MARYLAND OYSTER POPULATION STATUS REPORT
2001 FALL SURVEY

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INTRODUCTION

Since 1939, various state agencies in Maryland have conducted annual dredge-based surveys of oyster bars. These assessments have provided biologists and managers with information on oyster spatfall intensity, observed mortality, and more recently, parasitic infection status in Maryland's 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 allows the discernment of trends in the oyster population. Monitored sites have included natural oyster bars, seed production grounds, seed oyster transplantation locations, and fresh shell plantings. Since this survey began, several changes and additions have been made to allow the development of structured indices and statistical frameworks while preserving the continuity of the long-term data set. In 1974, 53 sites referred to as the historical "Key Bar" set were fixed and form the basis of an annual spatfall intensity index (arithmetic mean) (Krantz and Webster 1980). These sites were selected to provide both adequate geographical coverage and continuity with data going back to 1939. An oyster parasite diagnosis component was added in 1958, and in 1990 a 43 bar subset (Disease Bar set) was established for obtaining standardized parasite prevalence and intensity data. Thirty one of the Disease Bars are among the 53 spatfall index oyster bars (Key Bars).

METHODS

The 2001 Annual Fall Dredge Survey was conducted by Shellfish Division staff from the Maryland Department of Natural Resources (MDNR) Fisheries Service between early October and mid-November. Oyster parasite diagnostic tests were performed by staff of the Sarbanes Cooperative Oxford Laboratory (SCOL). A total of 367 samples were obtained to examine 264 natural oyster bars, including Key Bar and Disease Bar sites, as well as contemporary seed oyster planting sites, shell planting locations, and seed production sites (Figs. 1a and 1b). Data on seed and shell plantings are provided in Hess (2001).

A standard 36 inch wide oyster dredge was used to collect the samples. At each of the 53 Key Bar sites and the 43 Disease Bars, two 0.5 bushel subsamples were collected from replicate dredge tows. On State seed production grounds, five 0.2 bushel subsamples were taken from replicate dredge tows. At all other sites, one 0.5 bushel subsample was collected from an oyster dredge tow. A list of data recorded from each sample appears in Table 1.

In past years, representative subsamples of 30 oysters, ≥40mm in shell height, were taken at each of the 43 Disease Bar sites. During 2001, results were obtained for only 42 sites because an adequate sample of oysters could not be caught at Flag Pond. Additional disease status samples were collected from seed production sites, seed oyster planting locations, and areas of special interest. All oysters were transported to SCOL for parasite diagnostic tests. Data reported for *Perkinsus marinus* (dermo disease) are from rectal Ray's fluid thioglycollate medium (RFTM) assays. Prior to 1999 the less sensitive hemolymph assays were performed. Data reported for *Haplosporidium nelsoni* (MSX disease) have been generated from tissue histology since 1999. Before 1999 hemolymph cytology was performed, while tissue samples were examined for *H. nelsoni* only from selected locations.

In this report, prevalence refers to the percentage of oysters in a sample that are infected with a parasite, regardless of infection intensity. Intensity refers to the mean infection stage or parasite concentration in sampled oysters. An index, ranging from zero to seven, based on pathogen concentration in hemolymph or solid tissue is used to classify intensities. (See Gieseker 2001 for a complete description of parasite diagnostic techniques and calculations).

Total observed mortality (small and market oysters combined) was calculated as the

light set was found in the upper bay along the Kent County side, which does not usually receive a spatfall.

The 2001 spatfall intensity data from the Key Bar set is compared with previous years through 1985 in Table 2. The overall spatfall intensity for 2001 was 15.9, a 2½ -fold improvement over the previous year but less than a third of the 17 year average of 55.5. Figure 4 charts the spatfall intensity index from 1985 through 2001, along with the 17 year mean, and gives three groupings of statistically similar years from greatest to least as determined from a multiple comparison procedure associated with Friedman's Two-Way Rank Sum Test. Despite the below average spatfall, 2001 fell into the middle tier of spatfall rankings.

The period from 1985-2001 (Fig. 4; Table 2) included some of the lowest spatfall intensity indices (1989, 1994, 1996, 1998 and 2000) and two of the highest (1991 and 1997) over the 62 year history of the Annual Fall Dredge Survey (Krantz 1996). Spatfall intensity indices from 1996-2001 included the lowest on record (1996) and the second highest (1997).

Friedman's Two-Way Rank Sum Test produced what appears to be an anomaly, with the extremely high index year of 1997 grouped in the middle tier (Fig. 4). However, spatfall intensity in 1997 was 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 part of the Little Choptank and St. Mary's Rivers (MDNR 2001). Only five of the 53 Key Bars contributed to over 75% of the 1997 index, while ten contributed nearly 95%. By contrast, the 1991 spatfall was far more widespread as evidenced by 15 Key Bars totaling 75% of the index (the 3rd highest on record), and 28 sites were needed to attain 95% of the spatfall intensity index. In 2001, eight of the 53 Key Bars totaled 75% of the index; however, the number of bars receiving a light set were more evenly distributed so that it took 21 bars to reach a 95% total. Since the spatfall intensity index is calculated as an arithmetic mean, several Key Bar sites with unusually high spatfall intensities can unduly influence the index. The data from 1991 and 1997 clearly indicate the utility of a statistically based ranking index, such as Friedman's Test, that more accurately defines spatfall intensity.

Oyster Parasites

Perkinsus marinus, the causative agent of dermo disease, essentially occurs throughout all of the Maryland oyster grounds, based on the results from the 43 Disease Bars (Fig. 5). The possible exception might be a few marginal bars in the lowest viable salinity areas; their disease status is uncertain as they were not tested and may not have been in close proximity to a Disease Bar. Oysters from all 43 of the Disease Bars tested positive for this parasite (Table 3). The prevalences of infected oysters on the individual bars averaged 93%, the highest recorded in the past 12 years (Fig. 6). Only four Disease Bars had prevalences below 80% (Table 3). Even lower salinity bars such as Swan Point in the upper bay and Lower Cedar Point in the Potomac River had prevalences of 90% or greater. Statistical results rank 2001 in the top tier for *P. marinus* prevalence since 1990, along with 1999 (Fig. 6).

More ominously, *P. marinus* intensity also rose to its highest level over the past 12 years, and was statistically ranked in the highest tier with only 1991 and 1999 (Fig. 7). Fifteen of the 43 Disease Bars had lethal intensities[2] in 50% or more of the oysters (Table 3).

Generally, *Perkinsus marinus* mean prevalence and infection intensity data patterns inversely followed patterns of freshwater flow. The only exceptions occurred with comparing data from 1993 and 1997 (Figs. 2, 6, and 7). As previously mentioned, the 1993 freshet was mainly confined to the Potomac River drainage and had little impact on salinities elsewhere in the Chesapeake. In 1997, relatively high flows occurred during the spring period and drought conditions did not prevail until mid-summer.

Haplosporidium nelsoni, commonly referred to as MSX, is another potentially devastating oyster parasite. This parasite can

[2] Defined as an intensity rating of 5 or greater.

cause rapid mortality in oysters and generally kills a wider range of oyster year classes than does *P. marinus*.

H. nelsoni was found in oysters from 28 of 42 Disease Bars, occurring as far upbay as lower Eastern Bay on the eastern shore and Holland Pt. on the western shore (Table 4; Fig. 5). This distribution is essentially unchanged from the previous year (MDNR 2001). The frequency of occurrence (the number of bars with MSX out of the total examined) also showed little change from 1999 and 2000, when *H. nelsoni* sharply expanded its range, coincident with the onset of the drought (Figure 6). In contrast, between 1996 and 1998, *H. nelsoni* was found on only eight or fewer of the 43 Disease Bar set.

The prevalence of *H. nelsoni* among oysters on the individual infected bars tended to be relatively low. Only five of the 28 affected Disease Bars had prevalences over 33%, and none exceeded 50% (Table 4).

Since 1990, there have been three *H. nelsoni* epizootics: 1991-1992, 1995, and 1999-2001. The most severe of these occurred in 1991-1992. The current epizootic, if it persists, will approach conditions seen in 1992. Both of the earlier recent epizootics were followed closely by periods of unusually high freshwater input into the Chesapeake Bay, in 1993 and in 1996. These freshet events were largely responsible for the dramatic contraction of the geographic distribution of *H. nelsoni* in 1993 and in 1996 (Table 4).

Oyster Mortality

Observed oyster mortalities throughout most of the Bay and major tributaries ranged between 26% and 50% (Fig. 8). The notable exceptions were in the Potomac and Patuxent Rivers, where observed mortalities exceeded 50%.

The average observed mortality on the 43 Disease Bars for smalls and markets in 2001 was 38%, compared with the 17-year average of 28% (Figure 9). The 2001 average was the third highest since 1985, statistically ranking it in the highest mortality tier. This marks three consecutive years of highest ranked mortalities. The highest 2001 Disease Bar observed mortality was 81% on Goose Creek Bar in Fishing Bay (Table 5).

Since 1997 there has been a steady increase in observed mortality. In addition, the number of sites with total observed mortality of 30% or greater increased substantially between 1996 and 2001. From 1996 through 1998, only between eight to eleven of the 43 Disease Bars exhibited total observed mortality of 30% or more. In 1999 and 2000, respectively, 21 and 24 of the Disease Bar sites (out of 42 in 2000) had mortalities of 30% and greater (Table 5). Thirty-four of the bars had observed mortalities of 30% or greater in 2001.

Friedman's Two-way Rank Sum test results indicated three tiers of observed mortality. Annual total mortality averages and rank tiers are shown for 1985-2001 in Figure 9.

