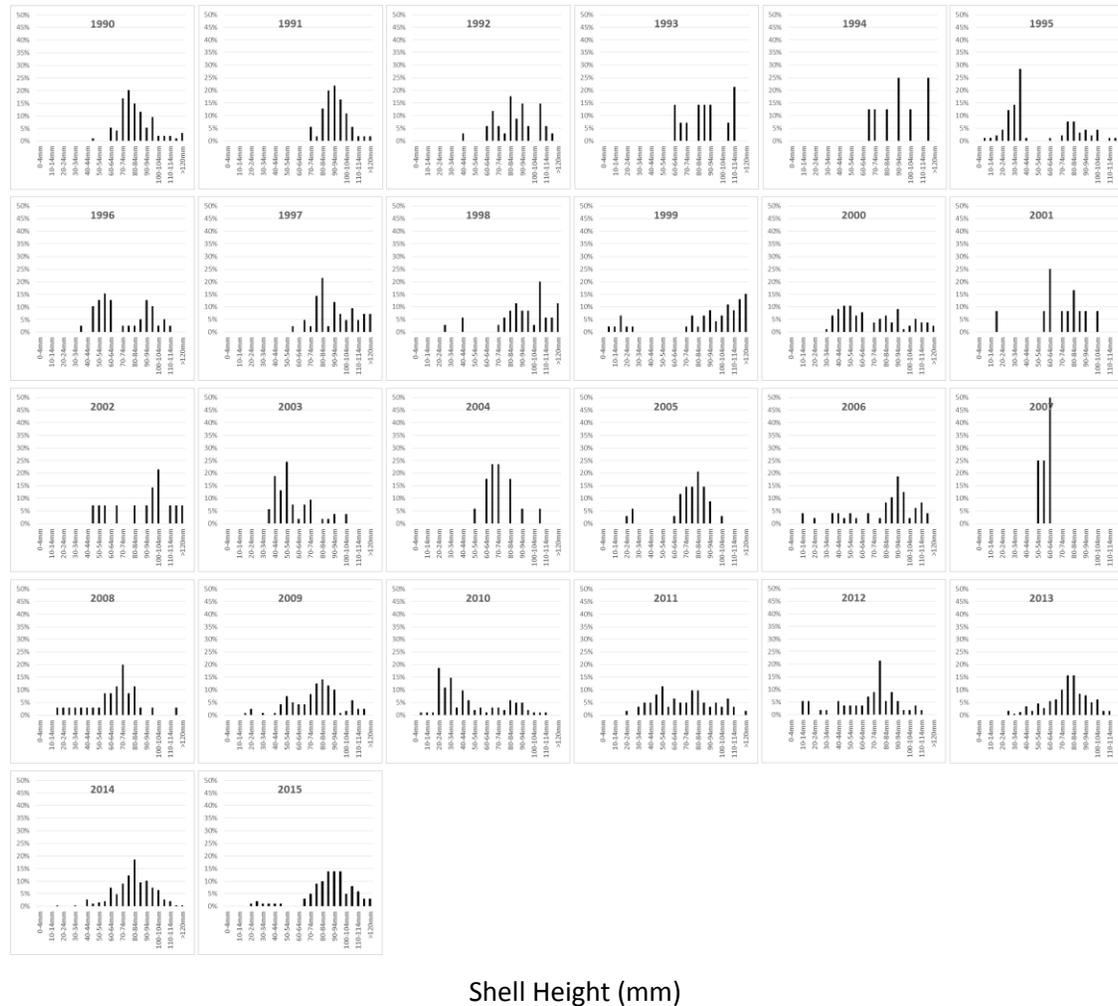


Figure B.36-2. Average number of live oysters per bushel of material by size class in the NOAA Code 368 (Patuxent River Upper). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

Frequency (%)



Shell Height (mm)

Figure B.36-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 368 (Patuxent River Upper). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

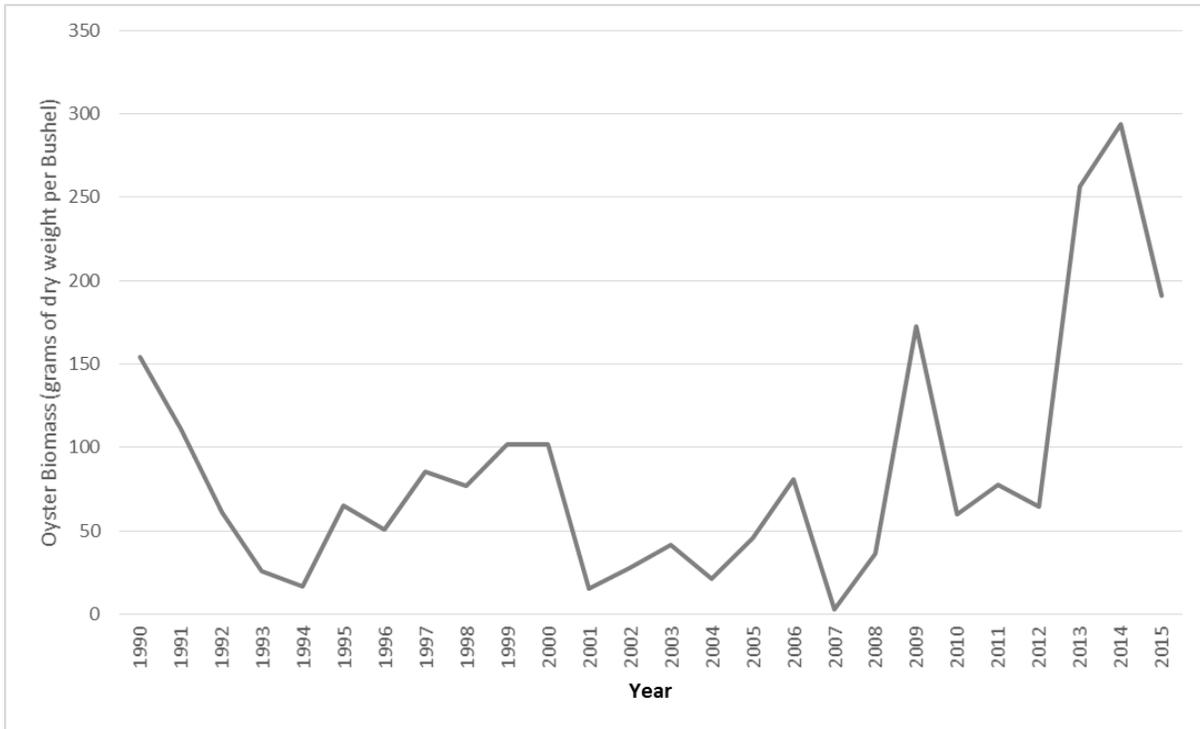


Figure B.36-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 368 (Patuxent River Upper). Data from Maryland’s Annual Fall Oyster Dredge Survey.

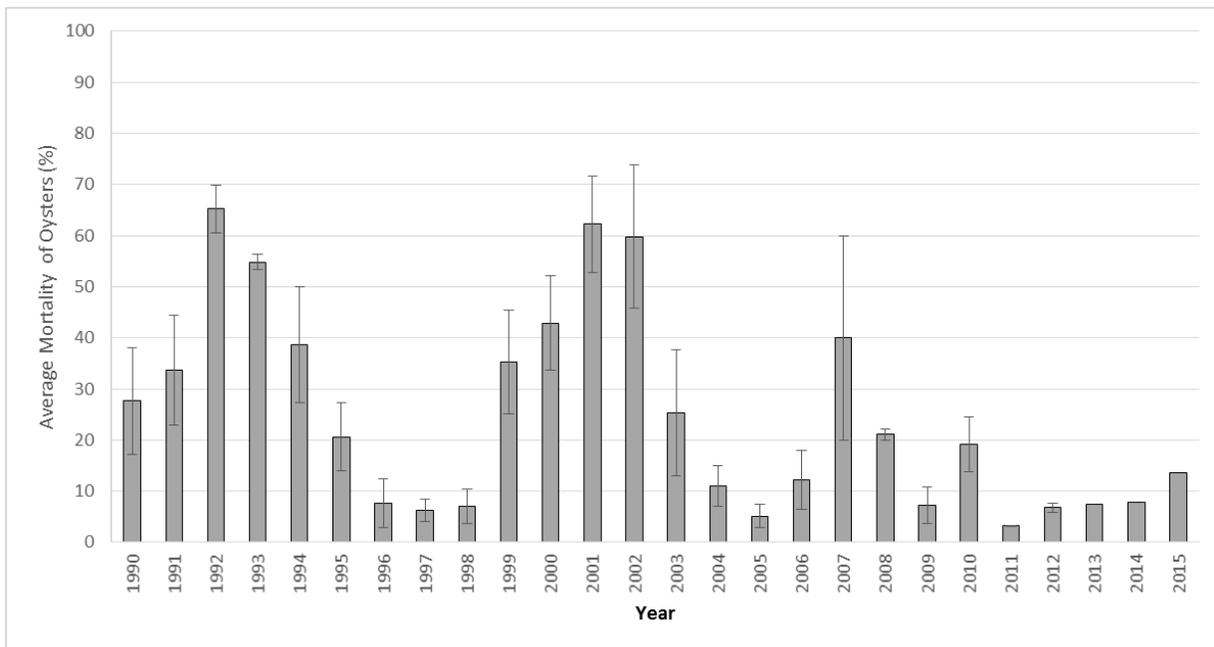


Figure B.36-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 368 (Patuxent River Upper). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

