Maryland Oyster Population Status Report
2022 Fall Survey

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Maryland Department of Natural Resources
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Cover Photo: Patent tonging in Tangier Sound, October 2022. (Photo: R. Bussell)

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EXECUTIVE SUMMARY

Since 1939, the Maryland Department of Natural Resources and its predecessor agencies have monitored the state's oyster population by means of annual field surveys – one of the longest running programs of this kind in the world. Currently over 250 bars are sampled annually. Integral to the Fall Survey are five types of indices intended to assess the status and trends of Maryland's oyster populations: the *Spatfall Intensity Index*, a measure of recruitment success and potential increase of the population obtained from a subset of 53 oyster bars; *Oyster Disease Indices*, which document disease infection levels as derived from a subset of 43 sentinel oyster bars; the *Total Observed Mortality Index*, an indicator of annual mortality rates of post-spat stage oysters calculated from the 43 Disease Bar subset; the *Biomass Index*, which measures the number and weight of oysters from the 43 Disease Bar subset relative to the 1993 baseline; and the *Cultch Index*, a measure of habitat at the 53 Spat Intensity Index bars.

The 2022 Fall Survey was conducted from 6 October to 22 November throughout the Maryland portion of Chesapeake Bay and its tributaries, including the Potomac River. A total of 345 samples was collected from 271 oyster bars. Locations monitored included natural oyster bars, oyster seed production areas, seed and shell planting sites, and sanctuaries.

Among the environmental factors affecting oyster populations, freshwater streamflow is critical as it controls the salinity regime of the bay, which in turn influences spatset, diseases, mortality and growth of oysters. For 2022, the annual average freshwater input was close to normal for the third consecutive year, following two years of record high streamflows. However, monthly mean freshwater flows were considerably lower relative to their respective 86-year averages from June to November, averaging 71% of the long-term mean for those months.

The Spatfall Intensity Index, was 32.1 spat/bu, a 27% decline from the previous year but remaining above the 38-year median for the third consecutive year. The spatset was not as well distributed as the previous year, with above-median recruitment occurring primarily in southern Maryland, especially the Tangier Sound region. The upper St. Marys River (including both sanctuary and open-harvest bars) was the highest of all regions, averaging 383 spat/bu, followed by mid-Tangier Sound (143 spat/bu). In contrast, few or no spat were found along the Western Shore upbay from Cove Point, the upriver half of the Potomac oyster growing region, the entire Chester River, and the east side of the bay north of Bloody Point, as well as the entire bay above the Bay Bridge.

A total of 1,558 oysters were analyzed for diseases in 2022 – 1,288 from the 43 Disease Bars (sentinel bars) and 270 from nine supplemental sites. Dermo disease rose appreciably in 2022 from the two previous years. The disease was detected in oysters on 100% of the Disease Bars and supplemental sites, whereas in 2020 it was found at 84% of the bars. Over the previous three years the percentage of individual infected oysters have been the lowest on record, but in 2022 the overall mean infection prevalence in oysters sampled on the Disease Bars increased substantially to 58%, compared to 36% in 2021; this was the highest average prevalence in the last five years. The trend in the mean infection intensity for dermo disease also increased in 2022. The 2022 mean infection intensity (1.7 on a 0-7 scale) was 42% higher than in 2021 (1.2). Nevertheless, this marks the 17th of the last 20 years that both dermo disease mean prevalences and intensities have been below the long-term averages since the record high epizootics at the turn of the millennium. The majority of the highest intensities were detected in southern Maryland, particularly in the Tangier Sound region.

Both the prevalence and geographic range of MSX disease increased on the Disease Bars in 2022.The mean prevalence of infected oysters rose from 0.4% to 1.9%. Despite the increase, this was nearly an order of magnitude lower than the most recent infection peak in 2016 (11.1%). The prevalences ranged from 3% to 17% on the Disease Bars where MSX was detected. When considering both the Disease Bars and supplemental sites, the geographic extent of MSX disease expanded throughout Tangier Sound region to a total of nine bars. In addition, MSX jumped across the bay to Butlers oyster bar on the Western Shore, which had a 3% prevalence (one infected oyster). The percent frequency of positive Disease Bar samples increased from 2% (one bar) in 2020 (one of the lowest MSX years) to 19% (eight bars).

The baywide Observed Mortality Index was 8.3%, a modest increase from the record-low 6.0% of the previous year. This was the 19th consecutive year that the mortality index was below the long-term

average. Regional average observed mortalities in typically higher disease areas remained at pre-epizootic levels. For example, Tangier Sound experienced a relatively low observed mortality for the fourth year in a row, averaging 9.6%.

The 2022 Oyster Biomass Index was 2.37, the second highest index of the 30-year record. Although this was a modest 12% decline from the record high index of 2021, it represents a gain of 72% over the long-term average. The decline is attributed to the substantial increase in landings during the previous season.

The three-year rolling average for the 2022 Cultch Index of 0.87 bu/100 ft. was similar to the 18-year average of 0.89 bu/100 ft. Strong regional differences in the Cultch Index were evident. The areas with the lowest cultch included most of the mainstem of the bay, followed by the combined Chester River/Eastern Bay region. The highest regional cultch indices were in areas with more favorable oyster recruitment and consequent addition to cultch, specifically the Tangier Sound and Choptank River tributaries.

A total of 93 oyster bars within 37 sanctuaries were sampled during the 2022 Fall Survey, including six sanctuaries and seven bars that were newly added to the survey. Recruitment was generally below the 18-yr average except in the upper St. Marys Sanctuary and harvest area. Trends in disease and mortality were in keeping with the baywide results. A Disease/Mortality/Biomass Index bar is located within each of 13 sanctuaries. In addition, seven supplemental disease sites are located in six additional sanctuaries. Dermo disease prevalences and intensities were well below long-term averages. Dermo levels trended somewhat higher in the sanctuaries than in adjacent harvest areas, likely because the sanctuaries had a higher proportion of larger, older oysters, which can accumulate higher burdens of the parasites. Despite the slightly higher dermo levels, observed mortality rates in the sanctuaries were comparable to those of harvest areas and continued to be markedly lower than the long-term average. Increasing prevalences of MSX disease were detected at eight Disease Bars in open harvest areas, as well as at two of the supplemental disease sites within sanctuaries but not in the five restoration sanctuaries. The 2022 average biomass index in the sanctuaries was considerably higher (+87%) than the baywide 30-year average, indicating population growth over time. Similarly, there was a substantial improvement (+66%) between the 2022 average biomass and the long-term index average in the open harvest areas. The open harvest areas index bars experienced a 14% loss in biomass from 2021, associated with the increase in harvests.

The priority restoration sanctuaries were compared with adjacent open areas. The sanctuaries had higher recruitment to varying degrees, except for the Tred Avon River and Broad Creek harvest areas. The highest spat counts of any of the comparison areas was in St. Marys Sanctuary, which averaged 932 spat/100 ft. tow and was almost four times as high as the open area. The average number of adult (small and market) oysters per 100 ft tow in the priority sanctuaries was consistently higher than in adjacent harvest areas, aside from Broad Creek. Disease and mortality trends were similar to the broader findings above. Excluding Deep Neck bar in Broad Creek, which had the highest biomass of these areas, the biomass on the sanctuary Index bars was more than twice as high as their respective open area Index bars. Cultch, the substrate required for spatset, generally was at lower densities in the open harvest areas than the sanctuaries, except for Broad Creek.

Commercial oyster landings during the 2021-22 season were the highest in 35 years (1986/87 season). With reported harvests of 547,000 bushels, oyster landings were 57.6% higher than the previous harvest season, the third year in a row of increased harvests, and were well above the 37-year average of 299,000 bu/yr. The average reported price also rose substantially to $39.31/bu from the previous year's $30.43/bu. Consequently, the total dockside value doubled from $10.5 million in 2021 to $21.5 million in 2022. Power dredging accounted for 48% of the landings, mainly from the lower Eastern Shore and Choptank regions. Patent tongs were the second dominant gear type, harvesting 32% of the total. The Tangier Sound region was by far the leading production area with 72% of the Maryland landings, primarily from upper Tangier Sound and Fishing Bay. The Choptank region followed with 10% of the landings, primarily from Broad Creek.

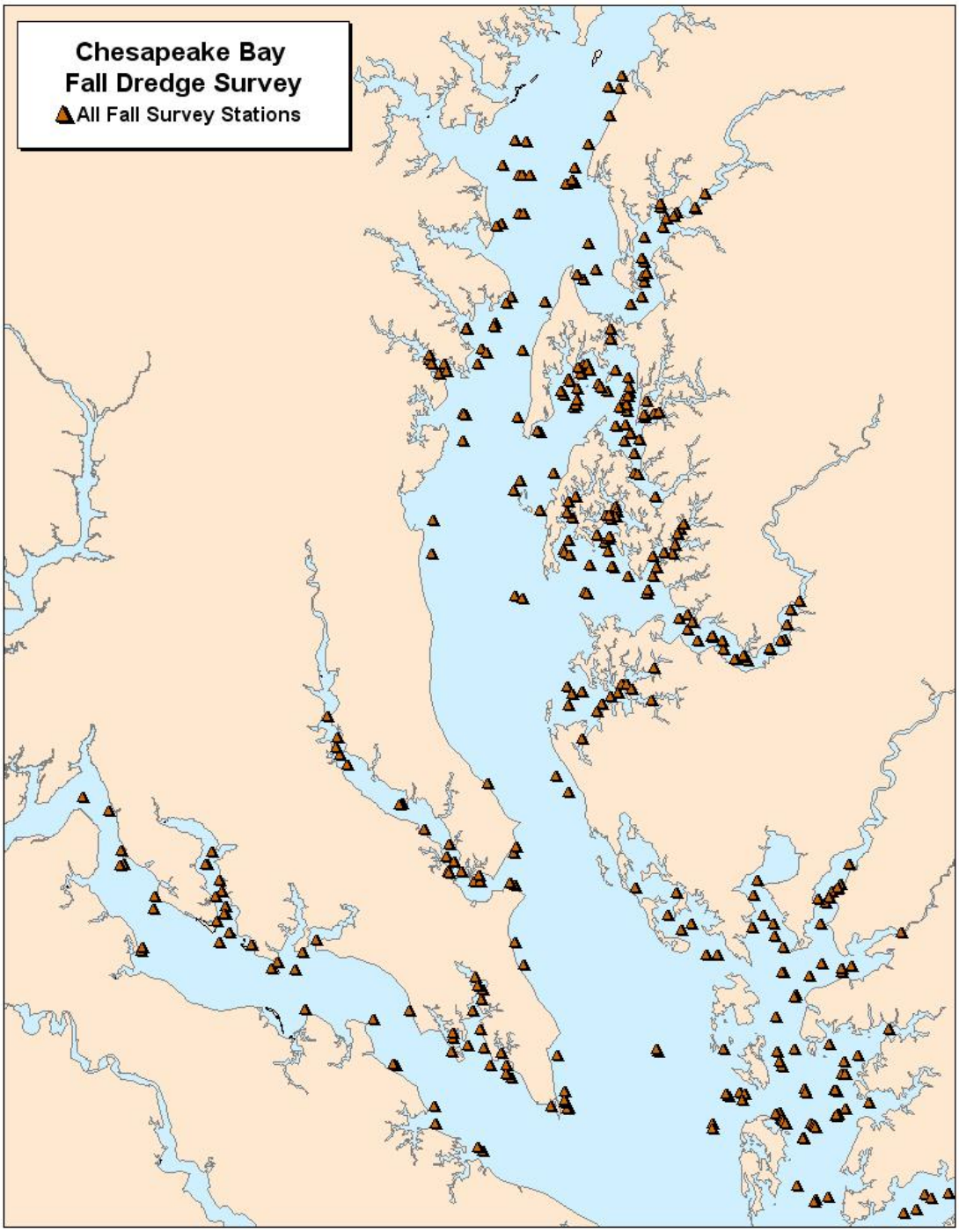

Figure 1a. 2022 Maryland Fall Survey station locations, all bar types included (Standard, Key, Disease, Seed).

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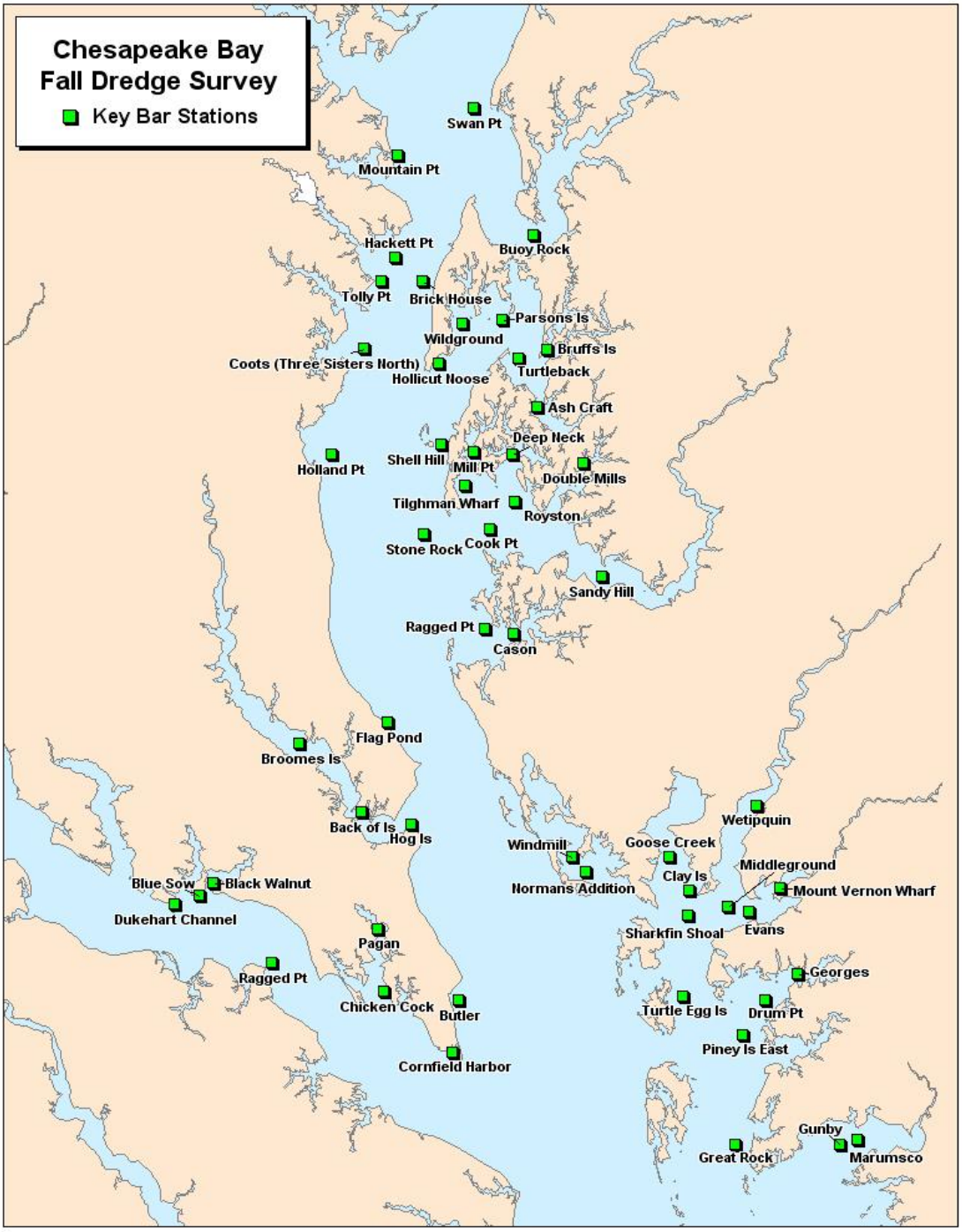

Figure 1b. Maryland Fall Survey Key Bar locations included in determining the annual Spatfall Intensity Index. Due to a lease on Blue Sow, this sample was collected from the adjacent Huggins Pt. bar in 2022.

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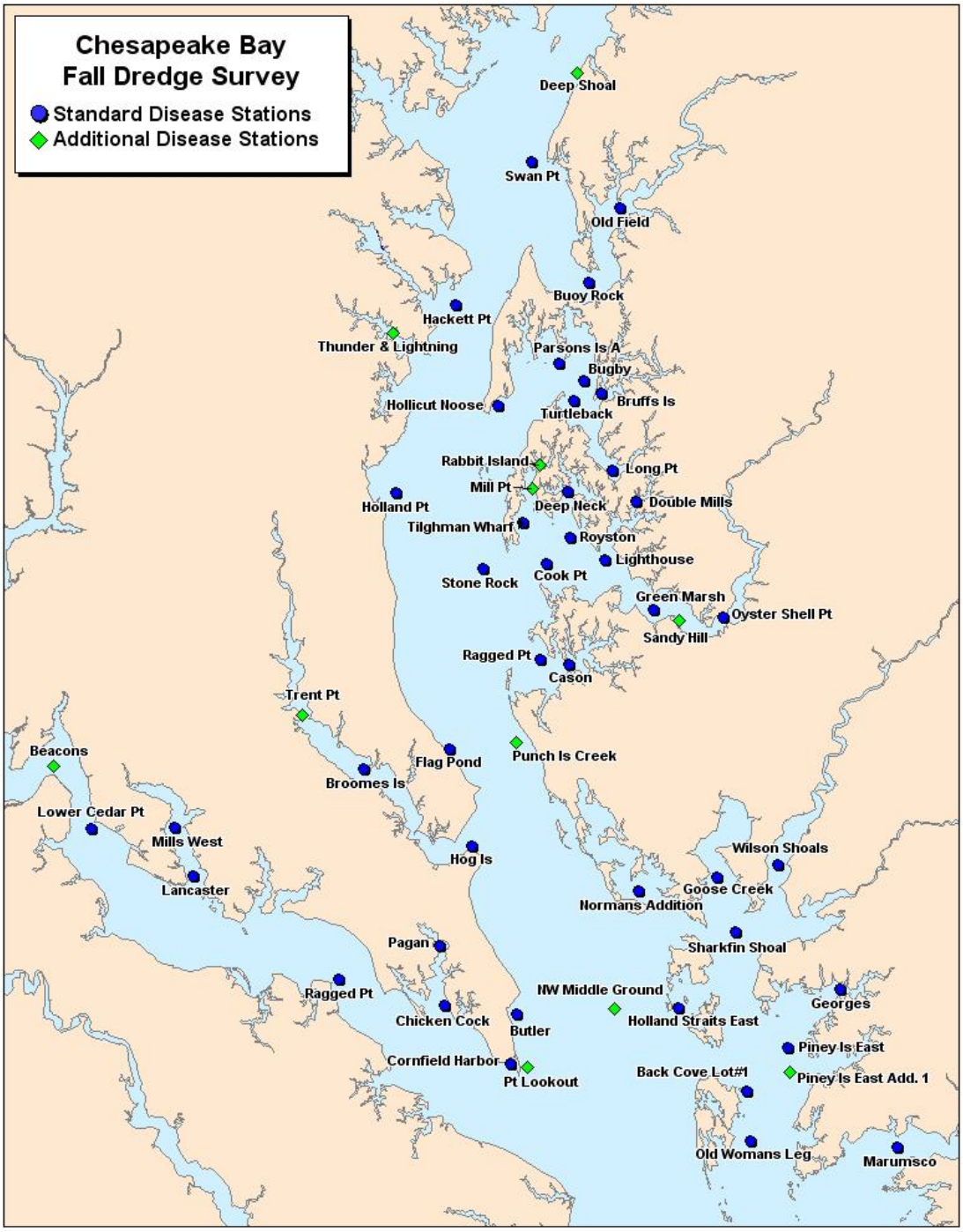

Figure 1c. Maryland Fall Survey standard Disease Bar monitoring locations and additional disease sample stations. Disease samples could not be obtained from the supplemental sites at Deep Shoal and Beacons in 2022.

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INTRODUCTION

Since 1939, a succession of Maryland state agencies have conducted annual dredge-based surveys of oyster bars. These oyster population assessments have provided biologists and managers with information on spatfall intensity, observed mortality, and more recently on parasitic infections, biomass, and habitat in the Maryland waters of Chesapeake Bay. The long-term nature of the data set is a unique and valuable aspect of the survey that gives a historical perspective and reveals trends in the oyster population. Monitored sites have included natural oyster bars, seed production and planting areas (Appendix 1), dredged and fresh shell plantings, and sanctuaries.

Since this survey began, several changes and additions have been made to develop structured indexes and statistical frameworks while preserving the uninterrupted integrity of the long-term data set. In 1975, 53 sites and their alternates, referred to as the historical "Key Bar" set, were fixed to form the basis of an annual spatfall intensity index (Krantz & Webster 1980). These sites were selected to provide both adequate geographic coverage and continuity with data going back to 1939. An oyster parasite diagnosis component was added in 1958, and in 1990 disease indexes were developed using standardized parasite prevalence and intensity data from a fixed 43-bar subset (Disease Bar set) (Appendix 2). Thirty-one of the Disease Bars are among the 53 spatfall index oyster bars (Key Bars). Mortality and Biomass Indexes are derived from the Disease Bar set, while a Cultch Index is based on the Key Bars. A glossary of technical terms is provided in Appendix 3.

This year a review was conducted to evaluate Fall Survey sites sampled yearly and recommend changes to sanctuaries or NOAA codes to improve data collection in those areas for the oyster stock assessment (Appendix 4). Of the sixteen sites that were proposed, a total of ten of those were added to the Fall Survey in 2022.

Collaborative Studies and Outreach

Throughout the years, the Fall Survey has been a source of collaborative research opportunities for scientists and students within and outside of the Department of Natural Resources. The Fall Survey continued to assist the Potomac River Fisheries Commission with an innovative fishery management program, examining oyster plantings on two Oyster Management Reserves and evaluating several rotational seed planting areas. Data from the Fall Survey was used extensively by the multi-partner Oyster Restoration Program under the 2014 Chesapeake Bay Watershed Agreement, as well as the legislatively mandated Oyster Stock Assessment, a collaborative effort between the department and the University of Maryland Chesapeake Biological Laboratory, which was completed in 2018 and updated in 2021. Disease data collected during the survey are now shared annually in a regional database of molluscan shellfish health hosted by Rutgers University that is intended to facilitate oyster aquaculture along the east coast of the United States. Two direct larval set trials conducted by the Queen Anne's Watermen Association were also examined. The survey assisted UMCES researchers with calibrating equipment to measure turbidity plumes from dredging. Two graduate students from the University of Rhode Island accompanied the survey to collect samples for their research.

METHODS

Field Collection

The 2022 Annual Fall Survey was conducted by Shellfish Division staff of the Maryland Department of Natural Resources Fishing and Boating Services from 6 October to 22 November. A total of 345 samples were collected during surveys on 271 natural oyster bars (Figure 1a), including Key Bar (Figure 1b) and Disease Bar (Figure 1c) fixed sentinel sites as well as management areas such as sanctuaries, contemporary seed oyster planting sites, shell planting locations, and former seed production areas.

A 32-inch-wide oyster dredge was used to obtain the samples. Sample volumes were measured in Maryland bushels (bu) (1 Md. bu = 1.3 U.S. standard bu).The number of samples collected varied with the type of site. At each of the 53 Key Bar sites and the 43 Disease Bars, two 0.5-bu subsamples were collected from replicate dredge tows. At all other sites, one 0.5-bu subsample was collected. A list of data categories recorded from each sample appears in Table 1. Oyster counts were reported as numbers per Maryland bushel. Since 2005, tow distances have been recorded for all samples using the odometer function of a global positioning system (GPS) unit, and the total volume of dredged material per tow was noted before the subsamples was removed. Photos illustrating the collection process can be viewed at:

dnr.maryland.gov/fisheries/Pages/shellfish-monitoring/sample.aspx

Fall Survey Indices

Integral to the Fall Survey are five categories of indices used to assess Maryland oyster populations: spatfall, disease, mortality, biomass, and cultch. The Spatfall Intensity Index is a measure of recruitment success and potential increase of the population obtained from an established subset of 53 oyster bars (Key Bars); it is the arithmetic mean of spat/bushel counts from this subset. Disease levels are documented by oyster disease prevalence indices (dermo and MSX disease) and an infection intensity index (dermo disease only) as derived from a subset of 43 oyster bars. The Observed Mortality Index is an indicator of annual natural mortality occurring among post-spat stage oysters from the 43 oyster bar Disease Index subset, calculated as the number of dead oysters (boxes and gapers) divided by the sum of live and dead oysters (Appendix 3). Although keyed to the Disease Index subset established in 1990, the Observed Mortality Index also includes data from 1985-1989. The Biomass Index measures the number and estimates the weight of post-spat oysters from the 43 Disease Bar subset relative to the 1993 survey year baseline. The Cultch Index is a relative measure of oyster habitat at the 53 Key spat index bars.

The time series for the Spat Intensity, Diseases, and Mortality indices are presented in Tables 2 - 5. The majority of Fall Survey data, including supplemental pathology data and disease indices, are entered into digital files. Fouling data and oyster condition are in paper files; the data on fouling (mussels, barnacles, tunicates, etc.) and other associated organisms are being converted to a digital format.

Spatfall Intensity Index

The annual Spatfall Intensity Index is the arithmetic mean of spat counts per bushel of cultch from the 53 fixed Key Bars. As such, it does not take into account geographic distribution (i.e., how widespread or concentrated the spatfall is around the bay), whereas the discontinued statistical tiers method did (see Tarnowski 2019, p.14 for explanation of discontinuing this analysis). For example, the near-record high spatfall intensity in 1997 was actually limited in extent, being concentrated in the eastern portion of Eastern Bay, the northeast portion of the

lower Choptank River, and to a lesser extent, in parts of the Little Choptank and St. Marys rivers (Homer & Scott 2001). Over 75% of the 1997 index was accounted for by only five of the 53 Key Bars, and only ten contributed nearly 95%. As a result, the 1997 spat index fell into the third statistical ranking tier (of six) despite being the second highest index on record and an order of magnitude higher than other Tier 3 index years (Tarnowski 2018, Figure 3a). In contrast, the 1991 spatfall (the third highest on record) was far more widespread. Fifteen Key Bars totaled 75% of the index that year, while 28 sites were needed to attain 95% of the spatfall intensity index, placing it in the top statistical ranking notwithstanding having a lower spatfall index than 1997.

Another approach to understanding these skewed spatfall distributions examines the annual medians of the index. Medians are generally higher when there is a more uniform geographic distribution and are lower when the geographic distribution is limited in extent or skewed. In cases such as in 2019, where 60% of the Key Bars accounted for only 5% of the spat index, the median was low even though the index was moderate, reflecting the disparity between the majority of bars which experienced low to zero spatset and the few relatively productive bars. In years when spatset is more widely distributed, the annual median is much higher, such as in 1985, 1991, and to a lesser extent 2010 and 2021. In contrast, most of the years had more geographically restricted spatset distributions, dominated by a few strong recruitment bars. Again, this is most vividly illustrated in 1997, when despite having the highest spat index of the time series, the median for that year was comparatively low (e.g., half of the 2012 median, even though the 1997 spat index was over four times higher than the 2012 index), resulting in a poor median:spat index ratio. Understanding the geographic distribution of recruitment in these terms provides a clearer picture of this component of oyster population dynamics.

Oyster Disease Analyses

Representative samples of 30 oysters that were at least one-year-old were taken at each of 43 Disease Bar sites. An additional nine samples for disease diagnostics were collected from supplemental sites, sanctuaries, and other areas of special interest. Oyster parasite diagnostic tests were performed by Shellfish Health Project staff of the Cooperative Oxford Laboratory. Data reported for *Perkinsus marinus* (dermo disease) are from Ray's fluid thioglycollate medium (RFTM) assays of rectum tissues. Prior to 1999, less-sensitive hemolymph (blood) assays were performed. Data reported for *Haplosporidium nelsoni* (MSX disease) have been generated by histology since 1999. Before 1999, hemolymph cytology was the diagnostic method used for every sample, while solid tissue histology preparations were examined for *H. nelsoni* only from selected locations.

In this report, prevalence refers to the percentage of oysters in a sample that were infected by a specific pathogen, regardless of infection intensity. Infection intensity is calculated only for dermo disease, and categorically ranks the relative abundance of pathogen cells in analyzed oyster tissues from 0-7 (Calvo et al. 1996). Mean infection intensities are calculated for all oysters in a sample or larger group (e.g., Disease Bars set), including zeroes for uninfected oysters. A measure of infection intensity that weights the mean intensity by removing uninfected oysters from the computation (zeroes) is also calculated. For details of parasite diagnostic techniques and calculations, see Gieseker (2001) and Maryland DNR (2018).

Biomass Index

Department of Natural Resources staff at the Cooperative Oxford Laboratory developed the size-weight relationships of oysters used in calculating the Biomass Index (Jordan et al. 2002). Oyster

shells were measured in the longest dimension and the meats were removed, oven-dried, then weighed. Average dry-meat weights (dmw) were calculated for oysters in each 5-mm grouping used in the field measurements, and those standards have been used to calculate the annual Biomass Index from size-frequency data collected from Fall Survey field samples, as follows.

For each of the 43 disease monitoring stations, the number of small and market oysters (= post-spat or 1+ year classes) in each 5-mm size class was multiplied by the average dry-meat weight (dmw) for that size class to obtain the total weight for each size grouping (Eq. 1). These were summed to get the total dry-meat weight of a 1.0 bu sample (two 0.5 bu subsamples) from a disease monitoring bar (Eq. 2). The sum of dry-meat weights from the 43 disease monitoring stations, divided by 43, yielded an annual average biomass value from the previous year's survey (Eq. 3). These annual average biomass values were keyed to the biomass value for 1993. The Biomass Index was derived by dividing the year's average biomass value by the 1993 average biomass value (1993 Biomass Index = 1.0) (Eq. 4).

Note that the baseline data are from the 1993 Fall Survey. Prior to 2012, the Biomass Index year followed the year the data were actually collected; e.g., the 1994 baseline index was from the 1993 Fall Survey. To avoid the confusion this caused, in this report the biomass index refers to the year the data were collected (survey year). Therefore, the baseline index year is now 1993, since the data were collected during the 1993 Fall Survey, and the 2022 Biomass Index is derived from the 2022 Fall Survey data.

Biomass Equations
For **each** monitoring station:
(# post-spat oysters per size class) x (avg. dmw per size class) = total dmw per size class
$\sum$ dmw per size class = total dmw per 1.0 bu station sample

For **all** monitoring stations:
($\sum$ dmw per 1.0 bu station sample)/43 = annual average biomass value
(annual average biomass value)/(1993 average biomass value) = Biomass Index

Cultch Index
The collection of quantitative cultch data was initiated during the 2005 Fall Survey. During a sampling tow, the distance covered by the dredge while sampling on the bottom is measured using a handheld GPS unit with an odometer function. After the dredge is retrieved, the total volume of oysters and shell is measured in bushel units. Since tow distances vary, the volume is standardized to a 100 ft. tow by dividing the total cultch volume by the actual tow distance, which yields the volume per foot of tow distance, and multiplying the result by 100. If the dredge is full, that sample is dropped from the analysis. The Cultch Index is calculated as the annual average of the standardized cultch volumes from the 53 Key Bars used in the Spat Index. Because the dredge is less than 100% efficient in catching oysters and shells, this is not an absolute measure of cultch but provides a relative index for temporal and spatial comparisons.

Harvest Records
Two data sources are used to estimate seasonal oyster harvests: dealer reports (also called buy tickets) and harvester reports. The volume of oysters in Maryland bushels caught each day by each license holder is reported to the Department of Natural Resources on both forms. Dealer reports are submitted weekly by licensed dealers who buy oysters directly from harvesters on the

day of catch. Reported on each buy ticket is the catch per day along with effort information, gear type, and location of catch. Both the dealer and the harvester must sign the buy ticket and include their license numbers. Each dealer is also responsible for paying a one dollar tax on each bushel purchased and an additional thirty-cent tax on each bushel exported out of state. Harvester reports are submitted monthly by each license holder authorized to catch oysters and include the catch each day along with effort information, gear type, and location of catch.

Buy ticket records are available from 1989 to present and harvester reports are available from 2009 to present. Although the area or river system was often recorded on buy tickets for much of the time series, the completeness of oyster bar and gear information is much more variable. Generally, harvester reports are more complete with regard to gear type and oyster bar name. Due to the longer time series available from the buy ticket record, this is the standard data source for long-term trends in harvest. However, for applications where gear or oyster bar name is considered critical, the harvester report data source is frequently used instead.

RESULTS

FRESHWATER DISCHARGE CONDITIONS

Salinity is a key quantifiable factor influencing oyster reproduction and recruitment, disease, and mortality. Whereas salinity is a site-specific measurement, which varies widely temporally and spatially throughout the Maryland oyster grounds, freshwater flow, which determines salinity, provides a more synoptic view of baywide conditions and is therefore used as a surrogate for salinity.

Annual Streamflow

The annual average freshwater flow into the Maryland portion of the bay (Sec. "C" in Bue 1968) in 2022 was within the normal range for the third consecutive year (Figure 2a). This follows record-high flows in 2018 (calendar year)/2019 (water year).

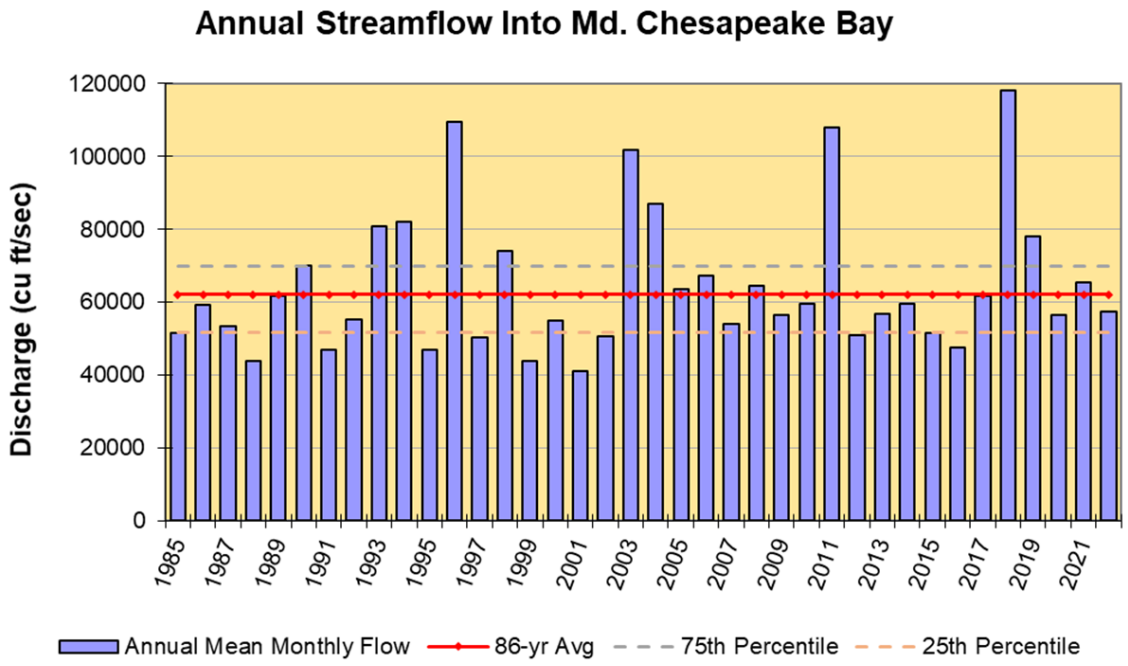

Figure 2a. Annual mean monthly freshwater flow into Chesapeake Bay, 1985-2022. USGS Section C: all Maryland tributaries and the Potomac River.

Note that the U.S. Geological Survey (USGS) account of 2019 as the record high flow year refers to a *water* year, which runs from 1 October of the previous year (2018) to 30 September of the reporting year (2019) (USGS 2020). In contrast, this report refers to the *calendar* year, which results in 2018 being the record-high flow year.

