Maryland Oyster Population Summary Status Report

2005 Fall Survey

DREDGING UNDER THE ICE.

Prepared by Mitchell Tarnowski
And the Staff of the Maryland Department of Natural Resources
Shellfish Program and Cooperative Oxford Laboratory
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FOR MORE INFORMATION PLEASE CONTACT

Maryland Department of Natural Resources
Fisheries Service
Tawes State Office Building
580 Taylor Avenue
Annapolis, MD 21401
1-800-688-FINS • 410-260-8258

MDNR GENERAL INFORMATION
1-877-620-8DNR
www.dnr.state.md.us
Fisheries Service Ext. - 8258

Robert L. Ehrlich, Jr., Governor
Michael S. Steele, Lt. Governor
C. Ronald Franks, Secretary, DNR

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

CONTRIBUTORS

Editor

Shellfish Program, MDNR

Mitchell Tarnowski, Shellfish Biologist

Technical Participants

Lead Scientist

Shellfish Program, MDNR

Mitchell Tarnowski, Shellfish Biologist

Field Operations

Deal Island Work Center, Shellfish Program, MDNR

John Hess, Manager
Mickey Astarb, Biologist
Stanley Daniels, Repletion Manager
David White, Captain R/V *Miss Kay*

Shellfish Program, MDNR

Robert Bussell, Biologist

Parasite Diagnostic Testing

Cooperative Oxford Laboratory, MDNR

Carol B. McCollough, Pathologist
Rosalee Hamilton, Managing Histologist
Jud Blazek, Histotechnician
Donna Real, Histotechnician
Stuart Lehmann, Histotechnician
Suzanne Tyler, Histotechnician

Data Management

Cooperative Oxford Laboratory, MDNR

Kelly Greenhawk, Programmer Analyst

Statistical Analyses

Shellfish Program, MDNR

Dr. Mark Homer, Research Statistician

Graphics

Shellfish Program, MDNR

Robert Bussell, Biologist

Streamflow Data

U.S. Geological Survey

Wendy McPherson, Hydrologist

Text

Shellfish Program, MDNR

Mitchell Tarnowski, Shellfish Biologist

Reviewers

Cooperative Oxford Laboratory, MDNR

Christopher Dungan, Research Scientist
Carol B. McCollough, Pathologist

Shellfish Program, MDNR

Christopher Judy, Director
Dr. Mark Homer, Research Statistician

2005 MARYLAND OYSTER POPULATION SURVEY

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2005 MARYLAND OYSTER POPULATION SURVEY

SUMMARY of RESULTS

INTRODUCTION

This document presents the results of the Maryland Department of Natural Resources (MDNR) 2005 Fall Oyster Survey in an abbreviated version. As in earlier reports, the complete set of figures and tables are provided for comparison with previous years. For a general overview of the project, a description of the methods employed, and a discussion of the results, see Tarnowski (2005).

The dredge-based survey was conducted by MDNR Shellfish Program staff between early October and early December. Table 1 lists the field data collected during the survey. Oyster parasite diagnostic tests were performed by MDNR staff of the Cooperative Oxford Laboratory (COL). A total of 385 samples were obtained to examine 268 natural oyster bars, including Key Bar and Disease Bar sites, as well as contemporary seed oyster planting sites, shell planting locations, and seed production areas (Figure 1a. and Figure1b.). Data on seed and shell plantings are provided in Hess (2005).

MDNR oyster survey vessel *Miss Kay*. *(M. Homer photo)*

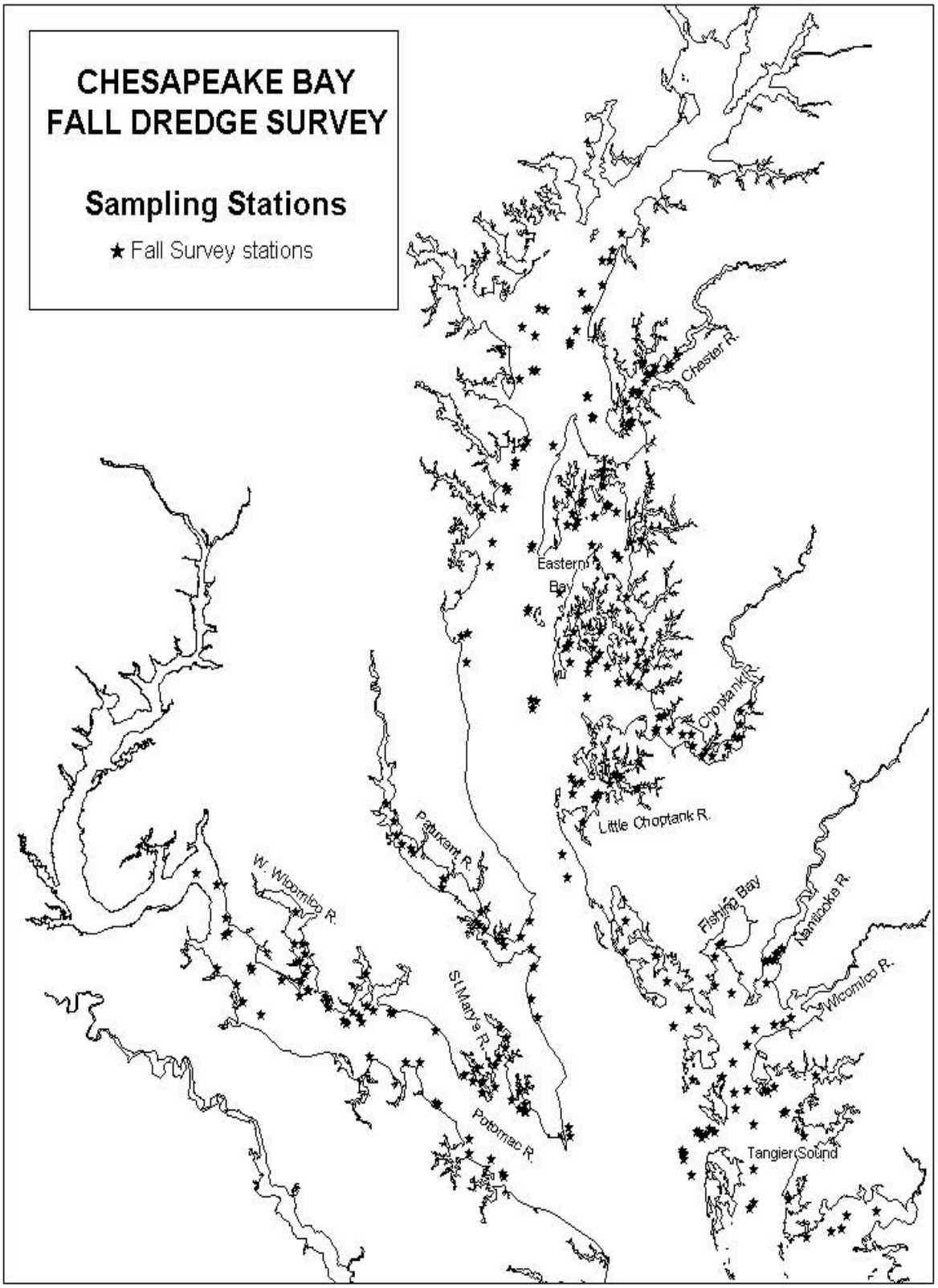

Figure 1a. Annual Maryland Fall Oyster Survey station locations, all bar types (standard, Key, Disease) included.

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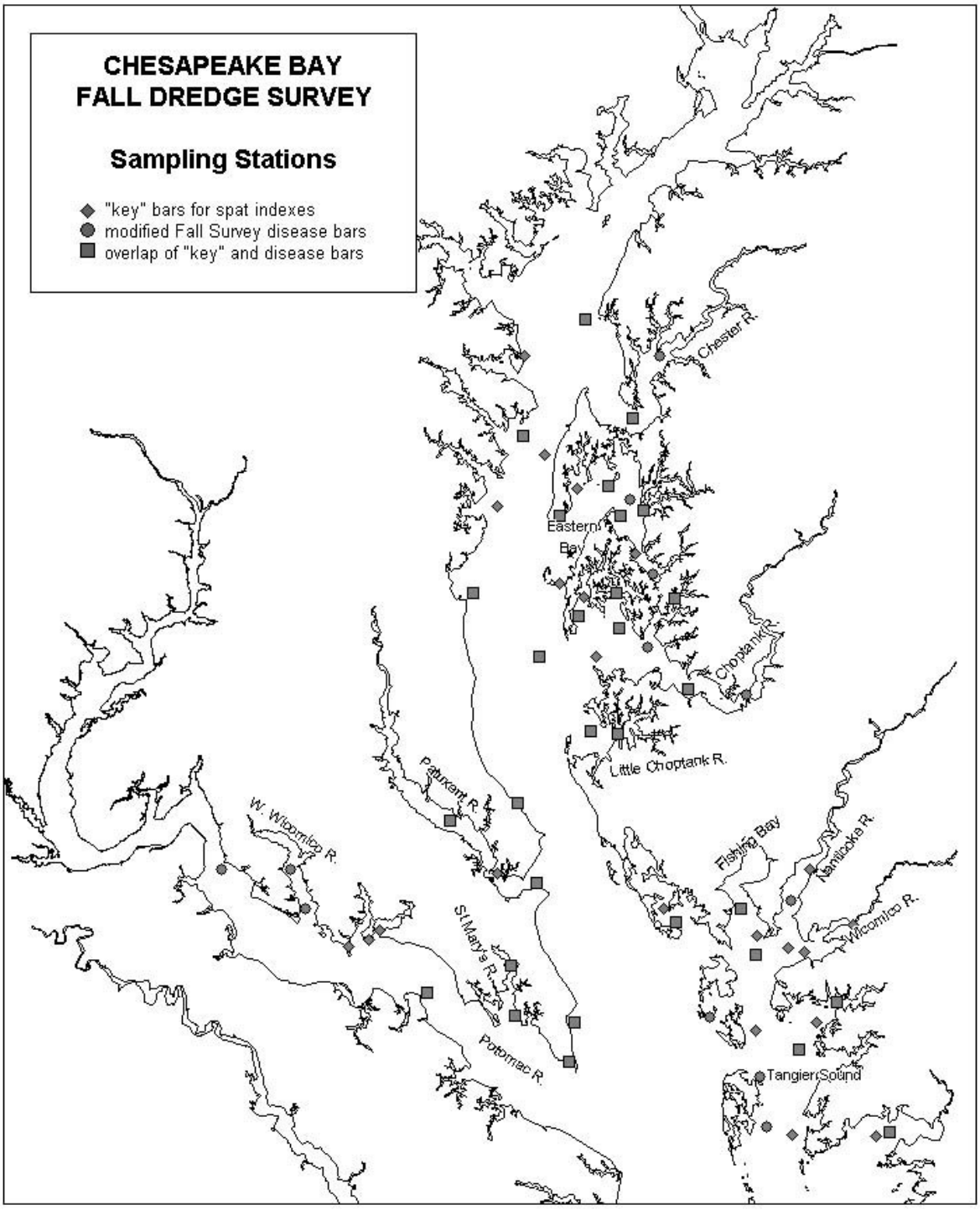

Figure 1b. Annual Maryland Fall Oyster Survey station locations for Key and Disease bars.

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FRESHWATER DISCHARGE CONDITIONS

Freshwater flow into Chesapeake Bay affects salinity, which is a key factor influencing oyster spatfall, disease, and mortality. Streamflows were about average during 2005 (Sec. "C" in Bue 1968; USGS 2006), in contrast to the wide fluctuations between wet and dry years[1] over the past decade and a half (Figure 2). This return to within the normal range of streamflow came after six years of particularly extreme conditions, during which a severe drought during 1999-2002 was followed in 2003-2004 by the second and third highest freshwater discharges over the past two decades.