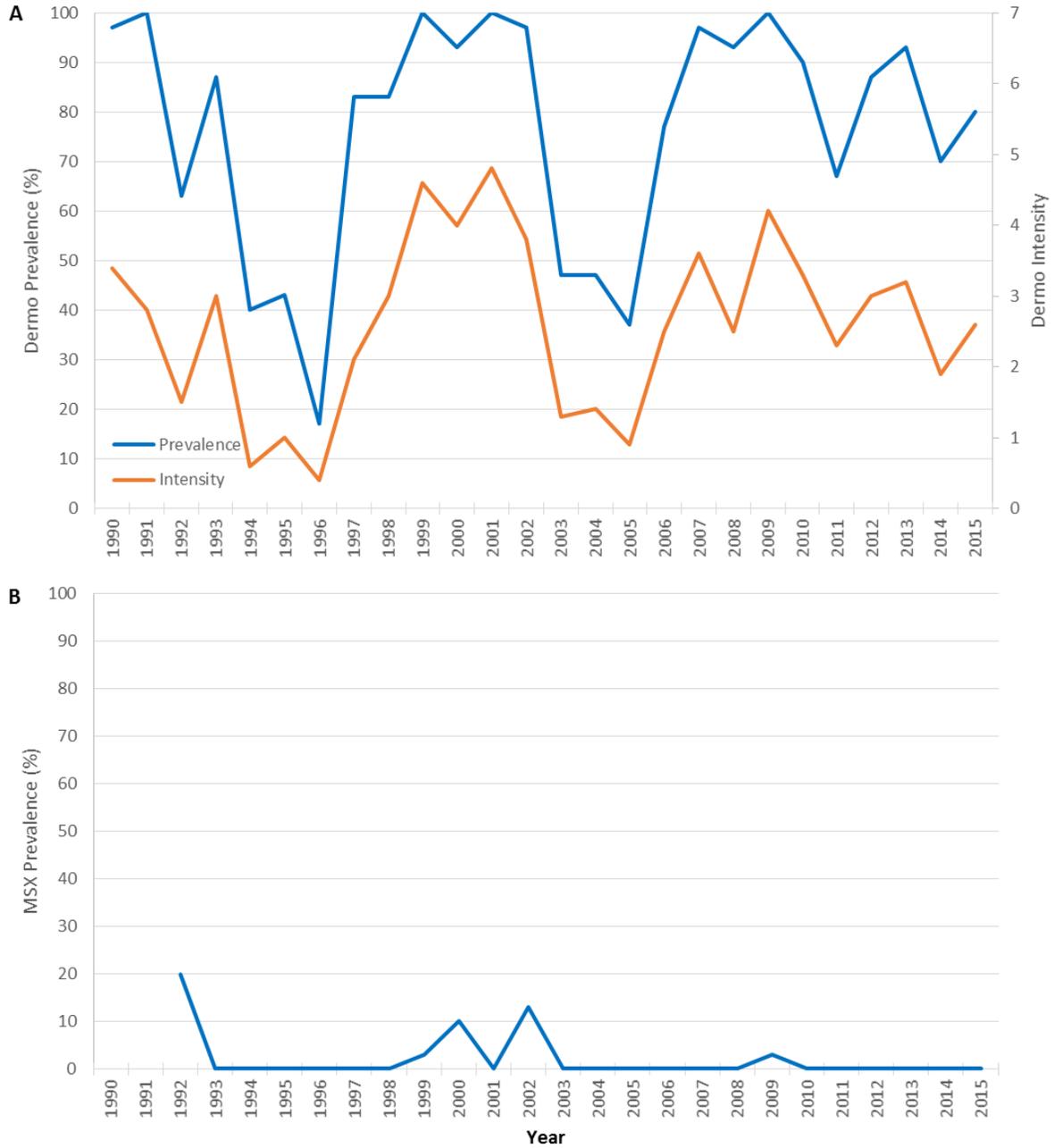


Figure B.36-6. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 368 (Patuxent River Upper). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland's Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 368 (Patuxent River Upper) since 1990 is presented in Figure B.36-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 76% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in six seasons to a maximum of 9,200 bushels in the 1990-1991 season. Harvest has been increasing since 2009-2010 with the 2015-2016 having the second highest harvest since 1990-1991. This could be partly attributed to the high spatfall in 2010. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. The majority of harvest in this area as reported on the oyster harvest reports was obtained by diving.

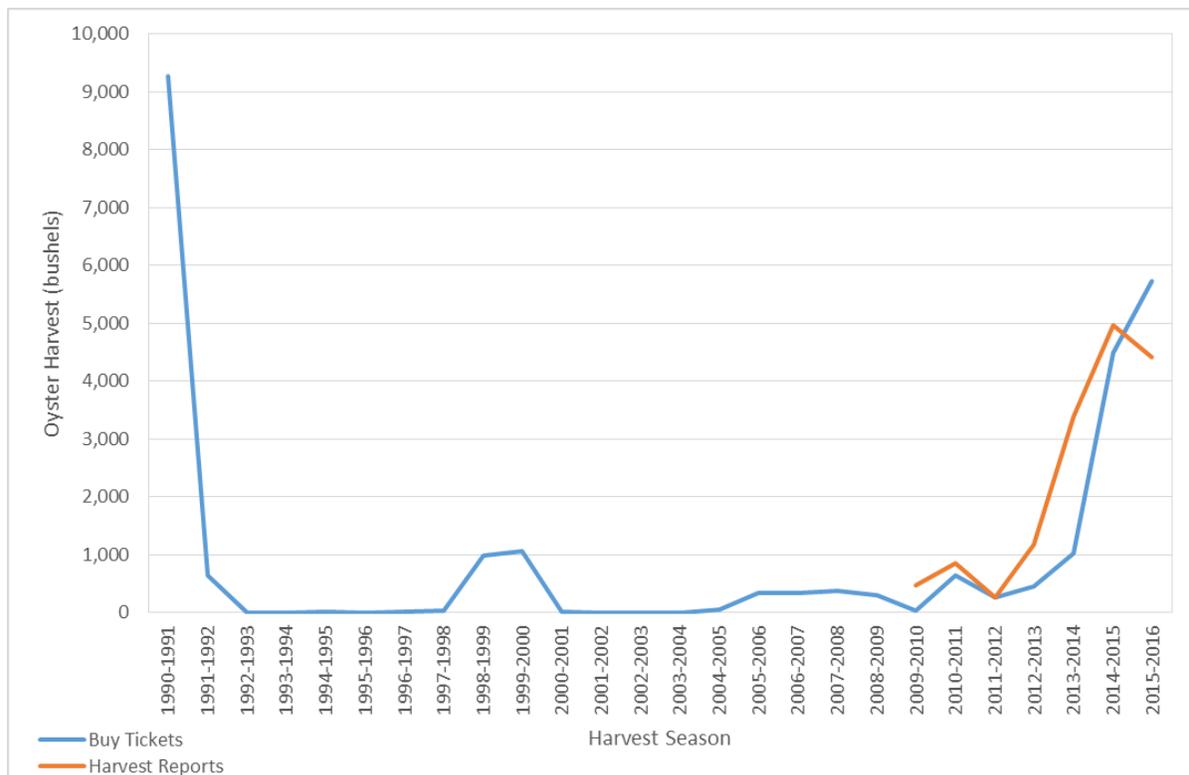


Figure B.36-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 368 (Patuxent River Upper). After the 2009-2010 season, 76% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.37: NOAA Code 437 – Harris Creek

NOAA Code 437 encompasses Harris Creek, a tributary of the Choptank River, and is located in Maryland’s mid-eastern portion of Chesapeake Bay (Figure B.37-1). The entire NOAA Code is 7,310 acres and has 18 historic oyster bars³⁸. The Harris Creek Sanctuary encompasses 64% (4,647 acres) of the NOAA Code. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 2,663 acres. There are 1,506 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code and outside the sanctuary. Within the NOAA Code, 1,862 acres were designated as a Public Shellfish Fishery Area in 2010, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s low salinity zone.

Replenishment Activities

Since 1990, approximately 152,820 bushels of fresh and dredged shell have been planted in NOAA Code 437 outside of the current sanctuary area (Table B.37-1). No wild seed or hatchery spat-on-shell has been planted since 1990.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1995	Dredged Shell	19.0	120.4	-
1996	Dredged Shell	53.8	377.2	-
1997	Dredged Shell	67.4	300.9	-
1998	Dredged Shell	18.0	85.3	-
2000	Dredged Shell	52.1	59.6	-
2001	Dredged Shell	53.4	232.9	-
2005	Dredged Shell	29.9	190.1	-
2012	Dredged Shell	5.0	3.9	-
2013	Fresh Shell	1.6	5.2	-

³⁸ See chart 15 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

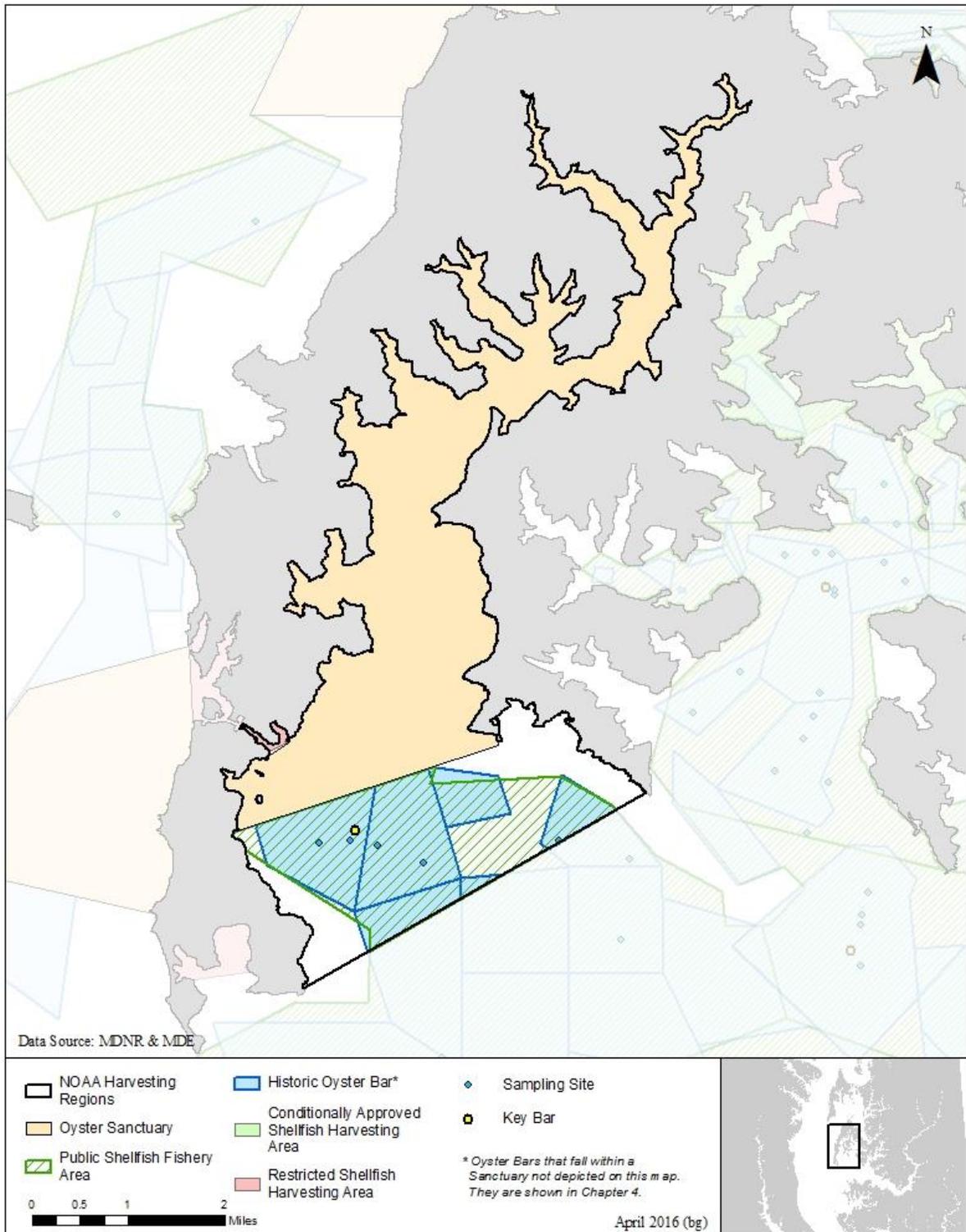


Figure B.37 -1. Map of NOAA Code 437 (Harris Creek).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled 2 to 3 oyster bars annually in NOAA Code 437 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 8 to 941 per bushel with an average of 238 (Figure B.37-2). The number of oysters was low from 2000 to 2009, and then began to increase starting in 2010. The average number of total live oysters was slightly greater in the years prior to 2010 than in 2010-2015 (Table B.37-2).