Monthly Streamflow

Although the annual streamflow was close to normal in 2022, monthly freshwater flows were considerably lower relative to their respective 86-year averages from June to November, averaging 71% of the long-term mean for those months (Figure 2b).

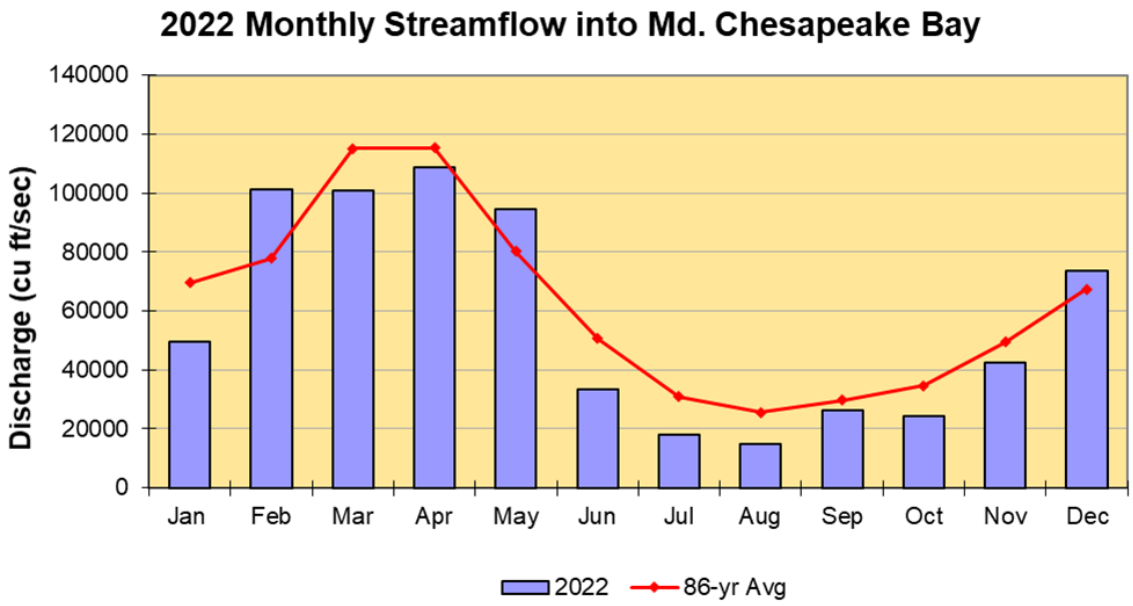

Figure 2b. Monthly average freshwater flow into Chesapeake Bay (Section C) during 2022, including the 86-yr monthly average.

Salinities

Monthly surface salinities for four regions of the Chesapeake Bay in Maryland during 2022 are shown in Figure 2c (Chesapeake Bay Program 2021). Salinities were close to normal throughout 2022, except at Swan Point in the upper bay, where salinities were more than double the long-term average during July and August. These examples demonstrate the influence of streamflow depending on distance from the Susquehanna River, the largest source of freshwater discharge into the bay. Not only does salinity increase from north to south, but the seasonal variability dampens in a downbay direction. Also, Swan Point showed the greatest variability in deviations from the long-term mean, reflecting its proximity to that river. In contrast, all but one of the months had salinities within 10% of the mean at the South Tangier Sound station, the southernmost of the monitoring sites.

A critical minimum threshold for a number of biological processes in oysters is about 5 parts per thousand (ppt) (Tarnowski 2019). Surface salinities at Swan Point were below this mark for three consecutive months in the spring; salinities were well above that mark for the remainder of the year (Figure 2c). None of the other locations had salinities below 5 ppt reported in 2022. The peak salinity was in southern Tangier Sound, reaching a near-record high of 20.6 ppt in November. All but one of the months at this station had salinities greater than 15 ppt, a critical threshold above which favors MSX disease. Note that surface salinity tends to be lower than bottom salinity, depending on water depth, freshwater input, and water column stratification. The upper bay oyster grounds tend to have larger differences between surface and bottom salinities due to fresh/brackish water at the surface and the tidal intrusion of saltier water at the bottom.

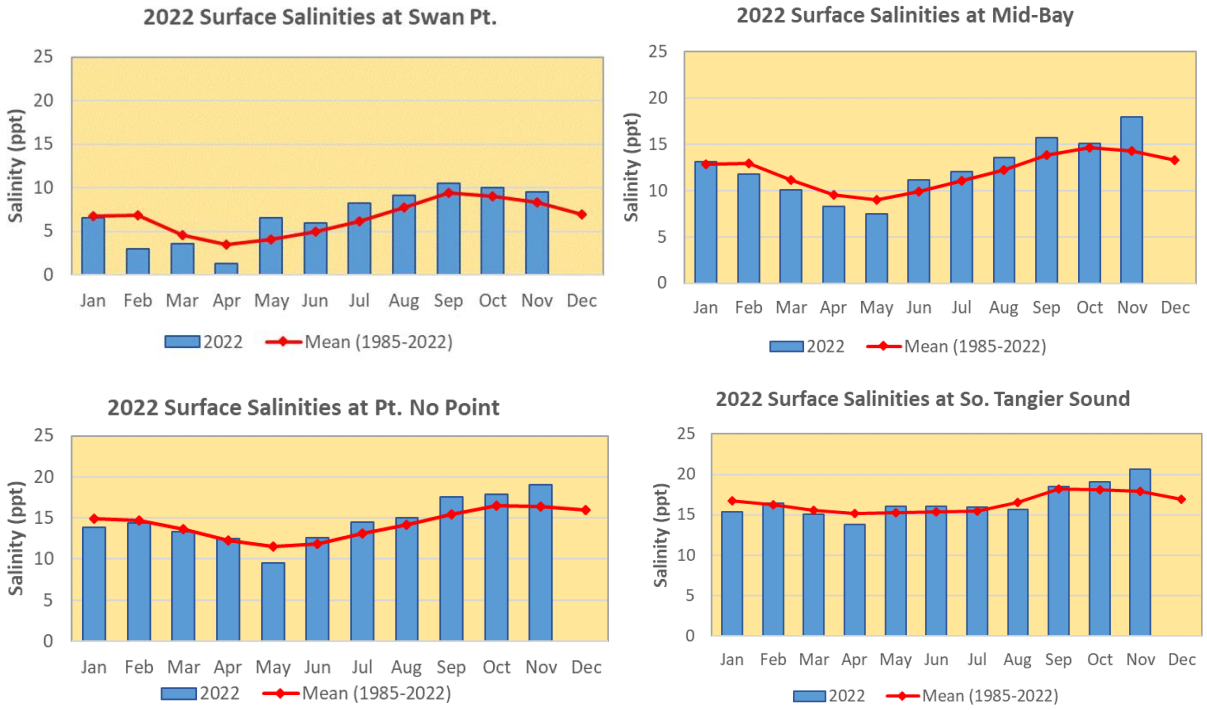

Figure 2c. Monthly surface salinities during 2022 at four monitoring stations along a salinity gradient in Chesapeake Bay. *Swan Pt. (CB3.2) is in the upper bay, the mid-bay station (CB4.2C) is off the mouth of the Choptank R., Pt. No Point (CB5.2) is in the lower mainstem, and the southern Tangier Sound station (EE3.2) is near the Virginia state line.* Sampling was not conducted in December.

SPATFALL INTENSITY

The Spatfall Intensity Index, a measure of recruitment success and potential increase in the population, was 32.1 spat/bu, a 27% decline from the previous year but remaining above the long-term median for the third consecutive year (Figure 3a). The drop in the overall Spatfall Intensity Index is reflected in the 64% of index bars showing decreases from the previous year vs. increases at 21% of the bars, with the balance showing no change (Table 2). Seven of the last 13 years have had above-median spat indexes, three of which can be considered exceptional (i.e., three to five times higher than the long-term median), while only two years during this period were substantially (>25%) below the long-term median (Figure 3b).

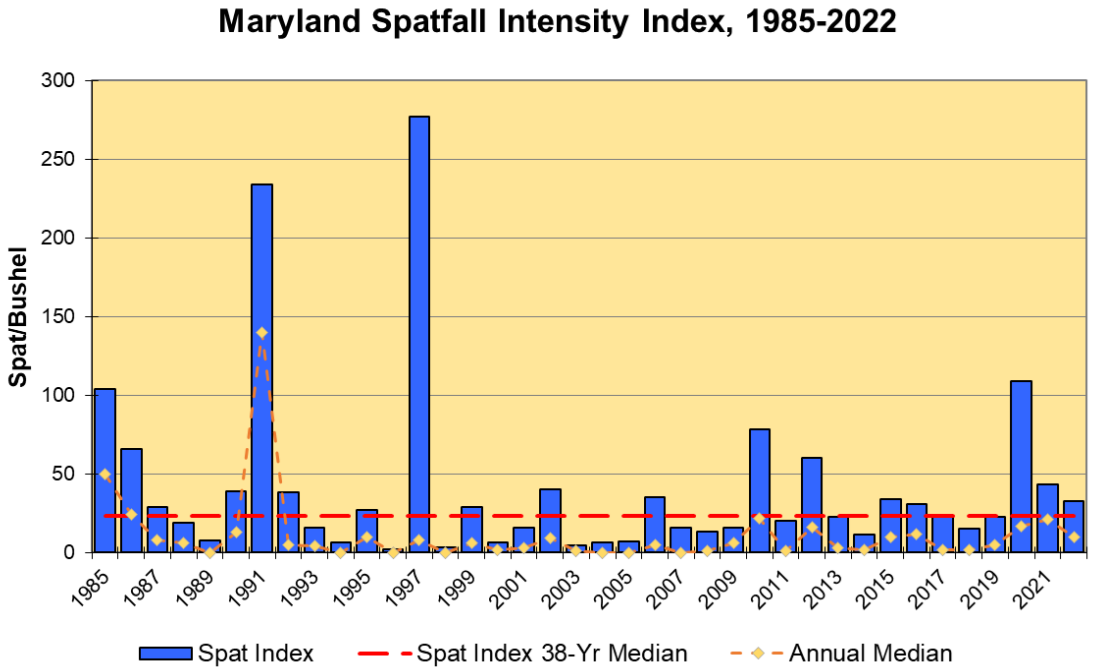

Figure 3a. Spatfall intensity (spat per bushel of cultch) on Maryland "Key Bars" for spat monitoring, including annual median values.

Spatfall distribution among the Key Bars in 2022 was more limited than in the previous year. Spat were observed on 41 of the 53 Key Bars, whereas 44 Key Bars had spat in 2021, while 40 bars had spat in 2020 and 37 bars had spat in 2019 (Table 2). As indicated by the annual spatfall median:spat index ratio, the numerical distribution in 2022 was in the middle of the time series, whereas the 2021 distribution was the second most widespread (Figure 3c). The spat total from only three bars accounted for 50% of the index, compared with seven bars in 2021, while in 2022, 25 bars contributed to 95% of the spat index, a decrease from 29 bars in 2021. The remaining 28 bars comprised just 5% of the Spat Intensity Index. In other words, 52.8% of the index bars had low productivity in 2022, with 12 bars (22.6%) having no spat found in the samples. This was a decline from the previous year, when 45% of the bars were largely unproductive, of which only 8 bars (15.1%) had no spat in the samples. Pagan bar in the St. Marys River had the highest count of the Index bars with 478 spat/bu, or 28% of the entire 2022 Spat Index. This was the second consecutive strong spatset on that bar, rebounding after three years of poor sets and a high mortality event in 2020, which resulted in an observed mortality of 49% of the adult oysters.

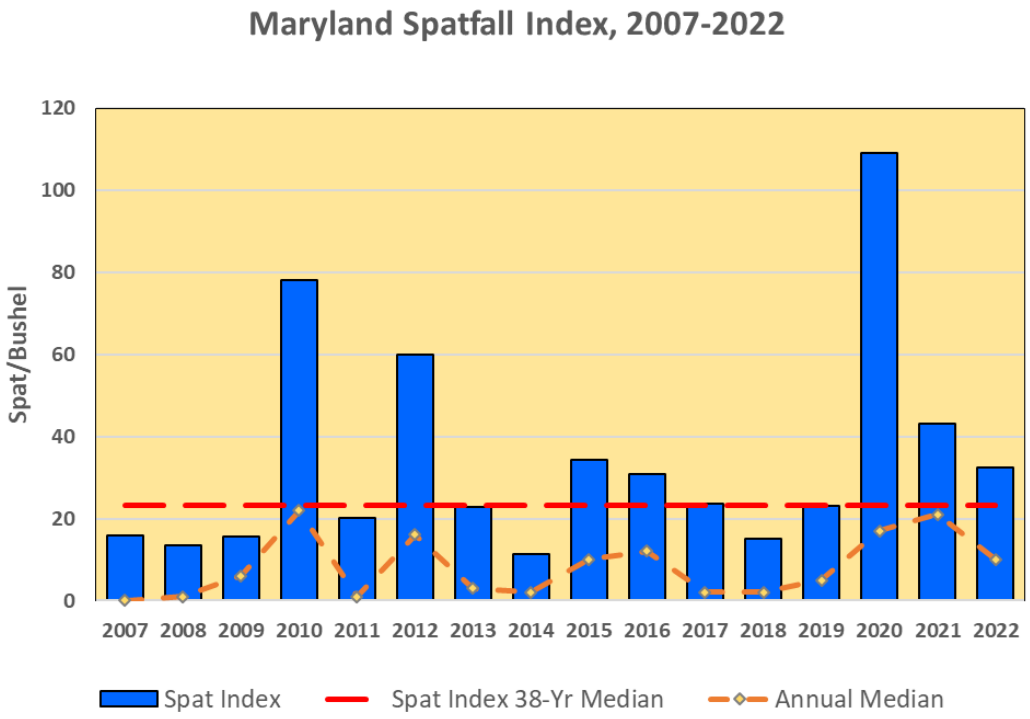

Figure 3b. Recent Maryland spatfall indices, 2007-2022, including annual median values.

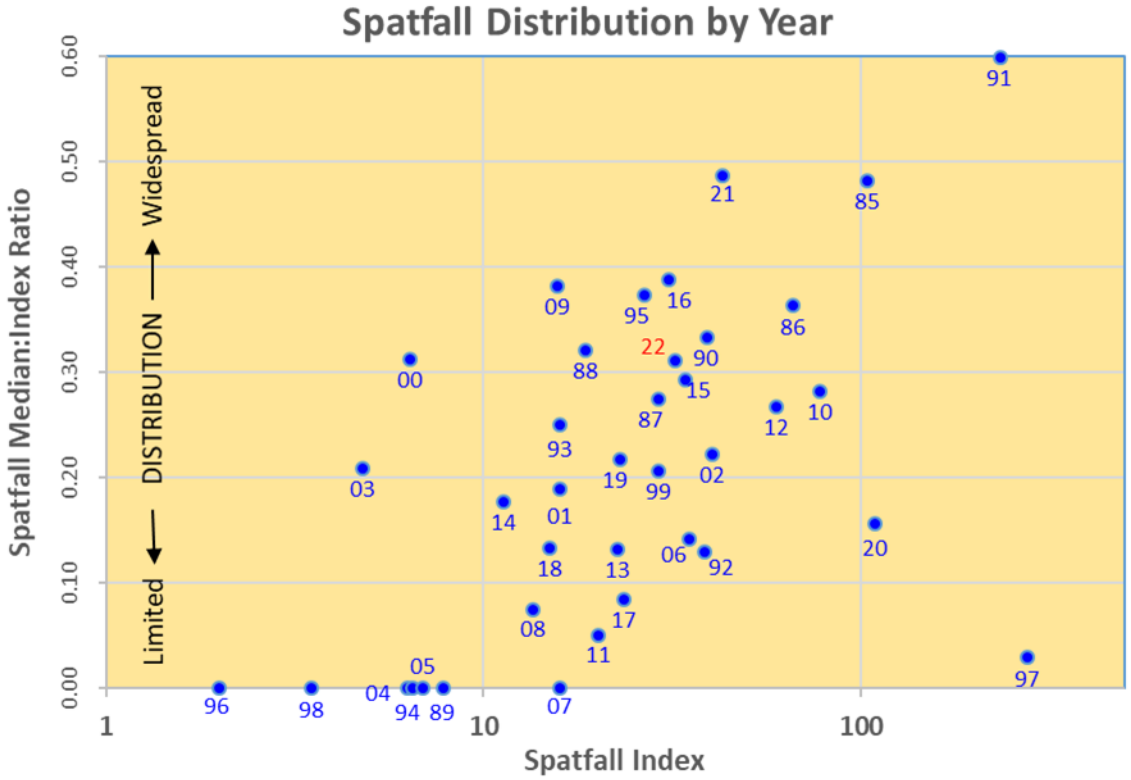

Figure 3c. Spatfall median:index ratios for the years 1985 to 2022 as denoted by "85" to "22" on the chart. The ratio measures the geographic distribution of spat counts for a given year. A lower ratio indicates that the spat counts are concentrated on fewer index bars, while a higher ratio indicates the numerical distribution of spat is more evenly spread among the index bars.

When considering all bars surveyed in addition to the Key Bars, the highest recruitment was observed in southern Maryland (Figure 4). The upper St. Marys River (including both sanctuary and open-harvest bars) led all regions, averaging 383 spat/bu. Other areas with recruitment averages greater than 100 spat/bu include mid-Tangier Sound (143 spat/bu), the lower mainstem east of the channel (117 spat/bu), and the lower north shore of the Potomac River (108 spat/bu). Light spatsets were observed in the upper reaches of several tributaries where recruitment tends to be more sporadic, including the Patuxent, Nanticoke, and Choptank rivers. The middle to upper Potomac River had few or no spat in the samples. No spat were found in samples along the Western Shore north of Cove Point, in the entire Chester River, and the east side of the bay north of Bloody Point.

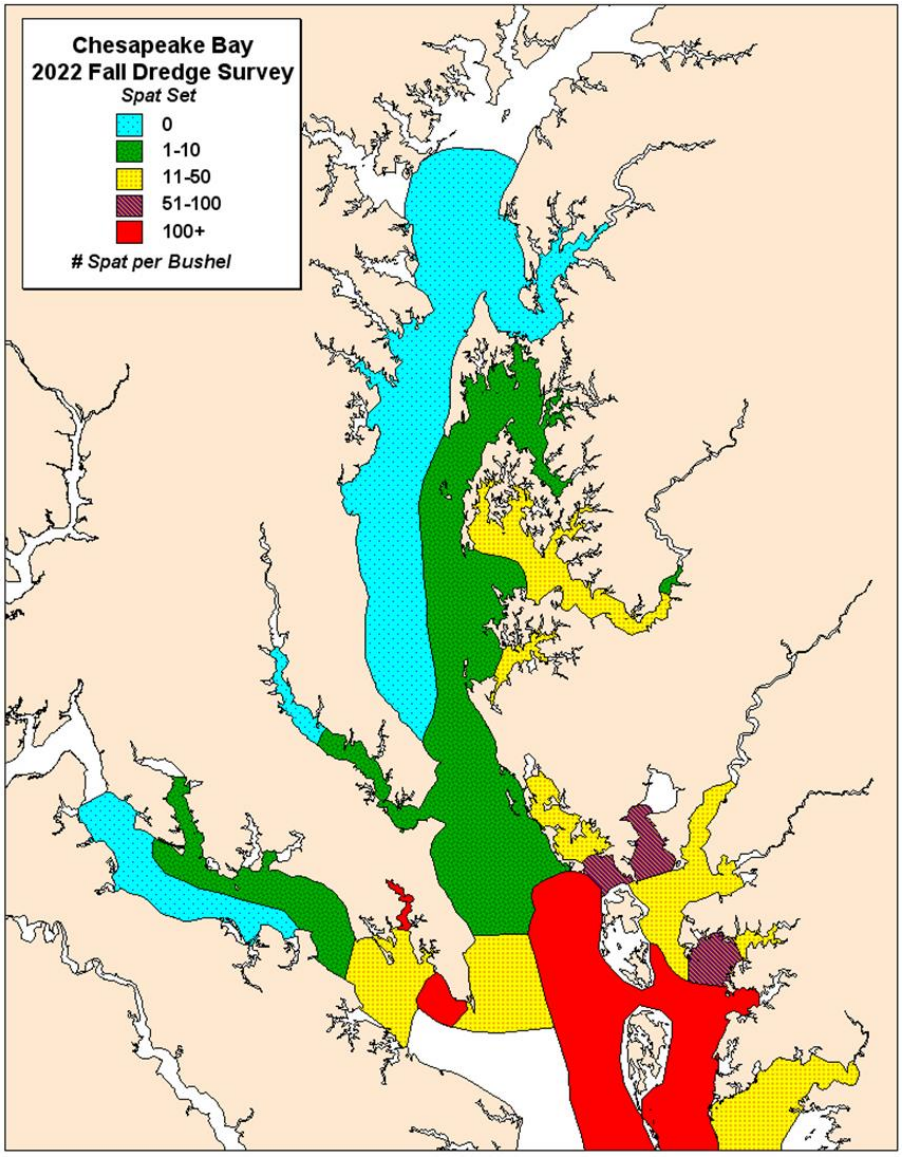

Figure 4. Oyster spatfall intensity and distribution in Maryland, 2022. Intensity ranges represent regional averages.

OYSTER DISEASES

A total of 1,558 oysters were analyzed for diseases in 2022 – 1,288 from the 43 Disease Bars (sentinel bars) and 270 from nine supplemental sites.

Dermo disease is caused by the parasite *Perkinsus marinus*. Prevalences and intensities wax and wane seasonally, and infections may persist from year to year before oysters die from the disease. Over several years of drought during the 1980s, *P. marinus* expanded its Chesapeake Bay distribution into upstream areas where it had been previously rare or absent and has remained widespread throughout Maryland ever since.

Dermo disease rose appreciably in 2022 from the preceeding two years. The disease was detected in oysters on 100% of the Disease Bars and supplemental sites (Table 3), whereas in 2020 it was found at 84% of the bars, the lowest frequency since the 43-bar subset was standardized in 1990. Over the previous three years the percentage of individual infected oysters have been the lowest on record, but in 2022 the overall mean **infection prevalence** in oysters sampled on the Disease Bars increased substantially to 58%, compared to 36% in 2021; this was the highest average prevalence in the last five years (Figure 5). Nevertheless, this marks the 17th of the last 20 years that dermo disease mean prevalences have been below the long-term average since the record high epizootics at the turn of the millennium.

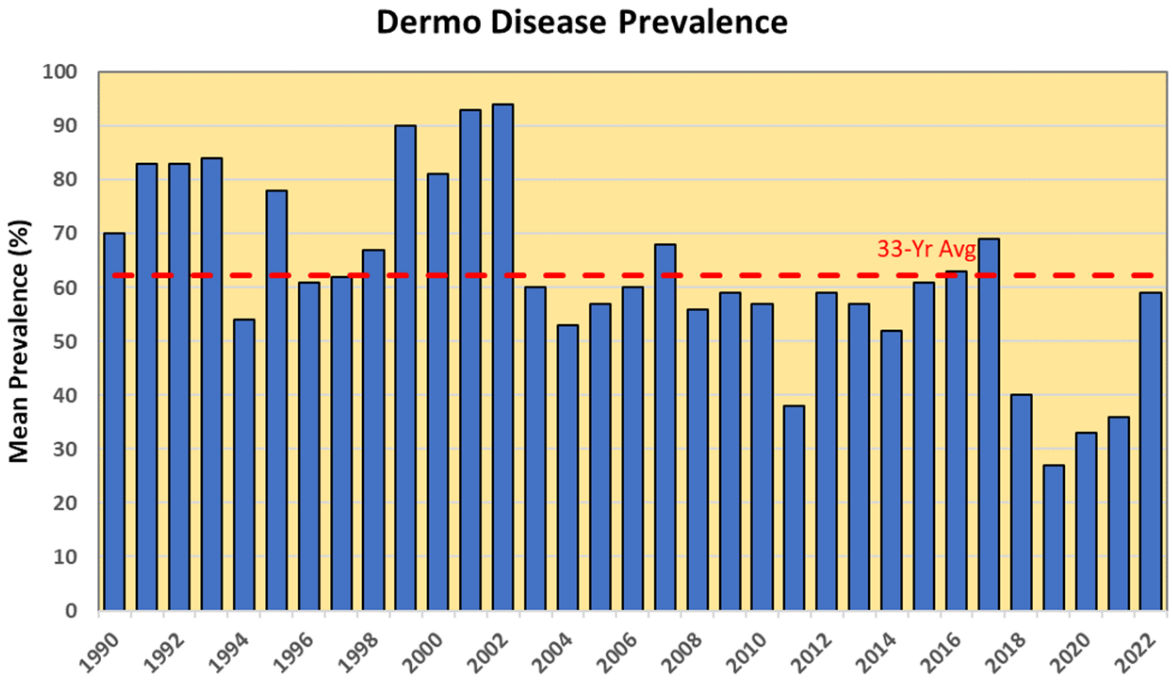

Figure 5. Annual mean *P. marinus* prevalences from Maryland disease monitoring bars.

The number of samples exhibiting high prevalences (>60%) had declined substantially over the previous four years from 60% of the Disease Bars in 2017 to 19% in 2020 and 21% in 2021, but remained widely distributed below the Bay Bridge (Figure 6). However, that changed in 2022, with 53% of the samples infected at high prevalences (Table 3).

Outside of the regular disease monitoring sites, dermo disease was found at all nine of the supplemental sites, with prevalences greater than 60% at seven of the bars, compared to four bars in 2021. The two supplemental bars furthest upstream, Deep Shoal in the mainstem and Beacon bar in the Potomac River (Figure 1c), once again were not sampled for disease in 2022 because of the absence or low densities of oysters due to freshet-related mortalities in 2018/19.

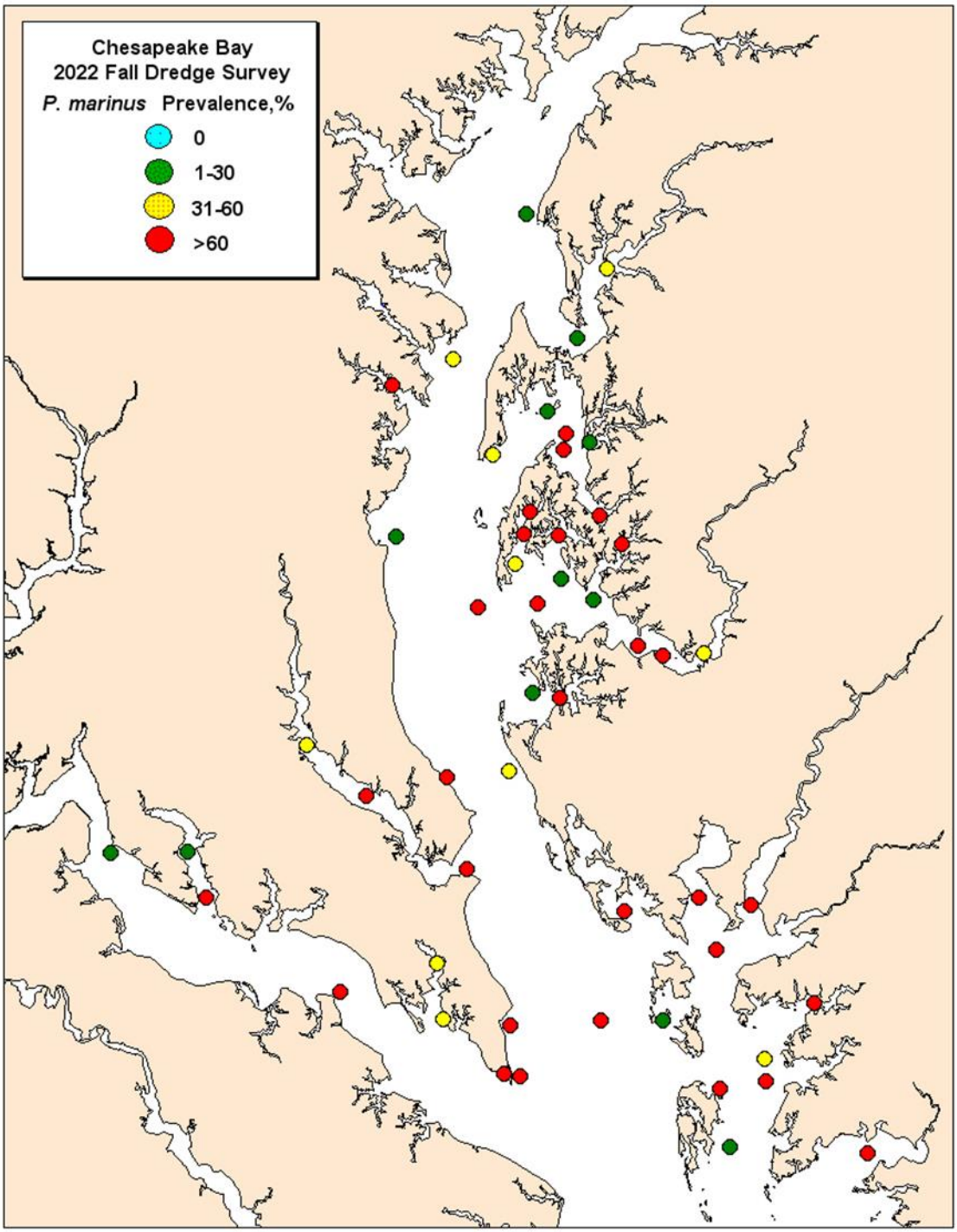

Figure 6. Geographic extent and prevalence of dermo disease in all disease samples, 2022.

The trend in the mean **infection intensity** for dermo disease also increased in 2022, but still remained below the long-term average (Figure 7). The 2022 mean infection intensity (1.7 on a 0-7 scale) was 42% higher than in 2021 (1.2) (Table 3). Similar to the trend in prevalences, this

is the 17th of the past 20 years that the infection intensity index has been at or below the long-term average (Figure 7). The average infection intensity over the 20 years since the end of the 1999-2002 drought is 1.8. In comparison, the annual infection intensities during this drought period averaged 3.4, which contributed to historically high mortalities.

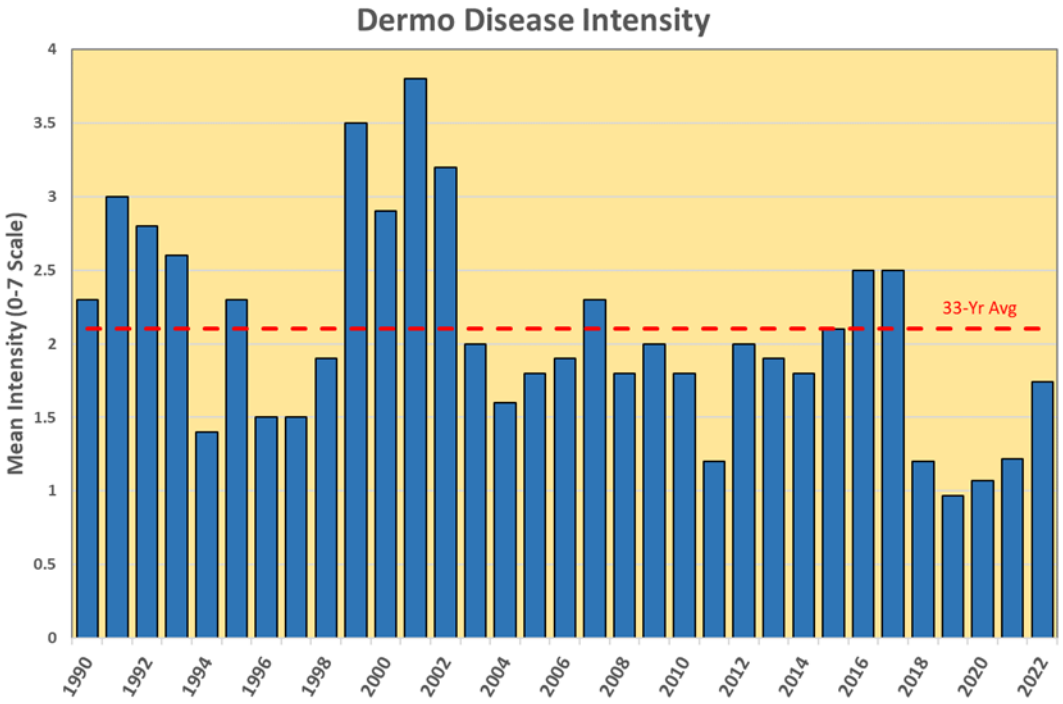

Figure 7. Annual *P. marinus* infection intensities on a scale of 0-7 in oysters from Maryland disease monitoring bars.

The 2022 frequency distributions of sample mean infection intensities on the Disease Bars remained in the moderate range, but the number of bars increased within the high end of the ranges (Figure 8). In 2022, nine of the sentinel bars (21%) had a mean intensity in the high range (3.0 or greater), compared to only one bar (2%) in 2021. For perspective, during the peak infection intensity year of 2001, 81% of the sentinel bars had dermo disease mean intensities equal to or greater than 3.0 and 51% had intensities equal to or greater than 4.0. The proportion of bars that were in the lowest intensity categories of zero and less than 1.0 was 35% in 2022, compared to 47% in 2021 and only14% in 2017. Meanwhile, the proportion of bars in the moderate intensity (1.0 to <3.0) range also decreased, from 51% in 2021 to 44% in 2022. Although dermo disease was detected on all of the bars in 2022, the infection intensities at two locations were so low that they rounded down to zero (Figure 8). Two of the nine supplemental bars had mean infection intensities of 3.0 in 2022; the remainder were below that level.

The geographic distribution of intensity ranges for both Disease Bars and supplemental sites are shown in Figure 9. The majority of the highest intensities were detected in southern Maryland, particularly in the Tangier Sound region.

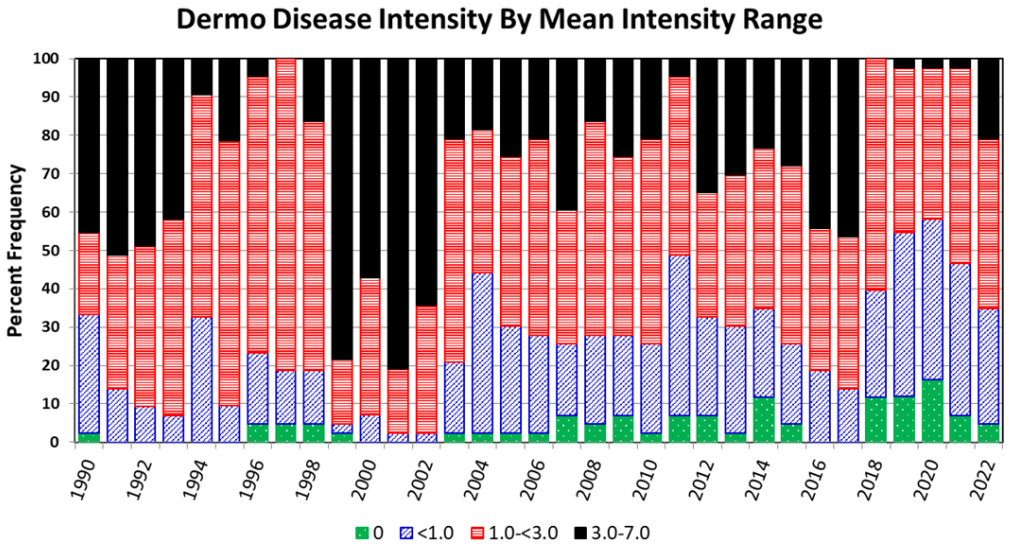

Figure 8. *Perkinsus marinus* infection intensity ranges (percent frequency by range and year) in oysters from Maryland disease monitoring bars.