Commercial Harvest [3]

The 2000-01 harvest of 348,000 bushels represents a slight drop from the previous year (Figure 10). This marks the second consecutive year of modest declines, reversing a half decade trend of increasing catches. Nevertheless, this harvest is more than four times the 1993-94 season, which had the lowest oyster landings on record.

Two-thirds of the total 2000-01 harvest came from only two regions, reflecting the strong 1997 year class recruited in those areas. Almost half of the total was from Eastern Bay and its tributaries (Table 6). The Choptank River region, primarily the Broad and Harris Creek tributaries, contributed another 23%. About 9% of the harvest came from the upper bay bars, ranking this region third in harvests. The region of sharpest decline was the Chester River, where landings plummeted by 70% from those of 2000, a loss of 50,000 bu. This was the second highest producing region in 1999-2000, contributing 18% of the total harvest. The middle

[3] Harvest data presented in this report are rounded. Exact information can be obtained from the MDNR Fisheries Service, Resource Management Division.

number of boxes and gapers[1] divided by the sum of live and dead oysters.

To provide a statistical framework for some of the Annual Fall Survey data sets, a nonparametric treatment, Friedman's Two-Way Rank Sum Test, was used (Hollander and Wolfe 1973). This procedure, along with an associated multiple range test, allowed among- year comparisons for a variety of parameters. Additionally, mean rank data can be viewed as annual indices, thereby allowing temporal patterns to emerge. Friedman's Two-Way Rank Sum Test, an analog of the normal scores general Q statistic (Hájek and Šidák 1967), is an expansion of paired replicate tests (e.g. Wilcoxon's Signed Rank Test or Fisher's Sign Test). Friedman's Test differs substantively from a Two-Way ANOVA in that interactions between blocks and treatments are not allowed by the computational model. (See Lehman (1962) for a more general model that allows such interactions). The lack of block-treatment interaction terms is crucial in the application of Friedman's Test to the various sets of Fall Survey oyster data, as it eliminates nuisance effects associated with intrinsic, site-specific characteristics. That is, since rankings are assigned across treatments (in this report, years), but rank summations are made along blocks (oyster bars), intrinsic differences among oyster bars are not an element in the test result. All Friedman test results in this report were evaluated at α=0.05.

To quantify annual relationships, a distribution-free multiple comparison procedure, based on Friedman's Rank Sum Test, was used to produce the "tiers" discussed in this report. Each tier consists of a set of annual mean ranks that are not statistically different from one another. This procedure (McDonald and Thompson 1967) is relatively robust, very efficient, and, unlike many multiple comparison tests, allows the results to be interpreted as hypothesis tests. Multiple comparisons were evaluated using "yardsticks" developed from experimentwise error rates of α=0.15.

[1] A box is a dead oyster with articulated valves but with no body tissue remaining; a gaper still has body tissue.

RESULTS

Freshwater Discharge Conditions

Freshwater flow affects salinity, which is a key factor in oyster spatfall, disease, and mortality. During 2001, freshwater flow into the Chesapeake Bay, its Maryland tributaries and the Potomac River was about two-thirds of the 50 year monthly mean, the lowest in the past 16 years (Sec. "C" in Bue 1968; USGS 2001) (Fig. 2). This marks the third consecutive year and seven out of the past 11 years that flows were below average.

Over the 14 year period prior to this sustained drought, low flow years had alternated with high flow years on an annual or at most bi-annual basis. Going back to 1985, significant freshets occurred in 1990, 1993, 1994, 1996, and 1998. These often resulted in substantial oyster mortalities, such as the 1993 event in the Potomac River drainage (MDNR 2001). The freshets of 1994, 1996, and 1998 had a more geographically widespread impact on oyster mortality. The freshets of 1993, 1994, and 1998 were winter/spring events unlike the 1996 high freshwater flows which persisted over the entire year (USGS 2001).

Moderate to severe low freshwater flows into the Chesapeake Bay resulted in elevated salinities during 1997, 1999, 2000 and 2001. Since 1985, low flows were particularly severe (≤80% of the 50 year average) in 1988, 1991, 1995, 1997, 1999 and 2001.

Spatfall Intensity

Maryland spatfall distribution for 2001, as number of spat per bushel of shell, is mapped in Figure 3. Spatfall was highest in Tangier Sound and the lower eastern mainstem of Chesapeake Bay. Noteworthy was the generally poor spatfall in the central part of the bay and tributaries, including the Choptank, Little Choptank and Patuxent Rivers and Eastern Bay. In contrast, the latter area had one of the heaviest spat sets on record in 1997. The Potomac River also had very little spat set. A

bay, Tangier Sound, and Potomac River tributaries also experienced steep production declines.

Regional harvest summaries from the 1985-86 season through the 1999-2001 season are given in Table 6. Over this period, harvesters have become increasingly dependent on the lower salinity zones such as the Chester River and the upper bay. The middle to higher salinity areas have become increasingly less reliable for commercial oyster production.

SUMMARY

It is clear that oyster mortality since the late 1980s has been strongly influenced by levels of freshwater discharge into the Chesapeake Bay, with freshets directly killing oysters and drought resulting in higher disease levels. During this period, the temporal pattern of *P. marinus* infection changed from acute (epizootic) to chronic (enzootic) on the majority of oyster bars in Maryland (Table 7). This profoundly changed the nature of *P. marinus'* impact on oyster populations. Before chronic conditions occurred, *P. marinus* infections would build up over a one to three year period. After an intense outbreak, the protozoan would then become undetectable in all but a few of the regional oyster populations. Once chronic infections became established in oyster populations, however, intense outbreaks became more frequent, with their periodicity largely controlled by freshwater discharge into the Bay (Ford and Tripp 1996). Since oysters situated in the lower salinity zones have been relatively safe from parasite-induced mortality, these areas have become increasingly important to the commercial fishery. However, these lower salinity populations have received little or no recruitment since 1991 and are at risk from high freshwater discharges as evidenced by mortalities from the 1993, 1994, 1996, and 1998 freshets (MDNR 2001). Given the chronic nature of *P. marinus* infections, low and even average freshwater discharges into the Chesapeake Bay tend to increase oyster infection intensities and mortalities. In addition, low flow conditions have generally resulted in *H. nelsoni* epizootics. This parasite can cause rapid mortality in oysters, kills a wider range of oyster year classes than does *P. marinus*, and typically produces a severe spike in mortality (Smith and Jordan 1992).

The 1996-2001 period included three of the lowest annual spatfall intensity indices on record as well as the second highest since 1939, the year to which this index was back-calculated (Krantz, 1996). Such volatility in spatfall intensity has been, at least from 1939, a characteristic of larval settlement in Maryland waters. Since the mid-1980s, however, high spatfall intensity years have generally been followed by periods of high *P. marinus* infection pressure and *H. nelsoni* epizootics, resulting in substantial year class losses. This pattern has been reflected in declining commercial fishery yields during this period, and in substantial changes and shifts in regional production.

During the 1996-2001 period, *P. marinus* disease pressure steadily increased, similar to the pattern observed between 1991-1993. What differs between the two periods, however, is that the later period exhibited increases in both the overall level of infection intensity (Figure 7) and the frequency of sample mean intensity levels of 3.0 or greater (Figure 11). While about 40% to 50% of the Chesapeake Bay oyster bars (as represented by the Disease Bar set) from 1991-1993 had mean *P. marinus* infection intensities of 3.0 or greater, over 67% of oyster bars had mean infection intensities of 3.0 or greater during 1999-2001.

A severe *H. nelsoni* epizootic occurred in 1999, the second such since 1990. Unlike the short-lived 1992 outbreak, however, the 1999 epizootic has persisted three years through 2001. The brevity of the 1992 epizootic was clearly associated with the 1993 freshet. Since the mid-1980s, both the geographic range of *H. nelsoni* epizootics and associated mortalities have substantively increased in Maryland (MDNR 1988; Krantz 1990).

Although high, recent (1999-2001) mortality levels fell within the range of values for the long-term 1985-2001 period of observed mortalities. However, the 28% mean observed

mortality average from 1985-2001 was substantially greater than the approximately 5-10% mortalities recorded in previous years (MDNR 1975-1984).

Although records of oyster mortality prior to 1975 are spotty and occasionally anecdotal, it appears that before the introduction of *H. nelsoni* and impacts from *P. marinus* outbreaks, mass natural mortality of oysters in Maryland's Chesapeake Bay was generally associated with freshets and occurred in the lower salinity areas. Since the onset of parasitic infections, mass mortalities have become more common and severe and increasingly widespread. This trend is clearly reflected in the historical records of the Annual Fall Dredge Survey and the commercial harvest yields. The period from 1999 through 2001 indicated a strengthening of this pattern.

LITERATURE CITED

Bue, C.D. 1968. Monthly surface-water inflow to Chesapeake Bay: U.S. Geological Survey Open-File Report, Arlington, Va, October 1968, 45p.

Ford, S, and M.R. Tripp. 1996. Chapter 17. Diseases and Defense Mechanisms. Pages 581-660 *in* V.S. Kennedy, R.I.E. Newell, and A.F. Eble (eds.), The Eastern Oyster, *Crassostrea virginica*. Maryland Sea Grant Publ. UM-SG-TS-96-01.

Gieseker, C.M. 2001. Year 2000 Maryland Oyster Disease Status Report. MDNR, Fisheries Service, Sarbanes Cooperative Oxford Lab. FS-SCOL-01-1. Oxford, Md.

Hájek, J. and Z. Šidák. 1967 Theory of Rank Tests. Academic Press, New York

Hess, J. 2001. Seed oyster and shell activity reports. MDNR, Shellfish Program, Annapolis, Md.