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 56	6 / 18
Number of Live Oysters per Bushel	249 \pm 58	205 \pm 37
Number of Live Small-Sized Oysters per Bushel	111 \pm 21	88 \pm 18
Number of Live Market-Sized Oysters per Bushel	43 \pm 7	64 \pm 21
Live Oyster Biomass (g Dry Weight per Bushel)	168 \pm 27	182 \pm 43
Mortality (%)	16.8 \pm 3.7	2.5 \pm 0.6

Oyster Size Structure

Since 1990, the Fall Survey has measured oyster shell heights on Tilghman Wharf bar within NOAA Code 437 (Figure B.37-3). The majority of oysters measured (73%) were 80 mm or less. Only 3% of oysters were larger than 100 mm.

Biomass

Since 1990, the Fall Survey has measured oyster biomass on Tilghman Wharf bar within NOAA Code 437. The annual biomass has ranged from 19 to 434 grams of dry weight per bushel and the average is 171 (Figure B.37-4). The average biomass was slightly greater for the years 2010 to 2015 than prior to 2010 (Table B.05-2). Biomass began declining in 2002 and remained low until 2011, with the exception of a slight peak in 2007. The highest biomass was recorded in 1996, with another peak in 2014.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 0 to 815 per bushel (Figure B.37-2), averaging 85. The largest spatfall occurred in 1997, with 815 per bushel. From 2000 to 2009,

there was very little spatfall, averaging 6 per bushel. From 2010-2015, spatfall averaged 53 per bushel.

Mortality

Mortality ranged from 0% to 53%, averaging 13%. Since 2004 mortality has been relatively low (Figure B.37-5), averaging 4%. The average mortality was lower from 2010 to 2015, compared to 1990-2010 (Table B.37-2).

Disease

Disease pressure from dermo has fluctuated from 0% to 100% (Figure B.37-6). Dermo prevalence averaged 83% from 1990 to 2004 and only reached 50% once in the following years (2006). Dermo intensity ranged from 0 to 3.5 and has never reached lethal levels (scale of 0 to 7 with values higher than 5 indicating lethal infections). Intensity also dropped significantly after 2004. MSX prevalence ranged from 0% to 60%. From 1999 to 2002, MSX prevalence averaged 24%. Since 2003, MSX prevalence has averaged less than 1%.

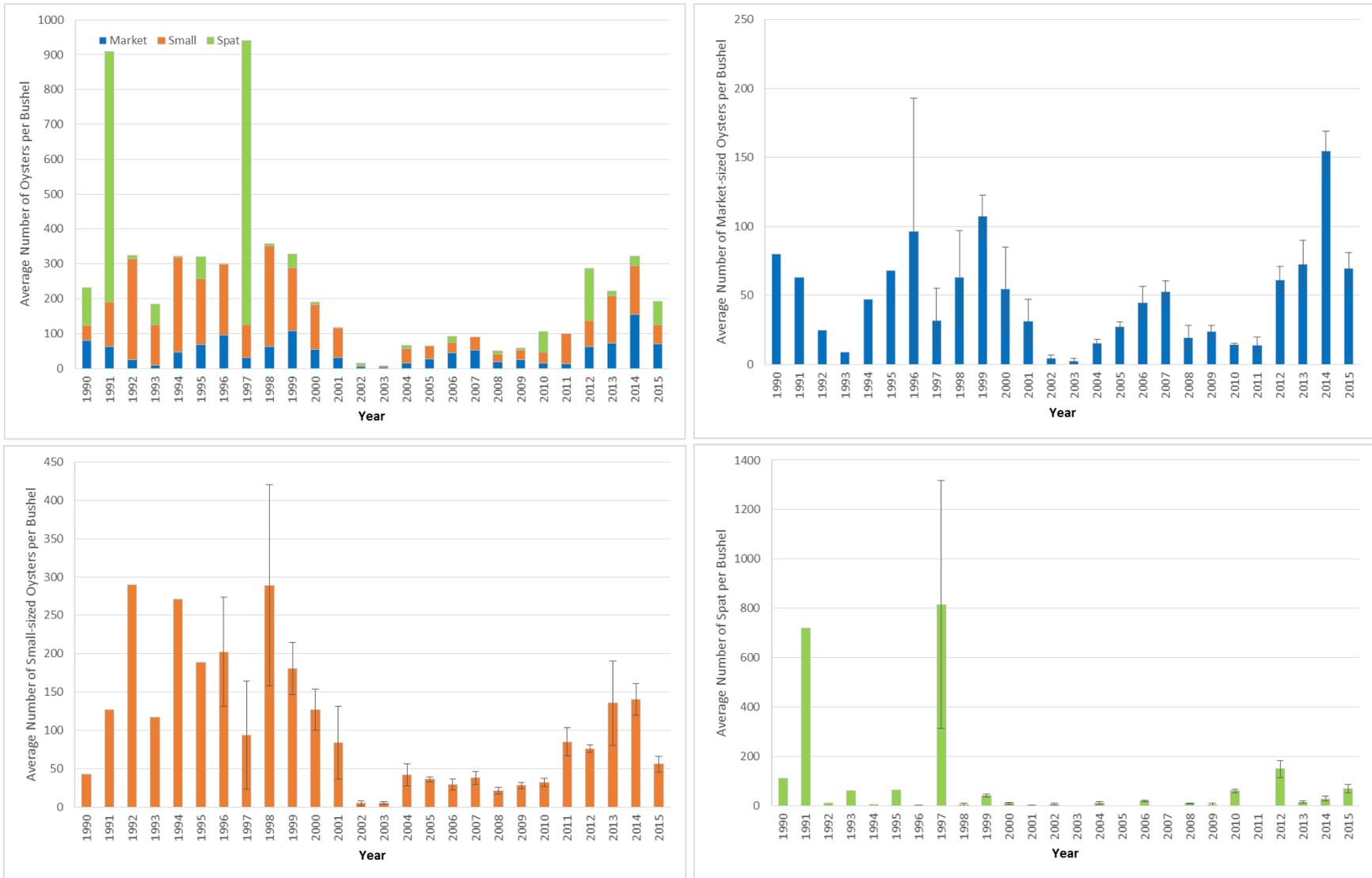
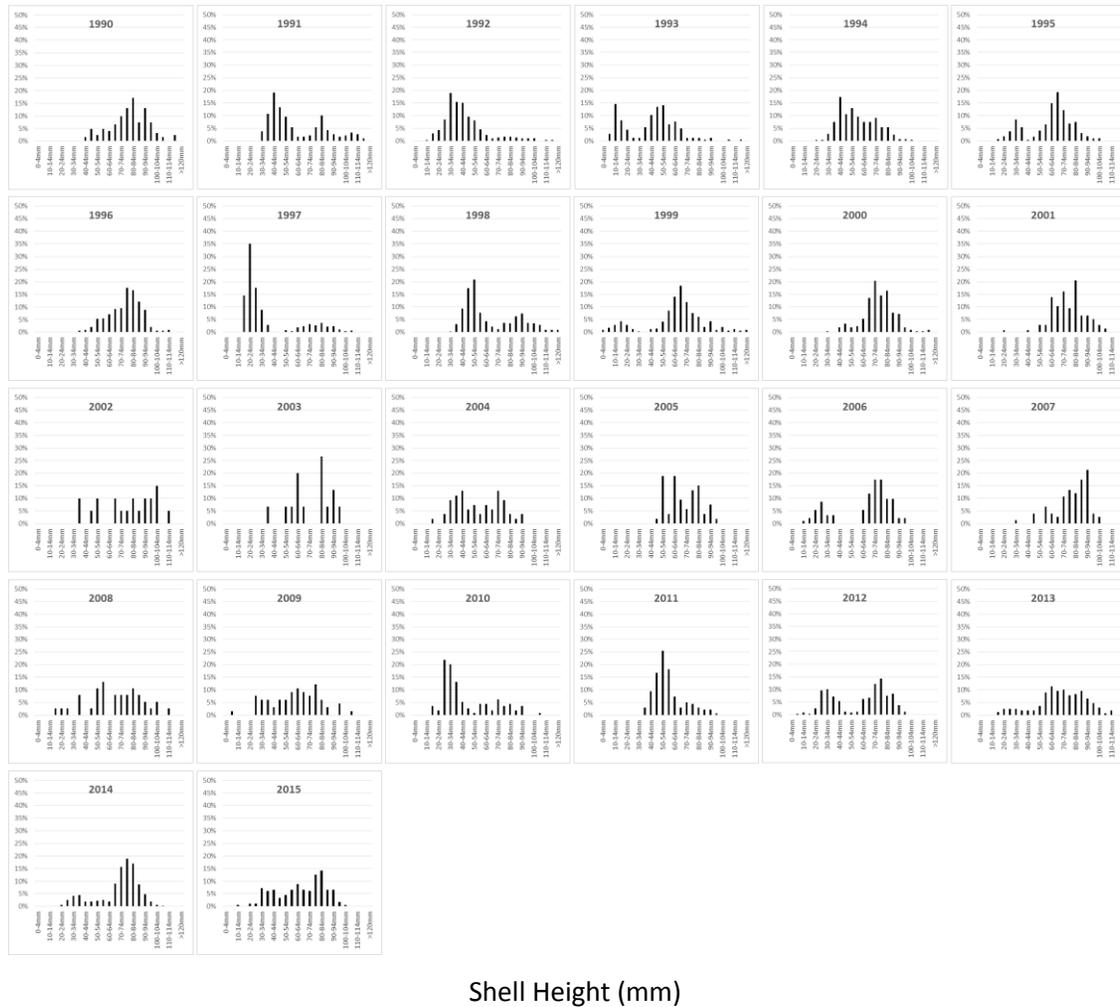


Figure B.37-2. Average number of live oysters per bushel of material by size class in the NOAA Code 437 (Harris Creek). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

Frequency (%)



Shell Height (mm)

Figure B.37-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 437 (Harris Creek). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.



Figure B.37-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 437 (Harris Creek). Data from Maryland’s Annual Fall Oyster Dredge Survey.