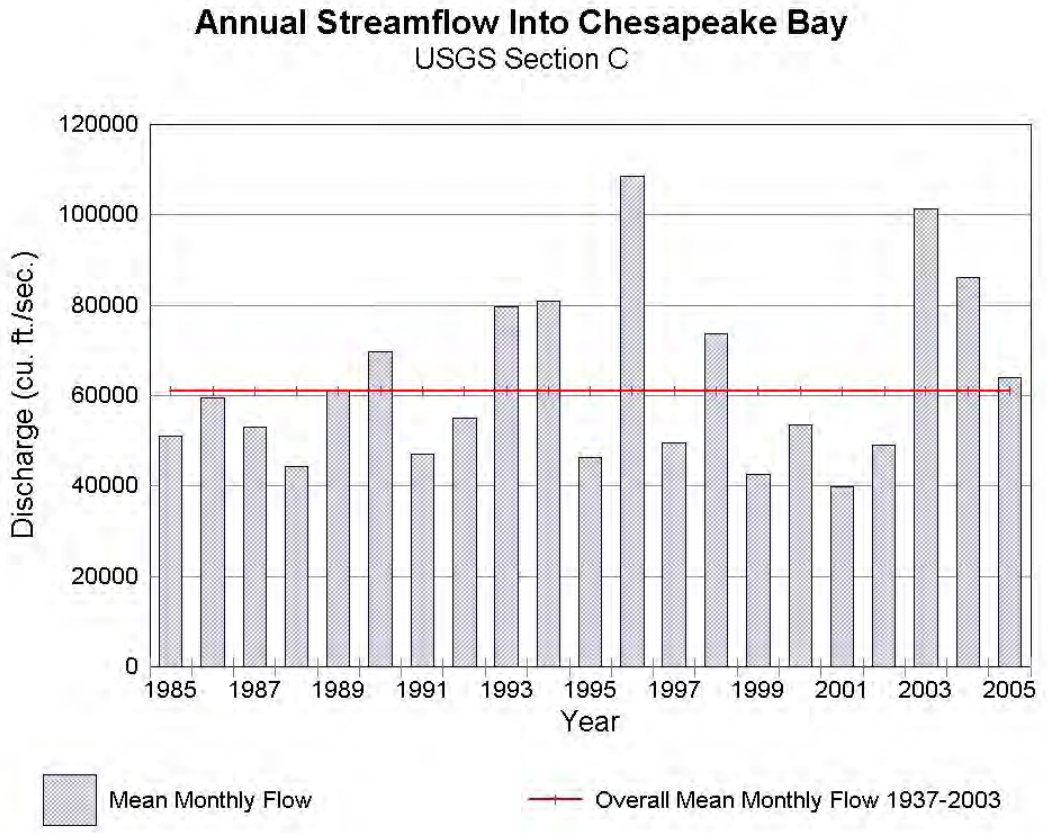

Figure 2. Mean monthly freshwater flow into Chesapeake Bay. Section C: all Maryland tributaries and the Potomac River.

[1] Categorized by the U.S. Geological Survey as freshwater flows above the 75th percentile or below the 25th percentile of mean monthly flows for the 1937-2003 period, respectively.

SPATFALL INTENSITY

Maryland oyster spatfall in 2005 remained extremely poor for the third consecutive year (Table 2). The spatfall intensity index was well below the 21-year average, ranking 2005 in the lowest statistical tier (grouping) for that time period (Figure 3). The distribution of highest spatfall, as number of spat per bushel of shell, was confined primarily to Tangier Sound and adjacent waters (Figure 4); even there, numbers were not especially noteworthy. No spat were observed in large portions of the bay and tributaries.

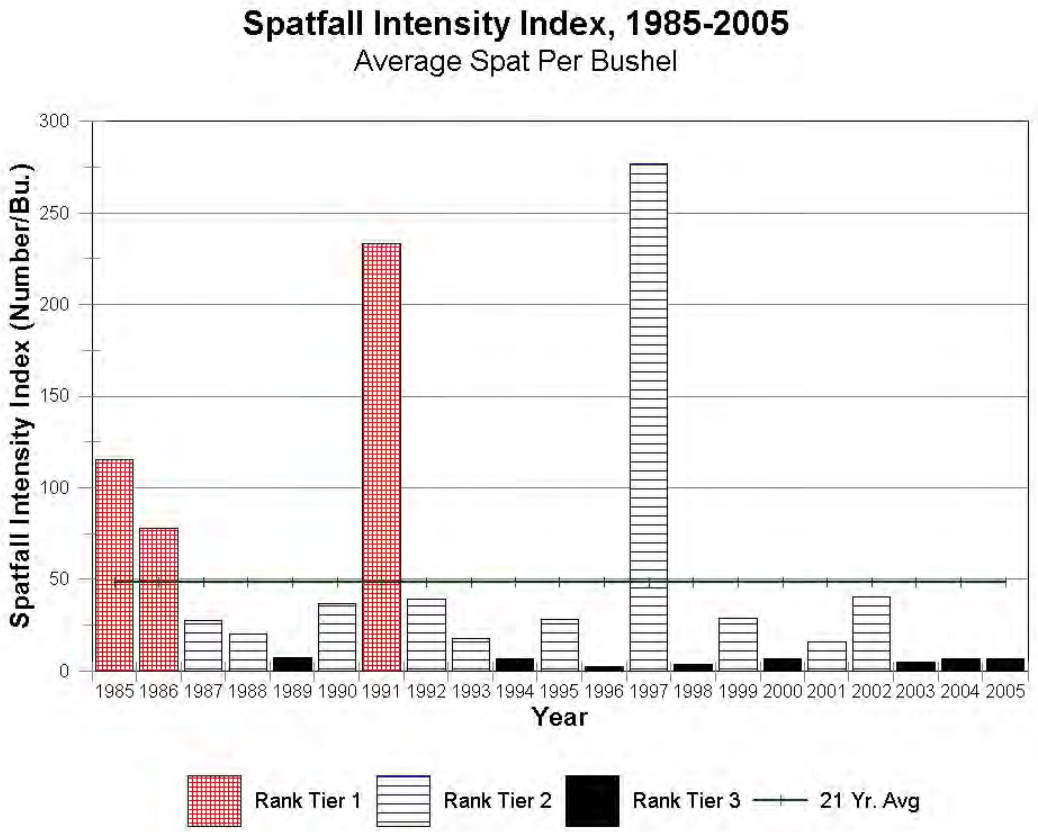

Figure 3. Spatfall intensity (spat per bushel of cultch) on Maryland "Key Bars" for spat monitoring. Years within each rank tier are statistically similar. For a discussion of the spatfall intensity statistical groupings, see Tarnowski (2005).

SPATFALL INTENSITY (cont'd)

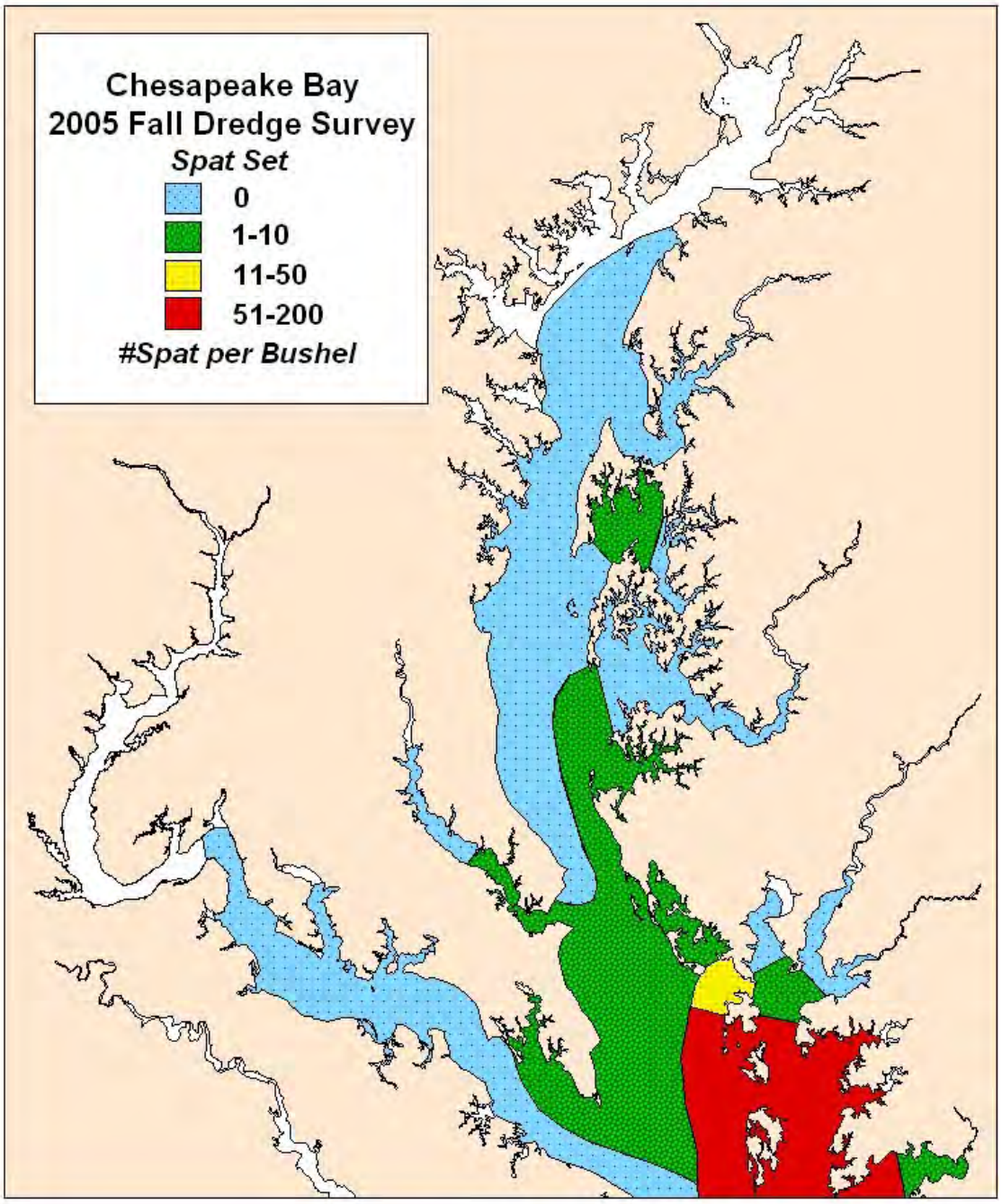

Figure 4. Spatfall intensity ranges and distribution in Maryland, 2005.

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OYSTER PARASITES

Oyster diseases remained attenuated for the third year in a row, following record high levels in 2002. In general, oyster parasite populations did not rebound with moderating streamflows.

Perkinsus marinus, the parasite that causes **dermo** disease, persisted on almost every oyster bar tested for the disease, with 54% of the oysters infected (Table 3). Nonetheless, the mean prevalence and intensity were almost identical to those of the previous year and were well below the 16-year average, ranking 2005 in the lowest statistical groupings (Figure 5 and Figure 6). The frequency distribution of infection intensities was similar to 2003 and 2004 (Figure 7). The highest prevalences were found not only in the higher salinity areas such as the southern portion of Chesapeake Bay and Tangier Sound, but also in most of the eastern shore tributaries, including the middle Choptank River and Eastern Bay regions, and as far up-bay as the Chester River (Figure 8). One disturbing trend was the level of dermo disease on two of the southernmost oyster sanctuaries – Pt. Lookout and Piney Island East Addition. Oysters in both sanctuaries had *P. marinus* prevalences of 93%, with relatively high mean infection intensities of 3.0 and 3.4, respectively. Pt. Lookout Sanctuary in particular has a thriving oyster population, as a result of good recruitment and low mortality in recent years. Should the salinity regime shift to favor dermo disease, these sanctuaries could suffer severe mortalities.