Hollander, M. and D.A. Wolfe. 1973. Nonparametric Statistical Methods. John Wiley and Sons, New York., N.Y.

Krantz, G.E. and D.W. Webster. 1980. Maryland Oyster Spat Survey Fall 1979. Tech. Rep. Md. Sea Grant Prog. No. UM-SG-TS-80-01. College Park, Md.

Krantz, G.E. 1990. Maryland Oyster Population Status Report, 1989 Fall Survey. MDNR, Ches. Bay Res. Monitoring Div., CBRM-OX-90-1. Oxford, Md

Krantz, G.E. 1996. Oyster Recruitment in the Chesapeake Bay, 1939 to 1993. MDNR, Fish. Serv. Spec. Publ. Oxford, Md.

Lehman, E.L. 1963. Asymptotically nonparametric inference in some linear models with one observation per cell. Ann. Math. Statist. 34:1494-1506.

McDonald, B.J. an W.A. Thompson, Jr. 1967. Rank sum multiple comparisons in one- and two-way classifications. Biometrika 54:487-497.

MDNR.1975-1984. Unpublished data, Bay-wide Bottom Survey and Annual Fall Dredge Surveys.

MDNR. 1988. Status and trends, Maryland's oyster resources. Tidewater Admin., Fish. Div., 61pp.

MDNR. 2001. Maryland Oyster Population Status Report: 1996-2000 Fall Surveys. Sarbanes Cooperative Laboratory and Shellfish Program.

Smith, G. and S. Jordan. 1993. Monitoring Maryland's Chesapeake Bay Oysters. MDNR, Ches. Bay Res. and Monitor. Division Rep. No. CBRM-OX-93-3. Oxford, Md.

USGS. 1985-2000. Annual Reports on Freshwater Inflow into The Chesapeake Bay Region. United States Geological Survey Inflow Database.

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

-Latitude and longitude

-Type of sample and date of action, ie. 1997 seed, natural, 1990 fresh shell planting, etc.

-Bottom type and depth

-Number and average and range of shell heights of live and dead spat, smalls, and markets

-Shell heights of oysters grouped into 5 mm intervals (Disease Bar sites 1990-2000)

-Stage of oyster boxes

-Relative volume of live and dead oysters

-Condition index and meat quality of live oysters

-Type and relative extent of fouling

-Relative volume of fouling organisms

-Temperature and salinity

Table 2. Spatfall intensity (spat per bushel of cultch) from the 53 "Key" spat monitoring bars, 1985-2001.

Oyster Bar	Spatfall Intensity, Number Per Bushel								
	1985	1986	1987	1988	1989	1990	1991	1992	1993
Mountain Point	6	0	0	0	0	0	0	0	13
Swan Point	4	0	2	2	0	0	2	0	3
Brickhouse	78	0	4	8	0	3	0	0	0
Hacketts Point	0	4	0	0	0	0	0	0	1
Tolly Point	2	2	2	0	0	0	0	0	0
Three Sisters	10	2	8	0	0	0	0	0	0
Holland Point	6	2	0	0	0	0	0	2	0
Stone Rock	136	150	20	30	5	37	355	15	4
Flag Pond	98	306	128	98	0	4	330	8	0
Hog Island	116	32	58	35	2	7	169	2	2
Butlers	418	196	171	16	2	24	617	3	2
Buoy Rock	16	0	6	0	0	1	0	0	0
Parsons Island	78	2	4	2	0	7	127	18	2
Wild Ground	46	8	4	8	0	18	205	8	4
Hollicutts Noose	24	8	12	6	0	1	11	1	0
Bruffs Island	82	0	0	2	0	1	12	8	0
Ash Craft	10	2	0	10	0	2	12	0	0
Turtleback	382	40	12	34	6	11	168	15	0
Shell Hill	50	10	0	6	0	0	79	0	0
Sandy Hill	74	16	2	0	0	28	179	2	0
Royston	440	8	8	0	0	57	595	10	8
Cooks Point	64	82	4	28	0	17	171	1	0
Eagle Point	255	28	2	6	6	18	387	4	15
Tilghman Wharf	156	128	38	4	2	109	719	10	59
Deep Neck	566	114	6	22	4	48	468	22	94
Double Mills	332	24	2	0	0	1	129	0	13
Ragged Point	134	118	34	112	0	65	1036	53	10
Cason	400	24	46	50	0	143	1839	43	37
Windmill	34	112	43	22	16	155	740	46	20
Normans Addition	56	214	38	17	34	82	1159	53	33
Goose Creek	34	79	16	18	4	4	153	41	43
Clay Island	4	78	14	48	18	12	256	46	58
Wetipquin	34	10	0	0	0	3	3	6	1
Middleground	18	12	26	9	14	40	107	63	14
Evans	16	10	12	14	9	2	20	27	7
Mt. Vernon Wharf	0	0	0	0	0	0	15	0	18
Georges	26	97	14	4	16	4	52	42	19
Drum Point	48	186	48	90	72	16	140	185	45
Sharkfin Shoal	18	44	22	24	2	16	43	97	18
Turtle Egg	160	90	12	26	26	204	289	591	37
Piney Island East	182	384	50	160	74	64	429	329	22
Great Rock	2	6	4	6	10	12	208	44	27
Gunby	124	88	50	9	8	21	302	156	176
Marumsco	29	50	18	3	12	6	142	34	55
Broomes Island	34	0	0	0	0	3	12	0	0
Back of Island	42	0	8	4	4	15	49	5	0
Chicken Cock	620	298	96	62	18	29	182	5	45
Pagan	140	34	52	36	6	613	190	62	15
Black Walnut	16	6	0	0	0	1	6	0	1
Blue Sow	34	35	0	0	0	1	22	0	1
Dukehart	21	4	2	0	0	2	19	0	2
Ragged Point	69	66	4	0	0	2	14	0	3
Cornfield Harbor	383	908	362	28	14	26	212	2	29
Spat Index	**115.6**	**77.7**	**27.6**	**20.0**	**7.2**	**36.7**	**233.5**	**38.8**	**18.0**

Table 2 (Continued).

Oyster Bar	Spatfall Intensity, Number Per Bushel							
	1994	1995	1996	1997	1998	1999	2000	2001
Mountain Point	0	0	0	1	0	0	0	0
Swan Point	0	1	0	0	0	0	0	0
Brickhouse	0	5	0	0	0	1	1	3
Hacketts Point	0	0	0	0	0	0	1	0
Tolly Point	0	0	0	0	0	2	2	1
Three Sisters	0	1	0	0	0	0	0	1
Holland Point	0	1	0	0	0	0	0	1
Stone Rock	4	29	0	18	0	3	34	2
Flag Pond	0	10	0	7	0	1	5	5
Hog Island	0	24	0	5	2	6	1	28
Butlers	1	7	1	8	0	6	1	27
Buoy Rock	0	6	0	8	0	0	0	2
Parsons Island	0	57	0	3,375	3	6	6	6
Wild Ground	0	68	0	990	0	2	5	5
Hollicutts Noose	0	7	0	56	0	6	2	1
Bruffs Island	1	15	0	741	4	5	9	6
Ash Craft	0	60	1	2,248	0	14	2	10
Turtleback	0	194	0	3,368	5	13	4	45
Shell Hill	0	15	0	19	1	4	4	0
Sandy Hill	0	4	0	55	0	4	0	1
Royston	0	14	0	289	0	39	0	3
Cooks Point	2	16	0	20	0	1	5	5
Eagle Point	0	67	0	168	2	16	0	5
Tilghman Wharf	4	64	0	472	0	49	1	1
Deep Neck	12	294	3	788	1	211	3	11
Double Mills	0	15	0	40	0	1	0	0
Ragged Point	3	16	0	106	0	43	3	5
Cason	28	48	5	228	4	53	5	2
Windmill	19	13	2	5	1	37	0	21
Normans Addition	17	25	0	8	0	31	1	30
Goose Creek	27	3	0	5	0	0	0	0
Clay Island	31	11	1	20	2	5	4	8
Wetipquin	4	1	0	0	10	0	0	0
Middleground	28	2	6	27	0	9	1	0
Evans	30	2	1	5	0	1	0	0
Mt. Vernon Wharf	0	3	0	0	1	0	0	0
Georges	9	16	0	8	6	50	6	1
Drum Point	13	14	10	16	11	157	27	44
Sharkfin Shoal	11	6	0	7	0	9	5	0
Turtle Egg	31	7	35	70	3	180	33	33
Piney Island East	25	23	25	45	16	118	28	167
Great Rock	11	3	7	0	1	82	6	140
Gunby	7	35	9	0	24	54	32	6
Marumsco	5	6	0	0	57	27	27	4
Broomes Island	0	58	0	0	1	7	0	1
Back of Island	1	17	0	3	0	22	9	44
Chicken Cock	4	78	2	36	10	132	16	12
Pagan	7	54	0	1,390	6	95	42	117
Black Walnut	0	1	0	2	0	3	0	1
Blue Sow	0	5	0	0	0	11	0	2
Dukehart	0	0	0	0	0	1	0	0
Ragged Point	0	20	0	2	0	1	1	0
Cornfield Harbor	0	49	0	4	11	25	5	35
Spat Index	**6.3**	**28.1**	**2.0**	**276.7**	**3.5**	**29.1**	**6.4**	**15.9**

Table 3. *Perkinsus marinus* prevalence and intensity (scale of 0-7) in oysters from the 43 disease monitoring bars, 1990-2001. ND indicates insufficient quantity of oysters for analytical sample.