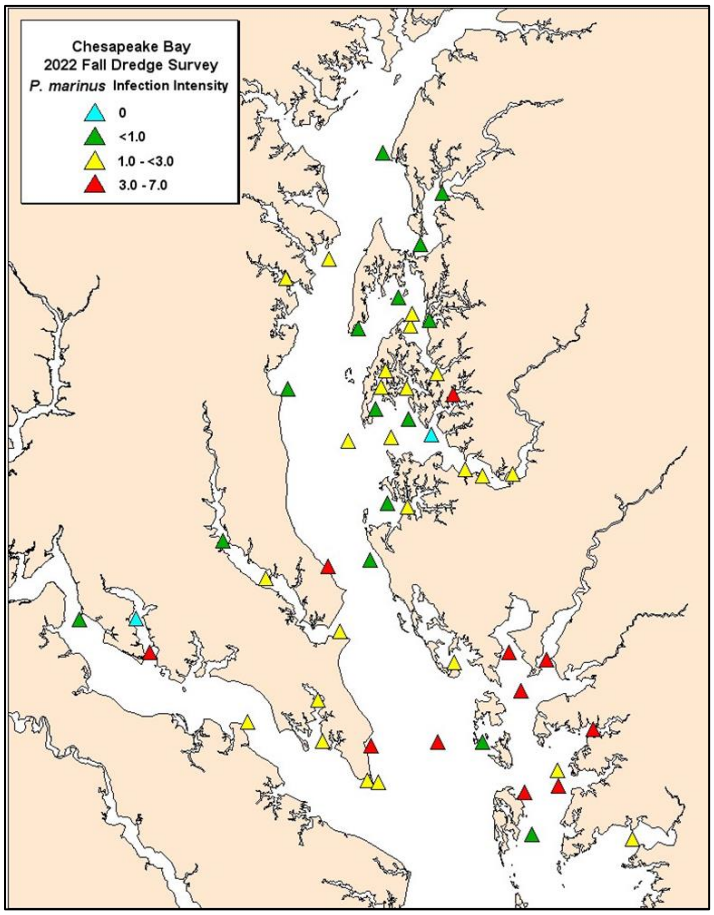

Figure 9. Geographic distribution of *P. marinus* infection intensity ranges in all disease samples, 2022.

Infection intensities in individual oysters that are ≥5.0 on a 0–7 scale are considered lethal; such infection intensities were found in 74% of sentinel samples in 2022, an increase from 70% in

2021. However, as a percentage of all oysters samples, lethal infections were detected in only 12% of individual oysters sampled in 2022, slightly up from 10% in 2021, but substantially lower than the 21% in 2017.

MSX disease, resulting from the parasite *Haplosporidium nelsoni*, is another potentially devastating oyster disease. This parasite can cause rapid mortality in oysters and generally kills a wide range of year classes, including younger oysters, over a long seasonal period. When MSX disease coincides with elevated dermo disease intensities, mortality levels can be extremely high, as seen in 2001 and 2002. In Chesapeake Bay, MSX disease is most active in higher salinity waters (>15 ppt) (Appendix 2).

Both the prevalence and geographic range of MSX disease increased on the Disease Bars in 2022. The mean prevalence of infected oysters rose from 0.4% to 1.9%. Despite the increase, this was nearly an order of magnitude lower than the most recent infection peak in 2016 (11.1%). This extends the trend of prevalences below the long-term average to six years, three of which were record lows (Table 4, Figure 9). The prevalences ranged from 3% to 17% on the Disease Bars where MSX was detected. The highest disease bar prevalence was found on Piney Island East in Tangier Sound, and was matched by Northwest Middleground, a supplemental disease site located in the lower mainstem east of the channel.

When considering both the Disease Bars and supplemental sites, the geographic extent of MSX disease expanded throughout Tangier Sound region (Figure 10). In addition, MSX jumped across the bay to Butlers bar on the Western Shore, which had a 3% prevalence (one infected oyster). In only two years, the percent frequency of positive Disease Bars increased from 2% (one bar) in 2020 to 19% (eight bars) in 2022 (Table 4). MSX was also detected on two supplemental disease sites, identical to 2021 occurrences, - NW Middleground and Piney Island East Addition in Tangier Sound. Although the number of bars with MSX infections increased, it remains below the most recent peaks. As recently as 2017, 14 Disease Bars (33%) had MSX-infected oysters, while 2016 was even higher with 24 (56%) infected bars (Table 4). For reference, at its greatest extent the parasite occurred on 90% of the bars in 2002.

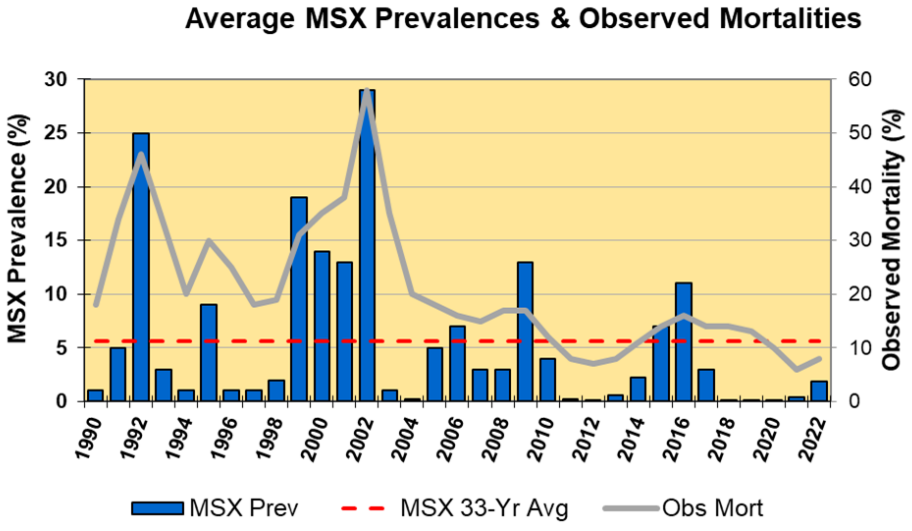

Figure 9. Annual percentage of Maryland oysters with MSX disease compared to 33-year mean and the correlation with observed mortalities on the disease monitoring bars from 1990-2022.

Historically, the abatement of MSX disease in 2003-2004 due to two consecutive years of greatly elevated freshwater flows into the bay signified the end of the most severe *H. nelsoni* epizootic on record in Maryland waters. The 2002 epizootic set record high levels for both the frequency of affected disease monitoring bars (90%) and the mean annual prevalence within the oyster populations (28%), leaving in its wake observed oyster mortalities approaching 60% statewide in conjunction with dermo disease. Since 1990, there have been five *H. nelsoni* epizootics: 1991-92, 1995, 1999-2002, 2009, and 2015-16. The first three were associated with prominent spikes in observed mortalities (Figure 9), while the 2009 and 2016 outbreaks were accompanied by modest mortality increases that were ameliorated by timely freshwater flows (Tarnowski 2011). All of these epizootics coincided with dry years (Figure 2a) and consequent elevated salinities. These were followed closely by periods of unusually high freshwater inputs into parts of Chesapeake Bay, which purged *H. nelsoni* infections from most Maryland oyster populations (Homer & Scott 2001; Tarnowski 2005, 2011). The current five-year period of greatly diminished *H. nelsoni* infections is associated with the extraordinarily high streamflows of 2018 and 2019, followed by a return to normal flows (Figure 2a).

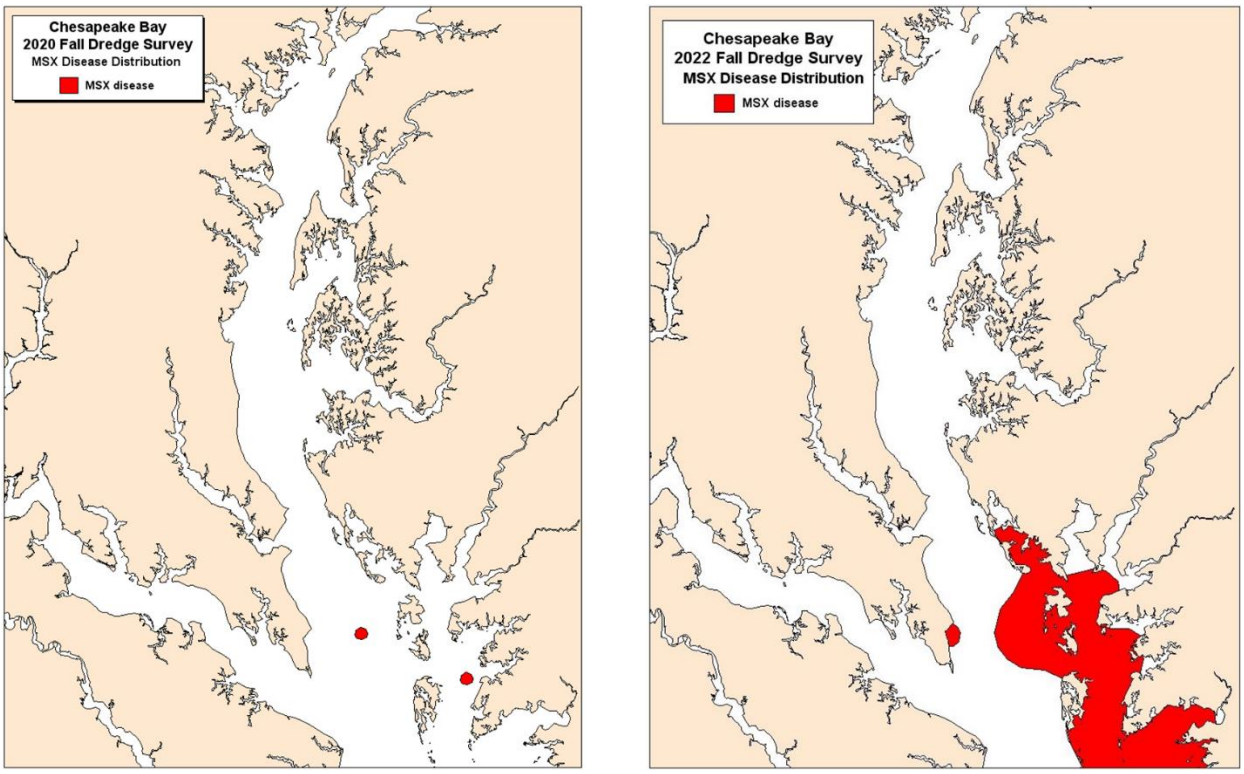

Figure 10. Geographic distribution and prevalence of MSX disease in Maryland waters in 2022 compared with 2020, illustrating how extensively the disease has spread in two years of favorable salinities.

OBSERVED MORTALITY

At 8.3%, the 2022 Observed Mortality Index rose slightly from 2021, which was the lowest of the 38-year time series (Table 5). Nevertheless, 2022 had the fifth lowest index in the time series and marks the 19th consecutive year that mortalities were substantially below the long-term mean of 21.2% (Figure 11), largely as a consequence of low to moderate disease pressure. From 2010 to 2022, the average observed mortality of 11.0% approaches the background mortality levels of 10% or less found prior to the mid-1980s disease epizootics (MDNR, unpubl. data). This is in remarkable contrast to 2002 when record-high disease levels devastated Maryland populations, resulting in a 58% observed mortality rate.

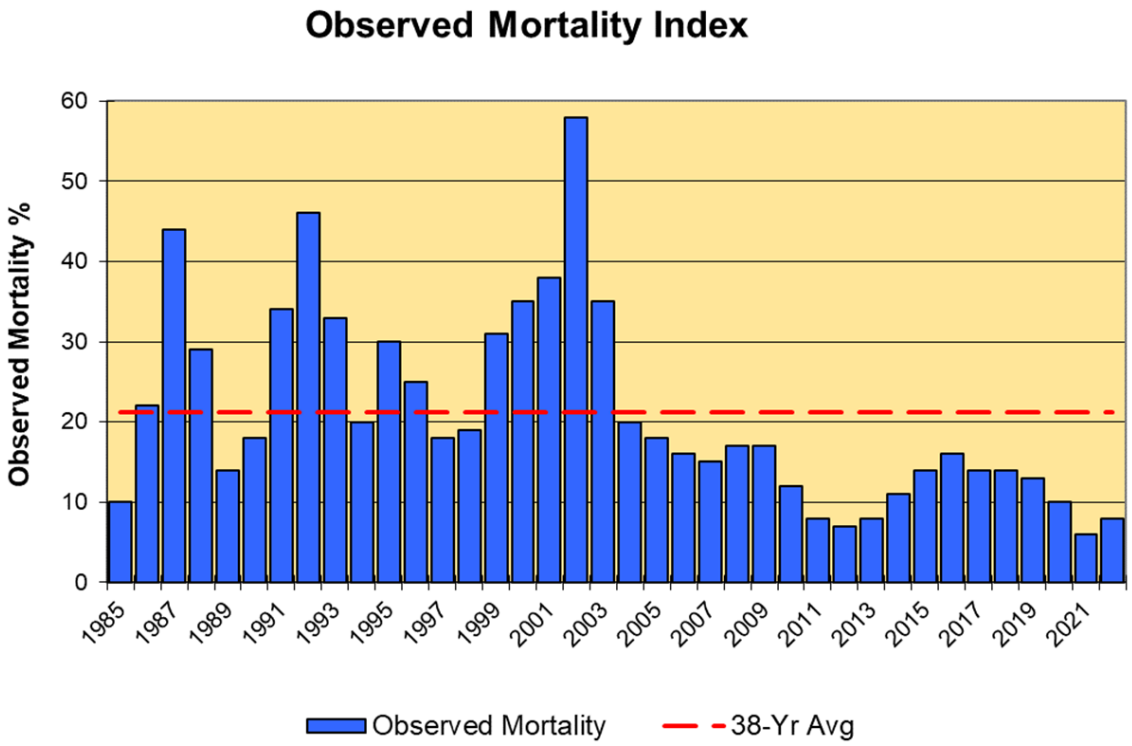

Figure 11. Mean annual observed mortality, small and market oysters combined.

Looking at all Fall Survey sites, observed mortalities were generally low. The north-south gradient in observed mortalities evident in most years was not apparent in 2022, with strikingly low average mortalities (10% or less) from the head of the bay to the Virginia line, including most tributaries (Figure 12). For example, Tangier Sound, typically a higher mortality area, experienced a notably low observed mortality for the fourth year in a row, averaging 9.7%, in contrast to 1999 at the start of the millennial epizootic when the average observed mortalities climbed to 48.0%. The highest Index-bar mortality on bars with 40 or more oysters older than one year was observed on Georges (25.5%) in the Manokin River, followed by Marumsco (23.1%) in Pocomoke Sound, Back Cove (22.3%) and Sharkfin Shoal (20.5%), the latter two in Tangier Sound (Table 5). For non-index bars with 40 or more oysters older than one year, the highest observed mortalities were on Nanticoke Middleground (27.1%) and Duck Island (23.0%) in Fishing Bay.

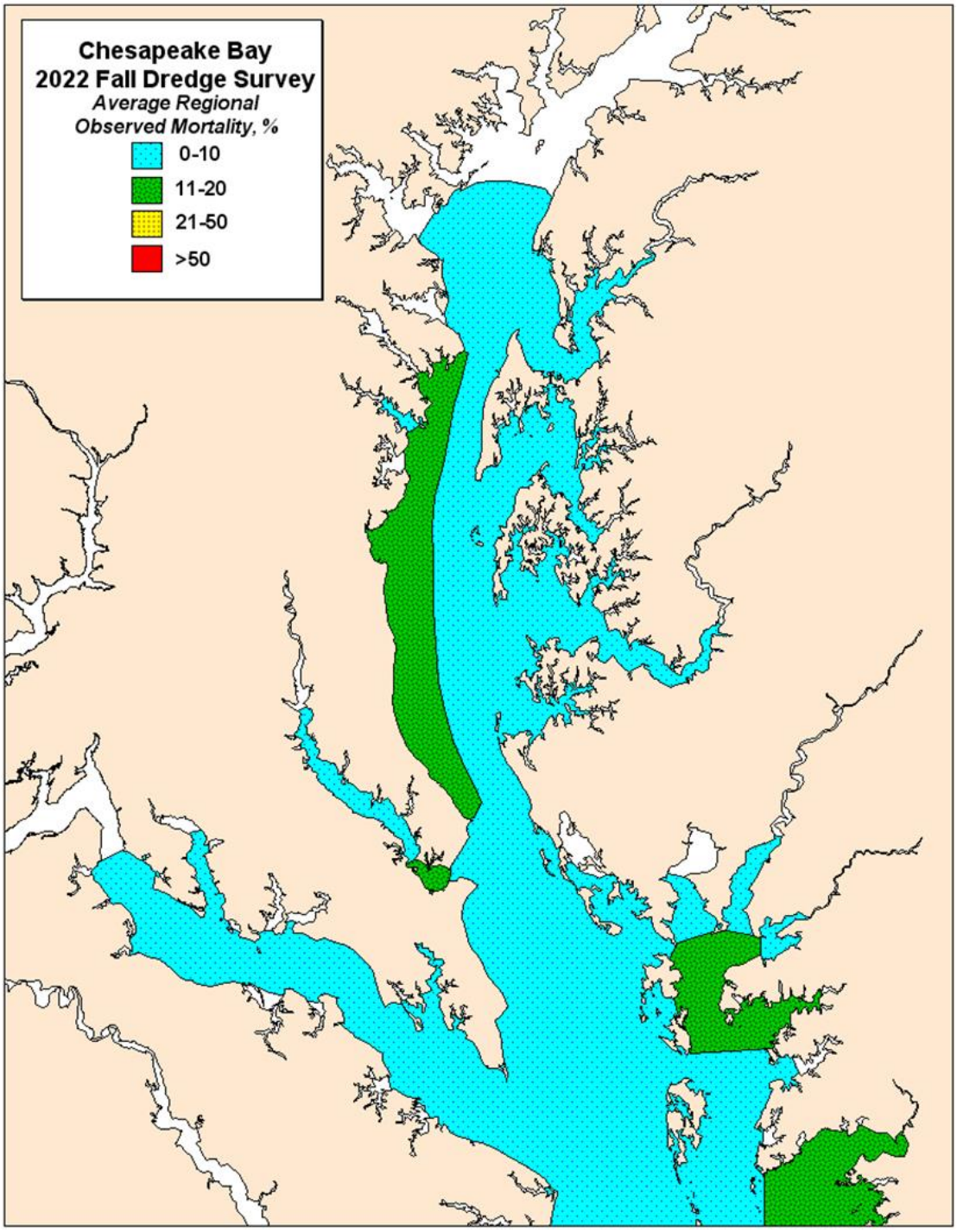

Figure 12. Geographic distribution of total observed oyster mortalities (small and market oysters) in Maryland, 2022. Mortality ranges represent regional averages; individual bars may vary substantially.

BIOMASS INDEX

The Biomass Index is a relative measure of how the oyster population is doing over time. It accounts for recruitment, individual growth, natural mortality, and harvesting in a single metric. In assessing the size of the population, the Biomass Index integrates both the abundance of oysters and their collective body weight (another way of looking at how large they are). For example, when examining two groups of oysters with the same abundance, the group with the greater number of larger oysters would have the higher biomass.

The Maryland Oyster Biomass Index was 2.37, the second highest index of the 30-year record, (Figure 13). Although this was a modest 12% decline from the record high index of 2021, it represents a gain of 72% over the long-term average.

The size distribution had more sublegal oysters relative to market oysters at a ratio of 1.07 sublegals to one market oyster, compared with the sublegal to market ratio of 1.13 in 2021 and 0.61 in 2020. This can also be expressed as the percentage of sublegal oysters: 51.7% in 2022, slightly down from 53.0% in 2021 but up substantially from 37.9% in 2020. This shift is reflected in the changes in average size of index bar oysters, from 79.8 mm in 2020, down to 74.6 mm in 2021 and 75.9 mm in 2022. As expected, the slight increase in the average oyster size should result in a corresponding increase in biomass. However, the second component of the Biomass Index, oyster abundance, showed a decline. For all index bars, the average number of oysters per sample dropped from 163.8/bu in 2021 to 137.7/bu, a loss of 16%. The large influx in the number of small oysters in the past two years and the slight increase in average size in 2022 was somewhat outweighed by the large increase in harvest (as related in a following section), which accounts for the decrease in the Biomass Index.

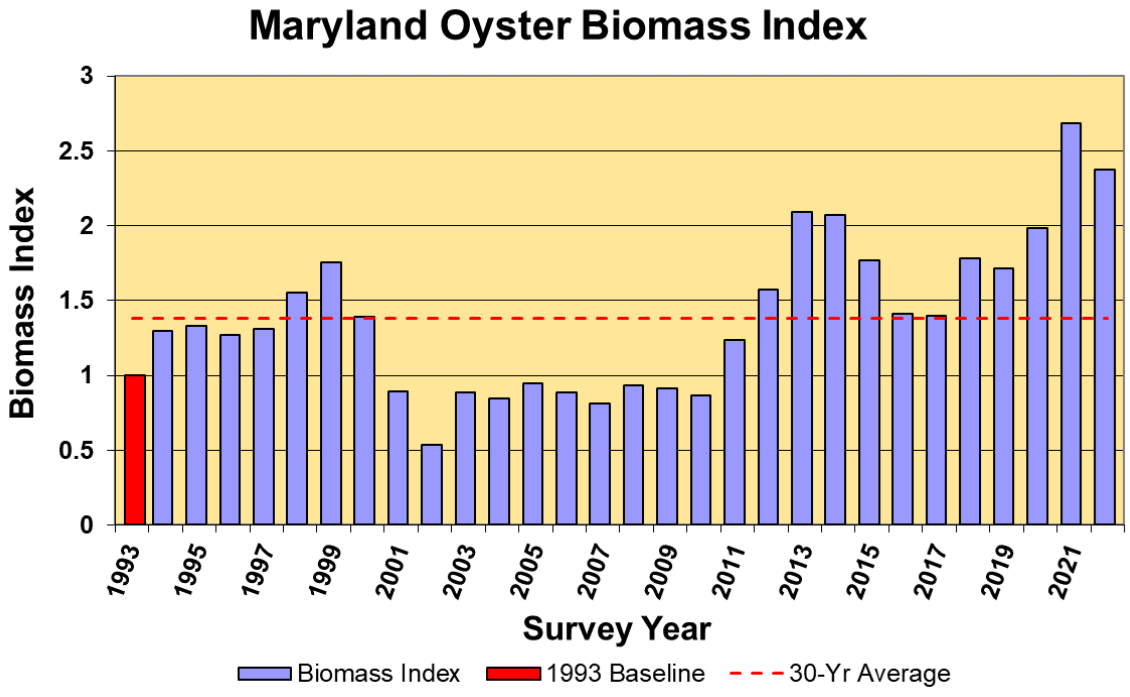

Figure 13. Maryland oyster Biomass Index. The year 1993 represents the baseline index of 1.0.

The oyster population had been slow to recover in the decade after its nadir in 2002, the last year of the devastating four-year disease epizootic. The Biomass Index remained below 1.0 for eight consecutive years despite low disease pressure and high oyster survivorship over this period.[1] Spatfall during this timeframe was sufficient to maintain the population at this level but not increase it. It was not until the strong recruitment event in 2010 - bolstered by another good spatset in 2012 - that the population began to grow, as mirrored in the increase in the Biomass Index. Since then, the Biomass Index has been above the long-term average in each of the last eleven years. With the strong spatsets of the last three years and ongoing restoration efforts in the sanctuaries, the index should continue to improve in the near future, depending on disease-related mortality remaining low, populations in the sanctuaries continuing to grow both in numbers and shell height, and the number of oysters removed by harvesting as these cohorts attain legal size.

[1] The baseline (Biomass Index = 1) year of 1993 was chosen because it had the lowest harvest on record when the index was established.

CULTCH INDEX

The Cultch Index is a relative measure of oyster habitat; because the dredge is less than 100% efficient, the index is not an absolute measure of cultch. Cultch is crucial for providing hard substrate for oyster setting as well as habitat for the myriad other organisms associated with the oyster community. For the purpose of the Fall Survey, cultch is defined as primarily both live and dead oysters plus shell combined. The collection of quantitative cultch data was initiated during the 2005 Fall Survey. A three-year rolling average was used to smooth the interannual variability inherent in the index (the rolling average is assigned to the terminal or third year of each grouping) and assist in following trends.

The three-year rolling average for the 2022 Cultch Index of 0.87 bu/100 ft. was similar to the 18-year average of 0.89 bu/100 ft. (Figure 14). However, some individual bars showed steep declines. Of the 53 bars used in this analysis, 13% had standardized volumes that were less than 75% of their respective 18-year averages (Figure 15).

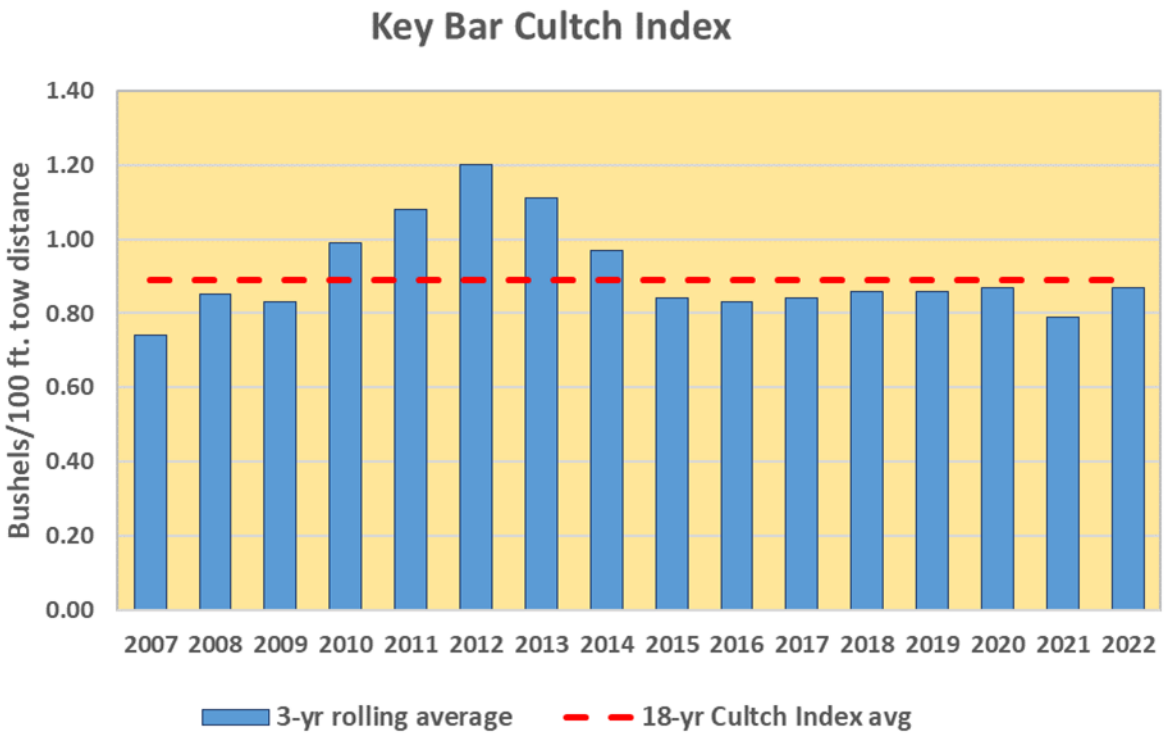

Figure 14. Three-year rolling average of annual means for the Key Bar Cultch Index, 2005-2022. The average is represented by the third year of the grouping (e.g., the 2005-07 average is graphed as 2007).

Although 18 years is a comparatively short time frame for discerning long-term trends in the Cultch Index, a distinctive pattern emerged over this period (Figure 14). The increase in the Cultch Index during the early 2010s reflects improvements in recruitment and survivorship during that period, especially the strong spatsets in 2010 and 2012 (Figure 3b). The growth and high survivorship of these year classes contributed substantially to the index. The subsequent decline may be due to harvesting and inconsistent recruitment, as well as ongoing taphonomic processes such as shell burial and degradation. The more recent rise in spatsets have been sufficient to maintain but not increase the index to date.

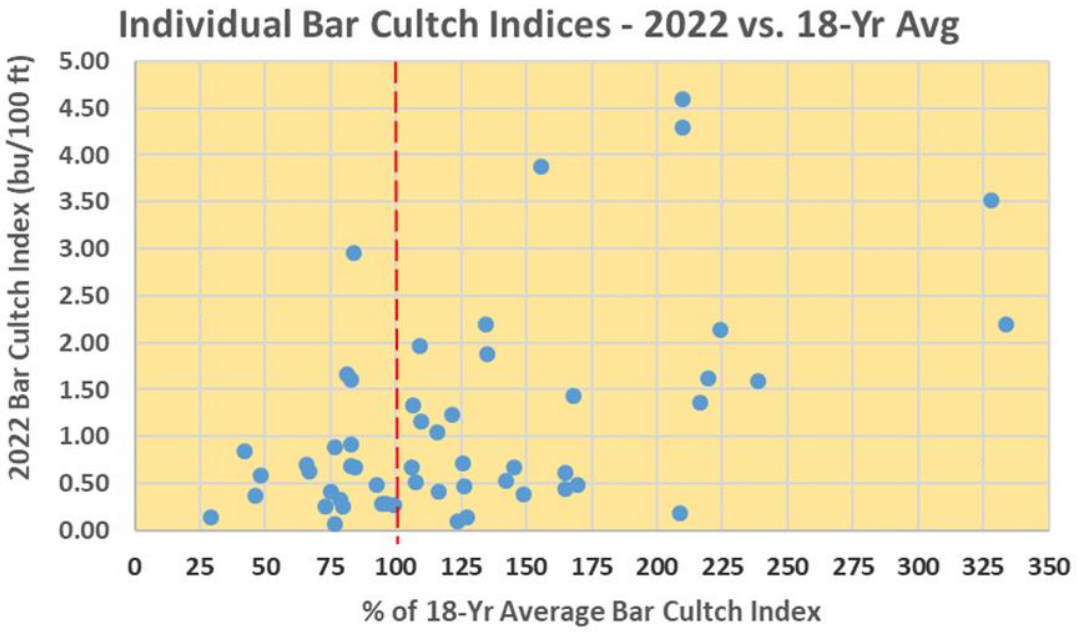

Figure 15. Range of cultch index values for individual Key bars in 2022 and the percent difference from their respective 18-year averages. The red dashed line represents the 18-year average.

Strong regional differences in cultch mean volumes were evident (Figure 16). The areas with the lowest standardized cultch averages included the mainstem of the bay, followed by the combined Chester River/Eastern Bay region. The highest cultch indexes were in areas with more favorable recruitment and consequent additions to cultch, specifically the Tangier Sound and Choptank River tributaries, and to a lesser extent the Patuxent River. All six regions had indexes close to their 18-year average (Figure 16). The Potomac region index is somewhat deceptive since it is largely driven by Pagan bar, whose 3-year average is nearly three times as high as the three-year average of the other six bars in this region; if not for Pagan the Potomac region index would be 18% lower. Removing Pagan would reduce the 18-year average for the Potomac region by 26%.

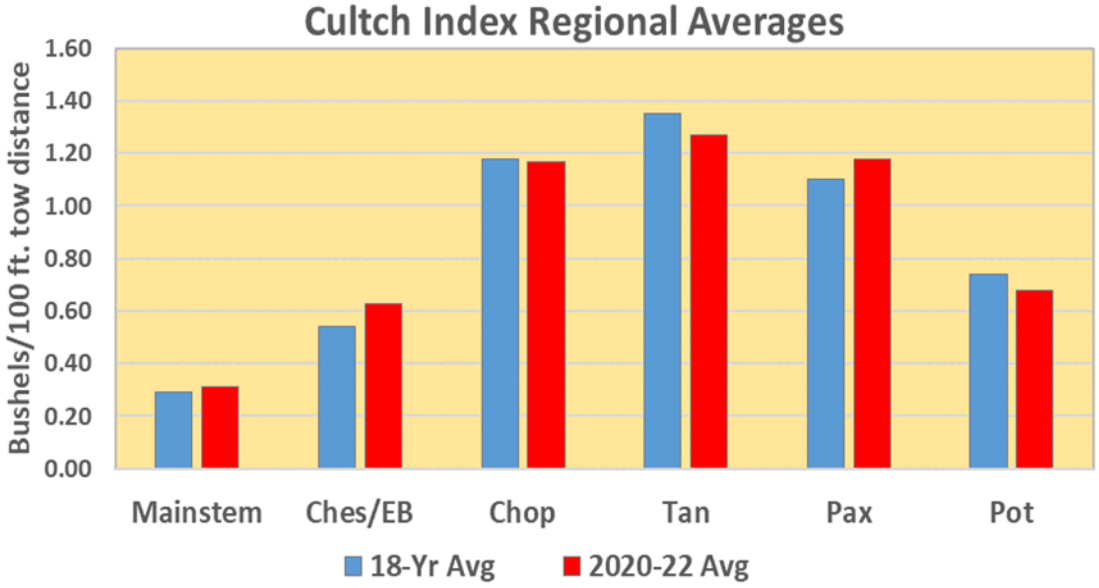

Figure 16. Regional cultch index averages for the 18-year time series and most recent three years. *Main=bay mainstem; Ch/EB=Chester River/Eastern Bay region; Chop=Choptank River region; Tan=Tangier Sound region; Pax=Patuxent River; Pot=Potomac River tributaries*

Cultch volumes among subregions of the broader regions can be highly variable. The greater part of the Tangier Sound region cultch index is contributed by the tributaries and not Tangier Sound proper (Figure 16a). In 2022, the three-year average of the index stations of the five subregional tributaries was 1.17 bu/100 ft. tow distance while the Tangier Sound proper stations averaged 0.77 bu/100 ft. The average cultch indexes for the individual tributaries were substantially higher in the Nanticoke River (1.67 bu/100 ft) and the Manokin River (1.63 bu/100 ft) sanctuaries - more than twice as high as Tangier Sound (Figure 16a).

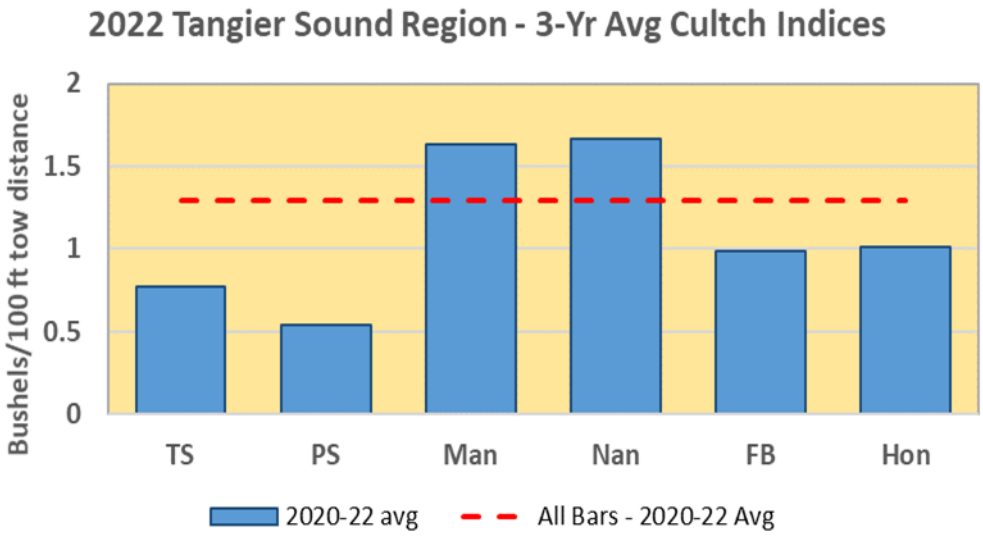

Figure 16a. Three-year averages (2019-2022) of bushels of cultch per 100 ft. tow distance for index stations by subregion within the Tangier Sound region. *TS=Tangier Sound; PS=Pocomoke Sound; Man=Manokin River; Nan=Nanticoke River; FB=Fishing Bay; Hon=Honga River*

COMMERCIAL HARVEST

Commercial oyster landings during the 2021-22 season were the highest in 35 years (1986/87 season). With reported harvests of 546,000 bushels, oyster landings were 58.6% higher than the previous harvest season, the third year in a row of increased harvests (Table 6, Figure 17a), and were well above the 37-year average of 299,000 bu/yr. The average reported price also rose substantially to $39.31/bu from the previous year's $30.43/bu, which were likely depressed due to the impact of COVID-19 on the demand for oysters. Consequently, the total dockside value doubled from $10.5 million in 2021 to $21.5 million in 2022 (Table 7a.).