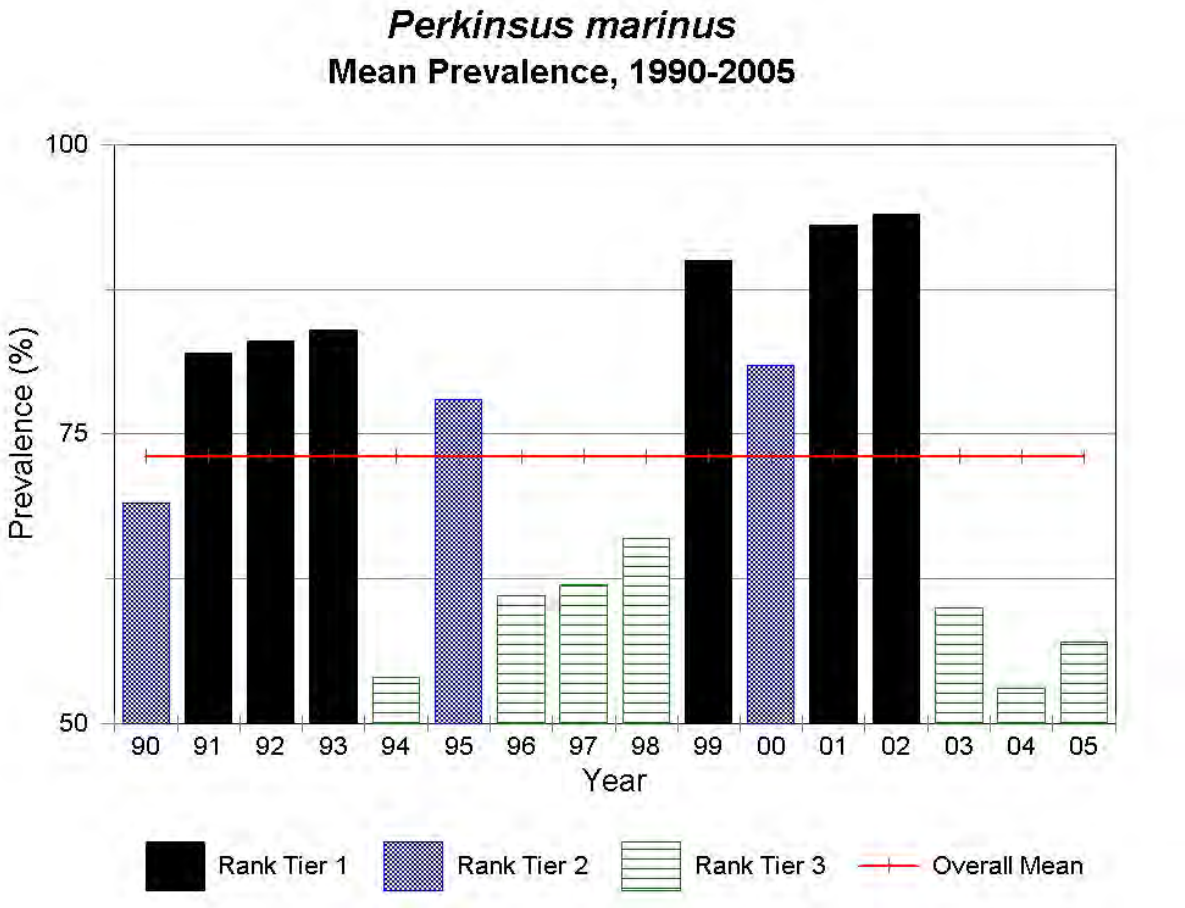

Figure 5. Statistical ranking and 16-year mean of *P. marinus* prevalence. Years within each rank tier are statistically similar.

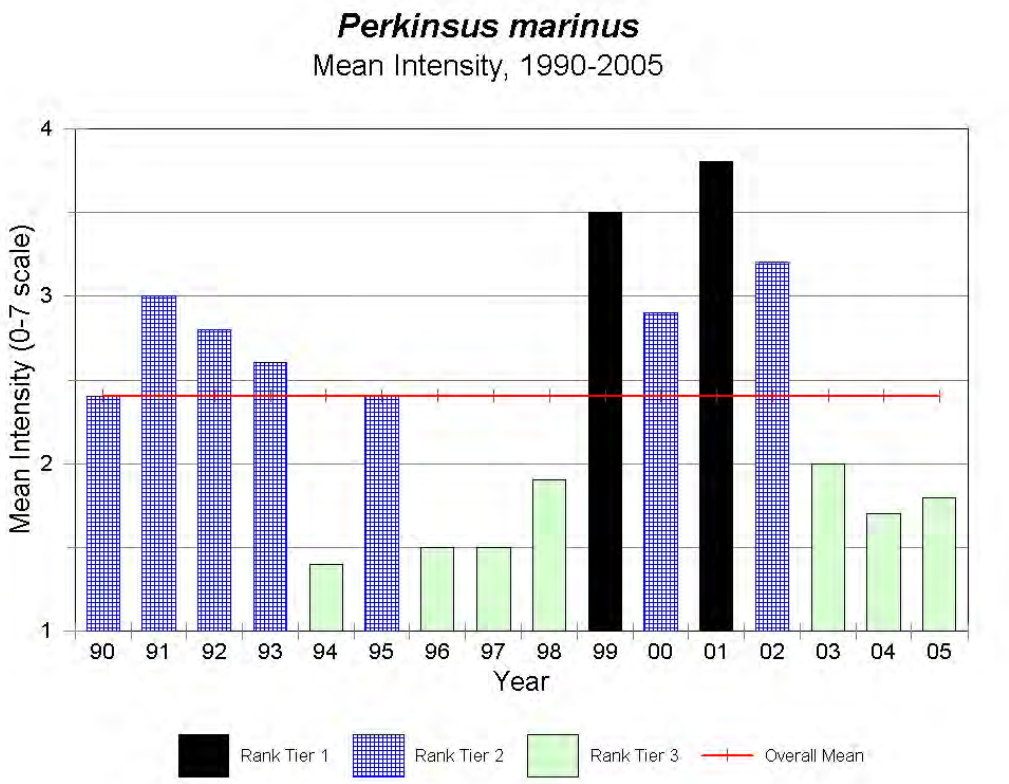

Figure 6. Annual mean *P. marinus* infection intensity on a scale of 0-7 in oysters from the 43 Maryland disease-monitoring bars. Years within each rank tier are statistically similar.

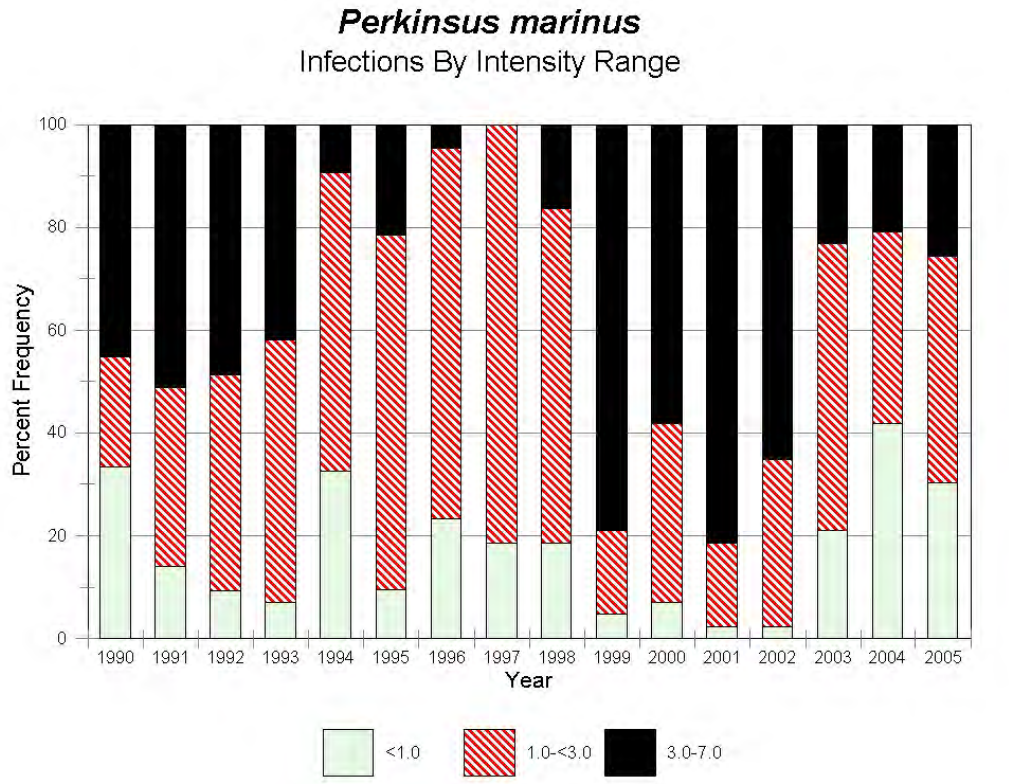

Figure 7. *P. marinus* infection intensity ranges, percent frequency by year and range.

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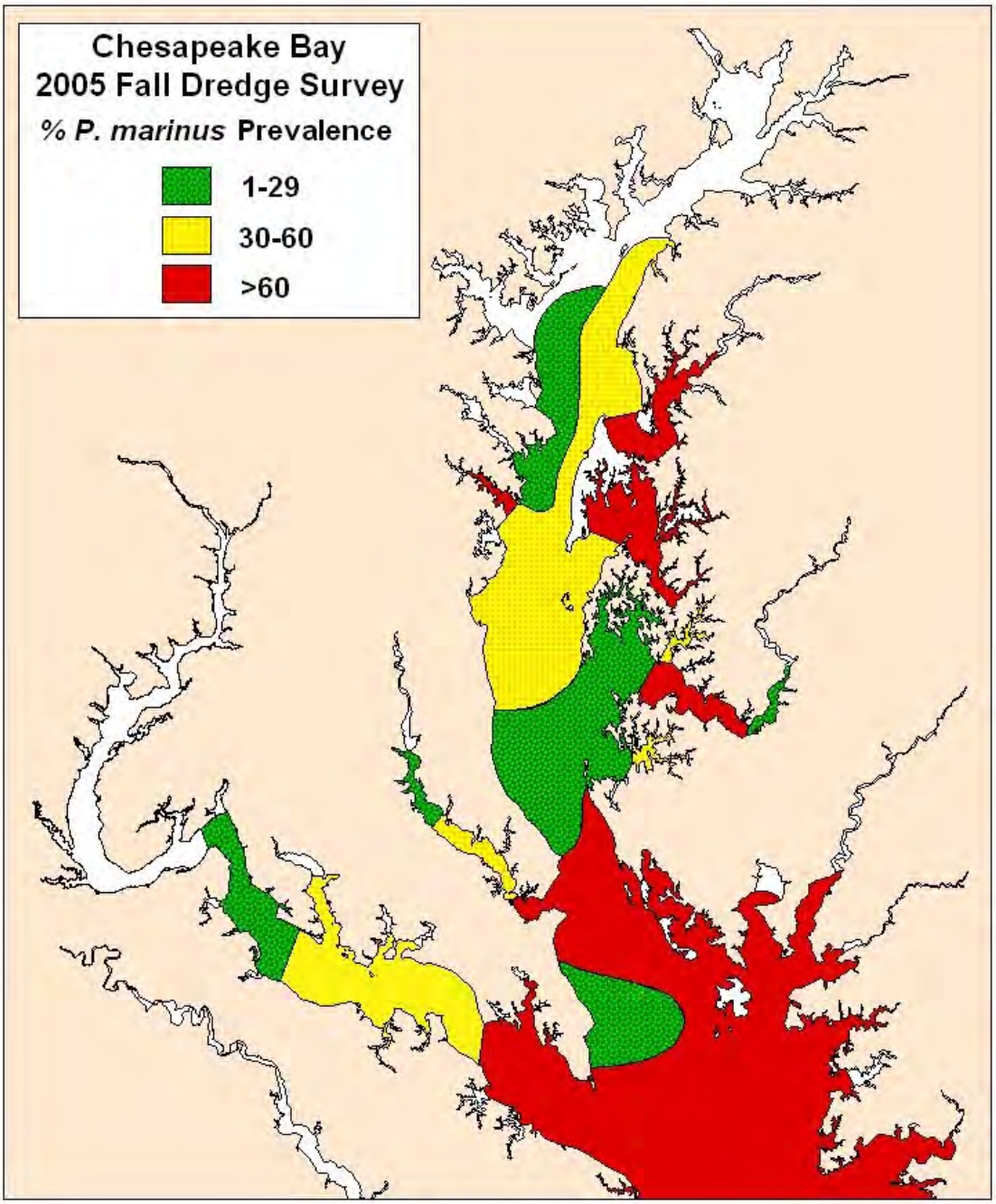

Figure 8. Geographic distribution of *P. marinus* prevalences in Maryland, 2005.

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OYSTER PARASITES (cont'd)

MSX disease, caused by the oyster parasite *Haplosporidium nelsoni*, was detected in two localized areas, lower Tangier Sound and Cooks Point at the mouth of the Choptank River (Figure 9). Prevalences, which plummeted during the high-flow years of 2003 and 2004, continued to be very low, even in the affected areas (Table 4); only one oyster on Cooks Point was infected.