Bar	*Perkinsus marinus* Prevalence (%) and Intensity (I)							
	1990		1991		1992		1993	
	%	I	%	I	%	I	%	I
Swan Point	7	0.1	27	0.7	23	0.4	37	0.8
Hacketts Point	0	0.0	27	0.8	57	1.2	97	3.2
Holland Point	20	0.5	47	1.1	80	2.4	93	3.0
Stone Rock	47	0.5	27	0.9	100	4.4	100	3.5
Flag Pond	30	0.8	97	2.6	97	5.7	88	2.7
Hog Island	90	3.0	97	4.5	100	4.2	93	2.4
Butlers	100	4.0	100	4.0	81	2.4	97	3.3
Buoy Rock	23	0.5	80	2.5	97	2.8	93	3.3
Oldfield	17	0.2	20	0.5	37	0.9	83	2.4
Bugby	100	3.4	100	4.0	73	1.8	100	3.0
Parsons Island	20	0.5	97	3.6	80	2.1	100	3.3
Hollicutts Noose	30	0.3	73	2.0	82	2.1	97	2.7
Bruffs Island	83	2.8	83	2.8	93	3.0	83	2.6
Turtleback	100	3.8	100	3.3	77	1.6	100	3.3
Long Point	73	2.3	94	4.3	86	3.0	77	2.6
Cooks Point	17	0.2	23	0.3	87	3.7	97	4.2
Royston	--	---	100	4.5	97	4.8	100	3.3
Lighthouse	90	2.3	100	4.0	100	4.6	93	3.2
Sandy Hill	100	5.0	100	5.7	100	4.2	100	3.8
Oyster Shell Point	3	0.1	60	1.7	100	3.9	93	2.8
Tilghman Wharf	100	3.2	97	3.0	100	3.4	100	3.2
Deep Neck	100	4.9	100	5.6	100	3.7	100	3.8
Double Mills	97	3.6	100	4.9	100	4.1	100	3.8
Cason	100	3.4	100	4.4	90	2.6	93	2.8
Ragged Point	100	4.8	100	4.6	100	5.0	100	3.9
Normans Addition	100	4.2	100	3.4	83	2.0	96	3.6
Goose Creek	60	1.8	100	3.1	100	3.6	87	2.1
Wilson Shoals	93	2.9	100	2.8	90	2.5	83	1.6
Georges	83	1.9	93	2.9	58	1.4	30	0.7
Holland Straits	100	4.2	100	4.0	100	3.4	76	2.3
Sharkfin Shoal	23	0.3	60	1.2	97	2.8	93	2.2
Back Cove	100	2.7	100	4.2	97	3.3	36	1.0
Piney Island East	93	2.7	97	3.1	87	2.7	83	2.2
Old Woman's Leg	57	1.1	100	4.5	100	4.0	82	2.0
Marumsco	97	3.5	93	3.3	60	1.3	87	2.5
Broomes Island	97	3.4	100	2.8	63	1.5	87	3.0
Chicken Cock	100	4.2	97	3.1	93	3.2	96	2.6
Pagan	93	3.3	97	2.3	100	3.0	93	2.1
Lancaster	97	3.6	97	2.8	67	1.4	67	1.6
Mills West	13	0.2	80	2.0	90	2.9	63	1.8
Cornfield Harbor	97	3.4	83	2.3	100	3.8	93	2.9
Ragged Point	97	3.8	90	2.8	40	0.9	50	1.4
Lower Cedar Point	40	0.7	10	0.3	23	0.6	7	0.1
***P. marinus* Indices**	**70**	**2.3**	**83**	**3.0**	**83**	**2.8**	**84**	**2.6**

Table 3 (Continued).

Bar	*Perkinsus marinus* Prevalence (%) and Intensity (I)							
	1994		1995		1996		1997	
	%	I	%	I	%	I	%	I
Swan Point	3	0.1	20	0.2	0	0.0	3	0.1
Hacketts Point	23	0.5	90	2.5	30	0.7	43	1.3
Holland Point	36	1.1	87	2.9	47	1.4	37	1.1
Stone Rock	90	2.5	87	2.2	93	2.7	90	2.3
Flag Pond	30	0.8	87	3.3	63	2.0	53	1.2
Hog Island	37	1.0	93	2.7	43	1.2	47	1.3
Butlers	80	2.1	87	2.5	60	1.6	57	1.0
Buoy Rock	10	0.3	67	1.7	13	0.4	7	0.7
Oldfield	20	0.6	83	2.3	0	0.0	10	0.2
Bugby	43	0.8	83	2.6	80	2.0	70	1.8
Parsons Island	93	3.1	70	2.1	73	2.8	63	1.4
Hollicutts Noose	70	1.7	90	2.8	60	1.4	50	1.0
Bruffs Island	63	1.3	73	2.1	67	1.4	17	0.2
Turtleback	60	1.2	100	2.8	83	2.1	83	1.8
Long Point	60	2.0	67	2.2	20	0.4	23	0.6
Cooks Point	90	3.0	ND	---	60	1.5	70	2.4
Royston	80	2.0	63	2.0	50	1.1	67	1.5
Lighthouse	47	1.2	90	3.3	77	1.8	57	1.5
Sandy Hill	83	2.3	89	3.4	30	0.7	60	1.3
Oyster Shell Pt	10	0.3	68	1.8	13	0.2	50	0.9
Tilghman Wharf	63	1.9	93	2.5	67	1.3	60	1.0
Deep Neck	67	2.3	97	3.0	83	2.1	100	2.6
Double Mills	90	2.0	75	2.5	70	1.2	83	2.0
Cason	83	2.2	93	2.3	87	1.9	93	2.4
Ragged Point	87	2.3	93	2.5	97	2.6	97	2.1
Normans Add.	93	3.3	87	2.8	93	2.4	73	1.6
Goose Creek	53	1.1	87	2.5	97	4.0	83	2.0
Wilson Shoals	40	0.9	63	1.1	83	1.8	80	1.9
Georges	50	1.2	87	2.8	93	2.0	93	2.2
Holland Straits	57	1.6	93	3.1	83	2.0	67	1.8
Sharkfin Shoal	63	1.4	90	3.0	97	2.1	93	2.6
Back Cove	80	2.2	83	3.0	97	3.2	93	2.9
Piney Isl East	87	3.1	93	2.5	63	1.7	73	2.2
Old Woman's Leg	73	2.1	100	4.2	80	2.3	57	1.3
Marumsco	72	1.6	100	4.2	90	2.4	61	2.1
Broomes Island	40	0.6	43	1.0	17	0.4	83	2.1
Chicken Cock	40	1.0	83	1.9	77	1.4	73	1.7
Pagan	10	0.3	93	2.2	82	1.4	86	1.7
Lancaster	20	0.2	27	0.6	56	1.2	80	1.6
Mills West	20	0.2	57	1.4	60	1.2	60	1.2
Cornfield Hrb	77	1.9	93	2.5	87	2.0	83	1.8
Ragged Point	10	0.2	33	0.8	7	0.2	0	0.0
Lower Cedar Pt.	7	0.1	13	0.2	3	0.3	0	0.0
***P. marinus* Indices**	**54**	**1.4**	**78**	**2.3**	**61**	**1.5**	**62**	**1.5**

Table 3 (Continued).

Bar	*Perkinsus marinus* Prevalence (%) and Intensity (I)							
	1998		1999		2000		2001	
	%	I	%	I	%	I	%	I
Swan Point	43	1.2	97	3.4	80	1.2	93	3.3
Hacketts Point	43	1.1	97	3.3	97	3.7	97	3.4
Holland Point	37	0.9	93	2.8	87	3.4	93	3.2
Stone Rock	100	3.5	100	4.0	93	3.6	83	2.8
Flag Pond	73	2.3	ND	---	ND	ND	ND	ND
Hog Island	97	3.2	93	5.5	83	3.9	93	3.4
Butlers	97	3.3	93	3.2	83	2.7	80	2.4
Buoy Rock	33	0.9	93	3.0	97	3.5	93	3.5
Oldfield	33	0.8	97	3.0	93	3.0	100	3.3
Bugby	60	1.4	100	3.9	100	4.0	100	4.6
Parsons Island	80	2.5	100	4.7	100	3.5	100	4.5
Hollicutts Noose	83	2.5	90	3.0	100	4.1	100	4.8
Bruffs Island	57	1.6	100	3.7	97	3.2	100	3.8
Turtleback	50	1.6	100	4.3	97	3.1	100	4.2
Long Point	100	2.7	100	3.6	97	3.3	100	4.2
Cooks Point	87	2.8	93	3.4	40	1.2	77	2.2
Royston	90	2.5	97	3.5	97	4.7	100	5.2
Lighthouse	43	1.5	87	2.3	100	3.4	100	3.3
Sandy Hill	40	1.0	97	3.4	87	3.6	100	4.5
Oyster Shell Pt	20	0.3	83	2.3	73	2.2	100	3.6
Tilghman Wharf	67	2.0	87	2.5	93	3.4	100	3.5
Deep Neck	97	2.9	97	4.5	100	4.0	97	4.8
Double Mills	100	3.0	100	4.8	100	4.7	100	5.5
Cason	50	1.4	97	3.8	100	3.6	100	4.3
Ragged Point	87	1.4	100	4.0	97	3.7	100	4.3
Normans Add.	73	2.3	93	3.5	80	3.4	90	3.0
Goose Creek	100	3.0	100	5.4	97	3.1	100	4.1
Wilson Shoals	70	1.6	100	4.3	70	2.1	100	4.0
Georges	83	2.4	93	3.5	80	2.3	100	5.2
Holland Straits	57	1.2	80	2.5	30	0.9	43	1.4
Sharkfin Shoal	80	2.7	100	4.3	80	2.3	90	3.7
Back Cove	90	2.3	100	5.5	40	1.2	100	5.0
Piney Isl East	83	1.9	63	2.4	86	2.3	60	1.5
Old Woman's Leg	90	3.2	87	3.9	70	1.7	100	5.0
Marumsco	80	2.8	90	3.4	93	2.7	100	5.0
Broomes Island	93	3.0	100	4.6	93	4.0	100	4.8
Chicken Cock	80	1.7	100	5.0	63	1.8	93	3.6
Pagan	73	1.7	97	3.4	68	1.6	100	4.6
Lancaster	37	0.7	83	2.5	90	2.7	100	4.5
Mills West	20	0.4	90	3.2	97	3.6	100	4.8
Cornfield Hrb	83	2.0	97	3.9	80	2.1	80	2.9
Ragged Point	0	0.0	17	0.5	13	0.7	33	0.5
Lower Cedar Pt.	0	0.0	0	0.0	17	0.5	90	2.3
***P. marinus* Indices**	**67**	**1.9**	**90**	**3.5**	**81**	**2.9**	**93**	**3.8**

Table 4. Prevalence of *Haplosporidium nelsoni* in oysters from the 43 disease monitoring bars, 1990-2001.