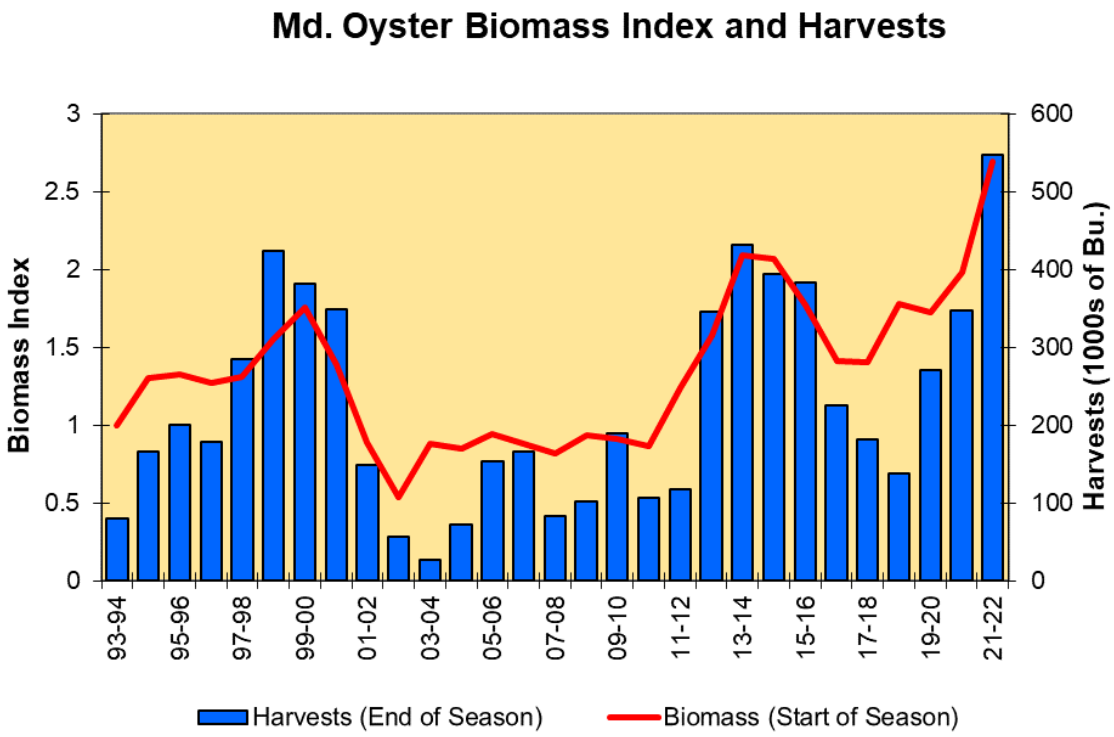

Figure 17a. Maryland oyster landings over the past 29 seasons and the relationship between the Biomass Index calculated at the start of the harvest season and total landings reported at the end of that same season. Note lag between the two metrics when abundant sublegal oysters add to the Biomass Index but have not yet entered the fishery.

Commercial oyster landings generally follow a similar pattern as the Biomass Index (Figure 17a). However, in some years there is a lag between the two metrics when abundant sublegal oysters add to the Biomass Index but have not yet entered the fishery (e.g., 2003-04, 2011-12, 2018-19).

During the ten years prior to the 2012-13 season, the fishery struggled to rebound from the devastating oyster blight that concluded in 2002. The Biomass Index reached its nadir that year, followed by the record low of 26,000 bu taken in 2003-04. The sizeable harvest increases of 2012-2016 (Figure 17a), following the below-average landings of the decade beforehand, were due to the strong 2010 and 2012 year-classes and subsequent good survivorship, allowing a larger proportion of those cohorts to attain market size. This abundance of oysters, as reflected in the Biomass Index, led to an increase in the number of harvesters and fishing effort, resulting in higher landings. However, unexceptional spat sets in 2011, 2013, and 2014 were insufficient to sustain harvests, leading to the substantial drop in landings in the 2016-17 to 2018-19 seasons. The Biomass Index did not parallel this harvest decline, but actually increased in 2019 because of above-median spatfalls in 2015 and 2016. As these two year classes of sublegal-size oysters

accumulated, their subsequent growth as well as continued growth of oysters protected in sanctuaries contributed to maintaining the Biomass Index despite the drop in landings. Furthermore, the high streamflows in 2018/19 inhibited the growth of these sublegal oysters, delaying their reaching market size (Tarnowski 2020). As these year classes have entered the fishery, the general correlation between harvests and Biomass Index resumed in the 2019-20 season, with the landings increase over the last three years reflected in the rise of the index.

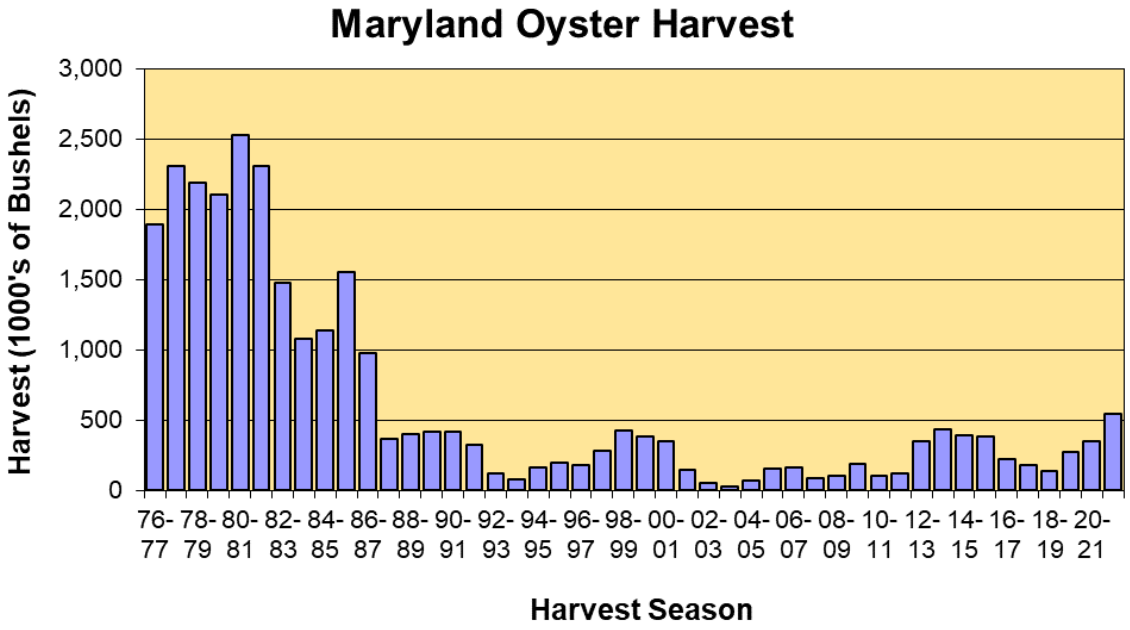

Figure 17b. Maryland seasonal oyster landings, 1976-77 to 2021-22.

Taken in the longer historical context, the average landings over the last several years remain a fraction of the harvests prior to the disease epizootics of the mid-1980s, when harvests ranged between one to two million bushels (Figure 17b). Since the heyday of the Maryland oyster fishery in the 19th century, annual landings below 100,000 bushels have been reported in only five seasons, all within the past 29 years (and four of these in the most recent 20 years) following the onset of a series of disease epizootics beginning in the mid-1980s

The Tangier Sound region, with landings of 393,000 bu, was the dominant harvest area, accounting for 72% of the 2021-22 landings in Maryland. The greatest proportion of these landings came from upper Tangier Sound (213,000 bu or 39% of the Maryland harvest) (Table 6). The Choptank River region was second with 55,000 bu, providing 10% of the total harvest, primarily from Broad Creek (37,000 bu). With the exceptions of the St. Marys River and to a lesser extent the lower Choptank River, middle bay mainstem, and Eastern Bay, the majority of the regions experienced increases in landings to varying degrees. The most substantial changes (>5,000 bu) in Maryland regional landings between the 2020-21 and 2021-22 seasons are listed below:

Upper Tangier Sound

-Increased 68,686 bu (+48%)

Lower Tangier Sound

-Increased 49,989 bu (+165%)

Patuxent River
-Increased 21,671 bu (+126%)
Honga River
-Increased 15,970 bu (+197%)
Lower Bay Mainstem
-Increased 9,350 bu (+114%)
Fishing Bay
-Increased 9,337 bu (+26%)
Nanticoke River
-Increased 7,811 bu (+55%)
Upper Bay Mainstem
-Increased 7,193 bu (+10,425%)

St. Marys River
-Decreased 5,446 bu (-41%)

The combined harvests in the entire Tangier Sound region increased by 154,521 bu or 65% from 2020-21. The combined Choptank River region, the second most-productive area, showed a much more modest increase of 5,270 bu (+10%). Despite the recent gains, many regions remained below their long-term harvest averages. The exceptions were the most productive areas, including Tangier Sound and most of its tributaries, Broad and Harris creeks, the Little Choptank, Patuxent, and St. Marys rivers, and the lower bay mainstem (Table 6).

Generally, the northern portion of the bay and tributaries continued to perform poorly due to a lack of recruitment and large-scale repletion activity. The exception was in the mainstem above the Bay Bridge, which experienced its highest landings (7,262 bu) since the 2009-10 season, due to several small-scale hatchery spat plantings that were opened for harvest this past season. For the most part, however, the combined percentage of landings from the upper bay and Chester River, which in some seasons in the 1990s and early 2000s accounted for over half of Maryland's total landings, has been negligible in recent years (Table 6). For reference, the 37-year harvest average for these two regions was 31,000 bu/year, primarily sustained by numerous seed plantings from the historic MDNR Repletion Program. Similarly, a decline in 2021-2022 harvests from the once-productive Eastern Bay region produced only 10% of the 37-year average landings. The mid-mainstem of the bay also suffered a harvest decline from the previous year, dropping to the fourth lowest on record at only 11% of the long-term average.

Not surprisingly, all gear types showing gains in harvests from the previous season (Table 7a). For the 15th consecutive season, power dredging was the predominant method of harvesting, accounting for 48% of the total landings (Table 7b). This activity was mainly in the lower Eastern Shore and Choptank regions. Patent tonging was second, producing 32% of the total harvests. Meanwhile, hand tonging slipped to 8% of the landings, primarily from Broad Creek - well below 74% of the landings during the 1996-97 season when power dredging was largely prohibited.

OYSTER SANCTUARIES

An in-depth analysis of the performance of Maryland's oyster sanctuary system is beyond the scope of this report but is provided in a stand-alone document examining longer-term trends (dnr.maryland.gov/fisheries/Pages/oysters/5-Year-Oyster-Review-Report.aspx). However, this report provides some important points and a concise view of the sanctuary oyster populations, focusing primarily on the priority (i.e., large-scale restoration) sanctuaries: Harris Creek, and the Tred Avon, Little Choptank, Manokin, and St. Marys rivers.

A total of 93 oyster bars within 37 sanctuaries were sampled during the 2022 Fall Survey, including six sanctuaries and seven bars that were newly added to the survey (Table 8). For comparison among areas, oyster counts were standardized to 100 ft tows, as the number per bushel count does not take into account varying tow lengths. Recruitment within the priority sanctuaries and adjacent open harvest areas was generally below their respective Key Bar 18-year averages (Table S-1). The main exceptions were the St. Marys River sections, which had extremely good spatsets. The St. Marys Sanctuary had the highest regional recruitment, while the harvest area was an order of magnitude higher than the long-term average. Aside from the Tred Avon River and Broad Creek harvest areas, priority sanctuaries had consistently higher recruitment to varying degrees compared to nearby harvest areas (Table S-1). It should be noted that the Broad Creek recruitment average is about five times as high as the Harris Creek Sanctuary over the 18-year time series, including prior to the creation of the sanctuary in 2010. For this comparison, Royston bar at the mouth of Broad Creek was omitted. This bar has substantially different characteristics from the remainder of the Broad Creek bars further upstream, with longer tow distances, fewer small and market oysters, and lower recruitment. Broad Creek averages with and without Royston are presented in Table S-1.

Table S-1. 2022 average number of oysters/100 ft tow by region and size/age class (Sm=smalls, Ma=markets) and average Key Bar (KB) spat/100 ft tow since 2005 (when tow distances were first measured) for priority restoration sanctuaries and nearby harvest areas. Broad Creek averages are presented both with and without Royston bar. n/a = There is no Key Bar in the Tred Avon River open area.

Region	**Status**	**Regional 2022 Sm+Ma** (#/100 ft tow)	**Regional 2022 Spat** (#/100 ft tow)	***KB Spat*** *18-yr Avg* (#/100 ft tow)	**2022 Regional Avg. Tow Dist.** (ft)
Harris Cr.	Sanc.	459	19	47.1	76
Harris Cr.	Open	372	7	10.7	227
Broad Cr.	Open	1,182	79	51.0[b]	66
Broad Cr.[a]	Open	1,360	83	241.0	49
Tred Avon R.	Sanc.	306	20	12.3	72
Tred Avon R.	Open	280	42	*n/a*	86
L.Choptank R.	Sanc.	476	22	61.7	78
L.Choptank R	Open	107	6	6.1	195
Manokin R.	Sanc.	286	60	177.5[b]	80
Mid-Tangier S.	Open	148	58	64.7[b]	175
St. Marys R.	Sanc.	828	932	241.8	42
St. Marys R.	Open	196	251	24.6	124

[a] Not including Royston bar.

[b] Average of two Key Bars.

The number of adult (small and market) oysters per 100 ft tow in the priority sanctuaries was consistently higher than in adjacent harvest areas, averaging over twice as many adult oysters in

the sanctuaries as their respective open areas, except for Broad Creek. Historically one of the highest oyster producing regions in Maryland (Table 6), Broad Creek had the greatest average number of adult oysters of any area in this comparison (Table S-1), thanks to the extraordinary spatset in 2020.

Twenty oyster disease samples from both Disease Bars and supplemental stations were obtained from 19 priority and non-priority sanctuaries. The average dermo disease levels in these sanctuaries rose sharply this past year since the record lows in 2019 (average prevalences of 71.9% in 2022 vs. 49.2% in 2021 and 36.1% in 2019; mean intensities of 2.1 in 2022 vs. 1.7 in 2021 and 1.3 in 2019). Of the 13 sentinel Disease Bars within oyster sanctuaries, eight bars had dermo disease prevalences and five of those had intensities above their 33-year site averages (Table 3). Dermo disease levels in the comparison harvest areas also rose substantially, averaging 55.9% prevalence, up from 32.8% in 2021, and 1.6 mean intensity, a gain from 1.1 in 2021 (Table S-2). The higher dermo disease levels in the sanctuaries can be attributed to the fact that they had a greater proportion of larger, older oysters than the harvest bars (Figure 18); parasite burdens tend to build up as oysters age (Ford & Tripp 1996). MSX disease was detected at two of the supplemental disease sites within sanctuaries (NW Middleground and Piney Island East Addition 1) but not in the priority sanctuaries, as well as eight Disease Bars in open harvest areas, including two bars in this comparison (Back Cove and Piney Island East) (Table 4).

Table S-2. 2022 Dermo disease levels and observed mortality estimates for disease bars and regional averages on priority restoration sanctuaries and nearby harvest areas. In these comparisons, MSX disease was only detected at Piney Island East and Back Cove, with 17% and 13% prevalences, respectively. Dermo disease and mortality averages for combined Disease Bars and Supplemental sites both within and outside sanctuaries are also presented. Regional mortality averages include bars with 40 or more oysters.

Region	Disease Bar	Status	Dermo		Observed Mortality %	
			Prev.%	Int.	Disease Bar	Regional
Harris Cr.	Mill Pt./Rabbit I.[a]	Sanc.	90/97	2.5/2.4	4.3/5.1	4.6
Harris Cr.	Tilghman Wharf	Open	40	0.9	1.3	1.3
Tred Avon R.	Double Mills	Sanc.	97	3.0	13.2	11.4
Mid-Choptank R	Lighthouse	Open	3	0.0	0.0	2.8
Broad Cr.	Deep Neck	Open	93	2.7	6.4	4.2
L. Choptank R.	Cason	Sanc.	90	2.6	1.7	6.1
L. Choptank R.	Ragged Pt.	Open	97	2.6	8.1	6.4
Manokin R.	Georges	Sanc.	90	4.0	25.5	12.6
Mid-Tangier S.	Piney Is E/Back Cove	Open	53/93	1.7/4.1	6.2/22.3	10.1
St. Marys R.	Pagan	Sanc.	50	1.6	6.9	6.9
St. Marys R.	Chicken Cock	Open	57	1.4	2.6	4.0
Average of all Sanctuary Disease Samples[b]			71.9	2.1	8.1	
Average of all Harvest Disease Samples[b]			55.9	1.6	6.5	

[a] Supplemental bars and not part of the Disease Index set. [b] Including both Disease Bars and Supplemental sites.

The higher dermo disease levels in the sanctuaries did not appear to contribute to elevated observed mortalities. Eleven Mortality Index bars within sanctuaries had observed mortalities below their respective 38-year individual bar averages (Table 5). Holland Point and Old Field were not included in this evaluation as they had fewer than 40 oysters (e.g., Holland Point had one live and one dead oyster), which could skew the averages. For the Mortality Index bars, observed mortalities averaged slightly higher in sanctuary bars than their proximal open harvest bars) (Table S-2). Although rising somewhat from the previous year, the regional averages of

observed mortalities associated with the five priority sanctuaries and adjacent harvest areas remained low. The average regional mortality in the restoration sanctuaries rose from 5.8% in 2021 to 8.1% in 2022, while in the corresponding harvest areas the average mortality went from 4.0% to 6.5%.

Of the 43 Biomass Index bars, 13 bars are within sanctuaries (Table 8). Recent trends in biomass, as measured in grams/bushel (g/bu), have been positive both in sanctuaries and harvest areas, with the results from 2021 exceeding their long-term averages by 67% and 118% respectively. In the open harvest areas, the average biomass per index bar in 2022 declined somewhat from the previous year, from 232.1 g/bu to 192.6 g/bu. In contrast, the average biomass in the sanctuaries remained essentially unchanged, from 214.1 g/bu in 2021 to 217.4 g/bu in 2022.

The distributions of oyster biomass between the two management areas were distinctly different. The Biomass Index bars in the sanctuaries had higher biomass in the larger size classes, while the open areas had greater biomass in the sublegal and smaller market size classes (Figure 18). The average biomass of sublegal oysters increased to 52.0 g/bu (+21.2%) in the sanctuaries, but fell to 57.2 g/bu (-26.3%) in the harvest areas as the 2020 cohort started to attain market size. While the average market oyster biomass in the sanctuaries declined slightly to 165.43 g/bu (-3.4%), it remained higher than the open harvest areas, which showed a greater loss to 135.4 g/bu (-14.0%). Thus the overall 12% decline in the 2022 Biomass Index (Figure 13) was likely attributable to the substantial increase in harvests.

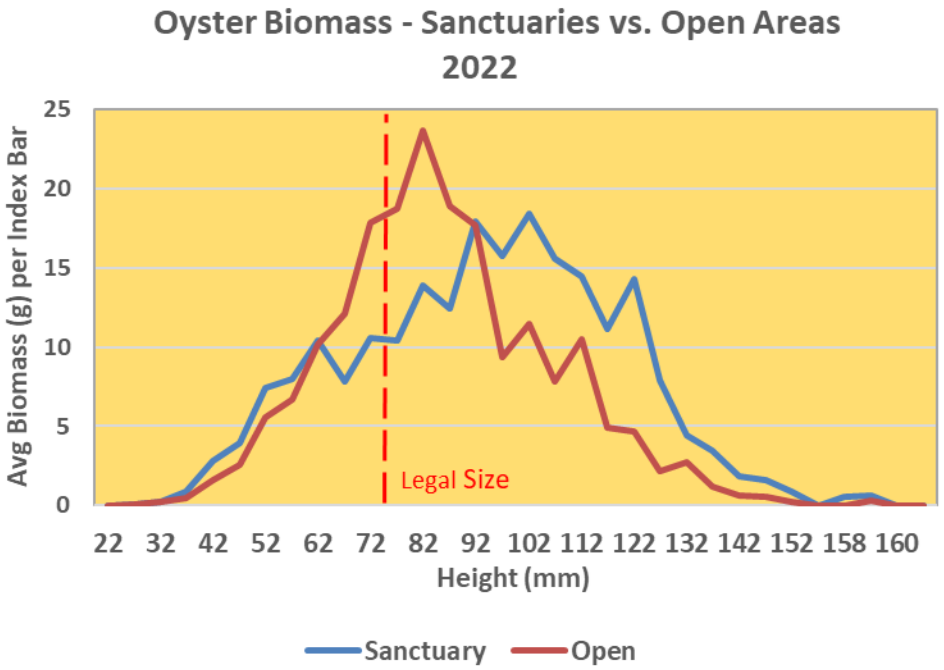

Figure 18. Average oyster biomass by 5 mm size classes on Biomass Index bars in harvest areas and sanctuaries. Dashed line indicates minimum legal harvest size.

A different picture emerges when comparing the Biomass Index bars in the large-scale restoration sanctuaries with their corresponding adjacent open areas. The average biomass standardized to a 100 ft tow distance for these five sanctuary bars was 626.2 g/bu, compared to the average biomass/100 ft tow on the seven Biomass Index bars in adjacent open areas of 271.9

g/bu. Aside from Deep Neck bar in Broad Creek, the biomass on the sanctuary Index bars was substantially higher than their respective open area Index bars (Figure 19). This was a function of higher oyster densities in the sanctuaries as reflected by the shorter average tow distance (56.6 ft for the five sanctuary bars versus 214.6 ft for the seven open area bars). The dominant size classes of the sanctuary oysters were generally smaller with a modal height of 52 mm, whereas the modal height in the adjacent open areas was 72 mm (Figure 20).

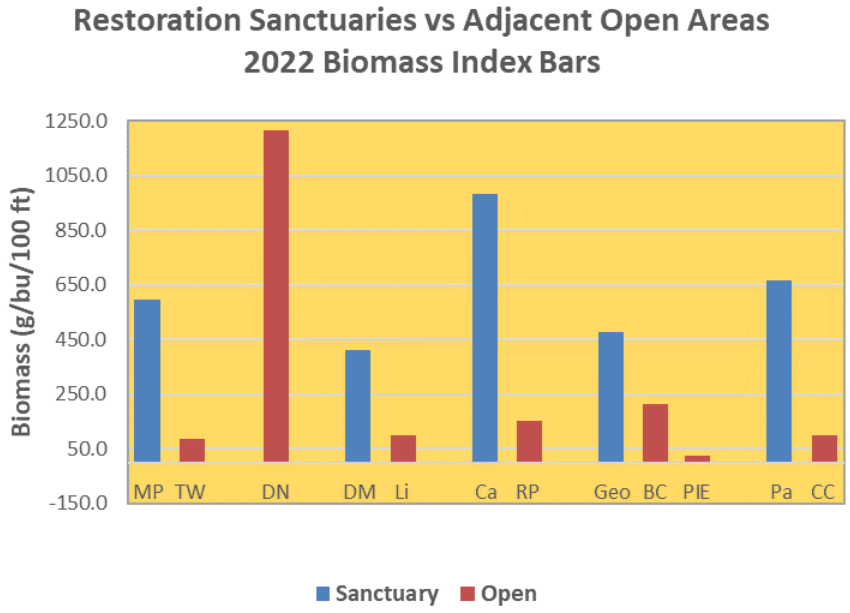

Figure 19. Comparison of biomass/100 ft tow between Biomass Index bars in the large-scale restoration sanctuaries and adjacent open areas. See Table S-2 for the locations of these bars. *MP=Mill Point (not a Biomass Index bar), TW=Tilghman Wharf, DN=Deep Neck, DM=Double Mills, Li=Lighthouse, Ca=Cason, RP=Ragged Point, Geo=Georges, BC =Back Cove, PIE=Piney Island East, Pa=Pagan, CC=Chicken Cock.*

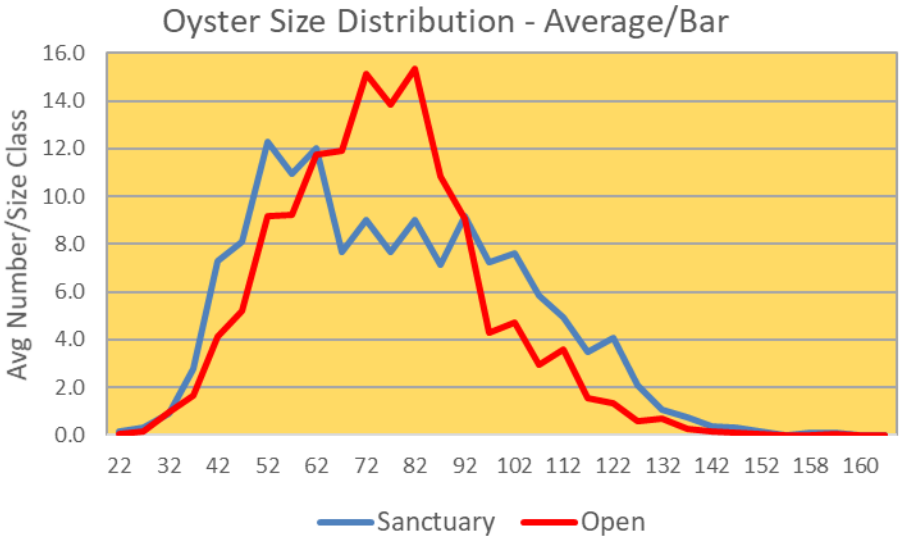

Figure 20. Size-frequency distributions of oysters in the sanctuaries and open harvest bars in 2022. Note the 52 mm mode in the sanctuaries representing the 2021 year class which accounts for the increase in biomass for sublegal oysters. The open area peak of 72 mm is due to the strong 2020 year class.

The average size of adult oysters (equal to or greater than one-year old) on the Biomass Index bars in the sanctuaries decreased substantially over the last two years (77.3 mm in 2022 vs. 81.5 mm in 2021 and 86.4 mm in 2020), while the harvest bars grew in average size (75.3 mm in 2022 vs. 72.4 mm in 2021). These changes were driven by the influx of small oysters from the strong recruitment events over the past three years - the earlier spatsets and subsequent growth in the harvest areas and more recently in the sanctuaries (Figure 20). There was little difference between the two management types in the proportion of sublegal oysters in each. Sublegal oysters comprised 51.2% of the adult oysters in the sanctuaries, up from 42.9% in 2021, and 52.0% in the open areas, a decrease from 56.1% in 2021.

Cultch, the substrate required for spatset, was at lower densities in the open harvest areas than the restoration sanctuaries, as indicated by the longer tow distances required to obtain a sample in the open areas (Table S-1). Again, Broad Creek was the exception when Royston bar was not included in the average, having the second shortest average tow distance of any region. This is reflected in the highest average cultch volume per sample, standardized to 100 ft. tows. Excluding Broad Creek, four of the five sanctuaries had greater cultch volumes compared to their immediately adjacent open areas (Figure 20). The exception was in the Tred Avon River, where cultch volumes were higher in the harvest area. Broad Creek had substantially more cultch than the other areas, again, boosted by the tremendous 2020 spatset; St. Marys Sanctuary was second. The lowest cultch volume was found in the Little Choptank harvest area, which was less than half of that in the sanctuary. Likewise, cultch volume in Harris Creek Sanctuary was double that of the harvest area in that creek.

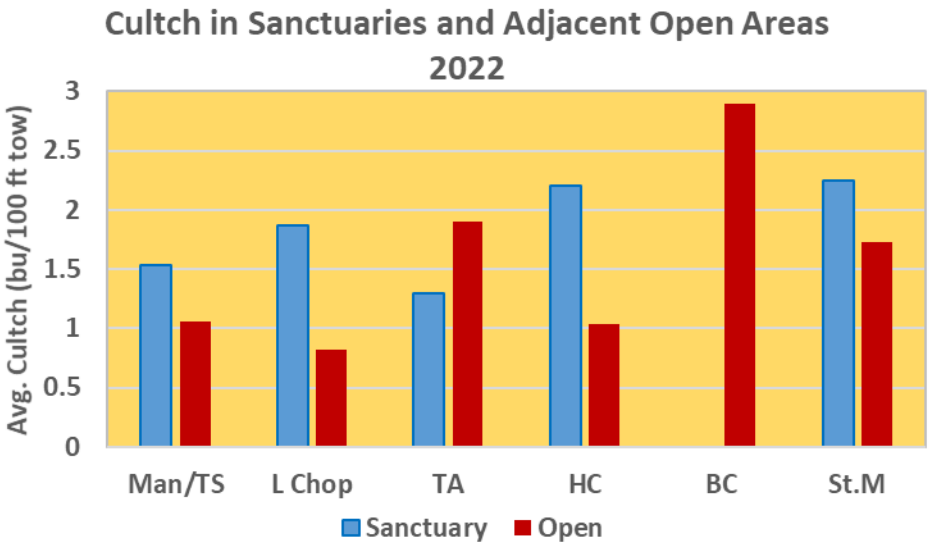

Figure 20. Comparison of cultch volumes between sanctuaries and adjacent open areas in 2022. All stations with sufficient data within an area were included in the averages, standardized to 100 ft. tow distances. *Man=Manokin River; TS=mid-Tangier Sound; L Chop=Little Choptank River; TA=Tred Avon River; HC=Harris Creek; BC=Broad Creek; St.M=St. Marys River*

DISCUSSION

Highest Landings in Thirty-Five Years

The highlight of the year was the final harvest figures for the 2021-22 oyster season. Landings jumped by almost 200,000 bu, or 58% from the previous year, exceeding the half-million bushel mark for the first time since the 1986-87 season, the span of a generation of watermen. The dockside value of $21.5 million was the highest on record (not accounting for inflation), and double the value of landings from the previous season.

Over 70% of the harvest came from the Tangier Sound region, which included Tangier Sound proper, Honga River, Fishing Bay, parts of the Nanticoke and Manokin rivers, and Pocomoke Sound. Upper Tangier Sound alone accounted for nearly 40% of the landings. Notably, the harvest from this region increased tenfold over a short period of time. In only four years, from the 2018-19 through the 2021-22 seasons, landings from the Tangier Sound region went from 39,735 bu to 394,884 bu, which was by far the largest increase of any region in Maryland. The statewide harvest tripled over this same time period.

This robust growth in landings was not entirely unexpected. The Biomass Index, which is compiled at the start of the harvest season, is generally correlated with subsequent landings in that season. Since the most recent nadir in 2017, the Biomass Index almost doubled to a record high in 2021. After including the 2021 Biomass Index, a regression model predicted the harvest for the upcoming season would be 547,490 bu, which was less than 2,000 bu above the final tally for the 2021-22 season (Figure 17a). The overall 12% decline in the 2022 Biomass Index was likely attributable to the substantial increase in harvest, since the Index bars in open harvest areas showed a biomass loss of 14% from the previous year.

The resiliency of Maryland's oyster populations over the last decade is discussed at length in Tarnowski (2023). In order for this trend in enhanced harvest to continue, two population requirements – good recruitment and low disease-related mortalities – must be balanced against appropriate removal rates. The slow initial rebound immediately following the record-high mortalities due to the millennial epizootics of 1999-2002 was marked by a period of lower disease levels but poor recruitment. From 2003 to 2005 the average spatfall was 6.1 spat/bu, a quarter of the long-term median, while through 2009 the average was still subpar at 14.1 spat/bu. This period of low spatsets coincided with years of below baseline Biomass Indexes, suggesting that recruitment was at least in part broodstock limited as a result of the devastating epizootics. The strong recruitment event in 2010 set in motion the buildup of the population that we see today, albeit still a long way from where it could be or has been in the past..

In contrast to the 2003-2009 time frame, the recent trend in increased harvests coincides with the growth of broodstock biomass in nearby priority sanctuaries and improved spatset. The Manokin Sanctuary is immediately east of upper Tangier Sound, where much of the recent higher recruitment and subsequent harvesting has taken place. Although not a priority restoration sanctuary, the Nanticoke Sanctuary on the upper end of Tangier Sound also has a considerable number of oysters, both on the natural oyster bars and on the numerous oyster aquaculture farms that may serve as a source of larvae. Landings in the Little Choptank River just outside of

another priority restoration sanctuary have grown from 222 bu in 2018-19 to 12,786 bu during the 2021-22 season. In the St. Marys River, the four sampled harvest bars closest to the sanctuary averaged over 400 spat/bu in 2022, possibly spillover from the sanctuary where the average spatset was more than double those counts. Although suggestive, a direct connection between broodstock sources in the sanctuaries and spatset in nearby fishing areas has yet to be confirmed.

While broodstock abundance is an important element in recruitment, there are several other factors as well. Cultch, the substrate on which larval oysters attach, is in short supply and diminishing in many areas. Even when cultch is present it may be compromised by silt or attached organisms. Environmental conditions, in particular salinity, are critical for successful recruitment. However, adequate salinity, although a necessary requirement, is not always sufficient to produce good spatsets, as there are certainly other factors, some that have yet to be determined. These topics have been discussed extensively in previous reports of this series (e.g., Tarnowski 2022, 2020, 2019, 2018, 2017, and earlier).

The Broad Creek Paradox

When analyzing the data for the section of this report comparing sanctuaries and adjacent public fishery areas, Broad Creek stood out as the exception to the general rule that the restoration sanctuary metrics were higher than in their corresponding harvest regions.

Deep Neck bar, a Key and Disease sentinel bar representative of Broad Creek, has the second-highest spatset average of the 53 bar suite that comprises the Spat Index over the 38-year time series. Historically, Deep Neck has consistently outperformed Key Bars in nearby tributaries, by nearly fourfold at Eagle Pt./Mill Pt. in Harris Creek and more than eight times higher than Double Mills in the Tred Avon River, even before they became sanctuaries. In recent years Deep Neck has experienced good to exceptional spatsets – seven of the last eight years exceeded the long-term median. The climax of this period was in 2020, when spatset was the second highest in the 81-year record at that bar, the 1,838 spat/bu was the highest count of any Index bar since 1997. Broad Creek overall averaged 1,032 spat/bu in 2020, with six of eleven bars having counts of over 1,000 spat/bu. In 2022, of all comparison areas, both sanctuaries and public harvest bars, Broad Creek bars had the highest average number of adult (small and market) oysters/100 ft dredge tow, a reflection of these spatsets.

Other metrics are also favorable in Broad Creek. Disease levels remain low, accompanied by single digit observed mortalities. MSX disease has been detected in only two of the past twenty years, the last time in 2015 with a meager 3% prevalence (one oyster). Deep Neck had the highest biomass standardized to a 100 ft tow of the sentinel bars in the comparison areas. Lastly, Broad Creek had the highest amount of cultch/100 ft tow. In this regard, Deep Neck had the shortest sampling tow distances of the entire survey, averaging 26 ft for 1.2 bu of material, an indication of abundant cultch. In comparison, the average tow distance for all surveyed bars was substantially longer - 139 ft for 1.3 bu.

Despite these positive indicators, one metric – landings – has remained flatlined for the past six seasons at about half of the harvests immediately prior to that. Harvests in these prior years received a boost from the strong 2010 and 2012 spatsets, increasing by over sixfold between the 2011-12 and 2012-13 seasons. Even with low disease-related mortalities, these greatly improved harvests lasted only four years before collapsing due to poor spatsets in 2011, 2013, and 2014,

which couldn't support that level of fishing activity. Landings have fallen by about 50% from their peak in 2013-14. Over this past decade, the contribution of Broad Creek to total Maryland landings dropped from 21.3% in 2013 to 6.9% in 2022.