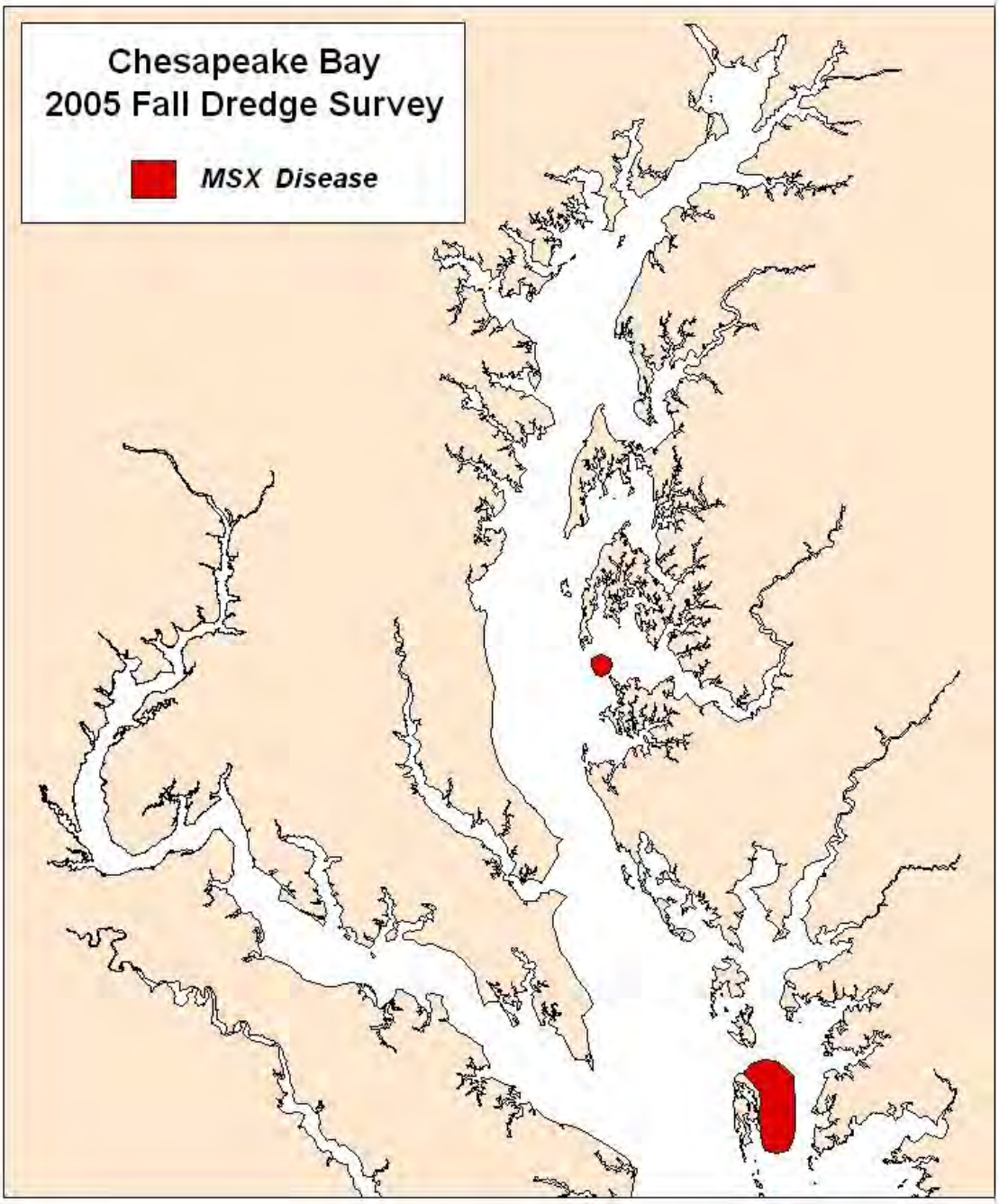

Figure 9. Geographic extent of MSX disease in Maryland waters, 2005.

OBSERVED MORTALITY

The observed mortality of 17% was the lowest since 1989 (Table 5), ranking 2005 in the lowest statistical grouping over a 21-year period (Figure 10). The highest observed mortalities were in the southern bay/Tangier Sound region, as well as the St. Mary's River, a lower Potomac River tributary (Figure 11). Most of the Chesapeake Bay and tributaries north of the Patuxent River had mortality levels typically observed prior to the disease epizootics of the mid-1980's. Although much of the decline in observed mortalities can be correlated with the abatement of MSX disease (Figure 12), the reduction of dermo disease infection intensities to below lethal levels, especially in the middle to upper bay regions, was also a major factor.

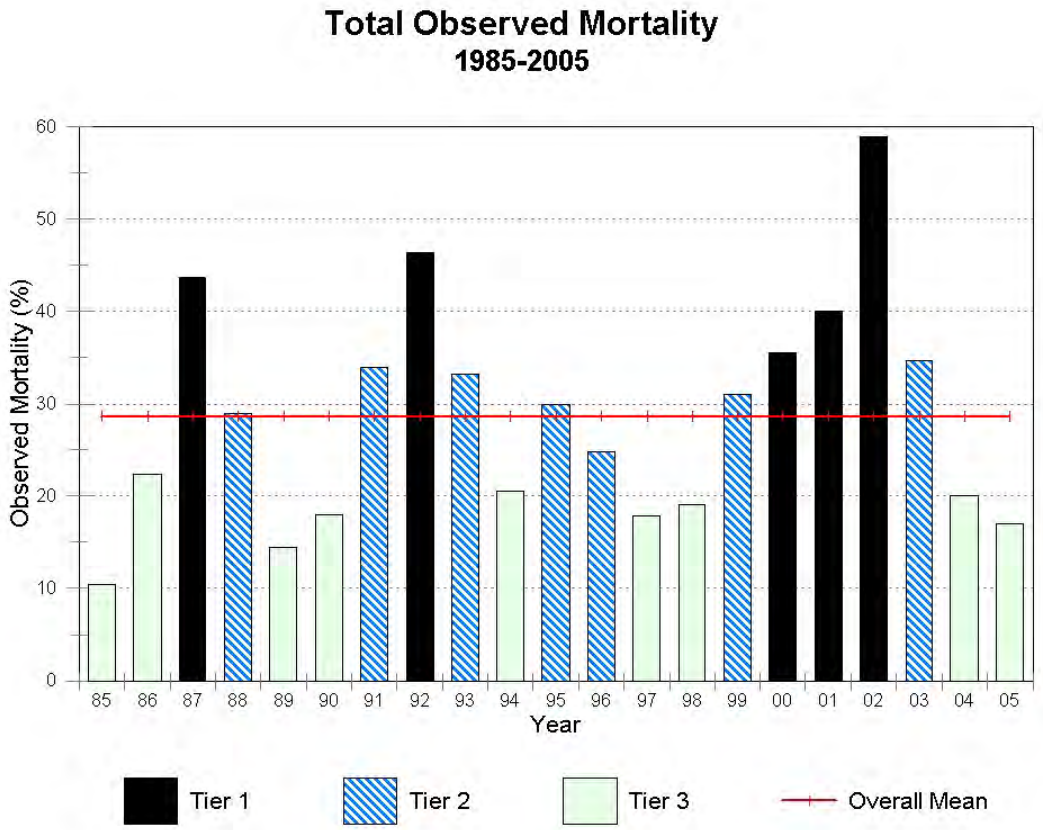

Figure 10. Mean annual total observed mortality, small and market oysters combined. Overall mean is for the period 1985 through 2005. Years within each rank tier are statistically similar.

OBSERVED MORTALITY (cont'd)

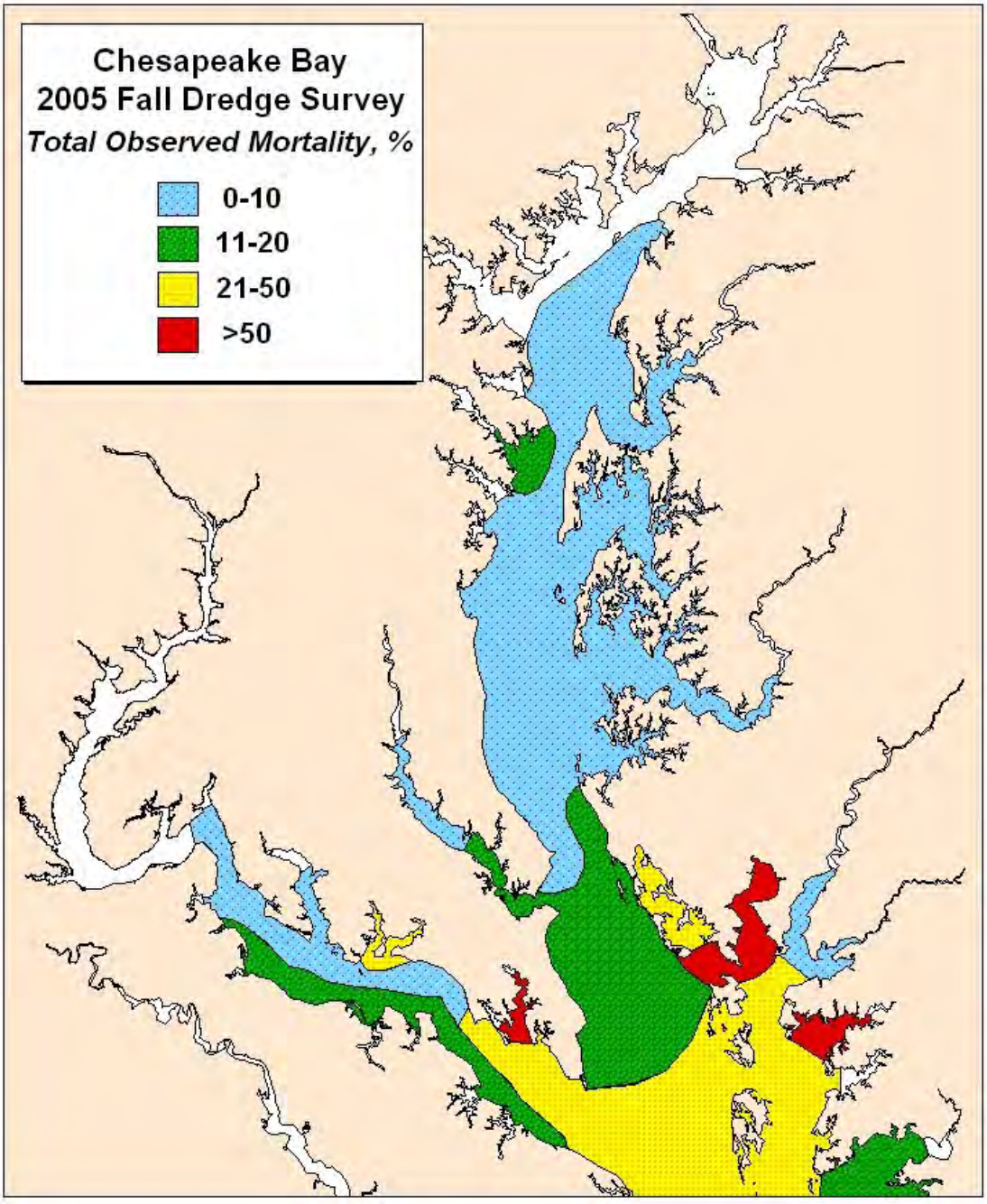

Figure 11. Distribution of observed oyster mortality levels in Maryland, 2005.

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OBSERVED MORTALITY (cont'd)

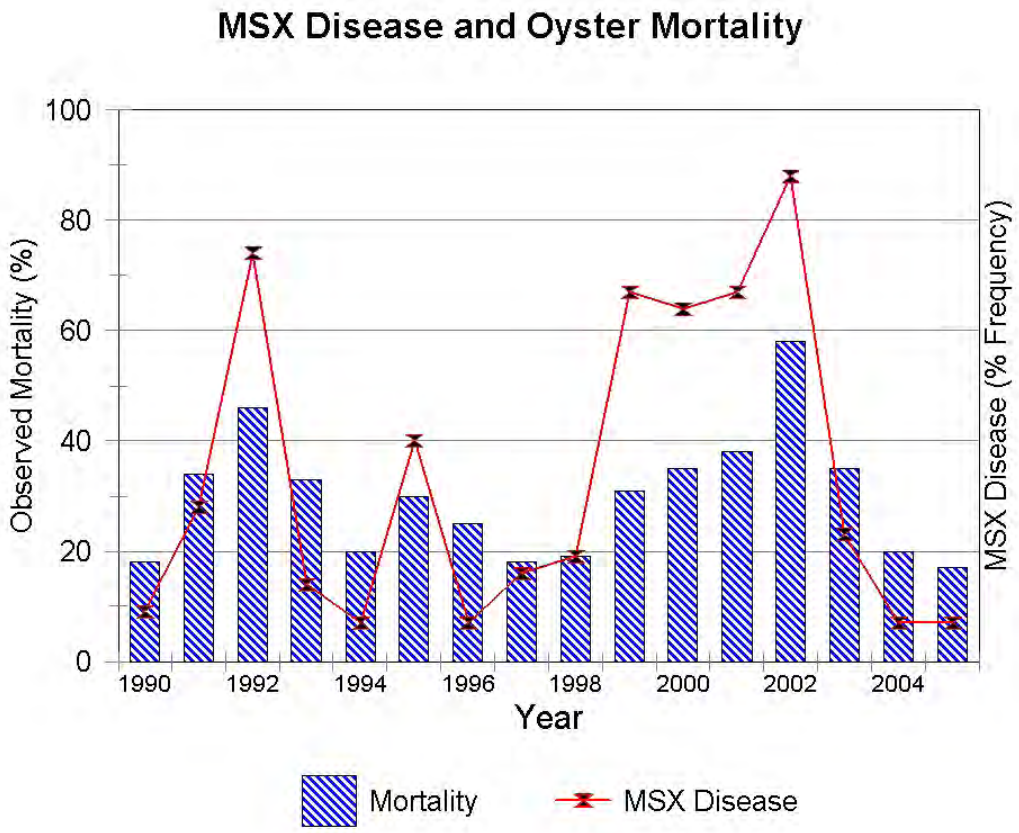

Figure 12. Changes in *H. nelsoni* frequency of occurrence on oyster bars and observed mortalities.