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

[1]ND=No samples taken; prevalence assumed to be 0. NA=unable to obtain a sufficient sample size.

Table 4 (Continued).

Bar	*Haplosporidium nelsoni* Prevalence (%)					
	1996	1997	1998	1999	2000	2001
Swan Point	0	0	0	0	0	0
Hacketts Point	0	0	0	0	0	0
Holland Point	0	0	0	0	3	7
Stone Rock	0	0	0	30	47	40
Flag Pond	0	0	0	NA	NA	NA
Hog Island	0	0	0	60	27	27
Butlers	0	7	3	47	17	27
Buoy Rock	0	0	0	0	0	0
Oldfield	0	0	0	0	0	0
Bugby	0	0	0	0	0	0
Parsons Island	0	0	0	0	0	3
Hollicutts Noose	0	0	0	7	10	17
Bruffs Island	0	0	0	0	0	3
Turtleback	0	0	0	0	0	7
Long Point	0	0	0	0	0	0
Cooks Point	0	3	0	13	33	37
Royston	0	0	0	3	7	0
Lighthouse	0	0	0	13	7	3
Sandy Hill	0	0	0	0	0	10
Oyster Shell Pt	0	0	0	0	0	0
Tilghman Wharf	0	0	0	3	27	7
Deep Neck	0	0	0	3	7	0
Double Mills	0	0	0	3	0	0
Cason	0	0	0	7	27	33
Ragged Point	0	0	0	20	47	40
Normans Add	0	0	3	63	37	37
Goose Creek	0	0	0	47	17	13
Wilson Shoals	0	0	0	4	10	10
Georges	0	0	0	40	20	13
Holland Straits	0	10	3	73	40	47
Sharkfin Shoal	0	0	20	53	37	20
Back Cove	3	3	10	33	37	10
Piney Isl East	7	13	17	43	53	40
Old Woman's Leg	20	4	23	53	30	13
Marumsco	0	11	7	37	30	17
Broomes Island	0	0	0	3	10	0
Chicken Cock	0	0	0	77	7	17
Pagan	0	0	0	3	13	10
Lancaster	0	0	0	0	0	0
Mills West	0	0	0	3	0	0
Cornfield Harb.	0	0	3	53	17	33
Ragged Point (Potomac)	0	0	0	13	10	7
Lower Cedar Pt.	0	0	0	0	0	0
Percent Frequency[2]	**7**	**16**	**19**	**67**	**64**	**67**

[2]ND=No samples taken; prevalence assumed to be 0. NA=unable to obtain a sufficient sample size.

Table 5. Oyster population mortality estimates from the 43 disease monitoring bars, 1985-2001.

Bar	Total Observed Mortality, Percent								
	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
Mortality Index	**10**	**22**	**44**	**29**	**14**	**18**	**34**	**46**	**33**

Table 5 (Continued).

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

Table 6. Regional summary of oyster harvests in Maryland, 1985-86 season through the 2000-01 season.

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	**1,500,000**	**1,000,000**	**360,000**	**390,000**	**413,000**

Table 6 (continued).

Region/Tributary	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01
Upper Bay	26,600	2,600	18,800	13,100	28,100	31,150
Middle Bay	12,600	20,000	15,300	55,800	31,500	16,400
Lower Bay	800	300	4,800	8,300	3,800	2,050
Total Bay Mainstem	40,000	22,800	38,900	77,200	63,400	49,600
Chester River	42,600	5,400	43,000	21,000	70,100	20,800
Eastern Bay	1,500	1,100	3,800	30,900	75,800	120,500
Miles R.	200	500	30	800	35,700	20,150
Wye R.	0	0	400	900	9,400	11,300
Total Eastern Bay Region	1,700	1,600	4,200	32,600	120,900	151,950
Upper Choptank River	11,600	3,200	4,800	3,100	7,100	1,100
Middle Choptank R.	15,000	4,700	5,600	2,800	1,900	8,150
Lower Choptank R.	900	300	200	2,400	8,300	350
Tred Avon R.	1,300	3,800	6,900	11,700	3,700	8,950
Broad Creek	1,000	4,000	27,600	46,200	18,200	36,850
Harris Cr.	5,000	13,600	21,400	67,000	18,200	26,200
Total Choptank R. Region	34,800	29,600	66,500	133,200	57,400	81,600
Little Choptank River	1,900	40,800	36,100	84,100	33,600	27,850
Upper Tangier Sound	12,100	8,100	6,000	3,500	1,500	100
Lower Tangier S.	500	10,100	4,200	8,500	2,800	1,450
Honga River	400	200	1,300	300	50	0
Fishing Bay	20,900	8,800	3,800	700	90	0
Nanticoke R.	15,200	23,000	30,300	21,700	8,800	600
Wicomico R.	100	1,400	2,200	1,400	500	50
Manokin R.	0	900	600	300	90	200
Annemesex R.	0	0	0	0	200	0
Pocomoke S.	0	300	400	80	100	10
Total Tangier Sound Region	49,200	52,800	48,800	36,500	14,100	2,400
Patuxent River	100	20	60	5,600	2,000	10
Wicomico R., St. Clement's and Breton Bays	27,500	7,300	10,200	13,700	8,800	2,600
St. Mary's River and Smith Cr.	900	16,200	36,700	16,400	4,500	6,150
Total Potomac Md Tributaries	28,400	23,500	46,900	30,100	13,300	8,750
Total Maryland	**199,000**	**178,000**	**285,000**	**423,000**	**380,700**	**348,000**

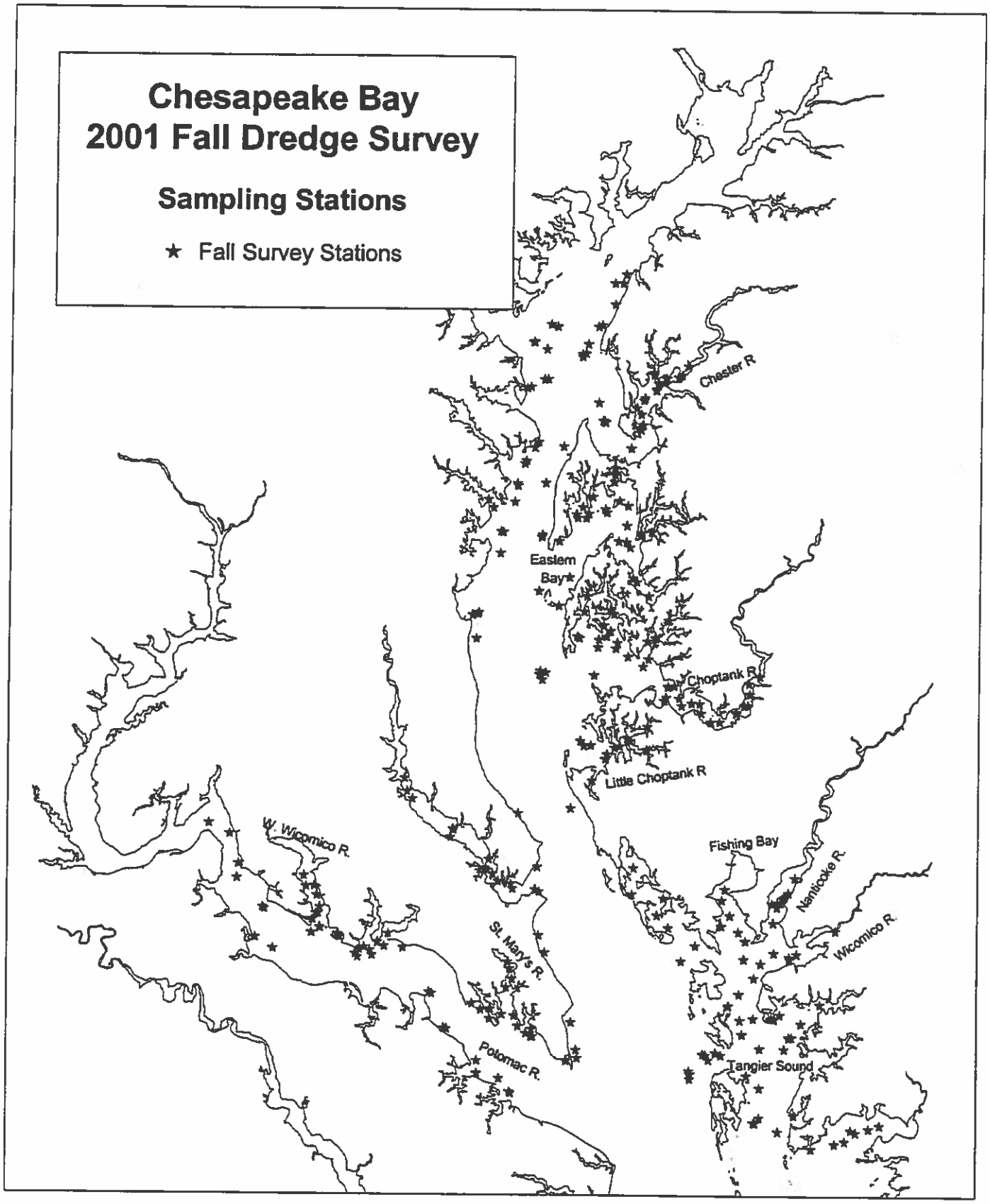

Figure 1(a). Annual Fall Survey station locations.