Paradoxically, another reason for the reduced harvests in Broad Creek over the last three years was the extraordinary spatset in 2020. Anecdotally, market oysters were so covered in spat and subsequent sublegal oysters that culling or removing them was extremely difficult, slowing down harvesting or leading some watermen to avoid the tributary. In 2022, the average size of oysters at Deep Neck was 65.6 mm, or still 10 mm below the legal market size, with market oysters comprising only 26.8% of the total adult oysters; for all sampled Broad Creek bars, the fraction of market oysters was even lower at 21.0%. These proportions further increased the time and tedium of culling.

In comparison to the 2020/21 year classes, the 2010/11 cohorts of Broad Creek oysters appear to have grown faster. Over the same 2+ years length of time at Deep Neck, by 2012 the average size of adult oysters was 74.2 mm or almost legal size, and the proportion of markets was 47.8%, leading to the substantial increase in landings during the 2012-13 season. Note that these average sizes include two year classes. The apparent slower growth of the 2020 year class may be attributable to continued good recruitment in 2021, which may have skewed the average size downward by adding more small oysters to the population, although the proportion of the 2021 cohort was only 8.8% of the 2020 cohort. In contrast, 2011 was a very poor recruitment year, which would have little effect on the average size of the combined 2010/11 cohorts. Other possible reasons for the apparent slower growth could be overcrowding (the 2020 spatset was ten times as high as the 2010 set) - competing with neighbors for space and food, or perhaps some environmental condition. Nevertheless, although lagging behind their predecessors in time to legal size, landings from Broad Creek can be expected to increase considerably over the next few years as this large population attains market size, which will also make culling easier.

Intensifying Disease a Potential Threat

Although disease levels and observed mortalities have remained below the long-term average over the past five years, the increases in dermo and MSX seen this year may be cause for concern in 2023, depending on environmental conditions, especially salinity. With favorable salinities over the past two years, MSX has spread rapidly, from one oyster at each of two locations in 2020 to occurring throughout much of the waters of the lower Eastern Shore and establishing a toehold on the Western Shore.

Persistent elevated salinities over the next year or so may allow for an unintended and perhaps unwelcome experiment. MSX becomes lethal at salinities above about 15 ppt (Appendix 2). A prolonged period of higher salinities could test the hypothesis that the lower observed mortalities of the last two decades are the result of disease resistance/tolerance in oysters (Appendix 3).

A counter hypothesis is that oyster survival is due to favorable salinities, not genetic improvements. Interannual streamflow and salinity patterns differed markedly between the high disease-related mortality period (mortality averaging 31%) from 1987 to 2002 (Period 1) and 2003 to 2022 (Period 2), with less favorable conditions for disease during the latter years (mortality averaging 14%). There has not been an extended high-salinity period and associated epizootics since the four-year millennial drought (1999-2002), which decimated oyster

populations in Maryland. Streamflows have been much less volatile over the past two decades - the variance of below average flow years during Period 2 was only 57% of the variance in Period 1 - with elevated salinities in Period 2 lasting for shorter durations and at greater annual intervals. For example, at Ragged Point bar in the Little Choptank River, 62% of the years in Period 1 averaged more than 15 ppt during August through November, while only 21% of the years during Period 2 were above 15 ppt. The average length of time between years when the August-November salinity averaged more than 15 ppt in Period 1 was 1.6 years (and not more than two years), while for Period 2 it was 4.0 years (maximum six years). Does the shorter periodicity of low-flow years in Period 1 have any effect on the virulence of disease or susceptibility of oysters (weakened physiological state)? Perhaps the oysters in Period 1 didn't have enough time to recover from one bout of disease before the next assault.

Low flow years in Period 1 were also more acute. Five of 16 years (31%) had flows below 75% of the time-series mean, with an average of 69.4% of the mean (range 64% - 73% of the mean). In contrast, the 20 years of the post-epizootic period (Period 2) had only one year (5%) when flows were below 75% of the time-series mean (74% of the mean). Comparing all below-average flow years between the two periods, Period 1 had significantly lower flows (t-test, p=0.004).

A well-timed pulse of freshwater can mitigate the impacts of MSX. MSX had been creeping up in 2016, a dry year. Alerts were sent out to growers by VIMS in early 2017 anticipating a worsening condition, especially with March flows being well below average. But above average streamflows for the next few months reduced the impact of MSX. For example, in southern Tangier Sound the salinity dropped from 19.59 ppt in Feb. to 15.47 ppt in June.

MSX is easier to comprehend than dermo disease, given its known salinity thresholds and evidence of resistance in other regions such as in Virginia and Delaware Bay (Carnegie & Burreson 2011, Ford & Bushek 2012). In Maryland, MSX resistance may have developed at Sharkfin Shoal in Tangier Sound, as suggested by lower prevalences in Period 2 compared to Period 1 at salinities over 15 ppt. Observed mortalities on that bar were significantly lower in Period 2 (t-test, p=0.001).

While an argument for MSX resistance may be made down bay, it cannot be invoked baywide. If environmental conditions are not factors, MSX should occur further upbay in Period 2 as it did previously. But MSX has largely been confined to southern Maryland in Period 2, with brief flareups upbay when conditions permitted. Through natural selection, the level and frequency of disease-related mortality on a bar may determine whether disease resistance or tolerance develops. However, the low-salinity bars were either never exposed to MSX or were challenged at such low frequencies (and possibly low intensities) that natural selection could not come into play. These lower-salinity oysters likely remain susceptible to MSX disease.

Dermo disease is more of a conundrum. There are unresolved questions of salinity thresholds for mortality, the relationship between intensity and mortality, the effect of temperature on lethality, whether there was a hypervirulent strain in Period 1 (Carnegie et al. 2021) that has run its course, whether the duality of MSX and dermo infections increased the lethality, and the possible development of resistance/tolerance.

In the case of both diseases, their impact on past oyster populations was greatly intensified by an extended period of elevated salinities. Should such a prolonged period occur again, it would test

whether and to what extent disease resistance/tolerance has developed in the current populations. The outcome of this "experiment" with persistently elevated salinities could determine whether the recent trend in population growth can maintain its momentum.

Conclusion

Two decades after the devastation from the last of the great epizootics, the oyster population in Maryland remains a long way from its pre-disease status of the early 1980s. Even with reduced disease pressure, recovery has been slow and uneven, and some recruitment-poor areas may never return to historical levels. But the positive trends in population indicators that began 12 years ago and have substantially improved over the past three years offer encouragement that a corner has been turned. Three years is a relatively short period of time for predicting trends, and it remains to be seen whether the oyster population continues to grow. Nevertheless, the past dozen or so years has seen a net gain for oysters in Maryland, especially when compared with the devastated post-epizootics populations of the previous decade. Seven of the last 13 years had spat indexes well above the long-term median, five to seven years (depending on the metric) during this period had the lowest disease levels of the 32-year time series, the average observed mortality for this period was lower than any but one year[2] of the 25 mortality index years prior to 2010, and the seven highest annual biomass indexes of the 30-year time series occurred during this decade – all leading to the highest harvest total in 35 years. Whether these trends will continue remains to be seen. But barring the resurgence of disease or some yet unknown threat, there is every reason to believe that oysters can continue to flourish in Maryland.

[2] 1985 – the last pre-epizootics year

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TABLES

Table 1. Listing of data recorded during the Annual Fall Dredge Survey.

Physical Parameters

-Latitude and longitude (deg., min., decmin.)

-Depth (ft.)

-Temperature (°C; surface at all stations, 1 ft. above bottom at Key & Disease Bars)

-Salinity (ppt; surface at all stations, 1 ft. above bottom at Key & Disease Bars)

-Tow distance (ft.) (2005-present)

Biological Parameters

-Total volume of material in dredge (Md. bu.) (2005-present)

-Counts of live and dead oysters by age/size classes (spat, smalls, markets) per Md. bushel of material

-Stage of oyster boxes (recent, old)

-Observed (estimated) average and range of shell heights of live and dead oysters by age/size classes (mm)

-Shell heights of oysters grouped into 5-mm intervals (Disease Bars, 1990-2009) or 1-mm intervals (Disease Bars and other locations totaling about 30% of all surveyed bars, 2010-present)

-Oyster condition index and meat quality

-Type and relative index of fouling and other associated organisms

-Type of sample and year of activity (e.g. 1997 seed planting, natural oyster bar, 1990 fresh shell planting, etc.)

The time series for the Spat Intensity, Diseases, and Mortality Indices are presented in Tables 2 - 5. The majority of Fall Survey data, including supplemental disease results, are contained in digital files. Fouling and oyster condition data are mostly in paper files.

(Return to Text)

Table 2. Spatfall intensity (spat per bushel of cultch) from the 53 "Key" spat monitoring bars, 1985-2022. (S) = bar within an oyster sanctuary since 2010.

Region	Oyster Bar	Spatfall Intensity (Number per Bushel)					
		1985	1986	1987	1988	1989	1990
Upper Bay	Mountain Point	6	0	0	0	0	0
	Swan Point	4	0	2	2	0	0
Middle Bay	Brick House	78	0	4	8	0	3
	Hackett Point	0	4	0	0	0	0
	Tolly Point	2	2	2	0	0	0
	Three Sisters	10	2	8	0	0	0
	Holland Point (S)	6	5	0	0	0	0
	Stone Rock	136	20	0	50	22	37
	Flag Pond (S)	52	144	128	0	0	4
Lower Bay	Hog Island	116	32	58	29	4	7
	Butler	nd	197	142	16	2	24
Chester River	Buoy Rock	16	0	6	0	0	1
Eastern Bay	Parsons Island	78	4	4	2	0	7
	Wild Ground	46	8	4	8	0	18
	Hollicutt Noose	24	8	12	6	0	2
Wye River	Bruffs Island (S)	82	0	0	2	0	2
Miles River	Ash Craft	10	2	0	10	0	2
	Turtle Back	382	40	12	52	6	11
Poplar I. Narrows	Shell Hill	50	6	0	6	0	48
Choptank River	Sandy Hill (S)	74	16	2	0	0	28
	Royston	440	8	8	0	0	57
	Cook Point (S)	66	82	4	28	0	17
Harris Creek	Eagle Pt./Mill Pt. (S)	258	92	2	6	6	18
	Tilghman Wharf	156	28	38	4	4	109
Broad Creek	Deep Neck	566	114	6	22	4	48
Tred Avon River	Double Mills (S)	332	24	2	0	0	1
Little Choptank R.	Ragged Point	134	82	34	112	0	65
	Cason (S)	102	24	46	50	0	143
Honga River	Windmill	34	112	28	22	16	155
	Norman Addition	56	214	38	17	34	82
Fishing Bay	Goose Creek	34	97	16	18	4	4
	Clay Island	4	78	14	48	18	19
Nanticoke River	Wetipquin (S)	34	10	0	0	0	3
	Middleground	8	12	26	9	16	40
	Evans	18	10	12	17	2	13
Wicomico River	Mt. Vernon Wharf	nd	0	0	0	0	0
Manokin River	Georges (S)	26	98	14	4	16	4
	Drum Point (S)	48	186	48	90	78	16
Tangier Sound	Sharkfin Shoal	18	44	22	24	2	16
	Turtle Egg Island	154	90	12	26	26	204
	Piney Island East	182	192	194	160	82	64
	Great Rock	2	6	4	6	10	66
Pocomoke Sound	Gunby	124	24	50	4	8	21
	Marumsco	26	50	18	5	12	6
Patuxent River	Broome Island	15	0	0	0	0	3
	Back of Island	42	0	8	4	4	15
St. Mary's River	Chicken Cock	620	298	96	62	18	29
	Pagan (S)	140	34	52	36	6	613
Breton Bay	Black Walnut (S)	16	12	0	0	0	1
	Blue Sow (S)	55	40	0	0	0	1
St. Clement Bay	Dukehart Channel	20	7	0	0	0	1
Potomac River	Ragged Point	69	35	4	0	0	2
	Cornfield Harbor	383	908	362	28	14	36
	Spat Index	**103.8**	**66.1**	**29.1**	**18.7**	**7.8**	**39.0**
	Median	**50**	**24**	**8**	**6**	**0**	**13**

Table 2 - Spat (continued).

Oyster Bar	Spatfall Intensity (Number per Bushel)							
	1991	1992	1993	1994	1995	1996	1997	1998
Mountain Point	0	0	3	0	0	0	1	0
Swan Point	1	0	3	0	0	0	0	0
Brick House	0	0	0	0	5	0	0	0
Hackett Point	0	0	0	0	0	0	0	0
Tolly Point	0	0	0	0	0	0	0	0
Three Sisters	0	0	0	0	0	0	0	0
Holland Point (S)	0	0	0	0	0	0	0	0
Stone Rock	355	9	4	4	16	0	18	0
Flag Pond (S)	330	0	8	0	10	0	7	0
Hog Island	169	0	0	0	17	0	5	2
Butler	617	3	2	1	7	1	8	0
Buoy Rock	0	0	0	0	6	0	8	0
Parsons Island	127	18	2	0	44	0	3375	3
Wild Ground	205	8	2	0	54	0	990	0
Hollicutt Noose	11	1	0	0	7	0	56	0
Bruffs Island (S)	12	8	0	0	15	0	741	4
Ash Craft	12	0	0	0	60	1	2248	0
Turtle Back	168	15	0	0	194	0	3368	5
Shell Hill	79	0	0	0	15	0	19	1
Sandy Hill (S)	179	2	0	0	4	0	55	0
Royston	595	20	10	0	10	0	289	0
Cook Point (S)	171	1	0	2	14	0	20	0
Eagle Pt./Mill Pt. (S)	387	4	15	0	62	0	168	2
Tilghman Wharf	719	10	59	4	64	0	472	0
Deep Neck	468	22	94	12	294	3	788	1
Double Mills (S)	129	0	13	0	15	0	40	0
Ragged Point	1036	53	9	1	25	0	106	0
Cason (S)	1839	43	37	28	48	5	228	4
Windmill	740	46	22	19	13	2	5	1
Norman Addition	1159	53	33	17	25	0	8	0
Goose Creek	153	41	43	27	3	0	5	0
Clay Island	256	46	58	31	11	1	20	2
Wetipquin (S)	3	6	1	4	1	0	0	10
Middleground	107	63	14	28	2	6	27	0
Evans	20	27	6	30	3	1	5	0
Mt. Vernon Wharf	15	0	18	0	3	0	0	1
Georges (S)	52	42	19	9	5	0	8	6
Drum Point (S)	140	185	45	13	14	10	16	11
Sharkfin Shoal	43	97	18	11	6	0	7	0
Turtle Egg Island	289	591	37	31	6	35	70	3
Piney Island East	429	329	22	25	23	25	45	16
Great Rock	208	44	27	11	3	7	0	1
Gunby	302	149	68	7	5	9	0	24
Marumsco	142	34	60	5	6	0	0	57
Broome Island	8	0	0	0	58	0	0	1
Back of Island	49	5	0	1	17	0	3	0
Chicken Cock	182	5	45	4	78	2	36	10
Pagan (S)	190	62	15	7	54	0	1390	6
Black Walnut (S)	6	0	1	0	1	0	2	0
Blue Sow (S)	22	0	1	0	7	0	0	0
Dukehart Channel	19	0	3	0	0	0	0	0
Ragged Point	26	0	2	0	19	0	2	0
Cornfield Harbor	212	2	29	0	49	0	4	11
Spat Index	**233.6**	**38.6**	**16.0**	**6.3**	**26.8**	**2.0**	**276.7**	**3.5**
Median	**140**	**5**	**4**	**0**	**10**	**0**	**8**	**0**

Table 2 - Spat (continued).

Oyster Bar	Spatfall Intensity (Number per Bushel)							
	1999	2000	2001	2002	2003	2004	2005	2006
Mountain Point	0	0	0	1	0	0	0	0
Swan Point	0	0	0	0	0	0	0	0
Brick House	1	1	3	97	0	0	0	0
Hackett Point	0	1	0	13	0	0	0	0
Tolly Point	2	2	1	10	0	0	0	0
Three Sisters	0	0	1	0	0	0	0	0
Holland Point (S)	0	0	1	4	0	0	0	0
Stone Rock	3	34	2	17	1	0	0	3
Flag Pond (S)	1	5	5	7	0	0	0	4
Hog Island	6	1	28	10	5	1	6	1
Butler	6	1	27	33	3	0	3	7
Buoy Rock	0	0	2	1	1	1	0	0
Parsons Island	6	6	6	5	2	0	3	0
Wild Ground	2	5	5	6	4	0	1	0
Hollicutt Noose	6	2	1	15	3	0	0	0
Bruffs Island (S)	5	9	6	0	4	0	0	0
Ash Craft	14	2	10	0	8	0	0	0
Turtle Back	13	4	45	9	72	1	5	0
Shell Hill	4	4	0	0	0	0	0	0
Sandy Hill (S)	4	0	1	1	0	2	0	5
Royston	39	0	3	10	0	14	0	44
Cook Point (S)	1	5	5	3	1	4	0	9
Eagle Pt./Mill Pt. (S)	16	0	5	4	1	12	0	19
Tilghman Wharf	49	1	1	4	0	15	0	22
Deep Neck	211	3	11	31	1	167	0	30
Double Mills (S)	1	0	0	0	0	3	0	3
Ragged Point	43	3	5	0	1	2	0	6
Cason (S)	53	5	2	9	1	5	1	93
Windmill	37	0	21	9	0	0	0	21
Norman Addition	31	1	30	33	2	0	6	80
Goose Creek	0	0	0	1	0	0	0	73
Clay Island	5	4	8	16	0	0	0	139
Wetipquin (S)	0	0	0	3	1	0	0	6
Middleground	9	1	0	14	0	0	1	54
Evans	1	0	0	12	0	1	0	13
Mt. Vernon Wharf	0	0	0	0	0	0	0	0
Georges (S)	50	6	1	280	15	4	5	75
Drum Point (S)	157	27	44	124	13	8	40	202
Sharkfin Shoal	9	5	0	57	0	2	4	63
Turtle Egg Island	180	33	33	207	25	7	90	181
Piney Island East	118	28	167	127	1	27	116	420
Great Rock	82	6	140	1	3	19	28	92
Gunby	54	32	6	108	0	29	24	36
Marumsco	27	27	4	89	0	14	11	22
Broome Island	7	0	1	15	1	0	3	4
Back of Island	22	9	44	27	11	0	0	1
Chicken Cock	132	16	12	151	56	2	2	6
Pagan (S)	95	42	117	535	9	6	10	125
Black Walnut (S)	3	0	1	2	0	0	0	0
Blue Sow (S)	11	0	2	4	1	0	0	0
Dukehart Channel	1	0	0	1	0	0	0	1
Ragged Point	1	1	0	1	0	0	0	1
Cornfield Harbor	25	5	35	31	9	0	8	6
Spat Index	**29.1**	**6.4**	**15.9**	**40.3**	**4.8**	**6.5**	**6.9**	**35.2**
Median	**6**	**2**	**3**	**9**	**1**	**0**	**0**	**5**

Table 2 - Spat (continued).

Oyster Bar	Spatfall Intensity (Number per Bushel)							
	2007	2008	2009	2010	2011	2012	2013	2014
Mountain Point	0	0	0	0	0	0	0	0
Swan Point	0	0	0	0	0	1	0	0
Brick House	0	0	6	4	1	7	0	0
Hackett Point	0	0	0	5	0	0	0	1
Tolly Point	0	0	0	2	0	1	0	0
Three Sisters	0	0	0	3	0	0	0	0
Holland Point (S)	0	0	0	1	0	0	0	0
Stone Rock	0	1	4	22	1	46	2	1
Flag Pond (S)	0	0	0	15	4	8	2	6
Hog Island	1	1	4	4	8	42	11	3
Butler	1	8	1	15	3	7	0	14
Buoy Rock	0	0	0	3	0	1	0	0
Parsons Island	0	0	8	2	0	13	0	1
Wild Ground	0	1	1	3	0	7	0	2
Hollicutt Noose	0	0	0	5	0	8	0	0
Bruffs Island (S)	0	0	0	3	0	18	0	0
Ash Craft	0	0	2	39	0	1	3	0
Turtle Back	0	0	13	13	0	16	1	1
Shell Hill	0	0	0	1	0	4	0	0
Sandy Hill (S)	3	1	5	5	0	6	1	1
Royston	2	5	20	27	0	46	9	19
Cook Point (S)	1	10	18	37	2	41	6	1
Eagle Pt./Mill Pt. (S)	0	2	17	44	0	29	4	1
Tilghman Wharf	0	6	15	72	0	183	20	46
Deep Neck	1	23	100	144	1	331	14	9
Double Mills (S)	1	3	11	4	0	5	2	1
Ragged Point	0	2	12	33	0	14	5	2
Cason (S)	0	13	9	50	0	65	14	4
Windmill	4	79	7	85	12	88	114	19
Norman Addition	0	102	6	155	27	138	145	38
Goose Creek	0	35	20	75	83	98	128	8
Clay Island	1	94	29	342	26	103	56	6
Wetipquin (S)	0	2	2	8	4	8	5	22
Middleground	0	21	6	92	23	78	59	7
Evans	0	14	9	27	10	98	3	1
Mt. Vernon Wharf	0	0	8	2	4	16	0	9
Georges (S)	5	28	22	753	243	133	117	35
Drum Point (S)	56	124	34	524	248	219	92	58
Sharkfin Shoal	1	16	14	169	23	65	46	24
Turtle Egg Island	7	32	17	202	23	153	47	24
Piney Island East	44	23	0	160	109	199	6	14
Great Rock	64	38	5	12	5	111	0	2
Gunby	4	5	24	317	25	251	20	43
Marumsco	14	12	24	261	44	81	43	19
Broome Island	0	3	5	52	2	8	4	2
Back of Island	2	7	8	47	7	70	6	3
Chicken Cock	9	1	16	37	11	27	15	38
Pagan (S)	616	0	321	227	110	325	196	64
Black Walnut (S)	0	0	0	1	0	0	0	0
Blue Sow (S)	0	0	3	0	0	0	0	0
Dukehart Channel	0	0	1	0	0	1	0	0
Ragged Point	2	1	2	0	1	0	0	2
Cornfield Harbor	7	1	1	28	3	7	7	46
Spat Index	**15.9**	**13.5**	**15.7**	**78.0**	**20.1**	**59.9**	**22.7**	**11.3**
Median	**0**	**1**	**6**	**22**	**1**	**16**	**3**	**2**

Table 2 - Spat (continued).

Oyster Bar	Spatfall Intensity (Number per Bushel)								
	2015	2016	2017	2018	2019	2020	2021	2022	*38-Yr Avg*
Mountain Point	0	0	0	0	0	0	0	0	*0.3*
Swan Point	0	0	0	0	0	0	0	0	*0.3*
Brick House	0	0	0	0	0	0	1	0	*5.8*
Hackett Point	0	0	0	0	0	0	0	0	*0.6*
Tolly Point	0	2	0	0	1	0	0	0	*0.7*
Three Sisters	0	0	0	0	1	0	1	0	*0.7*
Holland Point (S)	0	0	0	0	0	1	0	0	*0.5*
Stone Rock	2	17	0	4	6	7	1	0	*22.2*
Flag Pond (S)	10	12	28	0	2	0	0	0	*20.8*
Hog Island	9	22	1	0	19	8	14	7	*17.1*
Butler	68	90	2	1	42	34	65	28	*40.0*
Buoy Rock	0	0	0	0	0	0	0	0	*1.2*
Parsons Island	8	0	0	0	2	0	13	5	*98.5*
Wild Ground	15	0	0	0	1	2	9	2	*37.1*
Hollicutt Noose	1	0	0	0	0	2	7	4	*4.8*
Bruffs Island (S)	0	0	0	0	0	0	28	10	*25.0*
Ash Craft	0	0	0	0	0	1	14	0	*64.2*
Turtle Back	13	4	0	0	0	5	42	7	*118.9*
Shell Hill	4	2	1	5	2	0	7	9	*7.0*
Sandy Hill (S)	0	3	1	0	2	5	18	13	*11.5*
Royston	21	13	23	22	0	231	96	17	*55.2*
Cook Point (S)	1	21	2	4	7	68	28	10	*18.2*
Eagle Pt./Mill Pt. (S	34	68	55	28	0	187	51	7	*42.2*
Tilghman Wharf	45	58	13	40	5	247	134	22	*70.1*
Deep Neck	83	91	205	119	17	1838	162	75	*160.8*
Double Mills (S)	9	12	3	1	1	74	21	5	*18.8*
Ragged Point	19	125	35	2	1	18	6	0	*52.4*
Cason (S)	11	60	67	9	4	613	62	24	*99.2*
Windmill	16	9	9	4	12	62	66	8	*49.9*
Norman Addition	34	60	44	13	24	227	170	38	*82.6*
Goose Creek	11	44	27	23	18	448	44	65	*43.3*
Clay Island	43	68	41	43	14	43	35	79	*47.4*
Wetipquin (S)	2	6	0	21	33	15	13	17	*6.3*
Middleground	12	32	66	49	138	100	41	14	*30.9*
Evans	14	18	1	7	37	52	66	19	*14.9*
Mt. Vernon Wharf	1	3	1	10	7	42	4	11	*4.2*
Georges (S)	29	61	137	40	78	185	20	14	*69.4*
Drum Point (S)	59	172	78	110	160	445	61	58	*105.6*
Sharkfin Shoal	57	53	32	23	14	17	21	16	*27.3*
Turtle Egg Island	64	57	15	69	88	122	66	47	*88.5*
Piney Island East	3	0	2	0	68	196	103	95	*100.4*
Great Rock	13	4	14	93	151	258	44	288	*49.2*
Gunby	95	73	34	25	46	18	54	47	*57.0*
Marumsco	141	69	31	8	61	53	29	48	*40.9*
Broome Island	6	21	6	1	12	1	73	2	*8.3*
Back of Island	18	42	5	5	13	7	18	5	*13.8*
Chicken Cock	712	33	19	5	10	37	111	23	*78.1*
Pagan (S)	24	91	247	7	15	53	426	478	*178.1*
Black Walnut (S)	3	4	0	0	0	0	0	1	*1.4*
Blue Sow (S)	0	10	0	0	0	1	1	1	*4.2*
Dukehart Channel	0	3	0	0	0	0	0	2	*1.6*
Ragged Point	1	11	2	2	0	4	9	10	*5.5*
Cornfield Harbor	100	92	6	6	108	55	70	68	*72.6*
Spat Index	**34.2**	**30.9**	**23.6**	**15.0**	**23.0**	**109.1**	**43.9**	**32.1**	***41.1***
Median	**10**	**12**	**2**	**2**	**5**	**17**	**21**	**10**	***23.3***

(Return to Text)

Table 3. *Perkinsus marinus* prevalence and mean intensity (scale of 0-7) in oysters from the 43 disease monitoring bars, 1990-2022. NA = insufficient quantity of oysters for analytical sample. (S) = bar within an oyster sanctuary since 2010.

Region	Oyster Bar	***Perkinsus marinus* Prevalence (%) and Mean Intensity (I)**									
		1990		1991		1992		1993		1994	
		%	I	%	I	%	I	%	I	%	I
Upper Bay	Swan Point	7	0.1	27	0.7	23	0.4	37	0.8	3	0.1
Middle Bay	Hackett Point	0	0.0	27	0.8	57	1.2	97	3.2	23	0.5
	Holland Point (S)	20	0.5	47	1.1	80	2.4	93	3.0	36	1.1
	Stone Rock	47	0.5	27	0.9	100	4.4	100	3.5	90	2.5
	Flag Pond (S)	30	0.8	97	2.6	97	5.7	88	2.7	30	0.8
Lower Bay	Hog Island	90	3.0	97	4.5	100	4.2	93	2.4	37	1.0
	Butler	100	4.0	100	4.0	81	2.4	97	3.3	80	2.1
Chester River	Buoy Rock	23	0.5	80	2.5	97	2.8	93	3.3	10	0.3
	Old Field (S)	17	0.2	20	0.5	37	0.9	83	2.4	20	0.6
Eastern Bay	Bugby	100	3.4	100	4.0	73	1.8	100	3.0	43	0.8
	Parsons Island	20	0.5	97	3.6	80	2.1	100	3.3	93	3.1
	Hollicutt Noose	30	0.3	73	2.0	82	2.1	97	2.7	70	1.7
Wye River	Bruffs Island (S)	83	2.8	83	2.8	93	3.0	83	2.6	63	1.3
Miles River	Turtle Back	100	3.8	100	3.3	77	1.6	100	3.3	60	1.2
	Long Point (S)	73	2.3	94	4.3	86	3.0	77	2.6	60	2.0
Choptank River	Cook Point (S)	17	0.2	23	0.3	87	3.7	97	4.2	90	3.0
	Royston	NA	NA	100	4.5	97	4.8	100	3.3	80	2.0
	Lighthouse	90	2.3	100	4.0	100	4.6	93	3.2	47	1.2
	Sandy Hill (S)	100	5.0	100	5.7	100	4.2	100	3.8	83	2.3
	Oyster Shell Pt. (S)	3	0.1	60	1.7	100	3.9	93	2.8	10	0.3
Harris Creek	Tilghman Wharf	100	3.2	97	3.0	100	3.4	100	3.2	63	1.9
Broad Creek	Deep Neck	100	4.9	100	5.6	100	3.7	100	3.8	67	2.3
Tred Avon River	Double Mills (S)	97	3.6	100	4.9	100	4.1	100	3.8	90	2.0
Little Choptank R.	Cason (S)	100	3.4	100	4.4	90	2.6	93	2.8	83	2.2
	Ragged Point	100	4.8	100	4.6	100	5.0	100	3.9	87	2.3
Honga River	Norman Addition	100	4.2	100	3.4	83	2.0	96	3.6	93	3.3
Fishing Bay	Goose Creek	60	1.8	100	3.1	100	3.6	87	2.1	53	1.1
Nanticoke River	Wilson Shoals (S)	93	2.9	100	2.8	90	2.5	83	1.6	40	0.9
Manokin River	Georges (S)	83	1.9	93	2.9	58	1.4	30	0.7	50	1.2
Holland Straits	Holland Straits	100	4.2	100	4.0	100	3.4	76	2.3	57	1.6
Tangier Sound	Sharkfin Shoal	23	0.3	60	1.2	97	2.8	93	2.2	63	1.4
	Back Cove	100	2.7	100	4.2	97	3.3	36	1.0	80	2.2
	Piney Island East	93	2.7	97	3.1	87	2.7	83	2.2	87	3.1
	Old Woman's Leg	57	1.1	100	4.5	100	4.0	82	2.0	73	2.1
Pocomoke Sound	Marumsco	97	3.5	93	3.3	60	1.3	87	2.5	72	1.6
Patuxent River	Broome Island	97	3.4	100	2.8	63	1.5	87	3.0	40	0.6
St. Mary's River	Chicken Cock	100	4.2	97	3.1	93	3.2	96	2.6	40	1.0
	Pagan (S)	93	3.3	97	2.3	100	3.0	93	2.1	10	0.3
Wicomico R. (west)	Lancaster	97	3.6	97	2.8	67	1.4	67	1.6	20	0.2
	Mills West	13	0.2	80	2.0	90	2.9	63	1.8	20	0.2
Potomac River	Cornfield Harbor	97	3.4	83	2.3	100	3.8	93	2.9	77	1.9
	Ragged Point	97	3.8	90	2.8	40	0.9	50	1.4	10	0.2
	Lower Cedar Point	40	0.7	10	0.3	23	0.6	7	0.1	7	0.1
Annual Means		**69**	**2.3**	**82**	**3.0**	**83**	**2.8**	**84**	**2.6**	**54**	**1.4**
Frequency of Positive Bars (%)		**98**		**100**		**100**		**100**		**100**	

Table 3 - Dermo (continued).

Oyster Bar	***Perkinsus marinus* Prevalence (%) and Mean Intensity (I)**											
	1995		1996		1997		1998		1999		2000	
	%	I	%	I	%	I	%	I	%	I	%	I
Swan Point	20	0.2	0	0.0	3	0.1	43	1.2	97	3.4	80	1.2
Hackett Point	90	2.5	30	0.7	43	1.3	43	1.1	97	3.3	97	3.7
Holland Point (S)	87	2.9	47	1.4	37	1.1	37	0.9	93	2.8	87	3.4
Stone Rock	87	2.2	93	2.7	90	2.3	100	3.5	100	4.0	93	3.6
Flag Pond (S)	87	3.3	63	2.0	53	1.2	73	2.3	NA	NA	NA	NA
Hog Island	93	2.7	43	1.2	47	1.3	97	3.2	93	5.5	83	3.9
Butler	87	2.5	60	1.6	57	1.0	97	3.3	93	3.2	83	2.7
Buoy Rock	67	1.7	13	0.4	7	0.7	33	0.9	93	3.0	97	3.5
Old Field (S)	83	2.3	0	0.0	10	0.2	33	0.8	97	3.0	93	3.0
Bugby	83	2.6	80	2.0	70	1.8	60	1.4	100	3.9	100	4.0
Parsons Island	70	2.1	73	2.8	63	1.4	80	2.5	100	4.7	100	3.5
Hollicutt Noose	90	2.8	60	1.4	50	1.0	83	2.5	90	3.0	100	4.1
Bruffs Island (S)	73	2.1	67	1.4	17	0.2	57	1.6	100	3.7	97	3.2
Turtle Back	100	2.8	83	2.1	83	1.8	50	1.6	100	4.3	97	3.1
Long Point (S)	67	2.2	20	0.4	23	0.6	100	2.7	100	3.6	97	3.3
Cook Point (S)	NA	NA	60	1.5	70	2.4	87	2.8	93	3.4	40	1.2
Royston	63	2.0	50	1.1	67	1.5	90	2.5	97	3.5	97	4.7
Lighthouse	90	3.3	77	1.8	57	1.5	43	1.5	87	2.3	100	3.4
Sandy Hill (S)	89	3.4	30	0.7	60	1.3	40	1.0	97	3.4	87	3.6
Oyster Shell Pt. (S)	68	1.8	13	0.2	50	0.9	20	0.3	83	2.3	73	2.2
Tilghman Wharf	93	2.5	67	1.3	60	1.0	67	2.0	87	2.5	93	3.4
Deep Neck	97	3.0	83	2.1	100	2.6	97	2.9	97	4.5	100	4.0
Double Mills (S)	75	2.5	70	1.2	83	2.0	100	3.0	100	4.8	100	4.7
Cason (S)	93	2.3	87	1.9	93	2.4	50	1.4	97	3.8	100	3.6
Ragged Point	93	2.5	97	2.6	97	2.1	87	1.4	100	4.0	97	3.7
Norman Addition	87	2.8	93	2.4	73	1.6	73	2.3	93	3.5	80	3.4
Goose Creek	87	2.5	97	4.0	83	2.0	100	3.0	100	5.4	97	3.1
Wilson Shoals (S)	63	1.1	83	1.8	80	1.9	70	1.6	100	4.3	70	2.1
Georges (S)	87	2.8	93	2.0	93	2.2	83	2.4	93	3.5	80	2.3
Holland Straits	93	3.1	83	2.0	67	1.8	57	1.2	80	2.5	30	0.9
Sharkfin Shoal	90	3.0	97	2.1	93	2.6	80	2.7	100	4.3	80	2.3
Back Cove	83	3.0	97	3.2	93	2.9	90	2.3	100	5.5	40	1.2
Piney Island East	93	2.5	63	1.7	73	2.2	83	1.9	63	2.4	86	2.3
Old Woman's Leg	100	4.2	80	2.3	57	1.3	90	3.2	87	3.9	70	1.7
Marumsco	100	4.2	90	2.4	61	2.1	80	2.8	90	3.4	93	2.7
Broome Island	43	1.0	17	0.4	83	2.1	83	3.0	100	4.6	93	4.0
Chicken Cock	83	1.9	77	1.4	73	1.7	80	1.7	100	5.0	63	1.8
Pagan (S)	93	2.2	82	1.4	86	1.7	73	1.7	97	3.4	68	1.6
Lancaster	27	0.6	56	1.2	80	1.6	37	0.7	83	2.5	90	2.7
Mills West	57	1.4	60	1.2	60	1.2	20	0.4	90	3.2	97	3.6
Cornfield Harbor	93	2.5	87	2.0	83	1.8	83	2.0	97	3.9	80	2.1
Ragged Point	33	0.8	7	0.2	0	0.0	0	0.0	17	0.5	13	0.7
Lower Cedar Point	13	0.2	3	0.3	0	0.0	0	0.0	0	0.0	17	0.5
Annual Means	**78**	**2.3**	**61**	**1.5**	**62**	**1.5**	**67**	**1.9**	**90**	**3.5**	**81**	**2.9**
Bar Freq. (%)	**100**		**95**		**95**		**95**		**98**		**100**	

Table 3 - Dermo (continued).