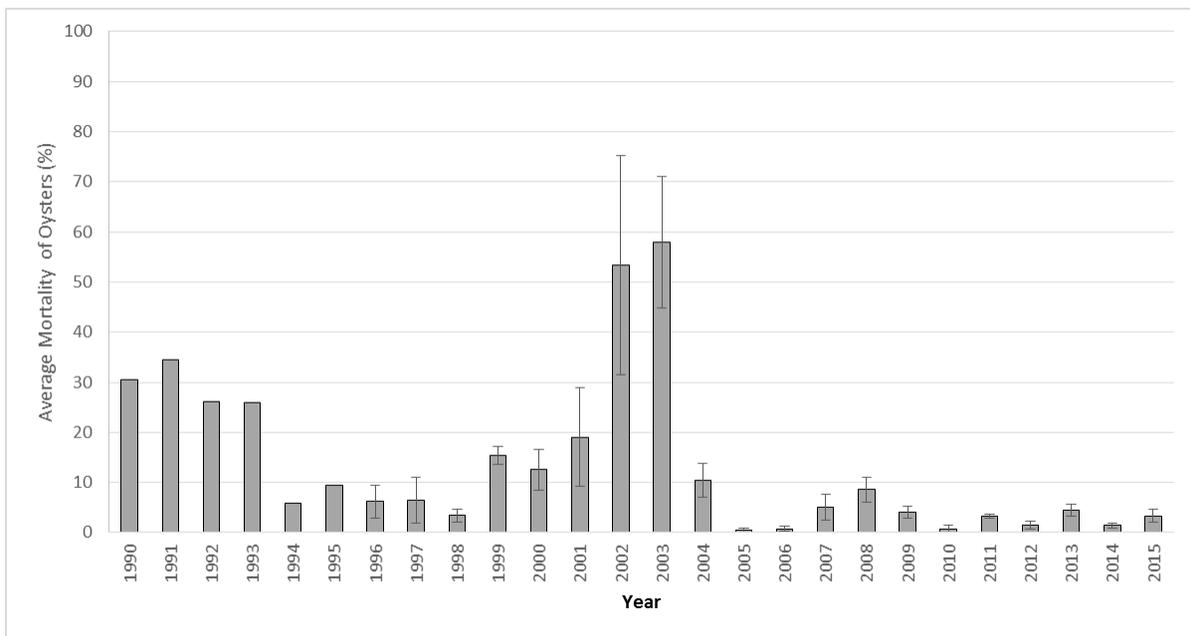


Figure B.37-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 437 (Harris Creek). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

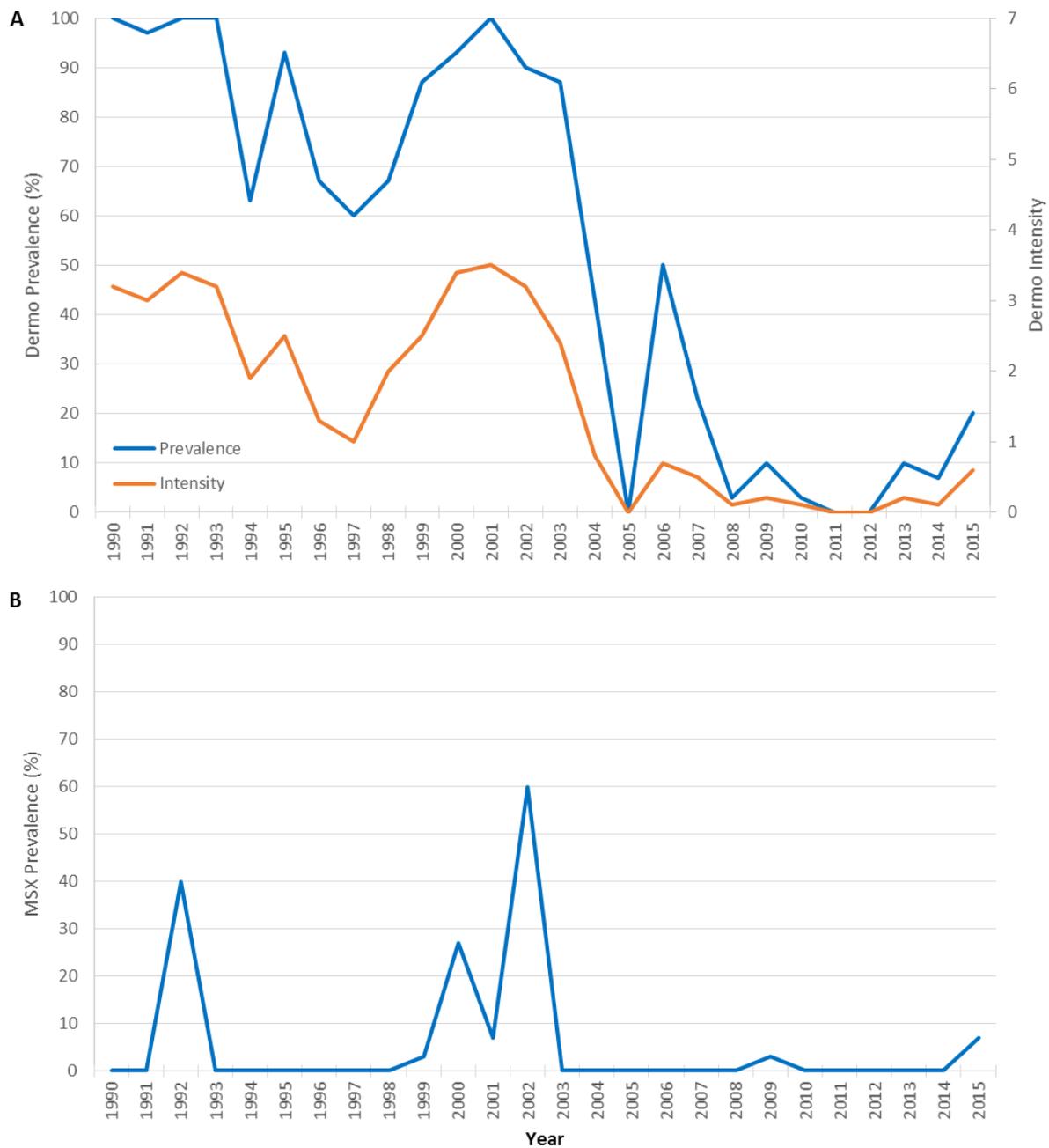


Figure B.37-6. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 437 (Harris Creek). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland’s Annual Fall Oyster Dredge Survey.

Harvest

Harvest for the entire NOAA Code 437 (Harris Creek) since 1990 is presented in Figure B.37-7. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 64% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in the 1993-1994 season to a maximum of approximately 67,000 bushels in the 1998-1999 season. Harvest has been increasing since the 2009-2010 season. This could be partly attributed to the 2010 high spatfall year. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. The majority of harvest in this area as reported on the oyster harvest reports is obtained by power dredging.

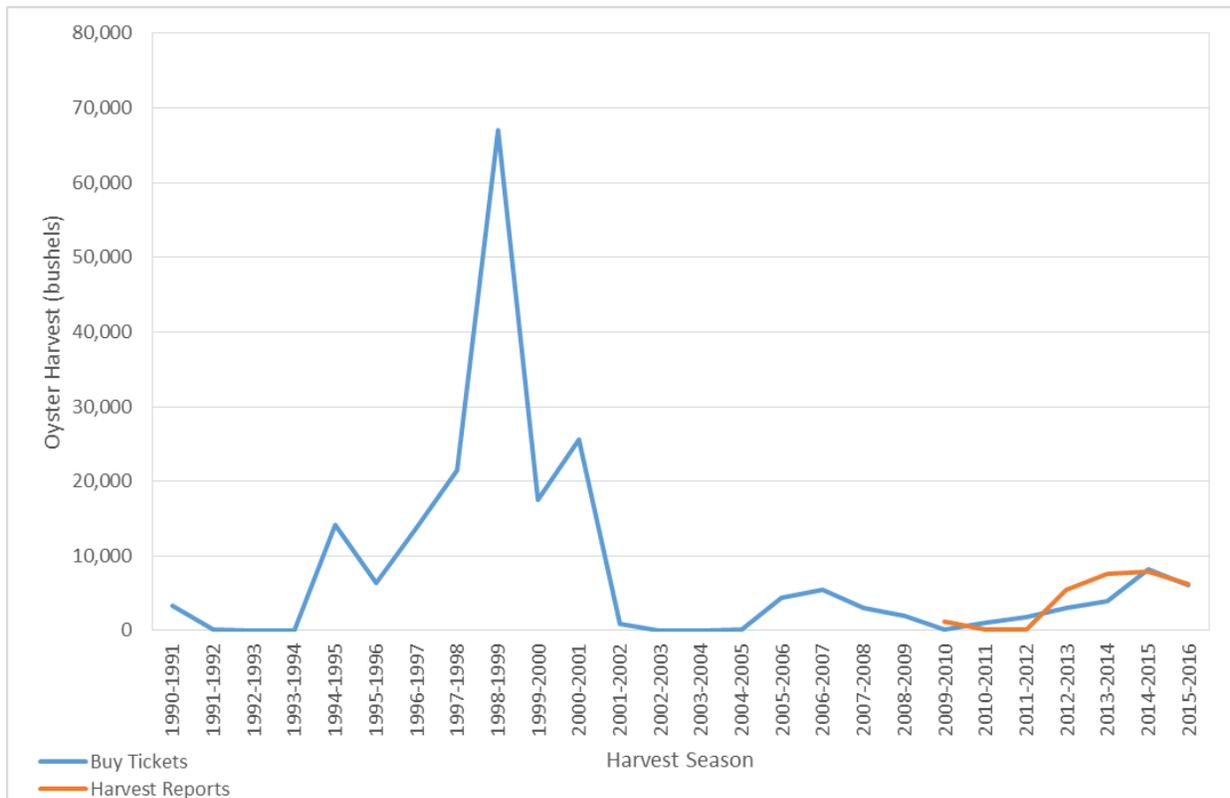


Figure B.37-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 437 (Harris Creek). After the 2009-2010 season, 64% of the NOAA Code area was a sanctuary where harvest is prohibited.

Section B.38: NOAA Code 537 – Broad Creek

NOAA Code 537 encompasses Broad Creek and is located in Maryland's mid-eastern portion of Chesapeake Bay as a tributary to the Choptank River (Figure B.38-1). The entire NOAA Code is 7,959 acres and has 23 historic oyster bars³⁹. There are 2,760 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code. Currently, none of the area within the NOAA Code is within an oyster sanctuary. There are 5,488 acres within the NOAA Code which were designated as a Public Shellfish Fishery Area in 2010, prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland's medium salinity zone.

Replenishment Activities

Since 1990, approximately 11,541,600 bushels of shell and 807,600 bushels of wild seed have been planted in NOAA Code 537 (Table B.38-1).

³⁹ See chart 15 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

Table B.38-1. Replenishment planting activities occurring since 1990 in NOAA Code 537 (Broad Creek). ND = No Data.

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Dredged Shell	38.8	2,150.9	-
1996	Fresh Shell	1.2	46.5	-
1997	Dredged Shell	5.2	453.4	-
1997	Fresh Shell	0.9	69.0	-
1998	Dredged Shell	7.5	388.0	-
1998	Wild Seed	9.1	60.5	-
1999	Dredged Shell	12.1	735.4	-
2000	Dredged Shell	10.2	599.8	-
2001	Dredged Shell	31.0	2,042.6	-
2001	Wild Seed	33.6	138.4	-
2002	Dredged Shell	30.0	1,888.5	-
2002	Wild Seed	14.0	78.7	-
2006	Dredged Shell	38.1	3,167.5	-
2008	Wild Seed	10.1	106.0	-
2009	Wild Seed	24.8	424.0	-
2012	Dredged Shell	150.7	ND	-
2013	Fresh Shell	8.9	310.0	-
2014	Fresh Shell	2.0	76.5	-
2015	Fresh Shell	80.8	314.1	-