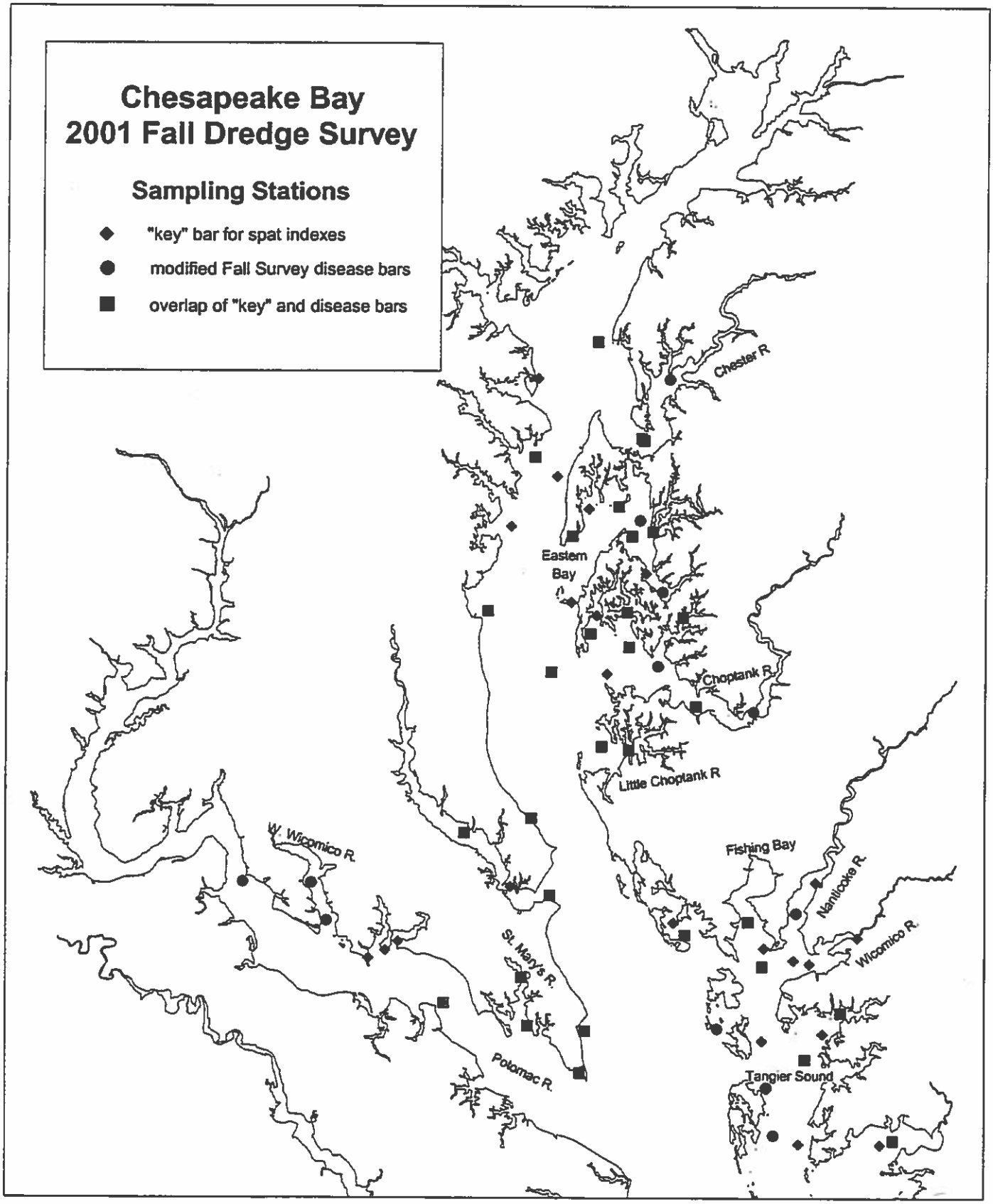

Figure 1(b). Annual Fall Survey station locations for key and disease bars, 2001.

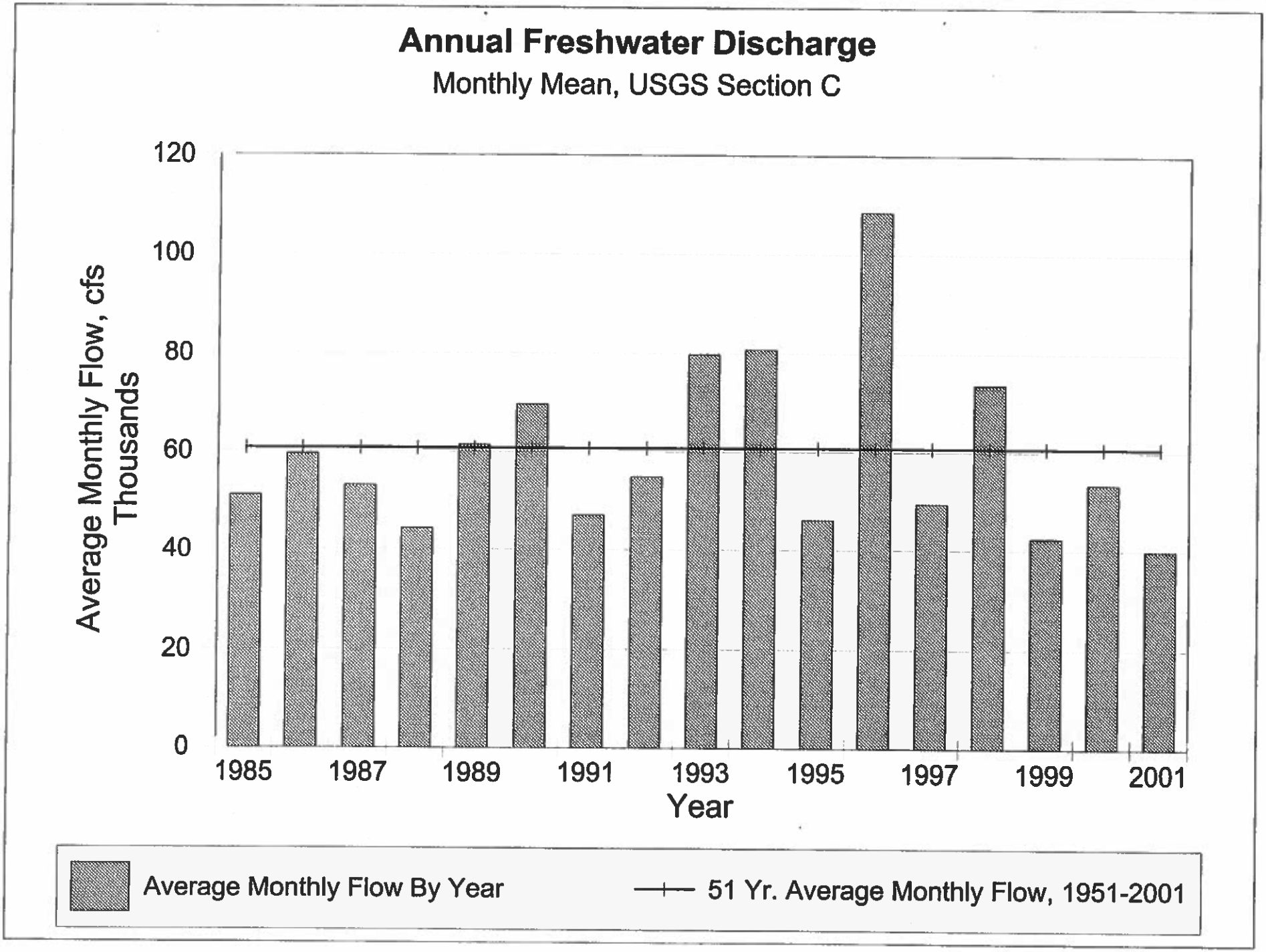

Figure 2. Mean monthly freshwater flow into Chesapeake Bay. Section C: all Md. tributaries and the Potomac River.