Oyster Bar	***Perkinsus marinus* Prevalence (%) and Mean Intensity (I)**											
	2001		2002		2003		2004		2005		2006	
	%	I	%	I	%	I	%	I	%	I	%	I
Swan Point	93	3.3	97	2.7	33	1.0	33	0.7	47	1.2	20	0.6
Hackett Point	97	3.4	100	3.3	33	1.1	30	0.8	13	0.4	70	1.3
Holland Point (S)	93	3.2	100	3.6	33	1.1	30	0.6	53	1.6	10	0.4
Stone Rock	83	2.8	100	2.3	77	2.4	10	0.2	50	1.3	77	1.9
Flag Pond (S)	NA	NA	37	0.5	0	0.0	3	0.03	13	0.3	43	0.9
Hog Island	93	3.4	87	2.9	53	2.3	53	1.4	93	3.4	93	4.4
Butler	80	2.4	80	1.4	10	0.3	7	0.1	30	1.1	40	1.2
Buoy Rock	93	3.5	100	2.6	97	3.7	50	1.5	77	2.4	63	1.8
Old Field (S)	100	3.3	97	2.5	80	2.5	33	0.7	57	1.1	63	1.4
Bugby	100	4.6	97	3.1	97	3.4	63	1.7	53	1.8	87	2.7
Parsons Island	100	4.5	100	4.4	90	3.3	93	2.8	87	2.6	87	2.1
Hollicutt Noose	100	4.8	100	3.6	80	2.7	40	1.5	40	1.0	83	2.9
Bruffs Island (S)	100	3.8	100	3.6	73	1.8	80	2.5	73	1.8	53	1.6
Turtle Back	100	4.2	100	4.7	100	3.6	80	2.8	100	3.3	97	3.8
Long Point (S)	100	4.2	100	3.1	97	2.8	97	3.2	90	2.7	80	2.1
Cook Point (S)	77	2.2	NA	NA	66	2.1	0	0.0	13	0.3	40	0.5
Royston	100	5.2	100	4.2	48	1.8	13	0.3	3	0.2	47	0.9
Lighthouse	100	3.3	100	4.6	20	0.6	43	1.2	27	0.6	30	0.4
Sandy Hill (S)	100	4.5	100	5.0	93	3.5	87	3.3	80	2.5	70	2.3
Oyster Shell Pt. (S)	100	3.6	100	3.0	43	1.0	43	0.8	17	0.3	30	1.1
Tilghman Wharf	100	3.5	90	3.2	87	2.4	43	0.8	0	0.0	50	0.7
Deep Neck	97	4.8	100	3.2	97	3.7	27	0.5	20	0.4	50	1.1
Double Mills (S)	100	5.5	97	2.9	53	1.7	53	2.1	53	1.6	40	1.1
Cason (S)	100	4.3	94	4.4	17	0.4	3	0.03	33	0.5	23	0.4
Ragged Point	100	4.3	100	3.5	43	1.0	13	0.2	10	0.3	23	0.4
Norman Addition	90	3.0	67	1.9	37	1.3	93	3.3	90	3.8	57	2.0
Goose Creek	100	4.1	93	4.0	57	2.0	77	2.0	63	2.2	8	0.3
Wilson Shoals (S)	100	4.0	100	3.6	83	2.3	97	2.3	90	3.0	93	3.7
Georges (S)	100	5.2	100	4.0	83	2.6	100	4.2	90	3.3	97	3.8
Holland Straits	43	1.4	50	1.1	40	0.7	70	1.7	83	3.0	83	2.1
Sharkfin Shoal	90	3.7	97	3.6	47	3.4	100	4.4	87	3.2	83	3.4
Back Cove	100	5.0	97	3.8	100	4.6	97	3.7	100	3.1	77	2.5
Piney Island East	60	1.5	100	3.1	100	3.9	100	3.9	100	3.7	80	3.4
Old Woman's Leg	100	5.0	100	3.7	100	4.4	93	3.7	80	2.4	57	1.8
Marumsco	100	5.0	97	4.1	90	2.3	87	2.8	93	3.3	67	2.8
Broome Island	100	4.8	97	3.8	47	1.3	47	1.4	37	0.9	77	2.5
Chicken Cock	93	3.6	100	2.9	23	0.7	40	0.9	87	3.5	90	3.4
Pagan (S)	100	4.6	93	4.0	60	1.3	83	2.3	83	2.9	80	3.1
Lancaster	100	4.5	97	2.7	50	1.5	37	0.9	57	1.5	73	2.2
Mills West	100	4.8	93	3.1	60	1.6	57	1.5	50	1.3	87	2.6
Cornfield Harbor	80	2.9	97	1.7	27	0.7	30	0.5	80	2.6	100	3.3
Ragged Point	33	0.5	93	2.6	24	0.7	9	0.1	37	0.9	0	0.0
Lower Cedar Point	90	2.3	97	2.5	13	0.5	17	0.4	13	0.2	10	0.1
Annual Means	**93**	**3.8**	**94**	**3.2**	**60**	**2.0**	**53**	**1.6**	**57**	**1.8**	**60**	**1.9**
Bar Freq. (%)	**100**		**100**		**98**		**98**		**98**		**98**	

Table 3 - Dermo (continued).

Oyster Bar	***Perkinsus marinus* Prevalence (%) and Mean Intensity (I)**											
	2007		2008		2009		2010		2011		2012	
	%	I	%	I	%	I	%	I	%	I	%	I
Swan Point	17	0.4	20	0.6	23	0.4	3	0.1	7	0.1	3	0.03
Hackett Point	87	2.9	80	2.7	73	1.9	63	1.3	33	1.0	33	0.8
Holland Point (S)	33	0.6	23	0.8	33	0.8	13	0.4	17	0.4	0	0.0
Stone Rock	93	3.5	47	1.3	30	0.9	53	1.2	17	0.4	57	2.0
Flag Pond (S)	87	2.0	67	2.3	57	2.1	33	1.2	38	0.9	53	1.5
Hog Island	80	3.1	50	2.0	67	2.7	70	2.0	40	1.0	77	2.2
Butler	77	1.7	43	1.2	43	1.3	77	2.7	60	1.9	90	3.4
Buoy Rock	80	3.2	70	2.2	64	1.5	65	2.2	20	0.5	10	0.3
Old Field (S)	100	4.0	90	3.3	87	3.3	70	2.2	40	0.8	67	2.2
Bugby	100	3.9	93	2.9	100	3.8	67	2.0	27	0.6	73	2.3
Parsons Island	97	4.0	87	3.1	100	2.5	60	1.8	10	0.4	23	0.7
Hollicutt Noose	87	3.0	93	3.3	43	1.4	53	1.4	20	0.9	13	0.3
Bruffs Island (S)	100	3.8	93	3.0	83	2.6	73	1.6	47	1.1	33	0.9
Turtle Back	100	4.4	100	4.1	97	2.9	73	1.8	23	0.6	50	0.9
Long Point (S)	93	3.8	87	3.1	46	1.6	50	1.3	31	0.7	46	1.5
Cook Point (S)	17	0.3	13	0.4	7	0.1	43	1.0	40	1.0	93	3.2
Royston	23	0.7	17	0.4	27	0.7	3	0.1	13	0.4	27	0.8
Lighthouse	0	0.0	0	0.0	10	0.1	10	0.1	0	0.0	13	0.2
Sandy Hill (S)	87	2.5	17	0.5	13	0.2	30	0.7	40	1.5	80	2.5
Oyster Shell Pt. (S)	27	0.7	0	0.0	0	0.0	0	0.0	3	0.1	0	0.0
Tilghman Wharf	23	0.5	3	0.1	10	0.2	3	0.1	0	0.0	0	0.0
Deep Neck	90	2.7	67	2.2	70	2.4	67	1.9	43	1.1	100	3.2
Double Mills (S)	87	2.9	67	2.2	80	2.1	63	1.5	53	1.7	83	3.4
Cason (S)	60	1.9	100	2.9	100	3.2	97	3.8	70	2.2	93	3.3
Ragged Point	93	2.7	37	1.0	80	2.5	83	2.3	60	1.7	93	3.1
Norman Addition	23	0.9	37	0.7	57	1.8	100	3.9	87	3.3	100	4.3
Goose Creek	0	0.0	20	0.2	0	0.0	10	0.2	10	0.3	50	1.3
Wilson Shoals (S)	93	2.7	80	2.3	87	2.9	80	1.9	62	2.0	97	4.1
Georges (S)	83	3.8	57	2.2	57	1.6	73	2.4	50	1.2	100	3.9
Holland Straits	80	3.0	50	2.0	47	1.5	70	2.2	37	1.4	83	3.0
Sharkfin Shoal	70	1.9	70	1.7	90	3.6	97	3.6	90	3.3	100	4.2
Back Cove	93	3.2	80	2.6	87	3.3	93	3.6	80	2.7	90	3.0
Piney Island East	67	2.5	90	3.3	90	3.4	97	4.1	70	2.7	80	2.5
Old Woman's Leg	73	2.2	90	2.8	97	4.7	70	3.0	47	1.9	77	2.7
Marumsco	37	1.1	57	1.7	90	3.0	73	2.7	67	2.5	97	3.2
Broome Island	97	3.6	93	2.5	100	4.2	90	3.3	67	2.3	87	3.0
Chicken Cock	90	4.0	40	1.3	90	3.5	83	3.3	20	0.6	50	1.3
Pagan (S)	90	2.5	57	1.8	93	2.7	97	3.9	53	2.0	87	2.8
Lancaster	97	4.2	77	2.1	73	2.4	60	2.0	37	0.8	47	1.1
Mills West	47	1.6	57	1.9	50	1.3	27	0.9	27	0.5	80	2.5
Cornfield Harbor	97	3.5	73	2.6	87	3.7	83	2.5	40	1.3	83	3.0
Ragged Point	0	0.0	8	0.1	0	0.0	4	0.1	0	0.0	3	0.03
Lower Cedar Point	30	0.6	7	0.1	10	0.3	40	0.9	20	0.4	20	0.3
Annual Means	**68**	**2.3**	**56**	**1.8**	**59**	**2.0**	**57**	**1.8**	**38**	**1.2**	**59**	**2.0**
Bar Freq. (%)	**93**		**95**		**93**		**98**		**93**		**93**	

Table 3 - Dermo (continued).

Oyster Bar	***Perkinsus marinus* Prevalence (%) and Mean Intensity (I)**											
	2013		2014		2015		2016		2017		2018	
	%	I	%	I	%	I	%	I	%	I	%	I
Swan Point	27	0.4	3	0.0	33	0.3	3	0.0	3	0.0	0	0.0
Hackett Point	13	0.6	0	0.0	10	0.3	40	1.2	56	1.6	27	0.9
Holland Point (S)	5	0.1	0	0.0	0	0.0	27	0.6	47	1.2	7	0.1
Stone Rock	67	2.0	100	4.0	93	4.5	97	4.4	83	3.4	53	1.7
Flag Pond (S)	23	0.8	10	0.3	18	0.5	50	1.9	52	1.6	27	0.6
Hog Island	27	0.9	43	1.2	87	3.0	97	4.3	100	4.5	63	2.1
Butler	70	2.4	73	2.4	60	2.0	37	1.5	63	2.2	73	2.1
Buoy Rock	27	0.6	13	0.4	17	0.2	20	0.7	30	0.8	0	0.0
Old Field (S)	57	1.5	47	1.5	57	1.7	63	2.1	60	2.1	27	0.7
Bugby	73	2.5	83	2.8	87	3.3	90	3.3	97	3.3	43	1.1
Parsons Island	30	0.9	15	0.4	53	1.3	77	2.2	83	2.9	43	1.3
Hollicutt Noose	13	0.4	23	0.6	33	0.7	50	1.5	57	1.8	17	0.5
Bruffs Island (S)	37	1.2	23	0.7	77	2.0	100	4.2	97	4.3	63	1.9
Turtle Back	63	2.2	80	2.5	100	4.2	83	3.5	83	3.2	70	2.1
Long Point (S)	37	1.2	10	0.4	20	0.5	73	2.6	36	1.1	7	0.3
Cook Point (S)	97	3.2	80	3.1	90	3.3	100	4.6	90	3.5	63	1.6
Royston	60	2.0	60	2.0	63	2.1	47	1.5	43	1.5	17	0.5
Lighthouse	10	0.3	10	0.3	23	0.5	10	0.4	17	0.4	7	0.2
Sandy Hill (S)	93	2.8	77	2.4	93	3.3	93	4.0	96	3.9	53	1.4
Oyster Shell Pt. (S)	7	0.2	3	0.0	40	1.0	80	2.6	77	2.8	57	1.8
Tilghman Wharf	10	0.2	7	0.1	20	0.6	47	1.5	70	2.2	47	1.2
Deep Neck	80	3.1	67	1.8	93	2.9	80	3.1	77	2.4	57	1.3
Double Mills (S)	83	3.1	73	2.6	70	2.9	87	3.6	97	3.9	67	2.1
Cason (S)	80	2.8	90	2.8	93	2.8	100	4.2	97	3.3	77	2.2
Ragged Point	97	3.0	83	2.3	100	3.2	93	4.0	97	3.7	67	1.7
Norman Addition	80	3.1	87	3.7	77	2.7	93	3.6	93	3.2	63	2.0
Goose Creek	80	2.6	83	2.5	100	3.4	93	4.3	80	3.0	70	2.7
Wilson Shoals (S)	93	3.0	90	3.4	80	2.8	90	3.2	87	3.2	73	2.1
Georges (S)	83	3.4	97	3.9	93	3.9	83	3.4	97	3.9	77	2.7
Holland Straits	90	3.7	80	3.6	83	3.0	13	0.3	30	0.6	7	0.2
Sharkfin Shoal	93	3.5	90	3.4	77	2.8	90	4.1	93	4.1	57	2.1
Back Cove	93	3.9	80	3.1	77	3.2	30	0.9	30	0.9	3	0.1
Piney Island East	63	2.0	40	1.4	53	1.8	60	2.4	70	2.3	27	1.1
Old Woman's Leg	52	1.3	60	2.6	67	2.1	11	0.2	50	1.6	6	0.1
Marumsco	100	4.4	80	3.5	90	3.6	93	3.7	100	3.9	63	1.6
Broome Island	93	3.2	70	1.9	80	2.6	90	3.8	93	4.0	50	1.3
Chicken Cock	50	1.2	67	1.9	67	2.1	73	2.4	97	3.1	63	2.1
Pagan (S)	77	2.4	83	2.1	83	2.9	83	3.1	80	3.1	63	1.4
Lancaster	30	1.2	20	0.8	3	0.2	37	1.6	47	1.8	10	0.1
Mills West	70	2.1	53	1.8	57	1.7	40	1.8	60	2.0	3	0.1
Cornfield Harbor	90	3.1	80	3.1	57	1.8	63	2.6	97	3.6	63	1.9
Ragged Point	0	0.0	3	0.0	0	0.0	3	0.0	7	0.1	0	0.0
Lower Cedar Point	20	0.4	3	0.1	55	1.6	33	1.1	50	1.6	0	0.0
Annual Means	**57**	**1.9**	**52**	**1.8**	**61**	**2.1**	**63**	**2.5**	**69**	**2.5**	**40**	**1.2**
Bar Freq. (%)	**98**		**95**		**95**		**100**		**100**		**91**	

Table 3 - Dermo (continued).

Oyster Bar	***Perkinsus marinus* Prevalence (%) and Mean Intensity (I)**									
	2019		2020		2021		2022		*33-Yr Avg*	
	%	I	%	I	%	I	%	I	*%*	*I*
Swan Point	3	0.1	0	0.0	0	0	13	0.2	*24.9*	*0.6*
Hackett Point	10	0.5	30	0.9	40	1.8	57	1.4	*48.5*	*1.5*
Holland Point (S)	0	0.0	0	0.0	3	0.1	3	0.1	*36.2*	*1.1*
Stone Rock	23	1.0	23	0.6	10	0.3	63	1.9	*67.7*	*2.2*
Flag Pond (S)	13	0.5	87	3.0	90	3.8	100	3.2	*50.6*	*1.6*
Hog Island	27	1.0	30	1.0	30	0.7	90	2.7	*70.4*	*2.6*
Butler	60	2.0	60	2.0	80	2.8	93	3.7	*67.9*	*2.2*
Buoy Rock	3	0.1	0	0.0	13	0.3	23	0.4	*46.9*	*1.5*
Old Field (S)	17	0.4	20	0.7	17	0.6	39	0.7	*54.0*	*1.6*
Bugby	90	2.8	57	1.6	67	2.2	90	2.5	*80.1*	*2.6*
Parsons Island	7	0.4	23	0.5	3	0.07	20	0.4	*65.6*	*2.2*
Hollicutt Noose	13	0.5	13	0.4	10	0.2	33	0.9	*55.7*	*1.8*
Bruffs Island (S)	70	2.3	33	0.8	57	2.3	13	0.3	*69.5*	*2.2*
Turtle Back	73	2.9	67	2.2	37	1	67	1.8	*81.6*	*2.8*
Long Point (S)	3	0.03	13	0.3	27	1	70	1.6	*60.9*	*2.0*
Cook Point (S)	37	1.2	80	2.6	57	2	90	2.2	*59.9*	*2.0*
Royston	20	0.6	60	1.5	13	0.5	27	0.5	*52.3*	*1.8*
Lighthouse	3	0.2	0	0.0	0	0	3	0	*40.0*	*1.3*
Sandy Hill (S)	53	2.4	67	2.1	27	0.7	70	1.5	*72.9*	*2.7*
Oyster Shell Pt. (S)	3	0.1	20	0.5	13	0.2	60	1.1	*39.3*	*1.1*
Tilghman Wharf	23	0.9	20	0.7	40	1.1	40	0.9	*50.3*	*1.5*
Deep Neck	33	1.2	30	0.9	57	1.4	93	2.7	*76.8*	*2.6*
Double Mills (S)	47	1.8	63	2.2	70	2.3	97	3	*78.7*	*2.8*
Cason (S)	60	2.0	50	1.7	57	1.7	90	2.6	*77.9*	*2.6*
Ragged Point	60	1.4	73	2.6	77	2.3	97	2.6	*79.9*	*2.6*
Norman Addition	37	1.5	23	0.8	7	0.3	67	1.9	*73.8*	*2.6*
Goose Creek	27	1.1	53	2.0	63	2.5	93	3.5	*66.5*	*2.3*
Wilson Shoals (S)	30	1.0	47	1.2	60	2	90	3	*81.0*	*2.5*
Georges (S)	77	3.1	77	2.9	73	2.6	90	4	*81.2*	*2.9*
Holland Straits	0	0.0	0	0.0	3	0.03	20	0.6	*57.7*	*1.9*
Sharkfin Shoal	63	2.4	67	2.7	57	2.8	93	4	*81.1*	*2.9*
Back Cove	3	0.2	10	0.3	83	2.6	93	4.1	*76.1*	*2.8*
Piney Island East	17	0.5	3	0.1	23	0.6	53	1.7	*71.2*	*2.4*
Old Woman's Leg	0	0.0	0	0.0	3	0.1	30	0.7	*65.4*	*2.3*
Marumsco	30	1.0	7	0.3	37	1.1	73	1.7	*77.3*	*2.7*
Broome Island	13	0.5	27	0.8	27	0.7	67	1.8	*71.4*	*2.4*
Chicken Cock	27	1.2	23	0.7	30	1.1	57	1.4	*68.5*	*2.2*
Pagan (S)	17	0.4	37	1.1	70	2.4	50	1.6	*76.1*	*2.3*
Lancaster	7	0.2	47	1.5	63	2	93	3.1	*57.1*	*1.7*
Mills West	0	0.0	3	0.2	3	0.2	3	0	*50.8*	*1.6*
Cornfield Harbor	40	1.3	53	2.0	43	1.6	90	2.3	*76.5*	*2.4*
Ragged Point	0	0.0	0	0.0	0	0	23	0.3	*18.3*	*0.5*
Lower Cedar Point	NA	NA	10	0.4	17	0.5	7	0.1	*21.3*	*0.5*
Annual Means	**27**	**1.0**	**33**	**1.1**	**36.2**	**1.2**	**58.9**	**1.7**	***62.3***	***2.1***
Bar Freq. (%)	**88**		**84**		**93**		**100**		***96.4***	

(Return to Text)

Table 4. Prevalence of *Haplosporidium nelsoni* in oysters from the 43 disease monitoring bars, 1990-2022. NA = insufficient quantity of oysters for analytical sample. ND = sample collected but diagnostics not performed; prevalence assumed to be 0. (S) = bar within an oyster sanctuary since 2010.

Region	Oyster Bar	***Haplosporidium nelsoni* Prevalence (%)**							
		1990	1991	1992	1993	1994	1995	1996	1997
Upper Bay	Swan Point	0	0	0	0	ND	0	0	0
Middle Bay	Hackett Point	0	0	3	0	0	0	0	0
	Holland Point (S)	0	3	13	0	0	0	0	0
	Stone Rock	0	0	43	0	0	3	0	0
	Flag Pond (S)	0	0	53	0	0	27	0	0
Lower Bay	Hog Island	0	0	43	0	0	14	0	0
	Butler	0	0	50	0	0	23	0	7
Chester River	Buoy Rock	ND	0	0	0	ND	0	0	0
	Old Field (S)	ND	0	0	0	ND	0	0	0
Eastern Bay	Bugby	0	7	3	0	0	0	0	0
	Parsons Island	ND	0	7	0	0	0	0	0
	Hollicutt Noose	0	0	17	0	0	0	0	0
Wye River	Bruffs Island (S)	0	0	0	0	0	0	0	0
Miles River	Turtle Back	0	0	0	0	0	23	0	0
	Long Point (S)	0	0	0	0	0	0	0	0
Choptank River	Cook Point (S)	0	7	73	0	0	NA	0	3
	Royston	NA	0	33	0	0	0	0	0
	Lighthouse	0	0	53	0	0	0	0	0
	Sandy Hill (S)	0	0	13	0	ND	0	0	0
	Oyster Shell Pt. (S)	0	0	30	0	ND	0	0	0
Harris Creek	Tilghman Wharf	0	0	40	0	0	0	0	0
Broad Creek	Deep Neck	0	0	30	0	0	0	0	0
Tred Avon River	Double Mills (S)	0	0	17	0	0	0	0	0
Little Choptank R.	Cason (S)	0	0	43	0	0	0	0	0
	Ragged Point	0	20	57	0	0	0	0	0
Honga River	Norman Addition	3	0	53	0	0	33	0	0
Fishing Bay	Goose Creek	0	10	27	7	0	20	0	0
Nanticoke River	Wilson Shoals (S)	0	0	57	0	ND	7	0	0
Manokin River	Georges (S)	10	7	23	0	0	33	0	0
Holland Straits	Holland Straits	0	20	13	13	0	52	0	10
Tangier Sound	Sharkfin Shoal	20	43	40	17	0	33	0	0
	Back Cove	0	17	27	33	7	20	3	3
	Piney Island East	7	23	17	20	13	10	7	13
	Old Woman's Leg	0	33	23	30	10	43	20	4
Pocomoke Sound	Marumsco	0	20	20	0	0	20	0	11
Patuxent River	Broome Island	0	ND	20	0	0	0	0	0
St. Mary's River	Chicken Cock	0	0	57	0	ND	0	0	0
	Pagan (S)	0	0	0	0	ND	0	0	0
Wicomico R. (west)	Lancaster	0	0	0	0	ND	0	0	0
	Mills West	0	0	0	0	ND	0	0	0
Potomac River	Cornfield Harbor	0	0	57	0	0	37	0	0
	Ragged Point	0	0	0	0	0	0	0	0
	Lower Cedar Point	ND	ND	0	0	ND	0	0	0
Average Prevalence (%)		**1.1**	**5.1**	**24.5**	**2.8**	**0.9**	**9.5**	**0.7**	**1.2**
Frequency of Positive Bars (%)		**9**	**28**	**74**	**14**	**7**	**40**	**7**	**16**

Table 4 – MSX (continued).

Oyster Bar	***Haplosporidium nelsoni* Prevalence (%)**									
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Swan Point	0	0	0	0	0	0	0	0	0	0
Hackett Point	0	0	0	0	13	0	0	0	0	0
Holland Point (S)	0	0	3	7	40	0	0	0	0	0
Stone Rock	0	30	47	40	30	3	0	0	0	0
Flag Pond (S)	0	NA	NA	NA	20	0	0	0	0	0
Hog Island	0	60	27	27	20	0	0	0	0	0
Butler	3	47	17	27	20	3	3	0	3	10
Buoy Rock	0	0	0	0	0	0	0	0	0	0
Old Field (S)	0	0	0	0	0	0	0	0	0	0
Bugby	0	0	0	0	27	0	0	0	0	0
Parsons Island	0	0	0	3	17	0	0	0	0	0
Hollicutt Noose	0	7	10	17	37	0	0	0	0	0
Bruffs Island (S)	0	0	0	3	17	0	0	0	0	0
Turtle Back	0	0	0	7	33	0	0	0	0	0
Long Point (S)	0	0	0	0	3	0	0	0	0	0
Cook Point (S)	0	13	33	37	NA	0	0	3	0	0
Royston	0	3	7	0	60	0	0	0	0	0
Lighthouse	0	13	7	3	67	0	0	0	0	0
Sandy Hill (S)	0	0	0	10	53	0	0	0	0	0
Oyster Shell Pt. (S)	0	0	0	0	7	0	0	0	0	0
Tilghman Wharf	0	3	27	7	60	0	0	0	0	0
Deep Neck	0	3	7	0	63	0	0	0	0	0
Double Mills (S)	0	3	0	0	33	0	0	0	0	0
Cason (S)	0	7	27	33	59	0	0	0	0	0
Ragged Point	0	20	47	40	30	0	0	0	0	0
Norman Addition	3	63	37	37	20	7	0	0	0	7
Goose Creek	0	47	17	13	33	0	0	0	0	3
Wilson Shoals (S)	0	4	10	10	27	0	0	0	0	7
Georges (S)	0	40	20	13	30	0	0	0	0	7
Holland Straits	3	73	40	47	57	7	0	0	0	23
Sharkfin Shoal	20	53	37	20	27	7	0	0	0	10
Back Cove	10	33	37	10	7	7	0	7	13	33
Piney Island East	17	43	53	40	17	10	3	0	3	17
Old Woman's Leg	23	53	30	13	13	3	3	13	13	13
Marumsco	7	37	30	17	30	0	0	0	0	10
Broome Island	0	3	10	0	13	0	0	0	0	0
Chicken Cock	0	77	7	17	30	3	0	0	0	3
Pagan (S)	0	3	13	10	40	0	0	0	0	0
Lancaster	0	0	0	0	10	0	0	0	0	0
Mills West	0	3	0	0	43	0	0	0	0	0
Cornfield Harbor	3	53	17	33	50	10	0	0	0	7
Ragged Point	0	13	10	7	60	0	0	0	0	0
Lower Cedar Point	0	0	0	0	0	0	0	0	0	0
Avg. Prev. (%)	**2.1**	**19.2**	**14.9**	**13.0**	**29.0**	**1.4**	**0.2**	**0.5**	**0.7**	**3.1**
Pos. Bars (%)	**19**	**67**	**64**	**67**	**90**	**23**	**7**	**7**	**9**	**30**

Table 4 - MSX (continued).

Oyster Bar	***Haplosporidium nelsoni* Prevalence (%)**										
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Swan Point	0	0	0	0	0	0	0	0	0	0	0
Hackett Point	0	0	0	0	0	0	0	0	0	3	0
Holland Point (S)	0	0	3	0	0	0	0	0	0	3	0
Stone Rock	10	23	3	0	0	0	0	7	13	10	0
Flag Pond (S)	3	13	7	0	0	0	0	12	10	0	0
Hog Island	7	17	0	0	0	0	0	10	40	3	0
Butler	7	37	17	0	0	0	3	13	48	0	0
Buoy Rock	0	0	0	0	0	0	0	0	0	0	0
Old Field (S)	0	0	0	0	0	0	0	0	0	0	0
Bugby	0	0	0	0	0	0	0	3	3	0	0
Parsons Island	0	0	0	0	0	0	0	0	7	0	0
Hollicutt Noose	0	13	0	0	0	0	0	0	10	0	0
Bruffs Island (S)	0	3	0	0	0	0	0	0	3	0	0
Turtle Back	0	0	0	0	0	0	0	3	7	0	0
Long Point (S)	0	0	3	0	0	0	0	0	0	0	0
Cook Point (S)	7	43	10	0	0	0	0	13	30	3	0
Royston	0	0	0	0	0	0	0	7	30	0	0
Lighthouse	0	13	3	0	0	0	0	0	37	0	0
Sandy Hill (S)	0	0	0	0	0	0	0	0	0	0	0
Oyster Shell Pt. (S)	0	0	0	0	0	0	0	0	0	0	0
Tilghman Wharf	0	3	0	0	0	0	0	7	27	0	0
Deep Neck	0	13	0	0	0	0	0	3	0	0	0
Double Mills (S)	0	0	0	0	0	0	0	0	0	0	0
Cason (S)	0	20	0	0	0	0	0	23	0	0	0
Ragged Point	0	13	10	0	0	0	0	20	17	3	0
Norman Addition	10	33	10	0	0	0	3	3	7	0	0
Goose Creek	7	27	0	0	0	0	0	13	7	0	0
Wilson Shoals (S)	0	7	0	0	0	0	0	3	0	0	0
Georges (S)	0	10	0	0	0	0	0	3	0	0	0
Holland Straits	7	33	23	0	0	0	3	10	13	0	0
Sharkfin Shoal	17	17	10	0	0	0	10	10	0	0	0
Back Cove	13	27	7	0	0	3	10	17	37	13	0
Piney Island East	0	33	7	0	0	10	27	33	10	13	3
Old Woman's Leg	0	27	20	7	3	3	20	23	17	25	0
Marumsco	0	17	3	0	3	0	10	10	0	3	0
Broome Island	0	3	0	0	0	0	0	0	7	7	0
Chicken Cock	13	57	10	0	0	0	0	23	60	7	0
Pagan (S)	0	30	0	0	0	0	0	0	0	0	0
Lancaster	0	0	0	0	0	0	0	0	0	0	0
Mills West	0	0	0	0	0	0	0	0	0	0	0
Cornfield Harbor	10	30	7	0	0	10	10	30	33	7	0
Ragged Point	0	0	0	0	0	0	0	0	3	10	0
Lower Cedar Point	0	0	0	0	0	0	0	0	0	0	0
Avg. Prev. (%)	**2.7**	**13.0**	**3.6**	**0.2**	**0.1**	**0.6**	**2.2**	**7.0**	**11.1**	**2.6**	**0.1**
Pos. Bars (%)	**30**	**60**	**40**	**2**	**5**	**9**	**21**	**56**	**56**	**33**	**2**

Table 4 - MSX (continued).

Oyster Bar	***Haplosporidium nelsoni* Prevalence (%)**				
	2019	2020	2021	2022	*33-yr avg*
Swan Point	0	0	0	0	*0.0*
Hackett Point	0	0	0	0	*0.6*
Holland Point (S)	0	0	0	0	*2.2*
Stone Rock	0	0	0	0	*7.9*
Flag Pond (S)	0	0	0	0	*4.8*
Hog Island	0	0	0	0	*8.1*
Butler	0	0	0	3	*10.3*
Buoy Rock	0	0	0	0	*0.0*
Old Field (S)	0	0	0	0	*0.0*
Bugby	0	0	0	0	*1.3*
Parsons Island	0	0	0	0	*1.1*
Hollicutt Noose	0	0	0	0	*3.4*
Bruffs Island (S)	0	0	0	0	*0.8*
Turtle Back	0	0	0	0	*2.2*
Long Point (S)	0	0	0	0	*0.2*
Cook Point (S)	0	0	0	0	*8.9*
Royston	0	0	0	0	*4.4*
Lighthouse	0	0	0	0	*5.9*
Sandy Hill (S)	0	0	0	0	*2.4*
Oyster Shell Pt. (S)	0	0	0	0	*1.2*
Tilghman Wharf	0	0	0	0	*5.3*
Deep Neck	0	0	0	0	*3.6*
Double Mills (S)	0	0	0	0	*1.6*
Cason (S)	0	0	0	0	*6.4*
Ragged Point	0	0	0	0	*8.4*
Norman Addition	0	0	0	13	*10.4*
Goose Creek	0	0	3	0	*7.1*
Wilson Shoals (S)	0	0	0	0	*4.1*
Georges (S)	0	0	0	0	*5.9*
Holland Straits	0	0	0	3	*13.6*
Sharkfin Shoal	0	0	3	7	*12.2*
Back Cove	0	0	3	13	*12.4*
Piney Island East	0	3	3	17	*14.3*
Old Woman's Leg	0	0	7	13	*15.3*
Marumsco	3	0	0	13	*8.0*
Broome Island	0	0	0	0	*2.0*
Chicken Cock	0	0	0	0	*11.4*
Pagan (S)	0	0	0	0	*3.0*
Lancaster	0	0	0	0	*0.3*
Mills West	0	0	0	0	*1.4*
Cornfield Harbor	0	0	0	0	*12.2*
Ragged Point	0	0	0	0	*3.1*
Lower Cedar Point	NA	0	0	0	*0.0*
Avg. Prev. (%)	**0.1**	**0.1**	**0.4**	**1.9**	***5.3***
Pos. Bars (%)	**2**	**2**	**12**	**19**	***28.1***

(Return to Text)

Table 5. Oyster population observed mortality estimates from the 43 disease monitoring bars, 1985-2022. NA = unable to obtain a sufficient sample size. (S) = bar within an oyster sanctuary since 2010.

Region	Oyster Bar	**Total Observed Mortality (%)**							
		1985	1986	1987	1988	1989	1990	1991	1992
Upper Bay	Swan Point	14	1	2	1	9	4	4	3
Middle Bay	Hackett Point	7	0	10	9	5	2	2	12
	Holland Point (S)	4	21	19	3	19	3	14	45
	Stone Rock	6	NA	NA	NA	NA	2	9	45
	Flag Pond (S)	NA	48	30	39	37	10	35	77
Lower Bay	Hog Island	NA	26	47	25	6	19	73	85
	Butler	NA	23	84	15	7	30	58	84
Chester River	Buoy Rock	10	0	0	1	10	5	11	16
	Old Field (S)	8	3	3	4	2	7	3	9
Eastern Bay	Bugby	8	25	46	33	25	39	53	18
	Parsons Island	19	1	26	13	2	7	43	27
	Hollicutt Noose	2	32	42	25	14	1	7	9
Wye River	Bruffs Island (S)	2	1	45	12	9	12	50	77
Miles River	Turtle Back	NA	1	19	27	15	27	51	23
	Long Point (S)	17	8	23	8	12	11	53	73
Choptank River	Cook Point (S)	40	20	45	63	6	11	2	88
	Royston	4	21	19	11	14	14	33	43
	Lighthouse	3	14	59	14	8	8	45	52
	Sandy Hill (S)	12	6	29	34	7	11	75	48
	Oyster Shell Pt. (S)	9	0	1	2	2	3	2	19
Harris Creek	Tilghman Wharf	2	36	57	NA	20	30	34	26
Broad Creek	Deep Neck	2	25	37	32	47	66	48	40
Tred Avon River	Double Mills (S)	4	7	13	9	6	28	82	50
Little Choptank R.	Cason (S)	4	22	60	37	40	63	25	48
	Ragged Point	5	31	84	38	7	23	53	49
Honga River	Norman Addition	15	53	82	NA	11	11	48	49
Fishing Bay	Goose Creek	6	26	84	59	19	7	23	63
Nanticoke River	Wilson Shoals (S)	23	65	51	41	38	10	29	60
Manokin River	Georges (S)	5	24	84	55	23	31	50	55
Holland Straits	Holland Straits	19	51	85	90	15	27	35	71
Tangier Sound	Sharkfin Shoal	25	61	94	80	8	0	10	63
	Back Cove	NA	NA	NA	NA	NA	11	49	88
	Piney Island East	21	16	88	11	5	23	57	55
	Old Woman's Leg	4	17	79	21	8	5	50	80
Pocomoke Sound	Marumsco	3	27	77	NA	20	8	31	44
Patuxent River	Broome Island	10	29	31	6	4	24	53	70
St. Mary's River	Chicken Cock	18	43	63	43	24	27	31	51
	Pagan (S)	9	30	27	13	20	39	24	19
Wicomico R. (west)	Lancaster	13	6	4	4	6	28	20	8
	Mills West	18	0	2	1	1	2	11	9
Potomac River	Cornfield Harbor	17	59	92	51	11	16	29	77
	Ragged Point	10	14	29	79	54	63	34	63
	Lower Cedar Point	6	9	2	1	6	6	7	5
Annual Means		**10**	**22**	**44**	**29**	**14**	**18**	**34**	**46**

Table 5 - Mortality (continued).