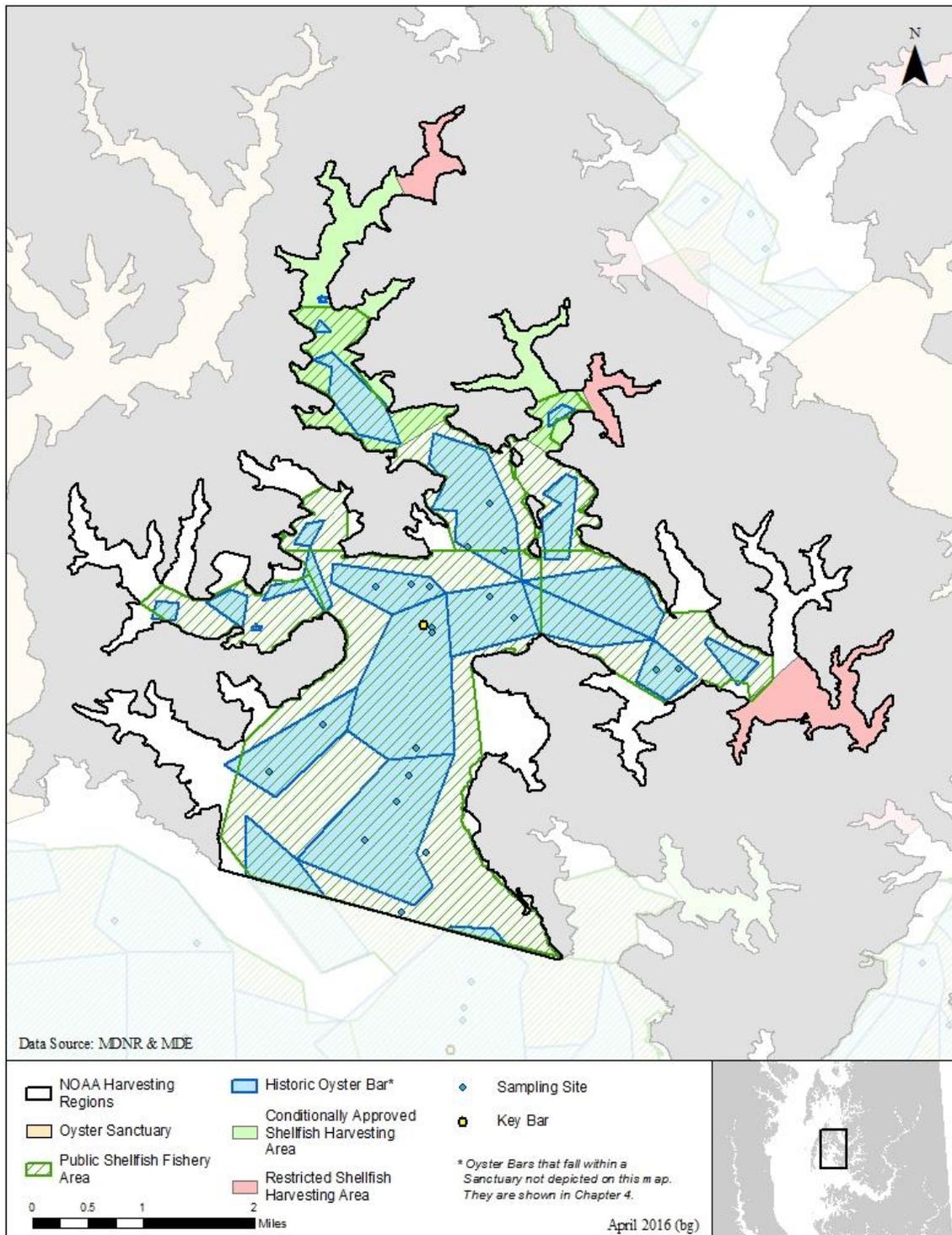


Figure B.38 -1. Map of NOAA Code 537 (Broad Creek.

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled 3 to 6 oyster bars annually in NOAA Code 537. The average number of total live oysters (market, small, and spat) from 1990 to 2015 ranged from 48 to 500 per bushel, with an average of 269 (Figure B.38-2). The average number of oysters was greater from 2010 to 2015 than prior to 2010 (Table B.38-2). On average, there were more small-sized oysters annually than market-sized oysters.

Table B.38-2. Oyster population characteristics based on the Fall Survey before and after the establishment of the three management areas (Sanctuary, PSFA, and Aquaculture) in 2010 within NOAA Code 537 (Broad Creek). Values are given as mean \pm standard error.		
	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 137	6 / 72
Number of Live Oysters per Bushel	253 \pm 48	322 \pm 33
Number of Live Small-Sized Oysters per Bushel	124 \pm 21	177 \pm 24
Number of Live Market-Sized Oysters per Bushel	34 \pm 6	79 \pm 14
Live Oyster Biomass (g Dry Weight per Bushel)	178 \pm 28	361 \pm 37
Mortality (%)	23.9 \pm 4.9	5 \pm 1.2

Oyster Size Structure

The Fall Survey has measured oyster shell heights on Deep Neck bar within NOAA Code 537 since 1990 (Figure B.38-3). Only three oysters greater than 120 mm were collected. The majority of oysters (74%) were less than 75 mm in height. A higher percentage of oysters (24%) were below 40 mm in size in the years prior to 2010, than in the years 2010-2015 (14%).

Biomass

The Fall Survey has measured oyster biomass since 1990 on Deep Neck bar within NOAA Code 537. The annual biomass has varied over the years from 19 to 467 grams of dry weight per bushel and the average is 88.8 \pm 13.6 (mean \pm SE; Figure B.38-4). The average biomass was greater from 2010 to 2015 than prior to 2010 (Table B.38-2). Average biomass declined from 2001 to 2004, and then increased to a peak in 2013 and 2014.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall was highly variable, ranging from 1 to 670 spat per bushel from 1990 to 2015 (Figure B.38-2). The largest spatfall occurred in 1997, with another peak in 2012. For most of the time period, there was no consistently high spatfall from year to year, however, spatfall has occurred in all years during the time period.

Mortality

Mortality has varied from 1990 to 2015 ranging from 0% to 75%; since 2004 mortality has been relatively low, averaging 6% (Figure B.38-5). The average mortality rate was lower from 2010 to 2015 compared to the rate in the years prior to 2010 (Table B.38-2).

Disease

From 1990 to 2015, dermo prevalence has ranged from 20% to 100% (Figure B.38-6). Dermo prevalence was greater than 80% during 16 of the 26 years disease information was collected. Dermo intensity ranged from 0.4 to 5.6. From 1999 to 2002, dermo intensity was consistently high with lethal infections occurring in 1991 (scale of 0 to 7 with values higher than 5 indicating lethal infections). MSX prevalence ranged from 0% to 30%. There were two peaks in MSX prevalence, in 1992 and 2002.

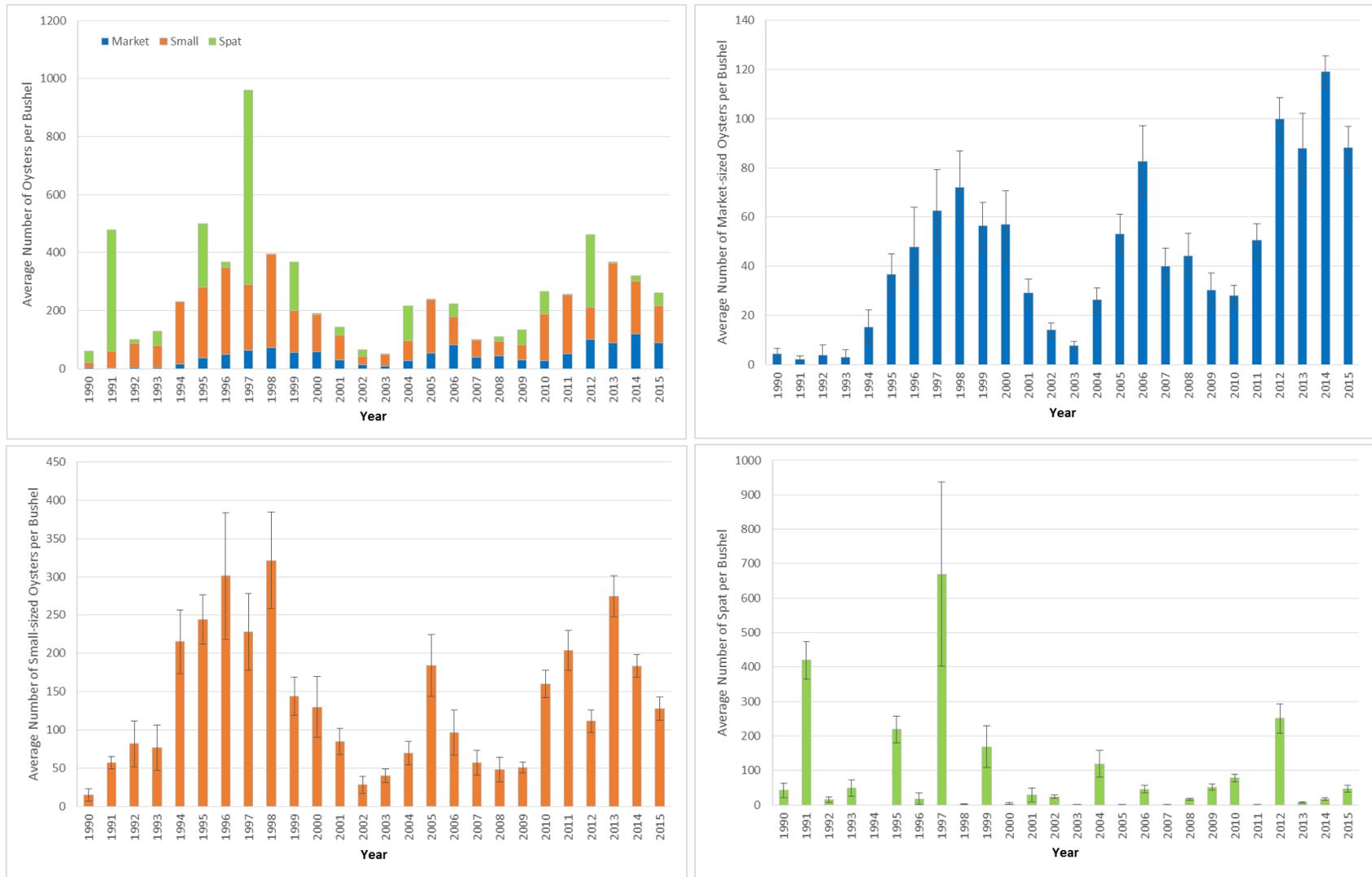
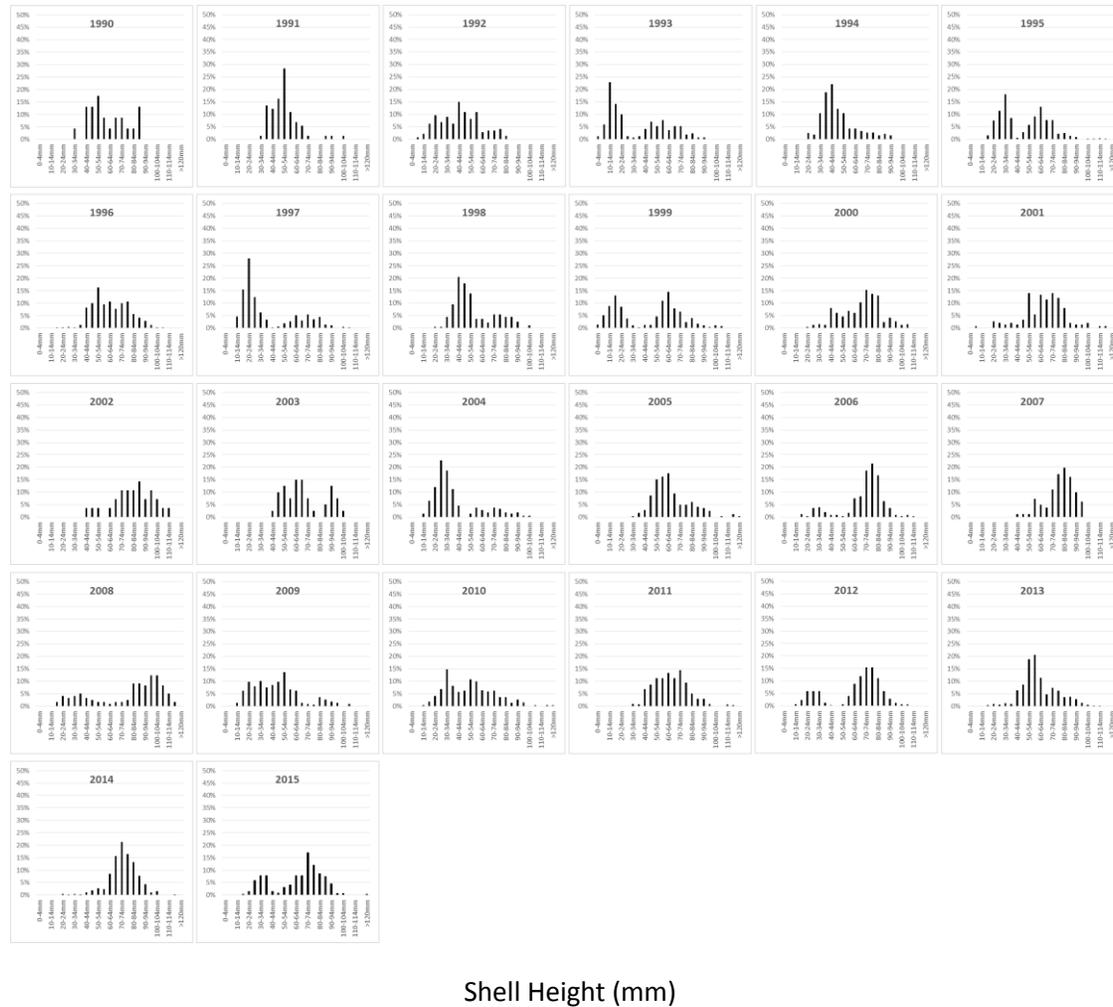