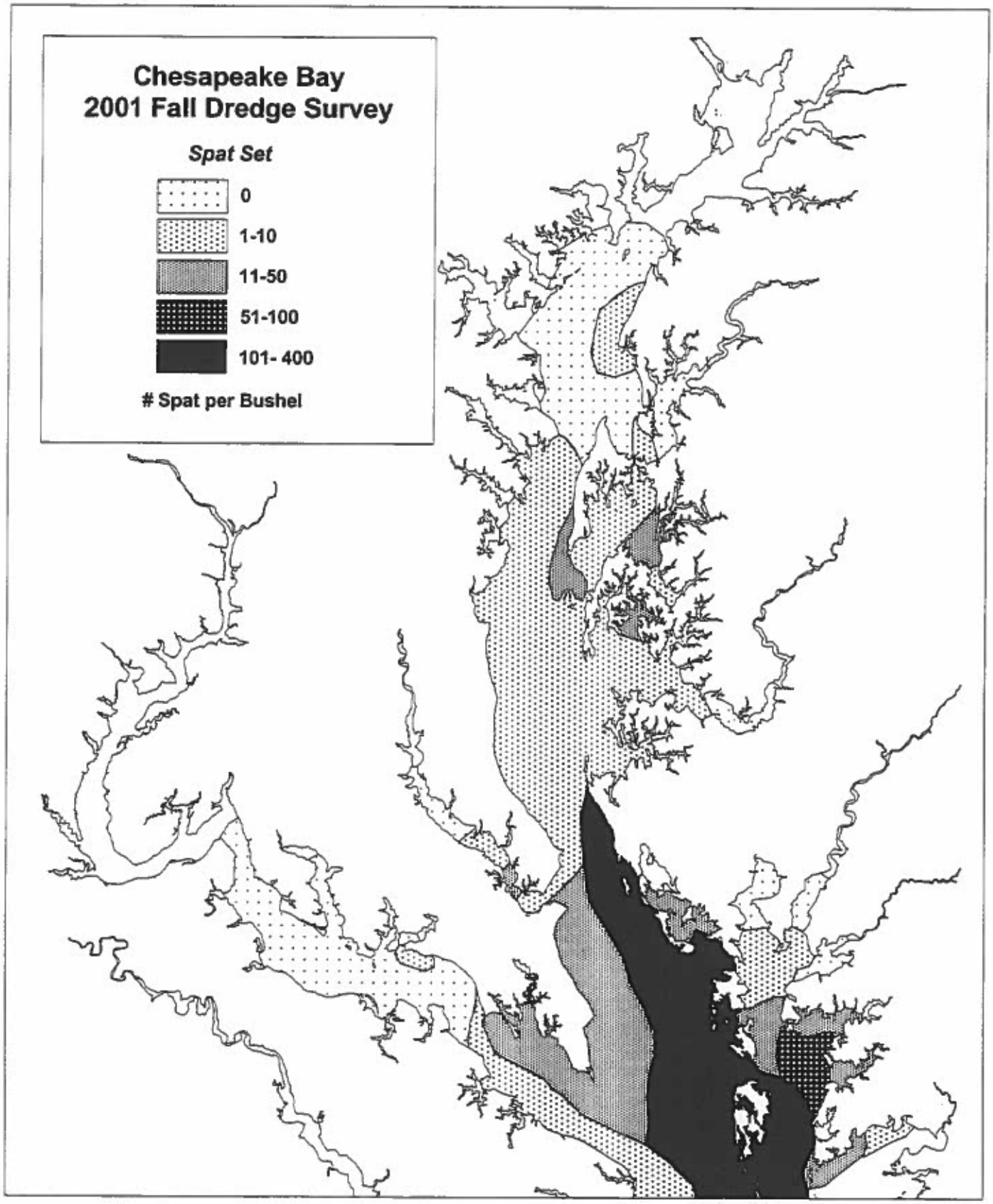

Figure 3. Spatfall intensity ranges, 2001.

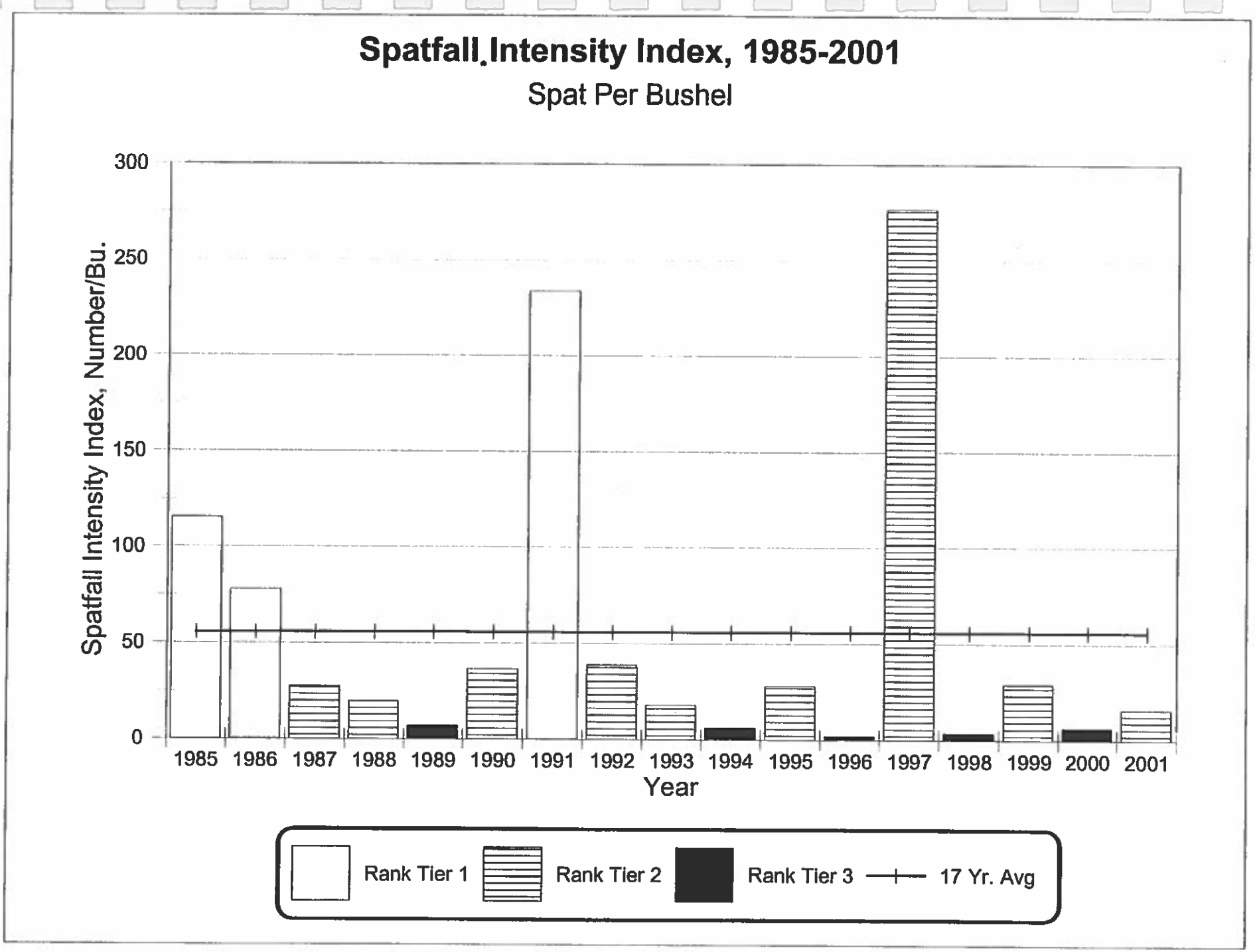

Figure 4. Spatfall intensity (spat per bushel of cultch) on Maryland "Key Bars" for spat monitoring.