Oyster Bar	Total Observed Mortality (%)									
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Swan Point	5	35	18	43	20	3	7	13	12	14
Hackett Point	18	30	30	16	10	26	22	13	30	60
Holland Point (S)	43	42	35	49	36	36	8	33	42	67
Stone Rock	30	29	40	25	15	33	46	66	30	86
Flag Pond (S)	43	28	24	16	13	33	50	NA	NA	23
Hog Island	76	16	45	20	16	33	67	67	14	31
Butler	66	37	63	17	20	20	48	67	32	11
Buoy Rock	51	33	22	17	7	7	6	25	43	61
Old Field (S)	8	12	8	17	8	5	8	21	36	47
Bugby	29	18	18	27	15	8	5	29	48	63
Parsons Island	29	18	36	22	25	8	16	29	60	59
Hollicutt Noose	29	32	30	13	15	14	13	38	55	85
Bruffs Island (S)	47	47	33	6	6	11	16	33	44	50
Turtle Back	24	40	51	21	9	9	26	38	48	54
Long Point (S)	44	8	28	8	3	9	14	33	34	66
Cook Point (S)	63	40	22	16	11	20	35	63	28	100
Royston	37	10	17	9	9	6	32	31	51	91
Lighthouse	57	27	18	15	5	6	20	33	44	92
Sandy Hill (S)	45	36	29	23	22	4	15	27	50	77
Oyster Shell Pt. (S)	20	14	18	25	6	2	1	15	28	55
Tilghman Wharf	36	6	10	9	15	6	12	19	34	85
Deep Neck	32	1	23	14	8	13	37	23	37	85
Double Mills (S)	24	10	20	9	8	10	38	40	50	85
Cason (S)	53	6	7	12	11	18	28	32	62	98
Ragged Point	71	17	16	12	13	19	34	37	70	94
Norman Addition	51	28	39	55	31	54	35	38	29	29
Goose Creek	38	7	38	69	64	20	64	63	81	85
Wilson Shoals (S)	23	10	17	11	11	9	29	25	26	52
Georges (S)	16	0	55	33	36	12	32	60	50	44
Holland Straits	18	16	45	43	20	18	35	35	17	12
Sharkfin Shoal	16	7	66	59	47	28	62	61	39	61
Back Cove	4	6	46	33	29	50	59	20	46	38
Piney Island East	13	20	65	56	49	67	38	27	12	20
Old Woman's Leg	15	25	63	46	33	38	42	15	53	27
Marumsco	21	8	78	53	49	26	40	22	35	45
Broome Island	53	27	8	0	13	11	44	25	59	72
Chicken Cock	33	28	15	10	7	24	82	63	28	63
Pagan (S)	17	11	9	27	15	3	14	35	51	84
Lancaster	7	4	19	25	8	8	18	48	58	52
Mills West	2	4	21	18	17	16	24	36	40	75
Cornfield Harbor	47	25	56	24	7	27	78	62	44	33
Ragged Point	28	35	8	11	4	25	10	8	33	NA
Lower Cedar Point	47	28	5	23	3	26	8	0	3	44
Annual Means	**33**	**20**	**30**	**25**	**18**	**19**	**31**	**35**	**38**	**58**

Table 5 - Mortality (continued).

Oyster Bar	Total Observed Mortality (%)									
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Swan Point	13	10	11	8	10	9	33	20	27	1
Hackett Point	17	10	2	5	11	26	15	14	0	13
Holland Point (S)	50	29	5	0	0	11	0	8	50	7
Stone Rock	13	5	5	20	5	25	16	8	2	2
Flag Pond (S)	0	0	2	4	0	14	26	20	11	0
Hog Island	11	6	12	25	42	14	18	12	8	14
Butler	9	2	3	23	0	9	8	8	12	4
Buoy Rock	41	28	6	21	20	24	43	8	4	2
Old Field (S)	34	10	38	12	12	17	17	11	21	12
Bugby	50	14	2	20	52	42	50	12	4	9
Parsons Island	37	11	8	35	50	34	36	16	10	4
Hollicutt Noose	25	3	6	48	43	27	12	23	0	0
Bruffs Island (S)	50	12	5	4	12	36	33	28	0	7
Turtle Back	43	11	12	51	57	55	34	5	11	4
Long Point (S)	54	10	10	14	38	46	17	33	0	33
Cook Point (S)	21	0	0	0	12	22	7	8	6	5
Royston	69	14	0	0	9	5	10	0	1	3
Lighthouse	89	47	0	0	0	0	4	1	3	4
Sandy Hill (S)	88	59	44	24	4	5	5	0	8	6
Oyster Shell Pt. (S)	48	20	0	4	0	4	4	2	1	3
Tilghman Wharf	62	17	0	1	10	14	2	2	3	0
Deep Neck	54	14	1	3	8	9	3	6	4	3
Double Mills (S)	59	23	8	0	7	4	19	6	4	14
Cason (S)	57	4	0	2	4	16	17	33	10	13
Ragged Point	52	5	4	13	13	2	22	15	4	2
Norman Addition	9	14	40	5	3	2	6	15	9	10
Goose Creek	53	59	50	50	1	2	6	0	3	1
Wilson Shoals (S)	19	27	7	21	7	30	10	3	5	8
Georges (S)	4	24	44	76	16	48	10	12	2	11
Holland Straits	11	18	43	48	17	27	12	14	5	7
Sharkfin Shoal	23	32	54	22	10	3	18	20	12	13
Back Cove	22	23	32	12	5	8	6	15	4	10
Piney Island East	28	48	50	23	6	18	20	26	17	11
Old Woman's Leg	35	56	26	0	12	14	37	38	26	0
Marumsco	4	11	29	20	10	21	7	13	4	15
Broome Island	14	19	6	6	20	20	11	14	3	6
Chicken Cock	2	38	50	20	20	7	27	22	11	1
Pagan (S)	7	29	66	9	4	11	29	13	5	11
Lancaster	35	27	14	7	31	17	24	0	0	0
Mills West	48	11	0	7	33	0	16	10	11	12
Cornfield Harbor	1	7	20	2	9	25	44	16	9	8
Ragged Point	76	NA	NA	NA	0	0	0	0	0	10
Lower Cedar Point	55	22	17	3	11	5	4	7	14	10
Annual Means	**35**	**20**	**17**	**16**	**15**	**17**	**17**	**12**	**8**	**7**

Table 5 - Mortality (continued).

Oyster Bar			Total Observed Mortality (%)								
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	*38-yr Avg*
Swan Point	4	0	3	0	0	8	12	3	3	12	*10.4*
Hackett Point	0	0	0	3	19	3	5	21	23	4	*13.0*
Holland Point (S)	12	40	29	0	0	50	nd	nd	0	50	*23.9*
Stone Rock	2	5	31	36	30	9	5	4	3	6	*20.4*
Flag Pond (S)	15	13	5	6	50	3	1	7	17	17	*20.5*
Hog Island	2	2	12	38	27	18	0	5	3	3	*25.4*
Butler	7	7	10	11	4	5	7	14	8	14	*22.9*
Buoy Rock	5	9	3	12	4	12	9	13	5	0	*15.6*
Old Field (S)	0	3	0	5	33	10	31	33	7	33	*14.4*
Bugby	8	31	21	21	13	12	17	18	23	9	*24.6*
Parsons Island	2	4	15	2	10	14	0	5	0	0	*19.3*
Hollicutt Noose	1	9	6	7	29	30	8	2	10	4	*19.7*
Bruffs Island (S)	0	4	5	16	20	41	38	25	20	4	*22.7*
Turtle Back	0	8	14	18	3	15	8	3	0	7	*22.8*
Long Point (S)	20	0	0	17	0	0	37	nd	0	0	*21.1*
Cook Point (S)	9	12	16	48	45	24	13	12	5	8	*24.9*
Royston	1	6	9	16	4	2	4	3	2	0.3	*16.1*
Lighthouse	1	1	2	9	7	0	4	2	1	0	*18.3*
Sandy Hill (S)	3	13	11	15	15	11	11	4	4	7	*23.3*
Oyster Shell Pt. (S)	2	5	2	11	11	18	24	12	4	3	*10.5*
Tilghman Wharf	5	1	5	11	1	7	4	6	1	1	*16.0*
Deep Neck	5	7	16	8	2	3	3	2	1	6	*19.2*
Double Mills (S)	11	12	10	20	13	11	2	7	6	13	*19.5*
Cason (S)	11	8	17	26	33	8	4	2	2	2	*23.6*
Ragged Point	15	13	21	45	14	6	3	11	4	8	*24.9*
Norman Addition	9	7	13	14	15	8	2	2	1	2	*22.8*
Goose Creek	5	15	22	27	6	10	3	4	5	7	*30.1*
Wilson Shoals (S)	5	4	7	17	6	4	4	6	9	2	*19.2*
Georges (S)	15	5	8	23	15	9	5	7	9	26	*27.2*
Holland Straits	9	48	71	18	4	17	4	1	0	6	*27.1*
Sharkfin Shoal	16	18	24	19	3	7	4	5	13	20	*29.6*
Back Cove	11	19	14	1	2	8	1	1	4	22	*21.2*
Piney Island East	7	10	9	21	25	38	33	4	9	6	*27.7*
Old Woman's Leg	50	75	15	0	50	25	10	5	5	5	*29.1*
Marumsco	13	13	17	13	20	34	36	4	8	23	*24.4*
Broome Island	7	8	14	21	3	4	0	4	1	2	*19.0*
Chicken Cock	1	7	16	32	20	17	20	2	6	3	*25.6*
Pagan (S)	4	13	22	28	6	4	4	49	11	7	*20.5*
Lancaster	13	0	3	1	1	10	5	2	5	10	*14.2*
Mills West	20	9	5	14	0	5	15	21	5	0	*14.2*
Cornfield Harbor	10	16	10	36	8	3	5	2	3	4	*26.1*
Ragged Point	0	0	50	10	8	4	33	0	12	0	*20.9*
Lower Cedar Point	0	0	6	8	27	96	100	100	1	1	*18.8*
Annual Means	**8**	**11**	**14**	**16**	**14**	**14**	**13**	**10**	**6**	**8**	***21.2***

(Return to Text)

Table 6. Regional summary of oyster harvests (bu.) in Maryland from buy tickets, 1985-86 through 2021-22 seasons as reported by seafood dealer buy tickets.

Maryland Oyster Harvests (bu)						
Region/Tributary	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
Upper Bay	5,600	30,800	19,100	17,700	15,700	19,800
Middle Bay	73,400	37,900	42,500	10,500	15,900	17,700
Lower Bay	32,500	5,900	70	0	3,600	37,900
Total Bay Mainstem	*111,500*	*74,600*	*61,700*	*28,200*	*35,200*	*75,400*
Chester R.	21,300	20,600	30,900	49,900	54,000	60,400
Eastern Bay	216,100	149,100	28,700	15,700	20,400	33,200
Miles R.	40,400	20,600	17,100	13,600	1,400	1,700
Wye R.	20,100	2,200	700	3,800	8,000	2,300
Total Eastern Bay Region	*276,600*	*171,900*	*46,500*	*33,100*	*29,800*	*37,200*
Upper Choptank R.	29,000	42,400	36,500	51,900	27,700	42,200
Middle Choptank R.	144,500	89,700	66,400	66,400	71,000	49,700
Lower Choptank R.	225,100	52,500	26,200	9,100	32,100	9,000
Tred Avon R.	67,700	60,900	13,700	42,400	92,100	22,000
Broad Cr.	12,900	58,700	8,500	13,500	8,100	4,300
Harris Cr.	3,500	16,700	6,900	7,800	8,800	3,300
Total Choptank R. Region	*482,700*	*320,900*	*158,200*	*191,100*	*239,800*	*130,500*
Little Choptank R.	27,100	10,500	21,500	15,000	19,000	8,800
Upper Tangier Sound	84,000	30,400	40	0	0	1,000
Lower Tangier Sound	64,400	22,200	90	0	0	1,600
Honga R.	29,400	49,300	7,700	300	1,100	5,600
Fishing Bay	107,600	87,300	90	20	20	900
Nanticoke R.	21,300	5,100	1,500	900	2,600	3,000
Wicomico R.	3,600	200	100	40	20	60
Manokin R.	40,800	47,400	500	70	10	60
Big Annemessex R.	90	10	10	0	40	0
Pocomoke Sound	32,700	22,300	0	0	0	300
Total Tangier Sound Region	*383,900*	*264,200*	*10,000*	*1,300*	*3,800*	*12,500*
Patuxent R.	96,300	16,800	1,400	3,700	8,900	48,400
Wicomico R., St. Clement and Breton bays	16,000	23,400	23,000	47,600	22,200	36,000
St. Marys R. and Smith Cr.	80,700	30,700	2,300	500	1,100	1,700
Total Md. Potomac Tribs.	*96,700*	*54,100*	*25,300*	*48,100*	*23,300*	*37,700*
Total Maryland (bu.)[1]	**1,500,000**	**976,000**	**360,000**	**390,000**	**414,000**	**418,000**

[1] Includes harvests from unidentified regions. Not all harvest reports provided region information, but were included in the Md. total.

Table 6 - Landings (continued).

Maryland Oyster Harvests (bu)						
Region/Tributary	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97
Upper Bay	35,200	18,200	8,900	7,800	26,600	2,600
Middle Bay	39,200	9,000	4,400	4,900	12,600	20,000
Lower Bay	9,300	90	0	1,100	800	300
Total Bay Mainstem	*83,800*	*27,300*	*13,300*	*13,800*	*40,000*	*22,800*
Chester R.	55,100	53,800	51,300	29,100	42,600	5,400
Eastern Bay	20,600	3,600	2,400	3,700	1,500	1,100
Miles R.	100	300	0	200	200	500
Wye R.	300	20	30	50	0	0
Total Eastern Bay Region	*21,000*	*3,900*	*2,400*	*4,000*	*1,700*	*1,600*
Upper Choptank R.	29,200	9,500	2,600	2,500	11,600	3,200
Middle Choptank R.	25,000	3,100	1,600	4,900	15,000	4,700
Lower Choptank R.	14,200	1,700	900	600	900	300
Tred Avon R.	800	0	0	5,900	1,300	3,800
Broad Cr.	40	50	10	400	1,000	4,000
Harris Cr.	100	20	0	14,200	5,000	13,600
Total Choptank R. Region	*69,300*	*14,400*	*5,100*	*28,500*	*34,800*	*29,600*
Little Choptank R.	3,800	50	300	19,300	1,900	40,800
Upper Tangier Sound	11,300	70	0	17,600	12,100	8,100
Lower Tangier Sound	1,700	40	0	5,400	500	10,100
Honga R.	600	20	100	1,700	400	200
Fishing Bay	6,400	500	30	11,900	20,900	8,800
Nanticoke R.	12,500	7,700	2,500	10,500	15,200	23,000
Wicomico R.	600	500	500	80	100	1,400
Manokin R.	200	40	10	100	0	900
Big Annemessex R.	10	0	0	0	0	0
Pocomoke Sound	500	0	0	100	0	300
Total Tangier Sound Region	*33,800*	*8,900*	*3,100*	*47,400*	*49,200*	*52,800*
Patuxent R.	24,500	0	0	30	100	20
Wicomico R., St. Clement and Breton bays	29,600	14,900	4,000	18,200	27,500	7,300
St. Marys R. and Smith Cr.	100	60	30	3,900	900	16,200
Total Potomac Md. Tribs.	*29,000*	*15,000*	*4,000*	*22,100*	*28,400*	*23,500*
Total Maryland (bu.)[1]	**323,000**	**124,000**	**80,000**	**165,000**	**200,000**	**178,000**

[1] Includes harvests from unidentified regions.

Table 6 - Landings (continued).

Maryland Oyster Harvests (bu)						
Region/Tributary	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
Upper Bay	18,800	13,100	28,100	31,150	16,100	18,930
Middle Bay	15,300	55,800	31,500	16,400	4,550	2,410
Lower Bay	4,800	8,300	3,800	2,050	600	50
Total Bay Mainstem	*38,900*	*77,200*	*63,400*	*49,600*	*21,250*	*21,390*
Chester R.	43,000	21,000	70,100	20,800	29,450	11,830
Eastern Bay	3,800	30,900	75,800	120,500	33,400	4,650
Miles R.	30	800	35,700	20,150	6,600	50
Wye R.	400	900	9,400	11,300	1,800	60
Total Eastern Bay Region	*4,200*	*32,600*	*120,900*	*151,950*	*41,800*	*4,760*
Upper Choptank R.	4,800	3,100	7,100	1,100	7,450	10
Middle Choptank R.	5,600	2,800	1,900	8,150	5,600	520
Lower Choptank R.	200	2,400	8,300	350	1,500	40
Tred Avon R.	6,900	11,700	3,700	8,950	1,000	40
Broad Cr.	27,600	46,200	18,200	36,850	4,900	700
Harris Cr.	21,400	67,000	18,200	26,200	3,300	30
Total Choptank R. Region	*66,500*	*133,200*	*57,400*	*81,600*	*23,750*	*1,340*
Little Choptank R.	36,100	84,100	33,600	27,850	2,400	190
Upper Tangier Sound	6,000	3,500	1,500	100	5,050	3,570
Lower Tangier Sound	4,200	8,500	2,800	1,450	13,200	5,960
Honga R.	1,300	300	50	0	50	590
Fishing Bay	3,800	700	90	0	0	390
Nanticoke R.	30,300	21,700	8,800	600	2,700	540
Wicomico R.	2,200	1,400	500	50	50	10
Manokin R.	600	300	90	200	1,850	970
Big Annemessex R.	0	0	200	0	0	0
Pocomoke Sound	400	80	100	10	20	0
Total Tangier Sound Region	*48,800*	*36,500*	*14,100*	*2,400*	*22,920*	*12,030*
Patuxent R.	60	5,600	2,000	10	0	0
Wicomico R., St. Clement and Breton bays	10,200	13,700	8,800	2,600	1,400	220
St. Marys R. and Smith Cr.	36,700	16,400	4,500	6,150	1,650	0
Total Potomac Md. Tribs.	*46,900*	*30,100*	*13,300*	*8,750*	*3,050*	*220*
Total Maryland (bu.)[1]	**285,000**	**423,000**	**381,000**	**348,000**	**148,000**	**56,000**

[1] Includes harvests from unidentified regions.

Table 6 - Landings (continued).

Maryland Oyster Harvests (bu)						
Region/Tributary	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Upper Bay	2,210	1,632	17,420	14,052	13,601	7,020
Middle Bay	750	295	17,346	17,004	3,728	1,870
Lower Bay	187	1,801	269	642	2,077	5,554
Total Bay Mainstem	*3,147*	*3,728*	*35,035*	*31,698*	*19,406*	*14.444*
Chester R.	557	3,239	4,385	7,201	4,685	4,826
Eastern Bay	5,446	16,767	49,120	36,268	8,582	7,390
Miles R.	56	353	3,660	1,133	27	910
Wye R.	0	173	122	0	0	12
Total Eastern Bay Region	*5,502*	*17,293*	*52,902*	*37,401*	*8,609*	*8,312*
Upper Choptank R.	0	78	591	11	95	15
Middle Choptank R.	30	67	967	2,510	597	597
Lower Choptank R.	0	267	1,250	3,037	2,426	2,535
Tred Avon R.	0	139	149	157	61	112
Broad Cr.	954	1,342	14,006	53,577	20,413	6,097
Harris Cr.	12	71	4,429	5,342	3,308	1,900
Total Choptank R. Region	*996*	*1,964*	*21,392*	*64,634*	*26,900*	*11,256*
Little Choptank R.	1,150	144	3,534	4,218	1,516	1,163
Upper Tangier Sound	7,630	13,658	2,874	3,856	4,614	12,454
Lower Tangier Sound	5,162	15,648	5,828	1,996	8,970	19,600
Honga R.	378	2,744	270	154	860	17,305
Fishing Bay	24	106	6	0	197	3,320
Nanticoke R.	57	965	387	97	97	134
Wicomico R.	0	0	0	30	11	118
Manokin R.	1,638	2,816	737	91	364	184
Big Annemessex R.	0	5	108	17	5	13
Pocomoke Sound	0	2,676	1,071	277	1,051	765
Total Tangier Sound Region	*14,889*	*38,618*	*11,281*	*6,518*	*16,169*	*53,893*
Patuxent R.	0	466	17,808	7,316	831	1,258
Wicomico R., St. Clement and Breton bays	13	18	1,414	80	698	808
St. Marys R. and Smith Cr.	0	91	1,863	2,069	1,252	1,643
Total Potomac Md. Tribs.	*13*	*109*	*3,277*	*2,149*	*1,950*	*2,451*
Total Maryland (bu.)[1]	**26,000**	**72,000**	**154,000**	**165,000**	**83,000**	**101,000**

[1] Includes harvests from unidentified regions.

Table 6 - Landings (continued).

Maryland Oyster Harvests (bu)						
Region/Tributary	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Upper Bay	8,723	6,310	297	19	45	606
Middle Bay	4,012	2,054	439	4,310	9,218	7,321
Lower Bay	14,927	2,759	2,249	8,134	13,670	12,298
Total Bay Mainstem	*27,662*	*11,123*	*2,985*	*12,463*	*22,933*	*20,224*
Chester R.	2,874	5,290	119	102	556	3,493
Eastern Bay	2,662	1,957	221	4,966	15,650	8,763
Miles R.	11	12	81	82	727	1,871
Wye R.	227	0	9	0	0	73
Total Eastern Bay Region	*2,900*	*1,969*	*311*	*5,048*	*16,377*	*10,707*
Upper Choptank R.	42	412	0	149	213	73
Middle Choptank R.	661	523	1,598	1,725	4,032	5,548
Lower Choptank R.	3,424	3,534	3,402	11,336	12,934	26,008
Tred Avon R.	0	68	402	1,095	2,038	2,850
Broad Cr.	5,328	7,646	11,382	72,643	76,125	62,436
Harris Cr.	1,227	191	100	3,043	3,353	8,112
Total Choptank R. Region	*10,682*	*12,374*	*16,884*	*89,991*	*98,695*	*105,028*
Little Choptank R.	923	0	568	1,216	2,137	5,044
Upper Tangier Sound	24,553	19,098	24,076	40,143	57,853	53,270
Lower Tangier Sound	61,771	27,849	29,578	38,802	45,301	25,660
Honga R.	24,696	10,213	10,391	20,182	24,594	22,122
Fishing Bay	14,949	10,174	13,852	51,038	61,909	39,054
Nanticoke R.	2,168	5,300	10,121	8,385	6,558	14,924
Wicomico R.	109	1,140	3,587	5,551	4,253	3,748
Manokin R.	888	1,477	1,731	84	1,863	3,158
Big Annemessex R.	0	1,036	546	79	730	576
Pocomoke Sound	1,165	855	3,859	35,193	33,343	18,262
Total Tangier Sound Region	*130,299*	*77,142*	*97,741*	*199,457*	*236,404*	*180,773*
Patuxent R.	3,456	6,535	8,419	13,764	19,984	45,781
Wicomico R., St. Clement and Breton bays	712	2,132	1,931	4,504	6,383	3,822
St. Marys R. and Smith Cr.	3,186	2,275	1,454	11,345	7,909	10,775
Total Potomac Md. Tribs.	*3,898*	*4,407*	*3,385*	*15,849*	*14,292*	*14,597*
Total Maryland (bu.)[1]	**185,245**	**123,613**	**137,317**	**341,232**	**416,578**	**388,658**

[1] Includes harvests from unidentified regions.

Table 6 - Landings (continued). Landing figures for the 2015-16 through 2021-22 seasons have been revised to reflect the most accurate data presently available.

Region/Tributary	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Upper Bay	3,637	4,657	2,603	794	48	69
Middle Bay	14,112	9,196	5,159	2,977	4,980	3,749
Middle Bay Tributaries	2,398	1,900	1,180	181	780	979
Lower Bay	4,285	4,314	9,187	11,073	13,447	8,577
Total Bay Mainstem	*24,432*	*20,067*	*18,129*	*15,024*	*19,255*	*13,374*
Chester R.	1,533	469	5,024	386	644	23
Eastern Bay	13,180	15,619	9,674	8,578	9,696	4,671
Miles R.	3,335	1,666	572	962	180	0
Wye R.	8	17	4	0	0	0
Total Eastern Bay Region	*16,523*	*17,302*	*10,250*	*9,540*	*9,876*	*4,671*
Upper Choptank R.	62	36	83	167	0	0
Middle Choptank R.	9,782	5,749	6,545	3,891	4,367	2,209
Lower Choptank R.	24,611	11,017	6,470	11,853	13,111	10,124
Tred Avon R.	3,901	2,431	889	2,730	631	375
Broad Cr.	68,039	32,075	32,575	32,359	39,984	34,000
Harris Cr.	7,028	2,663	3,631	5,220	6,508	3,248
Total Choptank R. Region	*113,423*	*53,971*	*50,192*	*56,220*	*64,600*	*49,956*
Little Choptank R.	1,937	2,020	445	222	9,909	8,684
Upper Tangier Sound	64,342	35,522	33,287	21,979	83,248	148,420
Lower Tangier Sound	28,461	9,471	7,277	2,790	7,522	29,462
Honga R.	13,285	11,164	2,116	818	2,788	7,678
Fishing Bay	20,258	13,637	7,503	5,748	23,329	33,621
Nanticoke R.	7,075	7,430	7,984	4,193	8,435	13,144
Wicomico R.	10,137	4,735	1,132	939	1,185	952
Manokin R.	1,409	1,054	1,843	1,029	407	20
Big Annemessex R.	4076	473	90	74	24	37
Pocomoke Sound	10,261	6,131	5,269	2,166	2,178	3,705
Total Tangier Sound Region	*159,303*	*89,616*	*66,501*	*39,735*	*129,115*	*237,038*
Patuxent R.	51,451	23,623	9,973	9,414	24,566	16,972
Wicomico R., St. Clement and Breton bays	5,608	3,452	893	1,166	356	231
St. Marys R. and Smith Cr.	10,574	7,974	19,224	12,283	11,684	13,167
Total Potomac Md. Tribs.	*16,182*	*11,426*	*20,117*	*13,449*	*12,040*	*13,398*
Total Maryland (bu.)[1]	***384782***	***218492***	***180629***	***143987***	***270003***	***344114***

[1] Includes harvests from unidentified regions.

Table 6 - Landings (continued). Landing figures for the 2015-16 through 2021-22 seasons have been revised to reflect the most accurate data presently available.

Region/Tributary	2021-22	*37-yr Avg*
Upper Bay	7,282	*11,492*
Middle Bay	1,545	*14,163*
Middle Bay Tributaries	889	*1,187*
Lower Bay	17,583	*6,600*
Total Bay Mainstem	*27,299*	*32,090*
Chester R.	856	*19,374*
Eastern Bay	3,181	*26,690*
Miles R.	3	*4,732*
Wye R.	0	*1,676*
Total Eastern Bay Region	*3,184*	*33,097*
Upper Choptank R.	0	*8,483*
Middle Choptank R.	2,518	*16,770*
Lower Choptank R.	6,722	*14,580*
Tred Avon R.	553	*9,769*
Broad Cr.	37,441	*23,091*
Harris Cr.	7,892	*7,658*
Total Choptank R. Region	*55,127*	*80,351*
Little Choptank R.	12,786	*11,079*
Upper Tangier Sound	213,858	*28,353*
Lower Tangier Sound	80,471	*16,048*
Honga R.	24,997	*7,986*
Fishing Bay	46,032	*16,059*
Nanticoke R.	22,043	*7,836*
Wicomico R.	1,646	*1,370*
Manokin R.	1,017	*3,133*
Big Annemessex R.	0	*223*
Pocomoke Sound	4,821	*5,131*
Total Tangier Sound Region	*394,884*	*86,136*
Patuxent R.	38,820	*13,737*
Wicomico R., St. Clement and Breton bays	4,697	*9,339*
St. Marys R. and Smith Cr.	8,004	*8,929*
Total Potomac Md. Tribs.	12,701	*18,249*
Total Maryland (bu.)[1]	***545,654***	***298,657***

[1] Includes harvests from unidentified regions.

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Table 7a. Bushels of oyster harvest by gear type in Maryland, 1989-90 through 2021-22 seasons as reported by seafood dealer buy tickets. Dockside value is in millions of dollars. Landing figures for the 2015-16 through 2021-22 seasons have been revised to reflect the most accurate data presently available.

Season	Hand Tongs	Diver	Patent Tongs	Power Dredge	Skipjack	*Total Harvest*[1]	*Dockside Value*
1989-90	309,723	47,861	31,307	11,424	14,007	*414,445*	*$ 9.9 M*
1990-91	219,510	74,333	105,825	4,080	14,555	*418,393*	*$ 9.4 M*
1991-92	124,038	53,232	108,123	6,344	31,165	*323,189*	*$ 6.4 M*
1992-93	71,929	24,968	18,074	1,997	8,821	*123,618*	*$ 2.6 M*
1993-94	47,309	19,589	11,644	787	133	*79,618*	*$ 1.4 M*
1994-95	99,853	29,073	31,388	1,816	2,410	*164,641*	*$ 3.2 M*
1995-96	115,677	25,657	46,040	6,347	7,630	*199,798*	*$ 3.2 M*
1996-97	130,861	16,780	15,716	8,448	6,088	*177,600*	*$ 3.8 M*
1997-98	191,079	37,477	30,340	14,937	10,543	*284,980*	*$ 5.7 M*
1998-99	294,342	58,837	36,151	25,541	8,773	*423,219*	*$ 7.8 M*
1999-2000	237,892	60,547	44,524	18,131	12,194	*380,675*	*$ 7.2 M*
2000-01	193,259	75,535	43,233	18,336	8,820	*347,968*	*$ 6.8 M*
2001-02	62,358	30,284	26,848	17,574	8,322	*148,155*	*$ 2.9 M*
2002-03	11,508	9,745	18,627	12,386	2,432	*55,840*	*$ 1.6 M*
2003-04	1,561	5,422	3,867	13,436	1,728	*26,471*	*$ 0.7 M*
2004-05	5,438	14,258	6,548	37,641	4,000	*72,218*	*$ 1.1 M*
2005-06	28,098	38,460	49,227	30,824	3,576	*154,436*	*$ 4.7 M*
2006-07	55,906	36,271	31,535	35,125	3,250	*165,059*	*$ 5.0 M*
2007-08	24,175	11,745	15,997	25,324	4,243	*82,958*	*$ 2.6 M*
2008-09	11,274	9,941	15,833	50,628	5,370	*101,141*	*$ 2.7 M*
2009-10	7,697	6,609	48,969	107,952	12,479	*185,245*	*$4.5 M*
2010-11	13,234	5,927	27,780	65,445	10,550	*123,613*	*$4.3 M*
2011-12	4,885	12,382	22,675	84,950	11,305	*137,317*	*$4.6M*
2012-13	53,622	8,107	48,095	212,837	18,471	*341,132*	*$10.9 M*
2013-14	67,093	21,510	75,937	242,964	9,074	*416,578*	*$14.1 M*
2014-15	57,289	25,126	98,187	154,716	33,518	*388,658*	*$17.1 M*
2015-16	78,720	37,237	102,974	125,498	38,477	*384,782*	*$14.9 M*
2016-17	45,089	22,027	53,032	79,924	17,451	*218,492*	*$10.3 M*
2017-18	37,323	22,511	31,154	77,874	11,099	*180,629*	*$8.6 M*
2018-19	35,832	11,461	20,953	63,479	12,243	*143,987*	*$6.5 M*
2019-20	43,953	19,708	69,480	111,888	24,925	*270,003*	*$12.2 M*
2020-21	39,110	14,548	102,402	148,236	39,733	*344,114*	*$10.5 M*
2021-22	45,071	15,237	176,875	261,049	47,404	*545,654*	*$21.5 M*

[1] Harvest reports without gear information were not included in harvest by gear type totals but were included in total harvest.

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Table 7b. Percent of oyster harvest by gear type in Maryland, 1989-90 through 2021-22 seasons as reported by seafood dealer buy tickets. Some years may not total 100% due to incomplete data. Percentages for the 2015-16 through 2021-22 seasons have been revised to reflect the most accurate data presently available.

Season	Hand Tongs	Diver	Patent Tongs	Power Dredge	Skipjack
1989-90	75	12	8	3	3
1990-91	52	18	25	1	3
1991-92	38	16	33	2	10
1992-93	57	20	14	2	7
1993-94	60	25	15	<1	<1
1994-95	61	18	19	1	1
1995-96	57	13	23	3	4
1996-97	74	9	9	5	3
1997-98	67	13	11	5	4
1998-99	69	14	9	6	2
1999-2000	62	16	12	5	3
2000-01	56	22	12	5	3
2001-02	41	20	18	12	6
2002-03	21	17	33	22	4
2003-04	6	20	15	51	7
2004-05	8	20	9	52	6
2005-06	18	25	32	20	2
2006-07	34	22	19	21	2
2007-08	29	14	19	30	5
2008-09	12	11	17	54	6
2009-10	4	4	26	58	7
2010-11	11	5	23	53	8
2011-12	4	9	17	62	8
2012-13	16	2	14	62	5
2013-14	16	5	18	58	2
2014-15	16	7	27	42	9
2015-16	20	10	27	33	10
2016-17	21	10	24	37	8
2017-18	21	12	17	43	6
2018-19	25	8	15	44	9
2019-20	16	7	26	41	9
2020-21	11	4	30	43	12
2021-22	8	3	32	48	9

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Table 8. Oyster bars within sanctuaries sampled during the 2022 Fall Survey. Newly added sanctuaries/survey stations are in *italics*.