Figure B.38-2. Average number of live oysters per bushel of material by size class in the NOAA Code 537 (Broad Creek). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

Frequency (%)



Shell Height (mm)

Figure B.38-3. Oyster shell height frequencies of live oysters per bushel of material from 1990 to 2015 in the NOAA Code 537 (Broad Creek). Data from Maryland’s Annual Fall Oyster Dredge Survey. Oyster sizes less than 37mm were not recorded by the Fall Survey at any sampling location in 2002 and 2003.

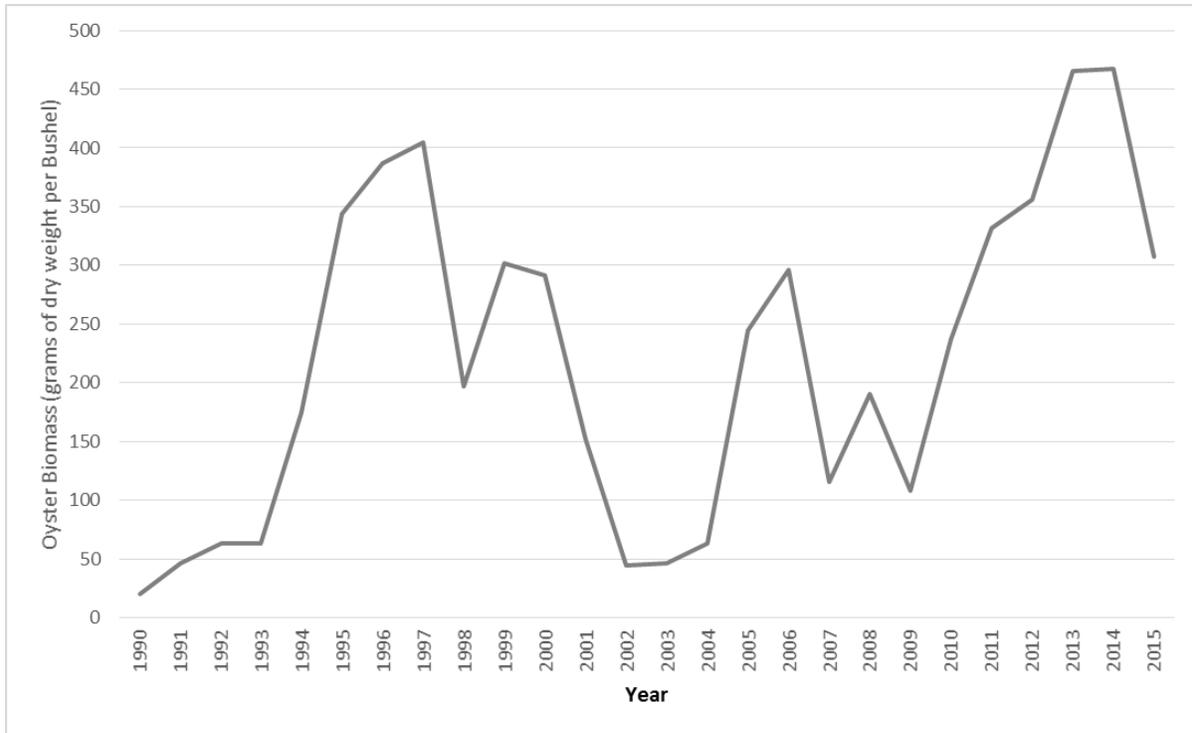


Figure B.38-4. Oyster biomass (grams of dry weight per bushel of material) from 1990 to 2015 in the NOAA Code 537 (Broad Creek). Data from Maryland’s Annual Fall Oyster Dredge Survey.

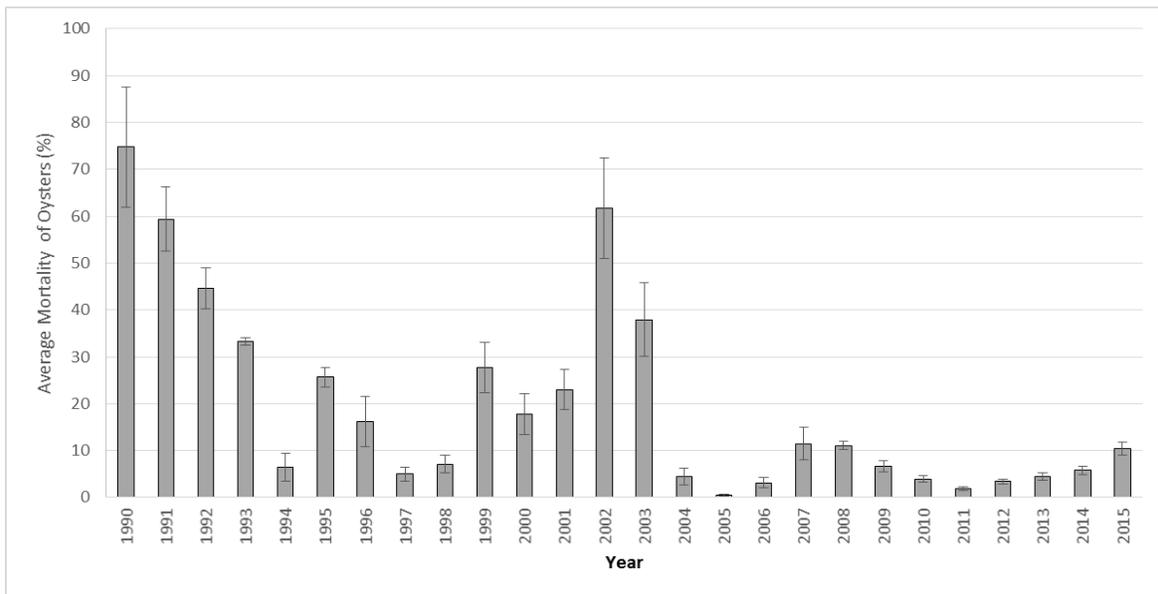


Figure B.38-5. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 537 (Broad Creek). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

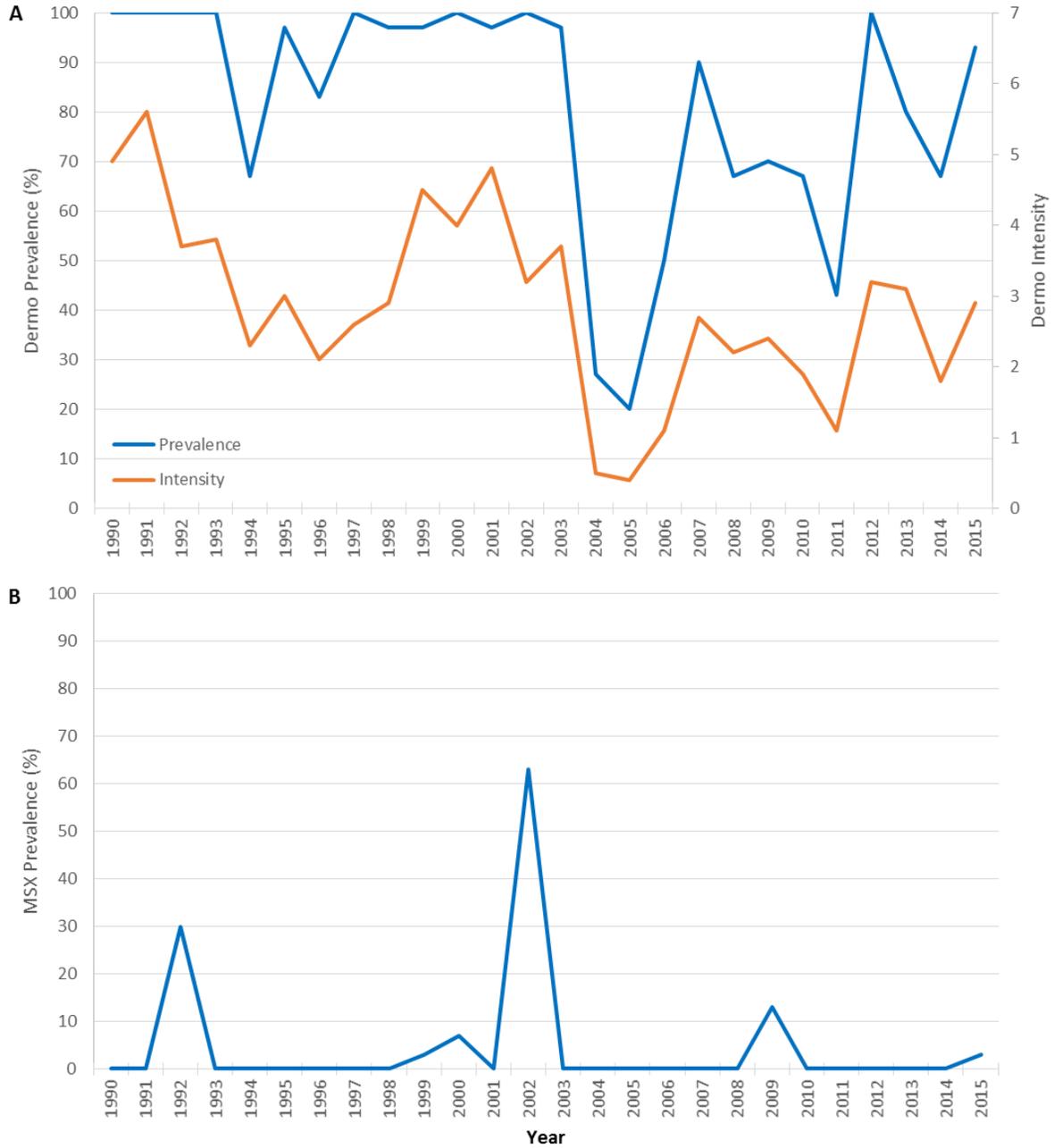


Figure B.38-6. Oyster disease prevalence and intensity from 1990 to 2015 in the NOAA Code 537 (Broad Creek). (A) Dermo prevalence and intensity (B) MSX prevalence (intensity is not examined). Data from Maryland's Annual Fall Oyster Dredge Survey.