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COMMERCIAL HARVEST

Oyster landings during the 2004-05 season increased over the previous season's, reversing a five-year trend of declining catches (Figure 13). The reported harvest of 72,218 bu. was nearly three times that of the record low 2003-04 season. The fishery benefited from a modest spatfall in 2001 and possibly some recruitment of the more numerous 2002 year class, coupled with low disease levels and good survivorship over the two preceeding growing seasons. More than half of the landings were from the Tangier Sound region (Table 6), which is largely open to power dredging, a more efficient harvesting method. However, the three recent successive years of spat failures bodes poorly for the near-term fishery.

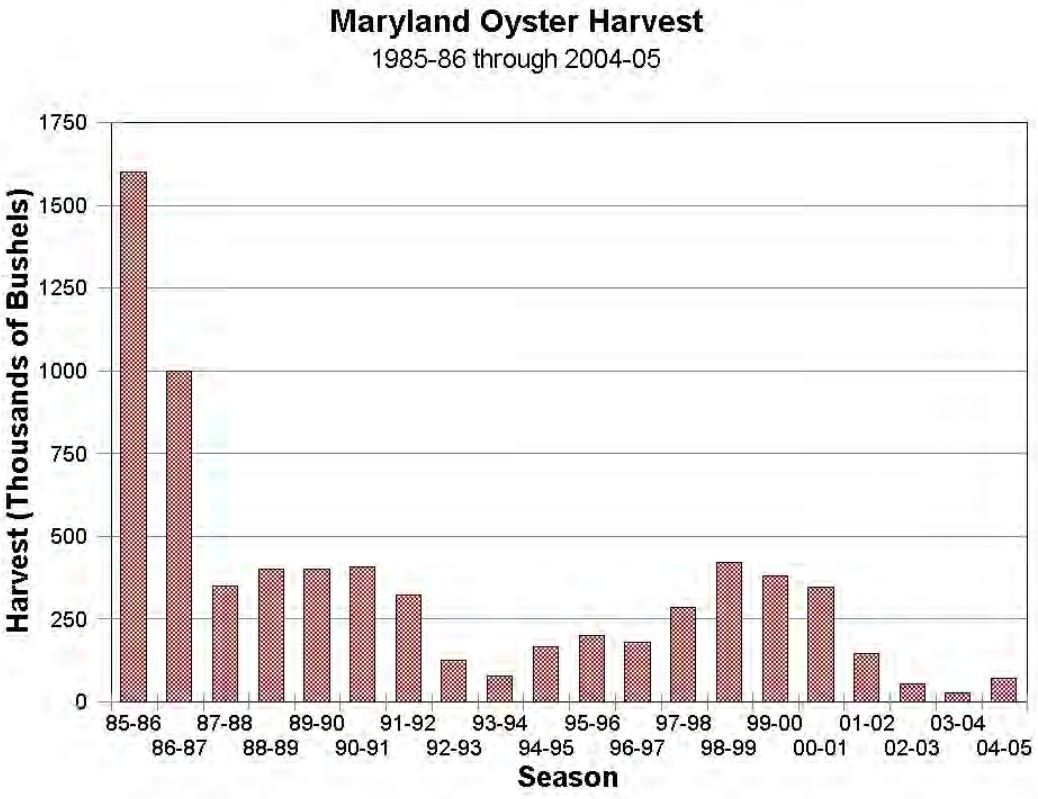

Figure 13. Maryland seasonal oyster landings.

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TABLES

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

Physical Parameters

-Latitude and longitude

-Bottom type

-Depth

-Temperature

-Salinity

Biological Parameters

-Counts of live and dead oysters by age/size classes (spat, smalls, markets)

-Stage of oyster boxes (recent, old)

-Average and range of shell heights of live and dead oysters by age/size classes

-Shell heights of oysters grouped into 5 mm intervals (Disease Bar sites, 1990-present)

-Condition index and meat quality of live oysters

-Type and relative extent of fouling

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

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Table 2. Spatfall intensity (spat per bushel of cultch) from the 53 "Key" spat monitoring bars, 1985-2005.

Oyster Bar	Spatfall Intensity, Number Per Bushel							
	1985	1986	1987	1988	1989	1990	1991	1992
Mountain Point	6	0	0	0	0	0	0	0
Swan Point	4	0	2	2	0	0	2	0
Brickhouse	78	0	4	8	0	3	0	0
Hacketts Point	0	4	0	0	0	0	0	0
Tolly Point	2	2	2	0	0	0	0	0
Three Sisters	10	2	8	0	0	0	0	0
Holland Point	6	2	0	0	0	0	0	2
Stone Rock	136	150	20	30	5	37	355	15
Flag Pond	98	306	128	98	0	4	330	8
Hog Island	116	32	58	35	2	7	169	2
Butlers	418	196	171	16	2	24	617	3
Buoy Rock	16	0	6	0	0	1	0	0
Parsons Island	78	2	4	2	0	7	127	18
Wild Ground	46	8	4	8	0	18	205	8
Hollicutts Noose	24	8	12	6	0	1	11	1
Bruffs Island	82	0	0	2	0	1	12	8
Ash Craft	10	2	0	10	0	2	12	0
Turtleback	382	40	12	34	6	11	168	15
Shell Hill	50	10	0	6	0	0	79	0
Sandy Hill	74	16	2	0	0	28	179	2
Royston	440	8	8	0	0	57	595	10
Cooks Point	64	82	4	28	0	17	171	1
Eagle Point	255	28	2	6	6	18	387	4
Tilghman Wharf	156	128	38	4	2	109	719	10
Deep Neck	566	114	6	22	4	48	468	22
Double Mills	332	24	2	0	0	1	129	0
Ragged Point	134	118	34	112	0	65	1036	53
Cason	400	24	46	50	0	143	1839	43
Windmill	34	112	43	22	16	155	740	46
Normans Addition	56	214	38	17	34	82	1159	53
Goose Creek	34	79	16	18	4	4	153	41
Clay Island	4	78	14	48	18	12	256	46
Wetipquin	34	10	0	0	0	3	3	6
Middleground	18	12	26	9	14	40	107	63
Evans	16	10	12	14	9	2	20	27
Mt. Vernon Wharf	0	0	0	0	0	0	15	0
Georges	26	97	14	4	16	4	52	42
Drum Point	48	186	48	90	72	16	140	185
Sharkfin Shoal	18	44	22	24	2	16	43	97
Turtle Egg	160	90	12	26	26	204	289	591
Piney Island East	182	384	50	160	74	64	429	329
Great Rock	2	6	4	6	10	12	208	44
Gunby	124	88	50	9	8	21	302	156
Marumsco	29	50	18	3	12	6	142	34
Broomes Island	34	0	0	0	0	3	12	0
Back of Island	42	0	8	4	4	15	49	5
Chicken Cock	620	298	96	62	18	29	182	5
Pagan	140	34	52	36	6	613	190	62
Black Walnut	16	6	0	0	0	1	6	0
Blue Sow	34	35	0	0	0	1	22	0
Dukehart	21	4	2	0	0	2	19	0
Ragged Point	69	66	4	0	0	2	14	0
Cornfield Harbor	383	908	362	28	14	26	212	2
Spat Index	**115.6**	**77.7**	**27.6**	**20.0**	**7.2**	**36.7**	**233.5**	**38.8**

Table 2 (Continued).

Oyster Bar	Spatfall Intensity, Number Per Bushel							
	1993	1994	1995	1996	1997	1998	1999	2000
Mountain Point	13	0	0	0	1	0	0	0
Swan Point	3	0	1	0	0	0	0	0
Brickhouse	0	0	5	0	0	0	1	1
Hacketts Point	1	0	0	0	0	0	0	1
Tolly Point	0	0	0	0	0	0	2	2
Three Sisters	0	0	1	0	0	0	0	0
Holland Point	0	0	1	0	0	0	0	0
Stone Rock	4	4	29	0	18	0	3	34
Flag Pond	0	0	10	0	7	0	1	5
Hog Island	2	0	24	0	5	2	6	1
Butlers	2	1	7	1	8	0	6	1
Buoy Rock	0	0	6	0	8	0	0	0
Parsons Island	2	0	57	0	3,375	3	6	6
Wild Ground	4	0	68	0	990	0	2	5
Hollicutts Noose	0	0	7	0	56	0	6	2
Bruffs Island	0	1	15	0	741	4	5	9
Ash Craft	0	0	60	1	2,248	0	14	2
Turtleback	0	0	194	0	3,368	5	13	4
Shell Hill	0	0	15	0	19	1	4	4
Sandy Hill	0	0	4	0	55	0	4	0
Royston	8	0	14	0	289	0	39	0
Cooks Point	0	2	16	0	20	0	1	5
Eagle Point	15	0	67	0	168	2	16	0
Tilghman Wharf	59	4	64	0	472	0	49	1
Deep Neck	94	12	294	3	788	1	211	3
Double Mills	13	0	15	0	40	0	1	0
Ragged Point	10	3	16	0	106	0	43	3
Cason	37	28	48	5	228	4	53	5
Windmill	20	19	13	2	5	1	37	0
Normans Addition	33	17	25	0	8	0	31	1
Goose Creek	43	27	3	0	5	0	0	0
Clay Island	58	31	11	1	20	2	5	4
Wetipquin	1	4	1	0	0	10	0	0
Middleground	14	28	2	6	27	0	9	1
Evans	7	30	2	1	5	0	1	0
Mt. Vernon Wharf	18	0	3	0	0	1	0	0
Georges	19	9	16	0	8	6	50	6
Drum Point	45	13	14	10	16	11	157	27
Sharkfin Shoal	18	11	6	0	7	0	9	5
Turtle Egg	37	31	7	35	70	3	180	33
Piney Island East	22	25	23	25	45	16	118	28
Great Rock	27	11	3	7	0	1	82	6
Gunby	176	7	35	9	0	24	54	32
Marumsco	55	5	6	0	0	57	27	27
Broomes Island	0	0	58	0	0	1	7	0
Back of Island	0	1	17	0	3	0	22	9
Chicken Cock	45	4	78	2	36	10	132	16
Pagan	15	7	54	0	1,390	6	95	42
Black Walnut	1	0	1	0	2	0	3	0
Blue Sow	1	0	5	0	0	0	11	0
Dukehart	2	0	0	0	0	0	1	0
Ragged Point	3	0	20	0	2	0	1	1
Cornfield Harbor	29	0	49	0	4	11	25	5
Spat Index	**18.0**	**6.3**	**28.1**	**2.0**	**276.7**	**3.5**	**29.1**	**6.4**

Table 2 (Continued).