Region	Oyster Sanctuary	Surveyed Bars Within Sanctuary
Upper Bay	Man O War/Gales Lump	Man O War Shoals, *Tea Table*
Middle Bay	Poplar Island	Poplar I.
	Herring Bay	Holland Pt.[1,2]
	Calvert Shore	Flag Pond[1,2]
Lower Bay	Lower Mainstem East	Northwest Middleground[3]
	Cedar Point	*Cedar Point Hollow Addition 1*
	Point Lookout	Pt. Lookout[3]
Chester River	Lower Chester River	Love Pt., Strong Bay, Wickes Beach
	Upper Chester River	Boathouse, Cliff, Drum Pt., Ebb Pt., Emory Hollow, Old Field[2], Sheep, Spaniard Pt.
	Chester ORA Zone A	Shippen Creek
Eastern Bay	Mill Hill	Mill Hill
	Prospect Bay	*Sawmill Creek*
	Cox Creek	Ringold Middleground
	Eastern Bay	*Tilghman Pt.*
Wye River	Wye River	Bruffs I.[1,2], Mills, Race Horse, Whetstone, Wye River Middleground
Miles River	Miles River	Long Pt.[2]
Choptank River	Cook Point	Cook Pt.[1,2]
	Lower Choptank River	Chlora Pt.
	Sandy Hill	Sandy Hill[1,2]
	Howell Point - Beacons	Beacons
	Upper Choptank River	Green Marsh[3], Shoal Creek, Bolingbroke Sand, The Black Buoy, Oyster Shell Pt. [2], Dixon, Mill Dam
	Choptank ORA Zone A	Tanners Patch, Cabin Creek, Drum Pt.
Harris Creek	Harris Creek	Change, Mill Pt.[1, 3], Seths Pt., Walnut, Little Neck, Rabbit I.[3]
Tred Avon River	Tred Avon River	Pecks Pt., Mares Pt., Louis Cove, Orem, Double Mills[1,2], Maxmore Add. 1
Little Choptank River	Little Choptank River	Little Pollard, Susquehanna, Cason[1,2], Butterpot, McKeils Pt., Grapevine, Town, Pattison
Hooper Straits	Hooper Straits	Applegarth, Lighthouse
Nanticoke River	Nanticoke River	Roaring Pt. East, Wilson Shoals[2], Bean Shoal, Cherry Tree, Cedar Shoal, Old Woman's Patch, Hickory Nut, Wetipquin[1]
Manokin River	Manokin River	Piney I. Swash, Mine Creek, Marshy I., Drum Pt. [1], Georges[1,2]
Tangier Sound	Somerset	Piney I. East Add. 1[3]
Magothy River	*Magothy River*	*Persimmon*
Severn River	Severn River	Chinks Pt.
South River	*South River*	*Almshouse*
Patuxent River	Upper Patuxent	Thomas, Broad Neck, Trent Hall, Buzzard I., Holland Pt.
	Neal Addition	Neale
	Lower Patuxent	*Millstone*
St. Marys River	St. Marys River	Pagan[1,2], Horseshoe
Breton Bay	Breton Bay	Black Walnut[1]

[1] Key Spat Bar [2] Disease/Biomass Index Bar [3] Supplemental Disease Bar

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Appendix 1
Hatchery Seed Plantings
Amy Larimer

Over 725 million hatchery spat-on-shell were planted on 41 oyster bars in the Maryland portion of Chesapeake Bay (Table A1-1) during 2022. The Fall Survey sampled 14 of these plantings (Figure A1-1). Most were entirely new locations on bars with other Fall Survey samples. Approximately 180 million hatchery seed were planted at sampled locations (Table A1-1), covering approximately 114 acres. The mean density of these plantings was 2.6 million spat per acre. All areas received diploid spat except Great Shoal in Wicomico River East and Nanticoke Middleground, where triploid spat were planted.

For most of the new stations, spat were counted and the number of spat per bushel was enumerated (Table A1-2). Approximately 50 spat at each station were measured, except for two of the Swan Point sites. Growth rate for spat was calculated in mm/day by dividing the mean size by the maximum days since planting.

The number of spat per bushel on these sites ranged from 268 to 2436, with a mean of 874 spat per bushel. The mean spat count was higher in 2022 than it was in either 2020 or 2021 (Table A1-3). Spat counts are generally a function of both the initial planting density as well as elapsed time. Shorter elapsed time in 2022 resulted in higher numbers of spat per bushel. Unlike 2020, spat did not appear to be unusually large at most locations. Spat sizes ranged from 3 to 64 mm shell height, with a mean of 31 mm, smaller than both 2020 and 2021 (means of 41.2 mm in 2020 and 35 mm in 2020). The maximum sizes from all plantings averaged 49 mm (compared to 60 mm for 2020 and 56 in 2021). The largest spat measured 64 mm, compared to 85 mm for 2020 and 88 for 2021.

The size distribution of measured spat was less variable than in past years, with median sizes generally between 30 and 40 mm, even for triploid spat (Figure A1-1). Although triploid spat at Great Shoal and Nanticoke Middleground exhibited higher growth rates, they were not markedly different from the other locations (Figure A1-2). The spat at Swan Point, located in the upper Chesapeake Bay, were considerably smaller than spat at other locations and had the slowest calculated growth rate. The highest growth rate occurred at Swan Point North, but these spat were not measured (the mean was estimated) and were not included in the figures.

In general, fewer days elapsed in 2022 between the planting of the spat and the Fall Survey sampling date than in past years (Table A1-3), averaging 83 days. No site was planted earlier than June 21, in contrast to 2020, when plantings began in April. The largest spat in 2022 were found on Chinks Point, in the Severn River, which was planted 113 days before the sample was taken.

Because some hatchery planting sites were sampled repeatedly, we can follow them over time. Table A1-4 lists the results in counts per bushel as well as sizes of spat, small- and market-sized oysters. In general, at least some of these plantings persisted until the oysters reached market size (76 mm) by the third year for diploid oysters. For triploid oysters (at Well Cove and Nanticoke Middleground bars), that interval was generally two years. Some sites were planted in both 2020 and 2021 (Bald Eagle Add 2, Bugby, Howells Point, Man O War Shoals, Swan Point, and Thunder and Lightning). In most cases, an effort was made to separate the oysters from different plantings, but this was not always possible (Bugby).

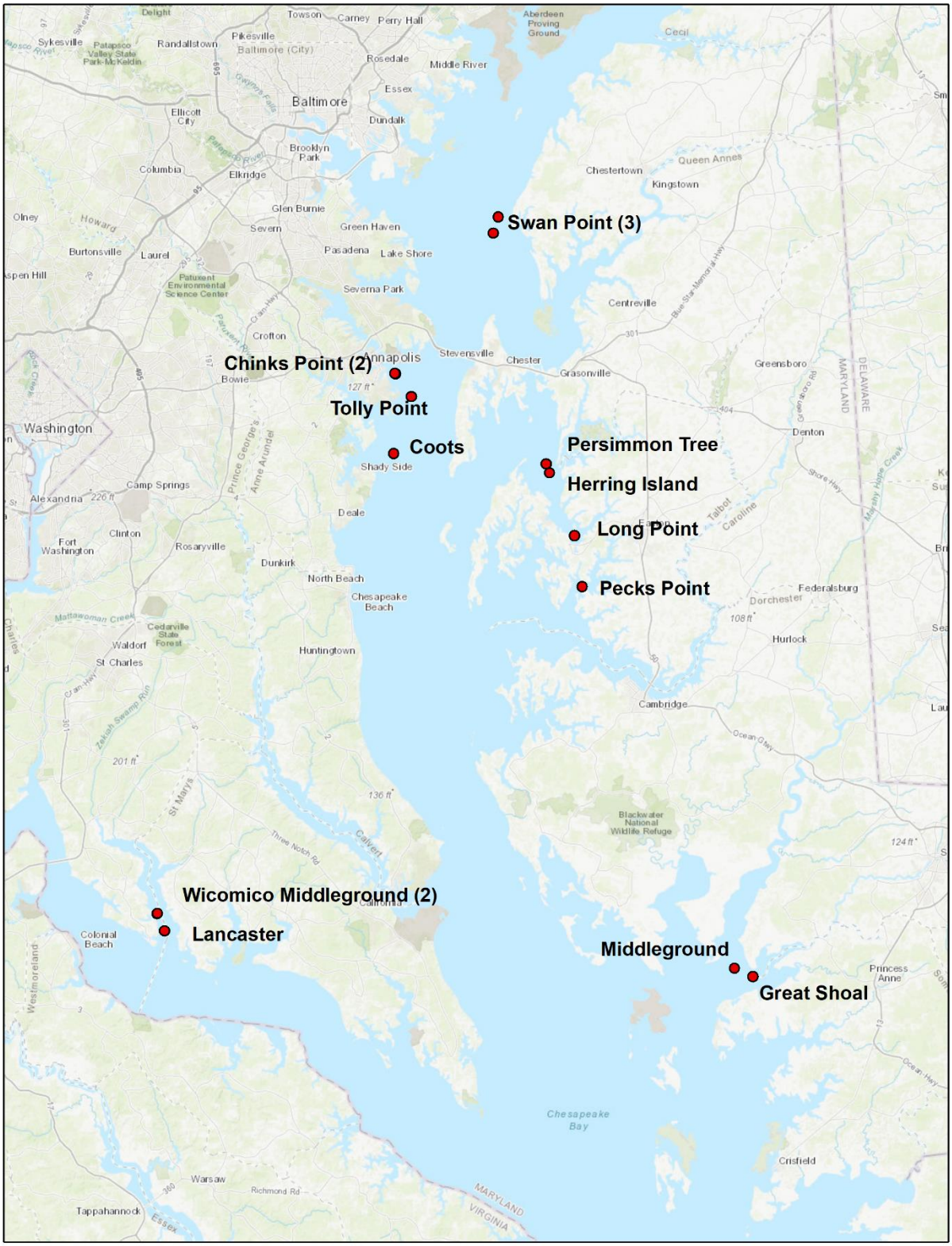

Figure A1-1. Map of 2022 hatchery plantings sampled during the Fall Survey

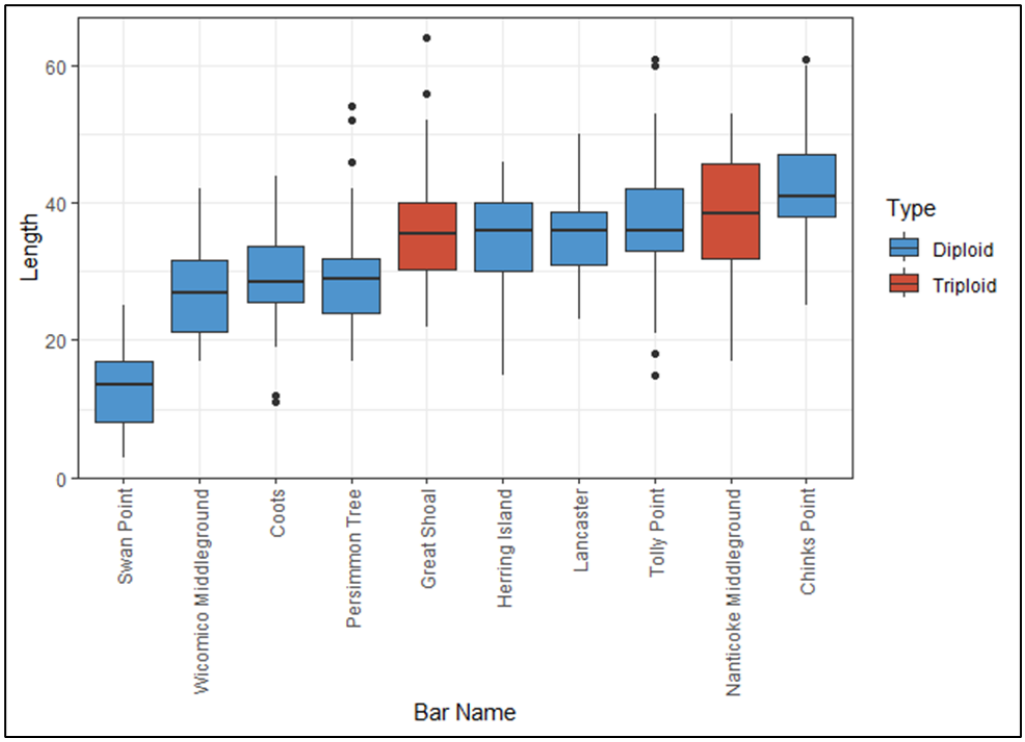

Figure A1-2. Size distribution of spat for Fall Survey planting sites, 2022. Stations in red were planted with triploid spat. Stations in blue were planted with diploid spat.

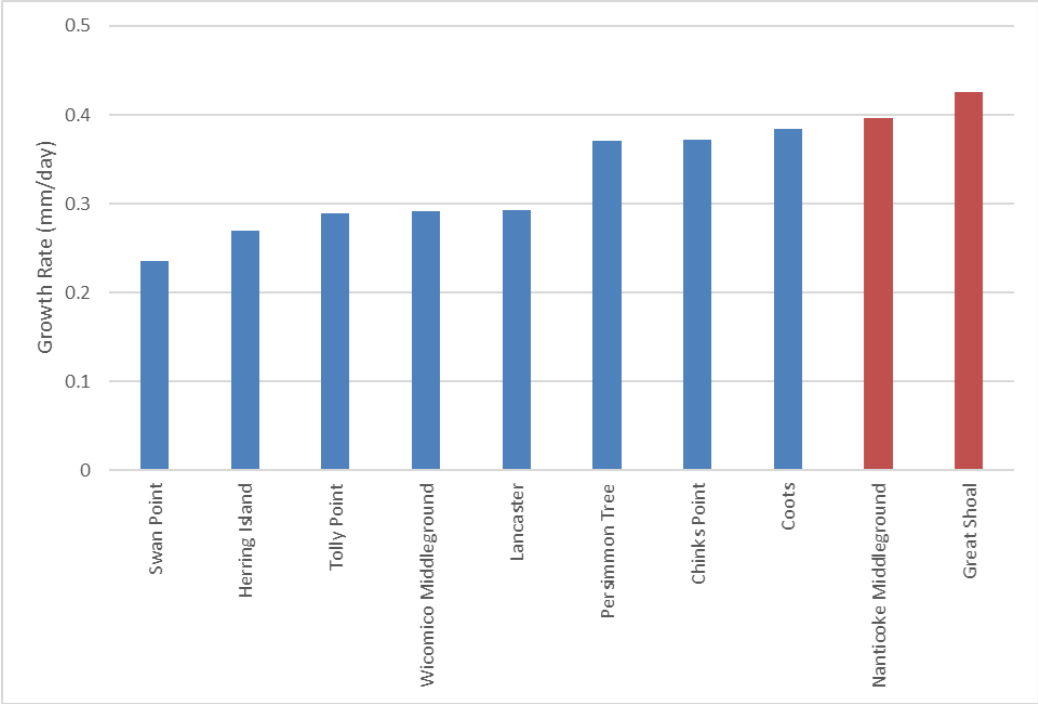

Figure A1-3. Growth rates of measured spat in hatchery plantings at Fall Survey sites in 2023. Locations in red received triploid spat, while those in blue received diploid spat.

Table A1-1. 2022 Hatchery seed plantings on Fall Survey bars. Sites with Fall Survey samples are in bold. Number in parentheses is the total number of sites.

[1]Spat were measured at only one of the locations.

Region	Barname	Area (acres)	Number Spat (millions)	Density Spat (Millions/acre)
Choptank River	Dickinson	2.86	10.14	3.55
Eastern Bay	Bald Eagle Add 2	5.63	8.44	1.50
	Bald Eagle Add 3	3.56	6.33	1.78
	Bugby	2.39	8.99	3.76
	Hood	2.12	13.36	6.30
	Lows Point	0.44	5.25	11.82
	Tilghmans Point	13.39	74.72	5.58
	Well Cove	2.10	3.48	1.66
Little Choptank River	Butterpot	2.45	7.71	3.15
	Cason	3.42	14.61	4.27
	Little Pollard	2.41	7.79	3.24
	Mckeils Point	4.26	16.63	3.90
	Susquehanna	23.37	27.80	1.19
Manokin River	Town	0.98	2.00	2.04
	Drum Point	8.59	59.23	6.90
	Georges	3.53	18.56	5.26
	Marshy Island	17.72	93.47	5.28
Mid-Bay West	**Coots**	**2.00**	**4.71**	**2.35**
	Tolly Point	**19.65**	**34.56**	**1.76**
Miles River	Coffee	0.14	1.00	7.20
	Herring Island	**3.31**	**11.65**	**3.52**
	Persimmon Tree	**0.98**	**7.06**	**7.20**
Nanticoke River	**Middleground**	**12.43**	**16.95**	**1.36**
Potomac River	Knotts Hollow	6.10	27.00	4.43
Severn River	**Chinks Point (2)**	**6.58**	**40.98**	**6.23**
South River	Rock Point	1.06	4.70	4.45
St. Marys River	Horseshoe Bend	0.13	0.96	7.36
	Pagan	0.16	0.41	2.53
Tred Avon River	Double Mills	2.66	16.64	6.26
	Louis Cove	10.06	46.18	4.59
	Mares Point	0.56	2.33	4.17
	Orem	0.45	4.63	10.33
	Pecks Point	10.83	46.71	4.31
Upper Bay East	**Swan Point (3)[1]**	**34.35**	**22.47**	**0.65**
Wicomico River East	Evans	1.96	4.08	2.08
	Great Shoal	**13.17**	**26.45**	**2.01**
Wicomico River West	**Lancaster**	**7.25**	**5.24**	**0.72**
	Manahowic Creek	5.55	5.69	1.02
	Mills East	2.59	6.42	2.48
	Rock Point	2.72	1.97	0.72
	Wicomico Middleground (2)	**14.47**	**7.75**	**0.54**
Grand Total		258.37	725.03	2.81

Table A1-2. Fall Survey sites on hatchery seed plantings for 2022, including counts, sizes, elapsed time since planting, daily growth rates, and averages for those values.

[1] Spat were not measured; average was estimated.

Region	Bar Name	# Spat	Min. Size (mm)	Max. Size (mm)	Avg Spat Size (mm)	Max # Days from Planting	Growth rate (mm/day)
Mid-Bay West	Coots	2436	11	44	29.2	76	0.38
	Tolly Point	1765	15	61	37.06	128	0.29
Miles River	Herring Island	750	15	46	34.8	129	0.27
	Persimmon Tree	1740	17	54	29.68	80	0.37
Nanticoke River	Middleground	505	17	53	38.46	97	0.40
Severn River	Chinks Point (2)	1000	25	61	42.06	113	0.37
Upper Bay East	Swan Point	268	3	25	12.96	55	0.24
	Swan Point North (2)[1]	698	8	42	30	64	0.46
Wicomico River E.	Great Shoal	1505	22	64	35.8	84	0.43
Wicomico River W.	Lancaster	364	23	50	35.4	121	0.29
	Wicomico Middleground (2)	606	17	42	27.44	94	0.29
Averages		874	16	49.3	32.1	94.7	0.34

Table A1-3. Comparison of sizes and time elapsed between the planting date and sampling data for 2020-2022.

	2020	2021	2022
Min. Size	22 mm	18 mm	16 mm
Mean Size	41 mm	35 mm	32 mm
Max. Size	60 mm	56 mm	49 mm
Min. Days Since Planting	72	42	21
Mean Days Since Planting	132	108	83
Max Days Since Planting	181	161	129
Min. Spat per Bushel	26	32	268
Mean Spat per Bushel	299	680	874
Max. Spat per Bushel	1288	4068	2436

Table A1-4. Hatchery planting results for Fall Survey sites from 2020-2022. All counts are in number per bushel and the final three columns are minimum and maximum sizes with average or typical in parentheses. *A mix of spat planted in 2021 and smalls from the 2020 planting.

Region	Bar Name	Year	Spat/Bu	Small/Bu	Market/Bu	Spat (mm)	Small (mm)	Market (mm)
Chester River	Durdin	2020	52			17-63 (43)		
		2021		80	36		45-152 (113)	
		2022		4	38		44-53 (48.5)	85-152(100)
	Piney Point	2020	54			31-70 (46)		
		2021		28	38		40-74 (63)	85-106(95)
		2022		4	4		62-73(67.5)	81-105(93)
Choptank River	Coots	2020	290			22-52 (36)		
		2021		28	76		53-75 (63)	76-116 (90)
		2022		114	42		44-75 (60)	80-123 (93)
	Howells Point	2020	286			35-74 (51)		
		2021	186	122	30	16-57 (36)	39-72 (59)	76-105 (86)
		2022		122	76		35-75 (60)	76-132 (103)
	Howells Point Add 2	2020	358			17-58 (42)		
		2021		26	38		48-75 (57)	83-126 (93)
		2022		74	36		52-74 (63)	76-105 (90)
Eastern Bay	Bald Eagle Add 2	2020	658			24-53 (43)		
		2021	524	12	24	31-88 (56)	50-68 (61)	76-102 (83)
	Bugby	2020	152			10-31 (27)		
		2021	318*			15-67 (52)		
		2022		36	76		46-70 (60)	80-120 (90)
	Crab Alley Lumps	2020	52			23-50 (43)		
		2021		202	18		40-75 (62)	76-84 (79)
		2022		58	14		35-75 (55)	76-95 (78)
	Well Cove	2020	110			38-85 (59)		
		2021		30	146		60-75 (70.5)	76-130 (92)
		2022			112			103-150 (105)
Lower Bay East	Punch Island Creek	2020	1288			17-58 (36)		
		2021		160	120		52-74 (65)	76-123 (89)
		2022		16	108		55-75 (65)	76-125 (98)
Mid-Bay West	Coots	2020	226			28-63 (45)		
		2021		30	24		51-74 (65)	76-104 (90)
	Hackett Point	2020	856			16-53 (35)		
		2021		154	10		33-74 (60)	78-95 (86)
		2022		12	18		51-75 (69)	83-117 (97)
	Tolly Point	2020	368			15-55 (36)		
		2021		110			35-75 (57)	
Nanticoke River	Middleground	2020		282			22-75 (51)	
		2021			104			76-140 (95)
	Middleground 1	2021	626			4-39 (21)		
		2022		125	62		37-75 (72)	78-104 (91)
	Middleground 2	2021	4068			6-55 (38)		
		2022		90	58		42-75 (70)	78-117 (89)

Table A1-4 (cont'd)

Region	Bar Name	Year	Spat/Bu	Small/Bu	Market/Bu	Spat (mm)	Small (mm)	Market (mm)
South River	Outer Round Point	2020	550			18-60 (36)		
		2021		105	153		54-74 (66)	76-116 (87)
		2022		44	168		60-75 (72)	76-137 (95)
	Thunder and Lightning	2021	852			23-52 (39)		
		2021	260					
		2022		404	64		45-75 (64)	76-148 (88)
Tred Avon River	Mares Point	2020	1150			21-65 (45)		
		2021	24	266	30			
		2022		122	146		40-75 (70)	76-127 (105)
	Town Point/Ferry Bar	2020	194			20-66 (37)		
		2021		252	50		33-75 (60)	76-125 (85)
		2022		158	116		44-75 (70)	76-114 (85)
Upper Bay East	Swan Point North	2020	520			21-66 (45)		
		2021	406	236	40	17-42 (25)	28-75 (65)	79-131 (95)
		2022	324	138	32	8-42 (30)	40-75 (65)	76-120 (85)
	Swan Point North (Peach Orchard)	2020	254			21-64 (43)		
		2021	316	102	2	11-38 (27)	30-75 (52.5)	
		2022	374	32	92	11-40 (30)	33-75 (65)	77-117 (93)
	Swan Point KB/DB	2020	59			22-51 (38)		
		2021		17	83		44-75 (61)	76-146 (93)
		2022		8	51		50-74 (64.5)	76-148 (103)
	Swan Point/Peach Orchard S	2020	94			12-55 (33)		
		2021	410	70		19-40 (29)	42-70 (57)	
Upper Bay West	Man O War Shoals	2020	168			27-66 (40)		
		2021	100	70		17-40 (25)	29-75 (49)	
		2022		102	16		43-75 (65)	77-139 (88)
Wicomico River East	Evans	2020	70			26-65 (45)		
		2021		64	108		44-75 (70)	77-141 (90)
		2022		18	112		41-75 (70)	83-135 (107)
Wicomico River West	White Point	2020	226			22-44 (35)		
		2021		358	42		46-73 (59)	78-100 (89)
		2022		86	104		48-75 (67)	76-103 (84)

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APPENDIX 2
Oyster Host & Oyster Pathogens

Chris Dungan, revised by Carol McCullough 2 July 2021

Oysters

The eastern oyster *Crassostrea virginica* is found in waters with temperatures of -2°C to 36°C and sustained salinities of 4 to 40‰, where ocean water salinity is 35‰. Oysters reproduce (spawn) when both sexes simultaneously release gametes. Spawning in Chesapeake Bay occurs from May-September, and peaks during June-July. Externally fertilized eggs develop into swimming planktonic larvae. These are transported by water currents for 2-3 weeks while feeding on phytoplankton as they grow and develop. Mature larvae attach to solid benthic substrates, preferably oyster shells, and metamorphose to become sessile juvenile oysters. Unlike fishes and other vertebrates, oysters do not regulate the salt content of their tissues. Instead, oyster tissues conform to the broad and variable range of salinities that are found in oyster habitats. Thus, oyster parasites with narrow salinity requirements may be exposed to adverse salinities, inhibiting their virulence and reducing prevalences to the point of being eliminated altogether. At death, oyster shells (valves) passively open, exposing the soft tissues to predators and scavengers. However, the resilient hinge ligament holds the articulated valves together for months after death. Empty, articulated oyster shells (boxes) in survey samples are interpreted to represent oysters that died during the previous year. In dredge samples the numbers of dead and dying (gaper) oysters are compared to those of live oysters to estimate natural mortalities.

Dermo disease

Although the protozoan parasite that causes dermo disease is now known as *Perkinsus marinus*, it was first described in Gulf of Mexico oysters and named *Dermocystidium marinum* (Mackin, Owen & Collier 1950), colloquially abbreviated then as ‘dermo’. Almost immediately, dermo disease was also reported in Chesapeake Bay (Mackin 1951). *Perkinsus marinus* is transmitted through the water to nearby uninfected oysters in as few as three days, and across distances as much as five kilometers from infected populations. Heavily infected oysters are emaciated; showing reduced growth and reproduction (Ray & Chandler 1955, McCollough et al. 2007). Although *P. marinus* survives low temperatures and low salinities, it multiplies most rapidly in the broad range of temperatures (20-35°C) and salinities (10-30‰) that are typical of Chesapeake Bay waters during oyster dermo disease mortality peaks (Dungan & Hamilton 1995). Over several years of drought during the 1980s, *P. marinus* expanded its Chesapeake Bay distribution into upstream areas where it had been previously rare or absent (Burreson & Ragone Calvo 1996, Carnegie et al. 2021). Between 1990 and 2018, at least some oysters in 91-100% of all regularly tested Maryland populations have been infected. During 2019, the percentage of infected bars dropped to a 30-year low of 88%. Annual mean prevalences for dermo disease have ranged at 27-94% of all tested oysters, with a 30-year average of 64%.

MSX disease

The high-salinity protozoan oyster pathogen *Haplosporidium nelsoni* was first detected and described as a *multinucleated sphere unknown* (MSX) from diseased and dying Delaware Bay oysters during 1957 (Haskin et al. 1966). It also infected oysters in lower Chesapeake Bay during 1959 (Andrews 1968). The common location of lightest *H. nelsoni* infections is in oyster gill tissues. Although this suggests waterborne transmission of infectious pathogen cells, the complete life cycle and actual infection mechanism of the MSX parasite remain unknown.

Despite numerous experimental attempts, MSX disease has rarely been transmitted to uninfected oysters in laboratories. However, captive experimental oysters reared in enzootic waters with salinity above 14‰ are frequently infected, and may die within 3-6 weeks. In Chesapeake Bay, MSX disease is most active in higher salinity waters with temperatures of 5-20°C (Ewart & Ford 1993). MSX disease prevalences typically peak during June, and deaths from such infections peak during August. In Maryland waters, annual average prevalences for MSX disease have ranged at 0.07-28%, with a 30-year average of 5.8%.

Since MSX disease is rare in oysters from waters with salinity below 10‰, the distribution of *H. nelsoni* in Chesapeake Bay varies as salinity changes with variable freshwater inflow. During an extended drought of 1999-2002, consistently low freshwater inflows raised salinities of Chesapeake Bay waters, which fostered upstream range expansions by MSX disease during each successive drought year (Tarnowski 2003). The geographic range for MSX disease also expanded widely during recent epizootics of 2009 and of 2014-2016. During 2003-2008, 2010-2012, and 2017-2018, freshwater inflows near or above historic averages reduced salinities of upstream Chesapeake Bay waters, and dramatically restricted the geographic range and effects of MSX disease (Tarnowski 2018). During 2018, low water salinities reduced the distribution and the mean prevalence of MSX disease to historic minima.

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APPENDIX 3
GLOSSARY

box oyster — Pairs of empty shells joined together by their hinge ligaments. These remain connected for months after the death of an oyster, providing a durable estimator of recent oyster mortality (see **gaper**). **Recent boxes** are those with no or little fouling or sedimentation inside the shells, generally considered to have died within the previous two to four weeks. **Old boxes** have heavier fouling or sedimentation inside the shells and the hinge ligament is generally weaker.

bushel — Unit of volume used to measure oyster catches. The official Maryland bushel is equal to 2,800.9 cu. in., or 1.0194 times the U.S. standard bushel (heaped) and 1.3025 times the U.S. standard bushel (level).

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cultch — Hard substrate, such as oyster shells, spread on oyster grounds or used in hatcheries for the attachment of spat.

dermo disease — The oyster disease caused by the protozoan pathogen *Perkinsus marinus.*

disease resistance/ tolerance — Disease **resistance** is the ability of the oyster to prevent infection. Disease **tolerance** is the maintenance of relatively normal function (growth, reproduction, survival) despite the presence of disease in the animal.

dredged shell — Oyster shell dredged from buried ancient (3000+ years old) shell deposits. Since 1960 this shell has been the backbone of the Maryland shell planting efforts to produce seed oysters and restore oyster bars.

fresh shell — Oyster shells from shucked oysters. It is used to supplement the dredged shell plantings.

gaper — Dead or moribund oyster with gaping valves and tissue still present (see **box oyster**).

Haplosporidium nelsoni — The protozoan oyster parasite that causes MSX disease.

infection intensity, individual — *Perkinsus* sp. parasite burdens of individual oysters, estimated by RFTM assays and categorized on a 0-7 scale. Uninfected oysters are ranked 0, heaviest infections are ranked 7, and intermediate-intensity infections are ranked 1-6. Oysters with infection intensities of 5 or greater are predicted to die within a short time.

infection intensity, mean sample — Averaged categorical infection intensity for all oysters in a sample:

sum of all categorical infection intensities (0-7) ÷ number of sample oysters

Oyster populations whose samples have mean infection intensities of 3.0 or greater are predicted to have significant near-term mortalities.

infection intensity, annual — Average of mean intensities for annual survey samples from constant mean sites:

sum of all sample mean intensities ÷ number of annual samples

intensity index, sample Infection intensities averaged only for infected oysters:
sum of individual infection intensities(1-7) ÷ number of infected oysters

intensity index, annual Infection intensities averaged for all infected survey oysters:
sum of all sample intensity indices ÷ number of annual samples

market oyster An oyster measuring 3 inches (76 mm) or more from hinge to bill (ventral margin).

MSX disease The oyster disease caused by the protozoan pathogen *Haplosporidium nelsoni.*

MSX % frequency, annual Percent proportion of sampled populations infected by *H. nelsoni* (MSX):
100 x (number of sample with MSX infections ÷ total sample number)

observed mortality, sample Percent proportion of annual, natural oyster population mortality estimated by dividing the number of dead oysters (boxes and gapers) by the sum of live and dead oysters in a sample:
100 x [number of boxes and gapers ÷ (number of boxes and gapers + number of live)]

observed mortality, annual Percent proportion of annual, bay-wide, natural oyster mortality estimated by averaging population mortality estimates from the 43 Disease Bar (DB) samples collected during an annual survey:
sum of sample mortality estimates ÷ 43 DB samples

Perkinsus marinus The protozoan oyster parasite that causes dermo disease.

prevalence, sample Percent proportion of infected oysters in a sample:
100 x (number infected ÷ number examined)

prevalence, mean annual Percent proportion of infected oysters in an annual survey:
sum of sample percent prevalences ÷ number of samples

RFTM assay Ray's fluid thioglycollate medium assay. Method for enlargement, detection, and counting of *Perkinsus marinus* cells in oyster tissue samples. This diagnostic assay for dermo disease has been widely used and refined for over sixty years to date.

seed oysters Young oysters produced by providing shell as a substrate for oyster larvae to settle on, either naturally or in a hatchery. The seed oysters are subsequently transplanted to growout (seed planting and sanctuary) areas.

small oyster An oyster equal to or greater than one year old but less than 3 inches (see market oyster, spat).

spat Oysters younger than one year old.

spatfall, spatset, set The process by which swimming oyster larvae attach to a hard substrate such as oyster shell. During this process the larvae undergo metamorphosis, adopting the adult form and habit.

spatfall intensity, sample site The number of spat per bushel of cultch. This is a relative measure of oyster spat density at a specific location, which may be used to calculate the annual spatfall intensity index.

spatfall intensity index The arithmetic mean of spatfall intensities from 53 fixed reference sites or Key Bars:

sum of Key Bar spatfall intensities ÷ number of Key Bars

spatfall intensity index, annual median The median of spatfall intensities from 53 fixed reference sites (Key Bars).

spatfall intensity index, long-term median The median of the spatfall intensity indices over the time series.

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Appendix 4
Fall Oyster Survey Site Evaluation and Recommendations

Amy Larimer

The Department is legally required to review the status of the oyster stock every two years. The annual Fall Oyster Survey provides much of the data used in the stock assessment. This mandate, along with the requirement that the Oyster Advisory Committee should identify management actions to increase oyster abundance, prompted this review of Fall Survey sampling coverage in oyster sanctuaries and public fishery areas. Ideally, all sanctuaries and NOAA codes (public fishery areas) would all have at least one sample in it, but this is not possible for a variety of reasons. Some sanctuaries lack adequate oyster habitat for sampling; others might have numerous leases (where sampling is not permitted). In other cases, restoration with certain reef-building materials makes sampling with current gear impossible. Similarly, not all NOAA Codes contain adequate area for sampling in the public fishery areas. Some are almost entirely sanctuary (Wye River, for example) or occupied by active oyster leases (West and Rhode Rivers).

This review was to evaluate Fall Survey sites sampled yearly and recommend changes to sanctuaries or NOAA codes to improve data collection in those areas for the oyster stock assessment (Table A4-1). Of the sixteen sites that were proposed, a total of ten of those were added to the Fall Survey in 2022. Two sites were not added to the Fall Survey (Buoy Bar in Monie Bay, Bluff Point in Wicomico River West) because there is very little oyster habitat in those locations. One site (Tedious Creek in Fishing Bay) was removed because of a lease that occupies most of the bar. A second permanent site (outside of the spat Key Bar) was not added because that bar is sampled heavily at hatchery planting sites. No changes were made at the final two locations.

Table A4-1. Proposed changes to NOAA Codes and Sanctuaries. Yellow highlights are new sites for 2022.

NOAA Code	Name	Sanctuary Name	Change
025	Upper Bay	Man O War/Gales Lump	Added one site on Tea Table bar
027	Mid-Bay	Tilghman Island Sanctuary	Added one site on Pone bar (not sampled in 2022)
039	Eastern Bay	Cox Creek Sanctuary	Site on Ringgold Middleground has been done for the past four years.
		Eastern Bay Sanctuary	Added one site on Tilghman Point
		Prospect Bay Sanctuary	Added one site on Sawmill Creek
043	Fishing Bay		Tedious Creek site on a lease, which covers most of the bar. Removed.
055	Magothy River	Magothy River Sanctuary	Added one site on Persimmon bar
057	Manokin River		Added one site on Cow Pen in the NOAA code outside sanctuary
060	Miles River	Miles River Sanctuary	Second site sampled for three consecutive years.
062	Nanticoke River		Make permanent one site on Middleground outside the sanctuary. Not added
088	South River	South River Sanctuary	Added one site on Almshouse bar
098	Monie Bay		Add one site in the NOAA code on Buoy bar. Not added.
168	Lower Patuxent River	Lower Patuxent Sanctuary	Added one site on Millstone bar
229	Lower Chesapeake Bay, W. of Channel	Cedar Point Sanctuary	Added one site on Cedar Point Hollow Add. 1
268	Middle Patuxent River		Added one site to Peterson bar
274	Wicomico River W.	Wicomico River Sanctuary	Add one site on Bluff Point in sanctuary, dependent on September 2022 patent tong survey results. Not added.

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