Harvest

Oyster harvesting has occurred in NOAA Code 537 (Broad Creek) since 1990 (Figure B.38-7). Harvest reported by seafood dealers on buy tickets has ranged from three bushels in the 1992-1993 seasons to a maximum of approximately 77,000 bushels in the 2013-2014 season. Harvest has increased since the 2009-2010 season with an average annual harvest of 69,000 bushels in the past four years. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. Approximately 70% of harvest in this area as reported on the oyster harvest reports is obtained by hand tonging and 27% by power dredging.

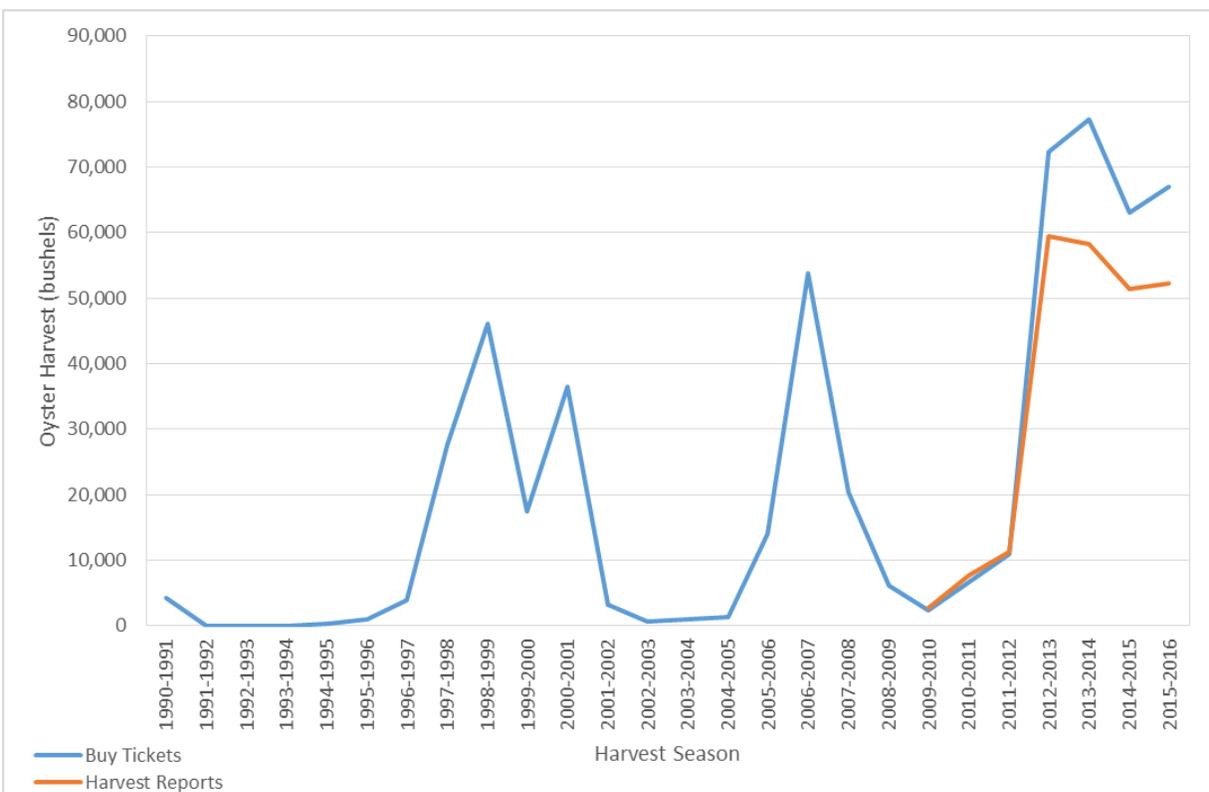


Figure B.38-7. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 537 (Broad Creek).

Section B.39: NOAA Code 637 – Tred Avon River

NOAA Code 637 encompasses the Tred Avon River and is located in Maryland’s mid-eastern portion of Chesapeake Bay (Figure B.39-1). The entire NOAA Code is 6,869 acres and 34 historic oyster bars⁴⁰, of which 61% (4,184 total acres) falls within the Tred Avon River and Oxford Sanctuaries. This section will focus on information collected within the NOAA Code but occurring outside of the current sanctuary area. This equates to 2,685 acres. There are 1,304 acres of historic oyster bottom (as charted in the Yates Oyster Survey from 1906 to 1912 plus its amendments) located within the NOAA Code that are not within a sanctuary. Within the NOAA Code, 1,738 acres were designated as a Public Shellfish Fishery Area in 2010 prohibiting aquaculture leasing. This NOAA Code is generally located within Maryland’s low salinity zone.

Replenishment Activities

Since 1990, 453,000 bushels of shell and 11,200 bushels of wild seed have been planted within NOAA Code 637 outside of the current sanctuary area (Table B.39-1).

Year	Planting Substrate Type	Area Planted (acres)	Thousands of Bushels Planted	Millions of Spat Planted
1990	Dredged Shell	29.6	210.2	-
1990	Fresh Shell	3.4	12.7	-
1991	Fresh Shell	2.6	5.4	-
1991	Wild Seed	9.4	6.2	-
1998	Dredged Shell	9.7	61.5	-
1999	Dredged Shell	9.9	46.8	-
2001	Dredged Shell	5.5	36.3	-
2002	Dredged Shell	1.9	44.3	-
2002	Wild Seed	9.5	5.0	-
2003	Dredged Shell	4.8	31.7	-

⁴⁰ See chart 16 for bar names and locations in the State of Maryland Shellfish Closure Areas Book <http://dnr.maryland.gov/fisheries/Pages/oysters/index.aspx>

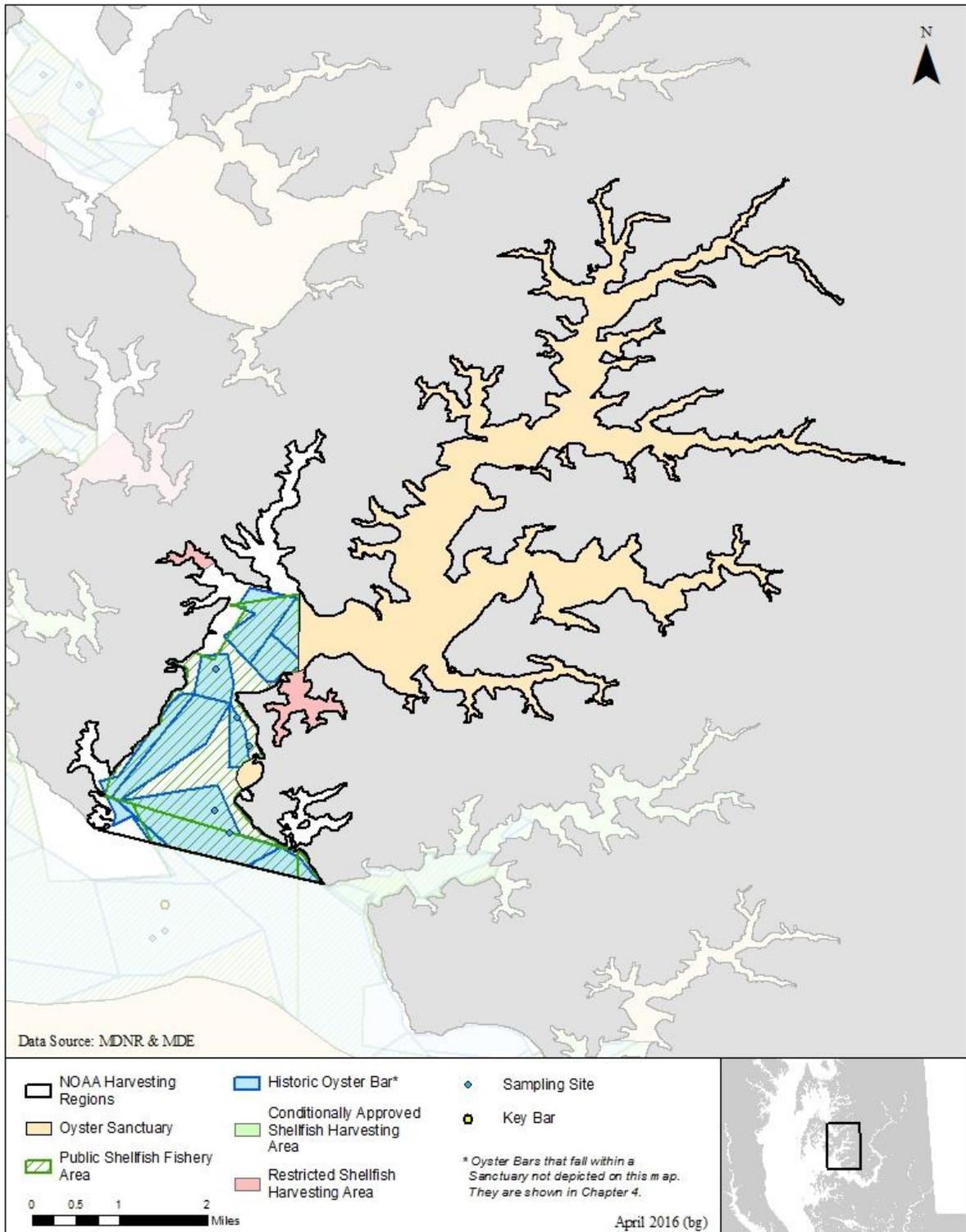


Figure B.39 -1. Map of NOAA Code 637 (Tred Avon River).

Oyster Population Characteristics

Since 1990, the Fall Survey has sampled 3 to 4 oyster bars annually in NOAA Code 637 outside of the current sanctuary area. The average number of total live oysters (market, small, and spat) ranged from 9 to 350 per bushel with an average of 88 (Figure B.39-2). The average number of oysters was similar from 2010 to 2015 than prior to 2010 (Table B.39-2).

	1990-2009	2010-2015
Number of Years Sampled / Number of Samples	20 / 65	6 / 18
Number of Live Oysters per Bushel	86 \pm 17	95 \pm 10
Number of Live Small-Sized Oysters per Bushel	30 \pm 7	34 \pm 6
Number of Live Market-Sized Oysters per Bushel	31 \pm 4	56 \pm 12
Live Oyster Biomass (g Dry Weight per Bushel)	ND	ND
Mortality (%)	23 \pm 3.2	6.4 \pm 1.9

Oyster Size Structure

Since 1990, the Fall Survey has not collected data on oyster size structure.

Biomass

Since 1990, the Fall Survey has not collected data on oyster biomass.

Recruitment (Spatfall)

Based on the Fall Survey spat data, spatfall ranged from 0 to 292 spat per bushel (Figure B.39-2). The largest spatfall occurred in 1991. From 1996 to 2015, there was very little spatfall, with the exception of 1997, when mean number of spat was 111 per bushel.