Oyster Bar	Spatfall Intensity, Number Per Bushel				
	2001	2002	2003	2004	2005
Mountain Point	0	1	0	0	0
Swan Point	0	0	0	0	0
Brickhouse	3	97	0	0	0
Hacketts Point	0	13	0	0	0
Tolly Point	1	0	0	0	0
Three Sisters	1	0	0	0	0
Holland Point	1	4	0	0	0
Stone Rock	2	17	1	0	0
Flag Pond	5	7	0	0	0
Hog Island	28	10	5	1	6
Butlers	27	33	3	0	3
Buoy Rock	2	1	1	1	0
Parsons Island	6	5	2	0	3
Wild Ground	5	6	4	0	1
Hollicutts Noose	1	15	3	0	0
Bruffs Island	6	0	4	0	0
Ash Craft	10	0	8	0	0
Turtleback	45	9	72	1	5
Shell Hill	0	0	0	0	0
Sandy Hill	1	1	0	2	0
Royston	3	10	0	14	0
Cooks Point	5	3	1	4	0
Eagle Point	5	4	1	12	0
Tilghman Wharf	1	4	0	15	0
Deep Neck	11	31	1	167	0
Double Mills	0	0	0	3	0
Ragged Point	5	0	1	2	0
Cason	2	9	1	5	1
Windmill	21	9	0	0	0
Normans Addition	30	33	2	0	6
Goose Creek	0	1	0	0	0
Clay Island	8	16	0	0	0
Wetipquin	0	3	1	0	0
Middleground	0	24	0	0	1
Evans	0	12	0	1	0
Mt. Vernon Wharf	0	0	0	0	0
Georges	1	280	15	4	5
Drum Point	44	124	13	8	40
Sharkfin Shoal	0	57	0	2	4
Turtle Egg	33	207	25	7	90
Piney Island East	167	127	1	27	116
Great Rock	140	1	3	19	28
Gunby	6	108	0	29	24
Marumsco	4	89	0	14	11
Broomes Island	1	15	1	0	3
Back of Island	44	27	11	0	0
Chicken Cock	12	151	56	2	2
Pagan	117	535	9	6	10
Black Walnut	1	2	0	0	0
Blue Sow	2	4	1	0	0
Dukehart	0	1	0	0	0
Ragged Point	0	1	0	0	0
Cornfield Harbor	35	31	9	0	8
Spat Index	**15.9**	**40.5**	**4.8**	**6.5**	**6.9**

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Table 3. *Perkinsus marinus* prevalence and intensity (scale of 0-7) in oysters from the 43 disease monitoring bars, 1990-2005. NA = unable to obtain a sufficient sample size for analysis.

Oyster Bar	*Perkinsus marinus* Prevalence (%) and Intensity (I)									
	1990		1991		1992		1993		1994	
	%	I	%	I	%	I	%	I	%	I
Swan Point	7	0.1	27	0.7	23	0.4	37	0.8	3	0.1
Hacketts Point	0	0.0	27	0.8	57	1.2	97	3.2	23	0.5
Holland Point	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	30	0.8	97	2.6	97	5.7	88	2.7	30	0.8
Hog Island	90	3.0	97	4.5	100	4.2	93	2.4	37	1.0
Butlers	100	4.0	100	4.0	81	2.4	97	3.3	80	2.1
Buoy Rock	23	0.5	80	2.5	97	2.8	93	3.3	10	0.3
Oldfield	17	0.2	20	0.5	37	0.9	83	2.4	20	0.6
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
Hollicutts Noose	30	0.3	73	2.0	82	2.1	97	2.7	70	1.7
Bruffs Island	83	2.8	83	2.8	93	3.0	83	2.6	63	1.3
Turtleback	100	3.8	100	3.3	77	1.6	100	3.3	60	1.2
Long Point	73	2.3	94	4.3	86	3.0	77	2.6	60	2.0
Cooks Point	17	0.2	23	0.3	87	3.7	97	4.2	90	3.0
Royston	--	---	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	100	5.0	100	5.7	100	4.2	100	3.8	83	2.3
Oyster Shell Point	3	0.1	60	1.7	100	3.9	93	2.8	10	0.3
Tilghman Wharf	100	3.2	97	3.0	100	3.4	100	3.2	63	1.9
Deep Neck	100	4.9	100	5.6	100	3.7	100	3.8	67	2.3
Double Mills	97	3.6	100	4.9	100	4.1	100	3.8	90	2.0
Cason	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
Normans Addition	100	4.2	100	3.4	83	2.0	96	3.6	93	3.3
Goose Creek	60	1.8	100	3.1	100	3.6	87	2.1	53	1.1
Wilson Shoals	93	2.9	100	2.8	90	2.5	83	1.6	40	0.9
Georges	83	1.9	93	2.9	58	1.4	30	0.7	50	1.2
Holland Straits	100	4.2	100	4.0	100	3.4	76	2.3	57	1.6
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
Marumsco	97	3.5	93	3.3	60	1.3	87	2.5	72	1.6
Broomes Island	97	3.4	100	2.8	63	1.5	87	3.0	40	0.6
Chicken Cock	100	4.2	97	3.1	93	3.2	96	2.6	40	1.0
Pagan	93	3.3	97	2.3	100	3.0	93	2.1	10	0.3
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
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 Mean	**70**	**2.3**	**83**	**3.0**	**83**	**2.8**	**84**	**2.6**	**54**	**1.4**

Table 3 (Continued).

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

Table 3 (Continued).

Oyster Bar	*Perkinsus marinus* Prevalence (%) and Intensity (I)									
	2000		2001		2002		2003		2004	
	%	I	%	I	%	I	%	I	%	I
Swan Point	80	1.2	93	3.3	97	2.7	33	1.0	33	0.7
Hacketts Point	97	3.7	97	3.4	100	3.3	33	1.1	30	0.8
Holland Point	87	3.4	93	3.2	100	3.6	33	1.1	30	0.6
Stone Rock	93	3.6	83	2.8	100	2.3	77	2.4	10	0.2
Flag Pond	NA	NA	NA	NA	37	0.5	0	0.0	3	0.3
Hog Island	83	3.9	93	3.4	87	2.9	53	2.3	53	1.4
Butlers	83	2.7	80	2.4	80	1.4	10	0.3	7	0.1
Buoy Rock	97	3.5	93	3.5	100	2.6	97	3.7	50	1.5
Oldfield	93	3.0	100	3.3	97	2.5	80	2.5	33	0.7
Bugby	100	4.0	100	4.6	97	3.1	97	3.4	63	1.7
Parsons Island	100	3.5	100	4.5	100	4.4	90	3.3	93	2.8
Hollicutts Noose	100	4.1	100	4.8	100	3.6	80	2.7	40	1.5
Bruffs Island	97	3.2	100	3.8	100	3.6	73	1.8	80	2.5
Turtleback	97	3.1	100	4.2	100	4.7	100	3.6	80	2.8
Long Point	97	3.3	100	4.2	100	3.1	97	2.8	97	3.2
Cooks Point	40	1.2	77	2.2	NA	NA	66	2.1	0	0.0
Royston	97	4.7	100	5.2	100	4.2	48	1.8	13	0.3
Lighthouse	100	3.4	100	3.3	100	4.6	20	0.6	43	1.2
Sandy Hill	87	3.6	100	4.5	100	5.0	93	3.5	87	3.3
Oyster Shell Pt	73	2.2	100	3.6	100	3.0	43	1.0	43	0.8
Tilghman Wharf	93	3.4	100	3.5	90	3.2	87	2.4	43	0.8
Deep Neck	100	4.0	97	4.8	100	3.2	97	3.7	27	0.5
Double Mills	100	4.7	100	5.5	97	2.9	53	1.7	53	2.1
Cason	100	3.6	100	4.3	94	4.4	17	0.4	3	3.3
Ragged Point	97	3.7	100	4.3	100	3.5	43	1.0	13	0.2
Normans Add.	80	3.4	90	3.0	67	1.9	37	1.3	93	3.3
Goose Creek	97	3.1	100	4.1	93	4.0	57	2.0	77	2.0
Wilson Shoals	70	2.1	100	4.0	100	3.6	83	2.3	97	2.3
Georges	80	2.3	100	5.2	100	4.0	83	2.6	100	4.2
Holland Straits	30	0.9	43	1.4	50	1.1	40	0.7	70	1.7
Sharkfin Shoal	80	2.3	90	3.7	97	3.6	47	3.4	100	4.4
Back Cove	40	1.2	100	5.0	97	3.8	100	4.6	97	3.7
Piney Isl East	86	2.3	60	1.5	100	3.1	100	3.9	100	3.9
Old Woman's Leg	70	1.7	100	5.0	100	3.7	100	4.4	93	3.7
Marumsco	93	2.7	100	5.0	97	4.1	90	2.3	87	2.8
Broomes Island	93	4.0	100	4.8	97	3.8	47	1.3	47	1.4
Chicken Cock	63	1.8	93	3.6	100	2.9	23	0.7	40	0.9
Pagan	68	1.6	100	4.6	93	4.0	60	1.3	83	2.3
Lancaster	90	2.7	100	4.5	97	2.7	50	1.5	37	0.9
Mills West	97	3.6	100	4.8	93	3.1	60	1.6	57	1.5
Cornfield Harbor	80	2.1	80	2.9	97	1.7	27	0.7	30	0.5
Ragged Point	13	0.7	33	0.5	93	2.6	24	0.7	9	0.1
Lower Cedar Pt.	17	0.5	90	2.3	97	2.5	13	0.5	17	0.4
Annual Mean	**81**	**2.9**	**93**	**3.8**	**94**	**3.2**	**60**	**2.0**	**53**	**1.7**

Table 3 (Continued).

Oyster Bar	*Perkinsus marinus* Prevalence (%) and Intensity (I)	
	2005	
	%	I
Swan Point	47	1.2
Hacketts Point	13	0.4
Holland Point	53	1.6
Stone Rock	50	1.3
Flag Pond	13	0.3
Hog Island	93	3.4
Butlers	30	1.1
Buoy Rock	77	2.4
Oldfield	57	1.1
Bugby	53	1.8
Parsons Island	87	2.6
Hollicutts Noose	40	1.0
Bruffs Island	73	1.8
Turtleback	100	3.3
Long Point	90	2.7
Cooks Point	13	0.3
Royston	3	0.2
Lighthouse	27	0.6
Sandy Hill	80	2.5
Oyster Shell Pt	17	0.3
Tilghman Wharf	0	0.0
Deep Neck	20	0.4
Double Mills	53	1.6
Cason	33	0.5
Ragged Point	10	0.3
Normans Add.	90	3.8
Goose Creek	63	2.2
Wilson Shoals	90	3.0
Georges	90	3.3
Holland Straits	83	3.0
Sharkfin Shoal	87	3.2
Back Cove	100	3.1
Piney Isl East	100	3.7
Old Woman's Leg	80	2.4
Marumsco	93	3.3
Broomes Island	37	0.9
Chicken Cock	87	3.5
Pagan	83	2.9
Lancaster	57	1.5
Mills West	50	1.3
Cornfield Harbor	80	2.6
Ragged Point	37	0.9
Lower Cedar Pt.	13	0.2
Annual Mean	**57**	**1.8**

(Return to Text)

Table 4. Prevalence of *Haplosporidium nelsoni* in oysters from the 43 disease monitoring bars, 1990-2005. ND = No samples taken; prevalence assumed to be 0. NA = unable to obtain a sufficient sample size.

Oyster Bar	*Haplosporidium nelsoni* Prevalence (%)							
	1990	1991	1992	1993	1994	1995	1996	1997
Swan Point	0	0	0	0	ND	0	0	0
Hacketts Point	0	0	3	0	0	0	0	0
Holland Point	0	3	13	0	0	0	0	0
Stone Rock	0	0	43	0	0	3	0	0
Flag Pond	0	0	53	0	0	27	0	0
Hog Island	0	0	43	0	0	14	0	0
Butlers	0	0	50	0	0	23	0	7
Buoy Rock	ND	0	0	0	ND	0	0	0
Oldfield	ND	0	0	0	ND	0	0	0
Bugby	0	7	3	0	0	0	0	0
Parsons Island	ND	0	7	0	0	0	0	0
Hollicutts Noose	0	0	17	0	0	0	0	0
Bruffs Island	0	0	0	0	0	0	0	0
Turtleback	0	0	0	0	0	23	0	0
Long Point	0	0	0	0	0	0	0	0
Cooks Point	0	7	73	0	0	ND	0	3
Royston	ND	0	33	0	0	0	0	0
Lighthouse	0	0	53	0	0	0	0	0
Sandy Hill	0	0	13	0	ND	0	0	0
Oyster Shell Pt	0	0	30	0	ND	0	0	0
Tilghman Wharf	0	0	40	0	0	0	0	0
Deep Neck	0	0	30	0	0	0	0	0
Double Mills	0	0	17	0	0	0	0	0
Cason	0	0	43	0	0	0	0	0
Ragged Point	0	20	57	0	0	0	0	0
Normans Add	3	0	53	0	0	33	0	0
Goose Creek	0	10	27	7	0	20	0	0
Wilson Shoals	0	0	57	0	ND	7	0	0
Georges	10	7	23	0	0	33	0	0
Holland Straits	0	20	13	13	0	52	0	10
Sharkfin Shoal	20	43	40	17	0	33	0	0
Back Cove	0	17	27	33	7	20	3	3
Piney Isl East	7	23	17	20	13	10	7	13
Old Woman's Leg	0	33	23	30	10	43	20	4
Marumsco	0	20	20	0	0	20	0	11
Broomes Island	0	ND	20	0	0	0	0	0
Chicken Cock	0	0	57	0	ND	0	0	0
Pagan	0	0	0	0	ND	0	0	0
Lancaster	0	0	0	0	ND	0	0	0
Mills West	0	0	0	0	ND	0	0	0
Cornfield Harbor	0	0	57	0	0	37	0	0
Ragged Pt. (Potomac)	0	0	0	0	0	0	0	0
Lower Cedar Pt.	ND	ND	0	0	ND	0	0	0
Percent Frequency[1]	**9**	**28**	**74**	**14**	**7**	**40**	**7**	**16**

[1] (Number of annual samples taken with *H. nelsoni* infections ÷ total number of samples) * 100

Table 4 (Continued).