Mortality

Mortality has varied from 1990 to 2015 ranging from 2% to 45%, however, since 2006 mortality has been relatively low (Figure B.39-3). The average mortality was lower from 2010 to 2015, compared to mortality prior to 2010 (Table B.39-2).

Disease

Since 1990, the Fall Survey has not collected data on oyster disease.

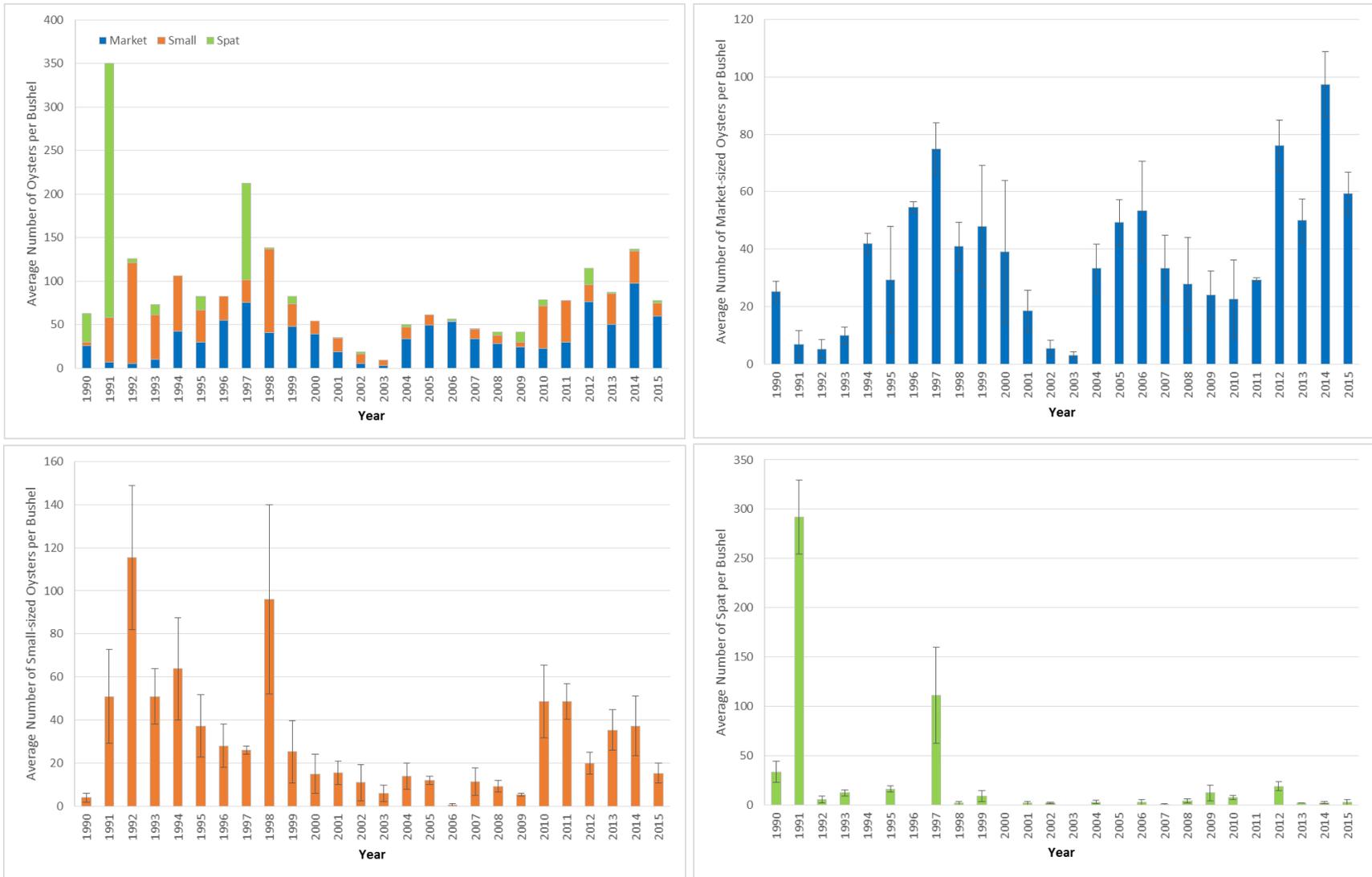


Figure B.39-2. Average number of live oysters per bushel of material by size class in the NOAA Code 637 (Tred Avon River). Error bars represent ± 1 standard error. Data from Maryland’s Annual Fall Oyster Dredge Survey. Note differing Y-axis scales.

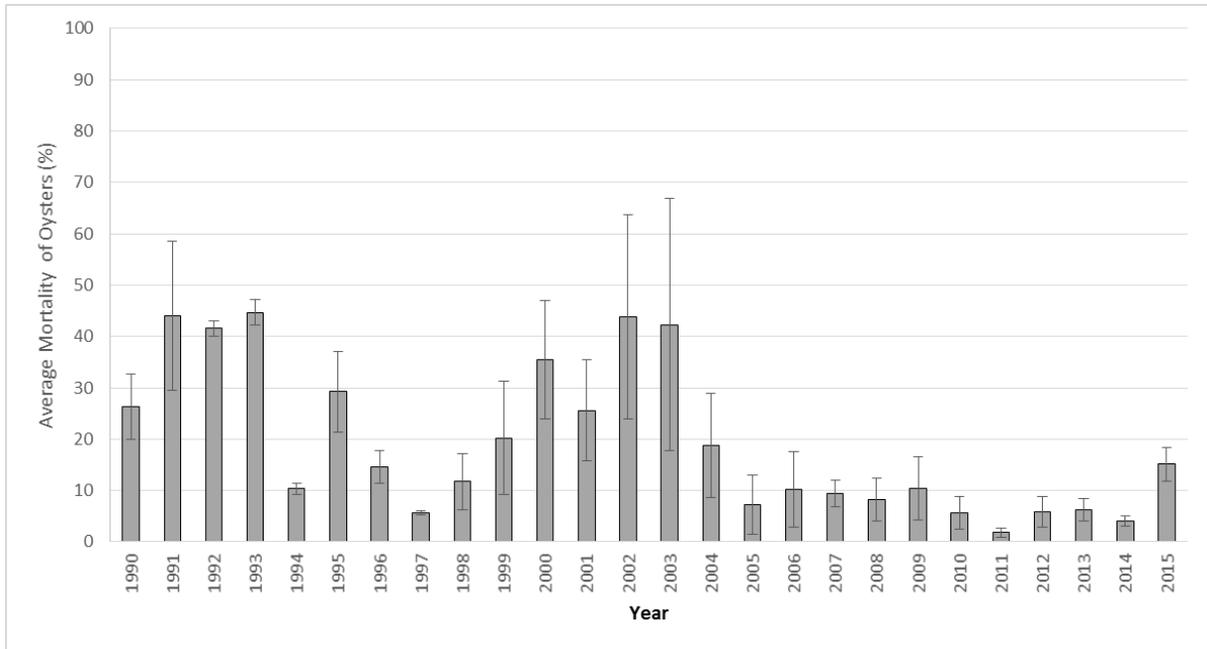


Figure B.39-3. Average mortality of market-sized and small-sized oysters from 1990 to 2015 in NOAA Code 637 (Tred Avon River). Data from Maryland’s Annual Fall Oyster Dredge Survey. Error bars represent ± 1 standard error.

Harvest

Harvest for the entire NOAA Code 637 (Tred Avon) from 1990-2015 is presented in Figure B.39-3. This figure includes past harvest data from areas in the NOAA Code that are now currently in a sanctuary area. After the 2009-2010 season, 61% of the NOAA Code area was a sanctuary where harvest is prohibited. Harvest reported by seafood dealers on buy tickets has ranged from no harvest in the 1993-1994 and 2003-2004 seasons to a maximum of approximately 12,000 bushels in the 1998-1999 season. Harvest has been steadily increasing since the 2011-2012 season. Harvest by watermen on oyster harvester reports was similar to the harvest reported by buy tickets. The majority of harvest in this area as reported on the oyster harvest reports is obtained by hand tong.

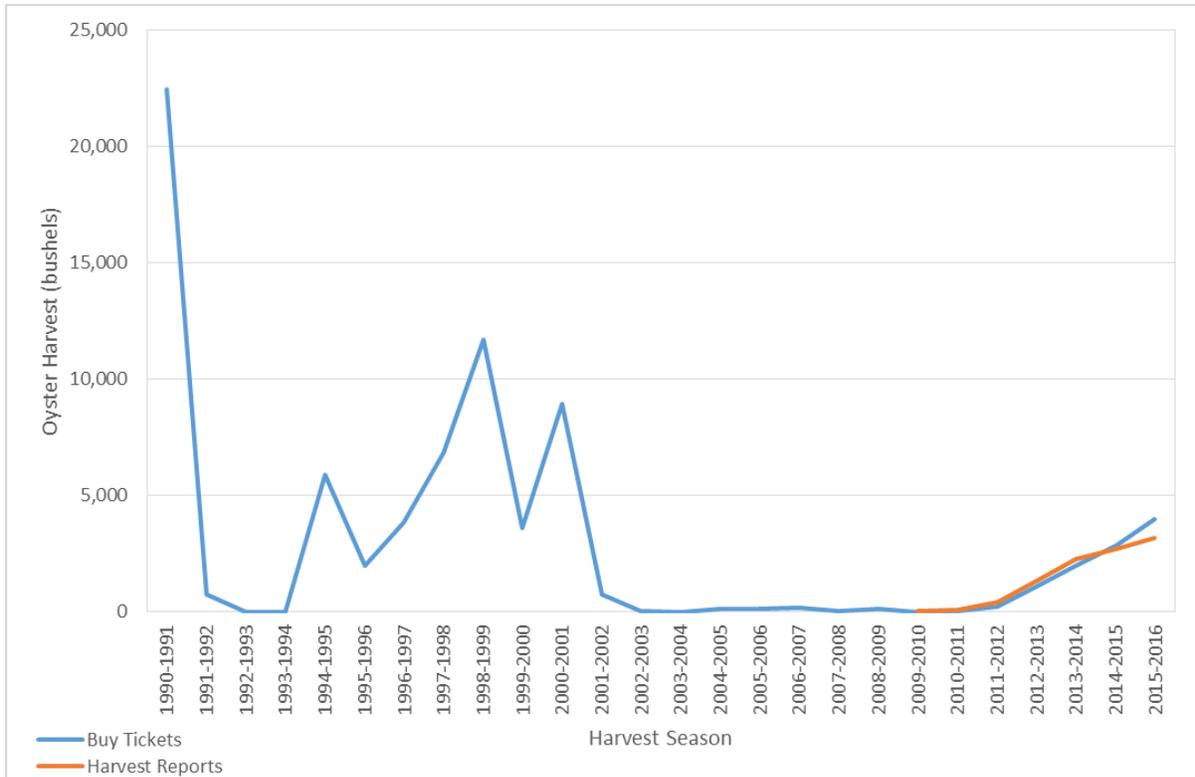


Figure B.39-3. Oyster harvest reported from seafood dealer buy tickets (1990-2016) and harvester reports (2009-2016) in the NOAA Code 637 (Tred Avon River). After the 2009-2010 season, 61% of the NOAA Code area was a sanctuary where harvest is prohibited.