Oyster Bar	*Haplosporidium nelsoni* Prevalence (%)							
	1998	1999	2000	2001	2002	2003	2004	2005
Swan Point	0	0	0	0	0	0	0	0
Hacketts Point	0	0	0	0	13	0	0	0
Holland Point	0	0	3	7	40	0	0	0
Stone Rock	0	30	47	40	30	3	0	0
Flag Pond	0	NA	NA	NA	20	0	0	0
Hog Island	0	60	27	27	20	0	0	0
Butlers	3	47	17	27	20	3	3	0
Buoy Rock	0	0	0	0	0	0	0	0
Oldfield	0	0	0	0	0	0	0	0
Bugby	0	0	0	0	27	0	0	0
Parsons Island	0	0	0	3	17	0	0	0
Hollicutts Noose	0	7	10	17	37	0	0	0
Bruffs Island	0	0	0	3	17	0	0	0
Turtleback	0	0	0	7	33	0	0	0
Long Point	0	0	0	0	3	0	0	0
Cooks Point	0	13	33	37	NA	0	0	3
Royston	0	3	7	0	60	0	0	0
Lighthouse	0	13	7	3	67	0	0	0
Sandy Hill	0	0	0	10	53	0	0	0
Oyster Shell Pt	0	0	0	0	7	0	0	0
Tilghman Wharf	0	3	27	7	60	0	0	0
Deep Neck	0	3	7	0	63	0	0	0
Double Mills	0	3	0	0	33	0	0	0
Cason	0	7	27	33	59	0	0	0
Ragged Point	0	20	47	40	30	0	0	0
Normans Add	3	63	37	37	20	7	0	0
Goose Creek	0	47	17	13	33	0	0	0
Wilson Shoals	0	4	10	10	27	0	0	0
Georges	0	40	20	13	30	0	0	0
Holland Straits	3	73	40	47	57	7	0	0
Sharkfin Shoal	20	53	37	20	27	7	0	0
Back Cove	10	33	37	10	7	7	0	7
Piney Isl East	17	43	53	40	17	10	3	0
Old Woman's Leg	23	53	30	13	13	3	3	13
Marumsco	7	37	30	17	30	0	0	0
Broomes Island	0	3	10	0	13	0	0	0
Chicken Cock	0	77	7	17	30	3	0	0
Pagan	0	3	13	10	40	0	0	0
Lancaster	0	0	0	0	10	0	0	0
Mills West	0	3	0	0	43	0	0	0
Cornfield Harbor	3	53	17	33	50	10	0	0
Ragged Pt. (Potomac)	0	13	10	7	60	0	0	0
Lower Cedar Pt.	0	0	0	0	0	0	0	0
Percent Frequency[1]	**19**	**67**	**64**	**67**	**90**	**23**	**7**	**7**

(Return to Text)

[1] (Number of annual samples taken with *H. nelsoni* infections ÷ total number of samples) * 100

Table 5. Oyster population mortality estimates from the 43 disease monitoring bars, 1985-2005.

Oyster Bar	Total Observed Mortality (%)								
	1985	1986	1987	1988	1989	1990	1991	1992	1993
Swan Point	14	1	2	1	9	4	4	3	5
Hacketts Point	7	0	10	9	5	2	2	12	18
Holland Point	4	21	19	3	19	3	14	45	43
Stone Rock	6	ND	ND	ND	NS	2	9	45	30
Flag Pond	ND	48	30	39	37	10	35	77	43
Hog Island	ND	26	47	25	6	19	73	85	76
Butlers	ND	23	84	15	7	30	58	84	66
Buoy Rock	10	0	0	1	10	5	11	16	51
Oldfield	8	3	3	4	2	7	3	9	8
Bugby	8	25	46	33	25	39	53	18	29
Parsons Island	19	1	26	13	2	7	43	27	29
Hollicutts Noose	2	32	42	25	14	1	7	9	29
Bruffs Island	2	1	45	12	9	12	50	77	47
Turtleback	ND	1	19	27	15	27	51	23	24
Long Point	17	8	23	8	12	11	53	73	44
Cooks Point	40	20	45	63	6	11	2	88	63
Royston	4	21	19	11	14	14	33	43	37
Lighthouse	3	14	59	14	8	8	45	52	57
Sandy Hill	12	6	29	34	7	11	75	48	45
Oyster Shell Point	9	0	1	2	2	3	2	19	20
Tilghman Wharf	2	36	57	ND	20	30	34	26	36
Deep Neck	2	25	37	32	47	66	48	40	32
Double Mills	4	7	13	9	6	28	82	50	24
Cason	4	22	60	37	40	63	25	48	53
Ragged Point	5	31	84	38	7	23	53	49	71
Normans Addition	15	53	82	ND	11	11	48	49	51
Goose Creek	6	26	84	59	19	7	23	63	38
Wilson Shoals	23	65	51	41	38	10	29	60	23
Georges	5	24	84	55	23	31	50	55	16
Holland Straits	19	51	85	90	15	27	35	71	18
Sharkfin Shoal	25	61	94	80	8	0	10	63	16
Back Cove	ND	ND	ND	ND	NS	11	49	88	4
Piney Island East	21	16	88	11	5	23	57	55	13
Old Woman's Leg	4	17	79	21	8	5	50	80	15
Marumsco	3	27	77	ND	20	8	31	44	21
Broomes Island	10	29	31	6	4	24	53	70	53
Chicken Cock	18	43	63	43	24	27	31	51	33
Pagan	9	30	27	13	20	39	24	19	17
Lancaster	13	6	4	4	6	28	20	8	7
Mills West	18	0	2	1	1	2	11	9	2
Cornfield Harbor	17	59	92	51	11	16	29	77	47
Ragged Point	10	14	29	79	54	63	34	63	28
Lower Cedar Point	6	9	2	1	6	6	7	5	47
Annual Mean	**10**	**22**	**44**	**29**	**14**	**18**	**34**	**46**	**33**

Table 5 (Continued).

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

Table 5 (Continued).

Oyster Bar	Total Observed Mortality (%)		
	2003	2004	2005
Swan Point	13	10	11
Hacketts Point	17	10	2
Holland Point	50	29	5
Stone Rock	13	5	5
Flag Pond	0	0	2
Hog Island	11	6	12
Butlers	9	2	3
Buoy Rock	41	28	6
Oldfield	34	10	38
Bugby	50	14	2
Parsons Island	37	11	8
Hollicutts Noose	25	3	6
Bruffs Island	50	12	5
Turtleback	43	11	12
Long Point	54	10	10
Cooks Point	21	0	0
Royston	69	14	0
Lighthouse	89	47	0
Sandy Hill	88	59	44
Oyster Shell Point	48	20	0
Tilghman Wharf	62	17	0
Deep Neck	54	14	1
Double Mills	59	23	8
Cason	57	4	0
Ragged Point	52	5	4
Normans Addition	9	14	40
Goose Creek	53	59	50
Wilson Shoals	19	27	7
Georges	4	24	44
Holland Straits	11	18	43
Sharkfin Shoal	23	32	54
Back Cove	22	23	32
Piney Island East	28	48	50
Old Woman's Leg	35	56	26
Marumsco	4	11	29
Broomes Island	14	19	6
Chicken Cock	2	38	50
Pagan	7	29	66
Lancaster	35	27	14
Mills West	48	11	0
Cornfield Harbor	1	7	20
Ragged Point	76	ND	ND
Lower Cedar Point	55	22	17
Annual Mean	**35**	**20**	**17**

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Table 6. Regional summary of oyster harvests (bu.) in Maryland, 1985-86 through 2004-05 seasons.

Region/Tributary	1985-86	1986-87	1987-88	1988-89	1989-90
Upper Bay	5,600	30,800	19,100	17,700	15,700
Middle Bay	73,400	37,900	42,500	10,500	15,900
Lower Bay	32,500	5,900	70	0	3,600
Total Bay Mainstem	111,500	74,600	61,700	28,200	35,200
Chester River	21,300	20,600	30,900	49,900	54,000
Eastern Bay	216,100	149,100	28,700	15,700	20,400
Miles R.	40,400	20,600	17,100	13,600	1,400
Wye R.	20,100	2,200	700	3,800	8,000
Total Eastern Bay Region	276,600	171,900	46,500	33,100	29,800
Upper Choptank River	29,000	42,400	36,500	51,900	27,700
Middle Choptank R.	144,500	89,700	66,400	66,400	71,000
Lower Choptank R.	225,100	52,500	26,200	9,100	32,100
Tred Avon R.	67,700	60,900	13,700	42,400	92,100
Broad Creek	12,900	58,700	8,500	13,500	8,100
Harris Cr.	3,500	16,700	6,900	7,800	8,800
Total Choptank R. Region	482,700	320,900	158,200	191,100	239,800
Little Choptank River	27,100	10,500	21,500	15,000	19,000
Upper Tangier Sound	84,000	30,400	40	0	0
Lower Tangier S.	64,400	22,200	90	0	0
Honga River	29,400	49,300	7,700	300	1,100
Fishing Bay	107,600	87,300	90	20	20
Nanticoke R.	21,300	5,100	1,500	900	2,600
Wicomico R.	3,600	200	100	40	20
Manokin R.	40,800	47,400	500	70	10
Annemesex R.	90	10	10	0	40
Pocomoke S.	32,700	22,300	0	0	0
Total Tangier Sound Region	383,900	264,200	10,000	1,300	3,800
Patuxent River	96,300	16,800	1,400	3,700	8,900
Wicomico R., St. Clement's and Breton Bays	16,000	23,400	23,000	47,600	22,200
St. Mary's River and Smith Cr.	80,700	30,700	2,300	500	1,100
Total Potomac Md Tributaries	96,700	54,100	25,300	48,100	23,300
Total Maryland (bu.)[1]	**1,500,000**	**1,000,000**	**360,000**	**390,000**	**413,000**

[1] Including regions not listed.

Table 6 (continued).

Region/Tributary	1990-91	1991-92	1992-93	1993-94	1994-95
Upper Bay	19,800	35,200	18,200	8,900	7,800
Middle Bay	17,700	39,200	9,000	4,400	4,900
Lower Bay	37,900	9,300	90	0	1,100
Total Bay Mainstem	*75,400*	*83,800*	*27,300*	*13,300*	*13,800*
Chester River	60,400	55,100	53,800	51,300	29,100
Eastern Bay	33,200	20,600	3,600	2,400	3,700
Miles R.	1,700	100	300	0	200
Wye R.	2,300	300	20	30	50
Total Eastern Bay Region	*37,200*	*21,000*	*3,900*	*2,700*	*4,000*
Upper Choptank River	42,200	29,200	9,500	2,600	2,500
Middle Choptank R.	49,700	25,000	3,100	1,600	4,900
Lower Choptank R.	9,000	14,200	1,700	900	600
Tred Avon R.	22,000	800	0	0	5,900
Broad Creek	4,300	40	50	10	400
Harris Cr.	3,300	100	20	0	14,200
Total Choptank R. Region	*130,500*	*69,300*	*14,400*	*5,100*	*28,500*
Little Choptank River	8,800	3,800	50	300	19,300
Upper Tangier Sound	1,000	11,300	70	0	17,600
Lower Tangier S.	1,600	1,700	40	0	5,400
Honga River	5,600	600	20	100	1,700
Fishing Bay	900	6,400	500	30	11,900
Nanticoke R.	3,000	12,500	7,700	2,500	10,500
Wicomico R.	60	600	500	500	80
Manokin R.	60	200	40	10	100
Annemesex R.	0	10	0	0	0
Pocomoke S.	300	500	0	0	100
Total Tangier Sound Region	*12,500*	*33,800*	*8,900*	*3,100*	*47,400*
Patuxent River	48,400	24,500	0	0	30
Wicomico R., St. Clement's and Breton Bays	36,000	29,600	14,900	4,000	18,200
St. Mary's River and Smith Cr.	1,700	100	60	30	3,900
Total Potomac Md Tributaries	*37,700*	*29,000*	*15,000*	*4,000*	*22,100*
Total Maryland (bu.)[1]	**411,000**	**323,000**	**123,000**	**80,000**	**164,000**

[1] Including regions not listed.

Table 6 (continued).

Region/Tributary	1995-96	1996-97	1997-98	1998-99	1999-00
Upper Bay	26,600	2,600	18,800	13,100	28,100
Middle Bay	12,600	20,000	15,300	55,800	31,500
Lower Bay	800	300	4,800	8,300	3,800
Total Bay Mainstem	*40,000*	*22,800*	*38,900*	*77,200*	*63,400*
Chester River	42,600	5,400	43,000	21,000	70,100
Eastern Bay	1,500	1,100	3,800	30,900	75,800
Miles R.	200	500	30	800	35,700
Wye R.	0	0	400	900	9,400
Total Eastern Bay Region	*1,700*	*1,600*	*4,200*	*32,600*	*120,900*
Upper Choptank River	11,600	3,200	4,800	3,100	7,100
Middle Choptank R.	15,000	4,700	5,600	2,800	1,900
Lower Choptank R.	900	300	200	2,400	8,300
Tred Avon R.	1,300	3,800	6,900	11,700	3,700
Broad Creek	1,000	4,000	27,600	46,200	18,200
Harris Cr.	5,000	13,600	21,400	67,000	18,200
Total Choptank R. Region	*34,800*	*29,600*	*66,500*	*133,200*	*57,400*
Little Choptank River	1,900	40,800	36,100	84,100	33,600
Upper Tangier Sound	12,100	8,100	6,000	3,500	1,500
Lower Tangier S.	500	10,100	4,200	8,500	2,800
Honga River	400	200	1,300	300	50
Fishing Bay	20,900	8,800	3,800	700	90
Nanticoke R.	15,200	23,000	30,300	21,700	8,800
Wicomico R.	100	1,400	2,200	1,400	500
Manokin R.	0	900	600	300	90
Annemesex R.	0	0	0	0	200
Pocomoke S.	0	300	400	80	100
Total Tangier Sound Region	*49,200*	*52,800*	*48,800*	*36,500*	*14,100*
Patuxent River	100	20	60	5,600	2,000
Wicomico R., St. Clement's and Breton Bays	27,500	7,300	10,200	13,700	8,800
St. Mary's River and Smith Cr.	900	16,200	36,700	16,400	4,500
Total Potomac Md Tributaries	28,400	23,500	46,900	30,100	13,300
Total Maryland (bu.)[1]	**199,000**	**178,000**	**285,000**	**423,000**	**380,700**

[1] Including regions not listed.

Table 6 (continued).

Region/Tributary	2000-01	2001-02	2002-03	2003-04	2004-05
Upper Bay	31,150	16,100	18,930	2,210	1,632
Middle Bay	16,400	4,550	2,410	750	295
Lower Bay	2,050	600	50	187	1,801
Total Bay Mainstem	*49,600*	*21,250*	*21,390*	*3,147*	*3,728*
Chester River	20,800	29,450	11,830	557	3,239
Eastern Bay	120,500	33,400	4,650	5,446	16,767
Miles R.	20,150	6,600	50	56	353
Wye R.	11,300	1,800	60	0	173
Total Eastern Bay Region	*151,950*	*41,800*	*4,760*	*5,502*	*17,293*
Upper Choptank River	1,100	7,450	10	0	78
Middle Choptank R.	8,150	5,600	520	30	67
Lower Choptank R.	350	1,500	40	0	267
Tred Avon R.	8,950	1,000	40	0	139
Broad Creek	36,850	4,900	700	954	1,342
Harris Cr.	26,200	3,300	30	12	71
Total Choptank R. Region	*81,600*	*23,750*	*1,340*	*996*	*1,964*
Little Choptank River	27,850	2,400	190	1,150	144
Upper Tangier Sound	100	5,050	3,570	7,630	13,658
Lower Tangier S.	1,450	13,200	5,960	5,162	15,648
Honga River	0	50	590	378	2,744
Fishing Bay	0	0	390	24	106
Nanticoke R.	600	2,700	540	57	965
Wicomico R.	50	50	10	0	0
Manokin R.	200	1,850	970	1,638	2,816
Annemesex R.	0	0	0	0	5
Pocomoke S.	10	20	0	0	2,676
Total Tangier Sound Region	*2,400*	*22,920*	*12,030*	*14,889*	*38,618*
Patuxent River	10	0	0	0	466
Wicomico R., St. Clement's and Breton Bays	2,600	1,400	220	13	18
St. Mary's River and Smith Cr.	6,150	1,650	0	0	91
Total Potomac Md Tributaries	*8,750*	*3,050*	*220*	*13*	*109*
Total Maryland (bu.)[1]	**348,000**	**148,200**	**55,840**	**26,471**	**72,218**

[1] Including regions not listed.

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APPENDIX 1
OYSTER HOST and OYSTER PARASITES
C. Dungan

Oysters
The eastern oyster, *Crassostrea virginica,* tolerates water temperatures of 0-36 °C and salinities of 3-35 ppt, where ocean water has 35 ppt salinity. Oysters reproduce when sexes simultaneously spawn their gametes into Chesapeake Bay waters during June and July. Externally fertilized eggs develop into planktonic larvae, which are transported in Chesapeake Bay waters for several weeks while feeding on phytoplankton as they grow and develop. Mature larvae seek solid substrates, preferably oyster shells (valves), to which they attach as they metamorphose to become sessile juvenile oysters. Unlike fishes and other vertebrates, oysters do not strictly regulate the salt content of their tissues. Instead, the salt content of functioning oyster tissues conforms to the broad and variable range of salinities in oyster habitats. Thus, oyster parasites with high or narrow salinity requirements may be exposed to low environmental salinities when shed into the environment and while infecting oysters whose habitat salinity is diluted by precipitation. Upon its death, an oyster's shell springs open by default and its tissues are consumed by predators and scavengers. However, the resilient hinge ligament holds the articulated valves together for months. Vacant, articulated oyster shells in our samples are interpreted to represent oysters that died during the previous year, and their relative numbers are used to estimate recent natural mortality.

Dermo disease
Although the protozoan parasite that causes dermo disease is now known as *Perkinsus marinus*, it was first described as *Dermocystidium marinum* in Gulf of Mexico oysters (Mackin, Owen, and Collier 1950), and its name was abbreviated accordingly. Once described, dermo disease was also reported in Chesapeake Bay oysters (Mackin 1951). *Perkinsus marinus* is transmitted through the water to uninfected oysters in as few as three days, and such infections may prove fatal by 18 days. Heavily infected oysters are emaciated; showing reduced growth and reproduction (Ray and Chandler 1955). Although *P. marinus* survives both low temperatures and low salinities, its proliferation is high in the broad range of temperatures (15-35 °C) and salinities (17-34 ppt) that are typical of Chesapeake Bay waters during oyster dermo disease mortality peaks (Dungan and Hamilton 1995). Over several years of drought during the 1980s, *P. marinus* expanded its Chesapeake Bay distribution into upstream areas where it had been rare or absent, and became prevalent in newly infected oyster populations (Burreson and Ragone Calvo 1996). Since 1990, oysters in most Maryland populations have been infected.

MSX disease
The high-salinity, protozoan oyster pathogen *Haplosporidium nelsoni* was first detected and described as a *multinucleated sphere X* (MSX) from diseased and dying Delaware Bay oysters during 1957 (Haskin et al. 1966) and was found infecting oysters from lower Chesapeake Bay during 1959 (Andrews 1968). Although the location of early *H. nelsoni* infections in oyster gill tissues suggests waterborne transmission, the complete life cycle and infection mechanism of this parasite remain unknown. Despite many attempts, MSX disease has never been experimentally transmitted in the laboratory; although experimental oysters deployed in affected waters above 14 ppt salinity may acquire infections and die within three to five weeks. In Chesapeake Bay, *H. nelsoni* infection rates peak during May and deaths from *H. nelsoni* infections peak during August, when MSX disease is most active at water temperatures of 5-20

°C (Ewart and Ford 1993). Since MSX disease is rare in oysters from waters below 9 ppt salinity, the distribution of *H. nelsoni* in Chesapeake Bay varies as salinities change with freshwater inflows. During 1999 through 2002, consistently low freshwater inflows to Chesapeake Bay have fostered upstream range extensions by *H. nelsoni*, and MSX disease mortalities, during each successive drought year.

Appendix 1 References

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APPENDIX 2
GLOSSARY

box oyster	Pairs of empty oyster shells attached by their hinge ligaments. These remain articulated for months after the death of an oyster, providing a durable estimator of recent oyster mortality.
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.
dermo disease	Oyster disease caused by the protozoan pathogen, *Perkinsus marinus*.
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 effort to produce seed oysters and restore oyster bars.
fresh shell	Oyster shell from shucked oysters. It is used to supplement the dredged shell plantings.
Haplosporidium nelsoni	The (haplosporidian) protozoan oyster parasite that causes MSX disease.
infection intensity, individual	*Perkinsus* sp. parasite burdens of individual oysters, estimated by RFTM assays and categorized on an eight-point 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 imminently.
infection intensity, mean sample	Averaged categorical infection intensities for all oysters in a sample: *sum of all categorical infection intensities (0--7) ÷ number of sample oysters*. Oyster populations whose samples show mean infection intensities of 3.0 or greater are predicted to experience significant near-term mortalities.
infection intensity, mean annual	Averaged categorical infection intensities for all annual survey oysters: *sum of all sample mean intensities ÷ number of annual samples*.
intensity index, sample	Categorical infection intensities averaged only for infected sample oysters: *sum of individual infection intensities (1--7) ÷ number of infected oysters*.
intensity index, annual	Categorical infection intensities averaged for all infected annual survey oysters: *sum of all sample intensity indices ÷ number of annual samples*.
mortality (observed), percent sample	Percent proportion of annual, non-fishing oyster population mortality estimated by dividing the number of recent-dead (box) oysters by the sum of live and recent-dead oysters in replicate samples: *[number of boxes ÷ (number of boxes + number of live oysters)] x 100*.

mortality, percent annual	Percent proportion of annual, Bay-wide, non-fishing oyster mortality estimated by averaging population mortality estimates from all samples collected during an annual survey: *sum of sample mortality estimates ÷ number of survey samples*.
MSX disease	The oyster disease caused by the protozoan pathogen, *Haplosporidium nelsoni*.
MSX frequency, percent annual	Percent proportion of sampled populations infected by *H. nelsoni* (MSX): *(number of samples with MSX infections ÷ total sample number) x 100.*
Perkinsus marinus	The (alveolate) protozoan oyster parasite that causes dermo disease.
prevalence, sample infection	The percent proportion of infected oysters in a sample: *(number infected ÷ number examined) x 100.*
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 described in 1952 [*Science* **116**:360-361] for enlargement, detection, and enumeration of *Perkinsus marinus* cells in oyster tissue samples. This diagnostic assay for dermo disease has been widely used and refined for over fifty years to date.
seed	Young oysters produced by planting shell in naturally productive (seed production) areas. If the spatfall is adequate, the seed are subsequently transplanted to growout (seed planting) areas, generally during the following spring.
spat	Oysters less than one year old.
spatfall, spatset, set	The process by which a swimming oyster larva attaches to a hard substrate such as oyster shell. During this process the larva undergoes metamorphosis, adopting the adult form and habit.
spatfall intensity	The number of spat per bushel of cultch. This is a relative measure of density used to calculate the spat index.
spatfall intensity index	The arithmetic mean of spatfall intensities from 53 fixed reference sites or Key Bars.