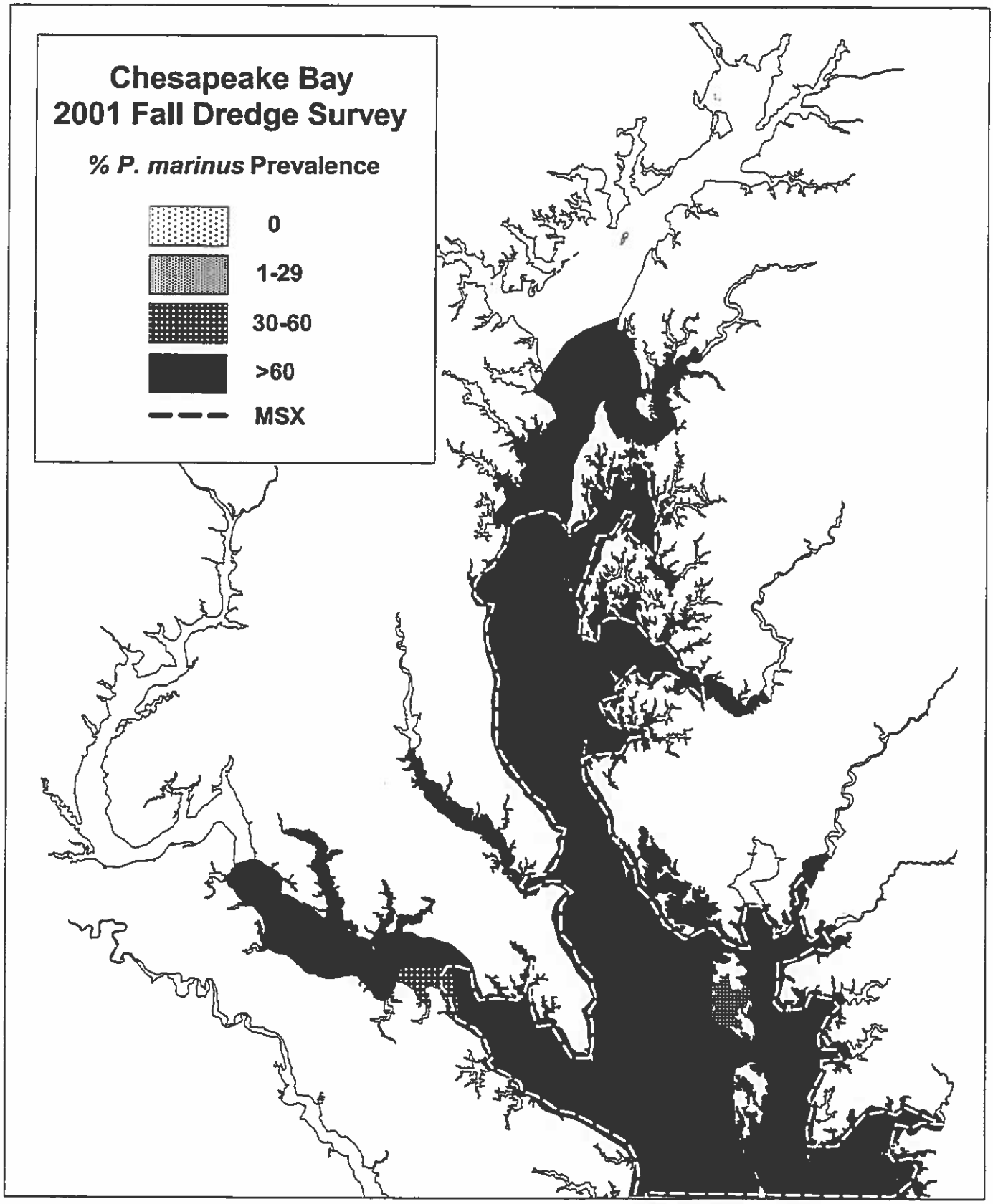

Figure 5. Perkinsis marinus prevalance ranges and geographical extent of Haplosporidium nelsoni, 2001.

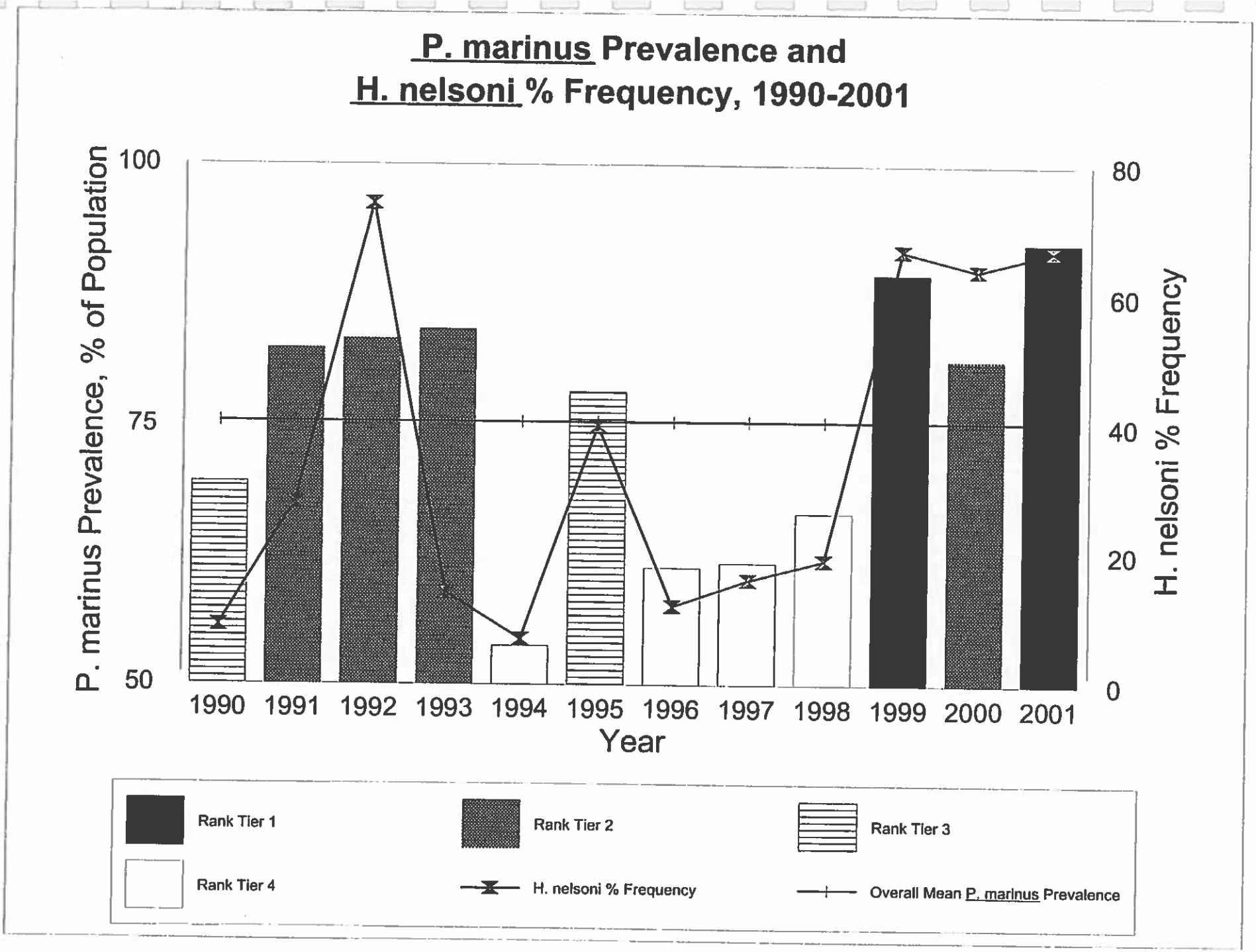

Figure 6. Statistical ranking of P. marinus prevalence and percent frequency of Disease Bars with H. nelsoni.

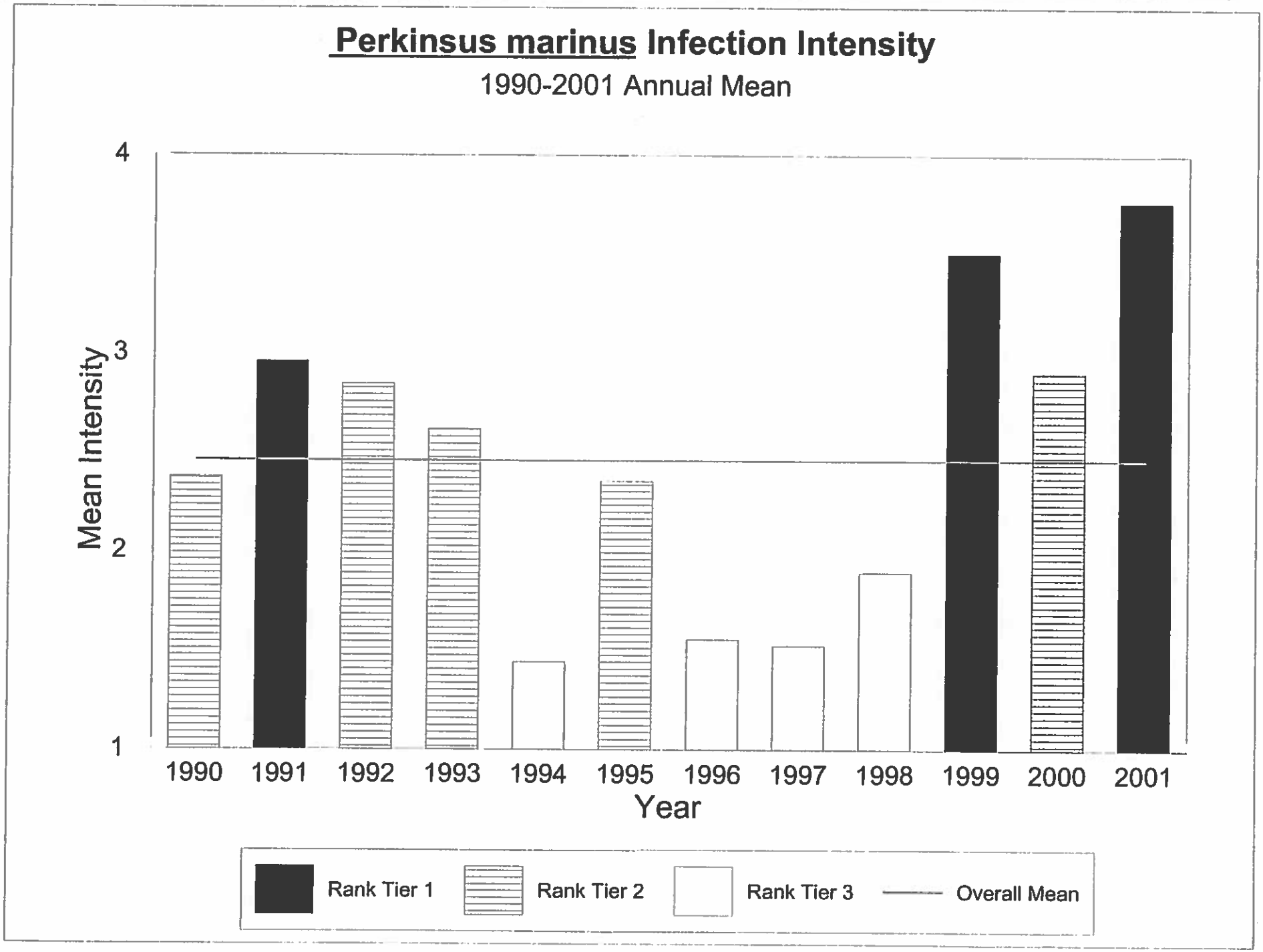

Figure 7. Annual mean Perkinsus marinus intensity on a scale of 0 to 7 in oysters from Maryland disease monitoring bars.

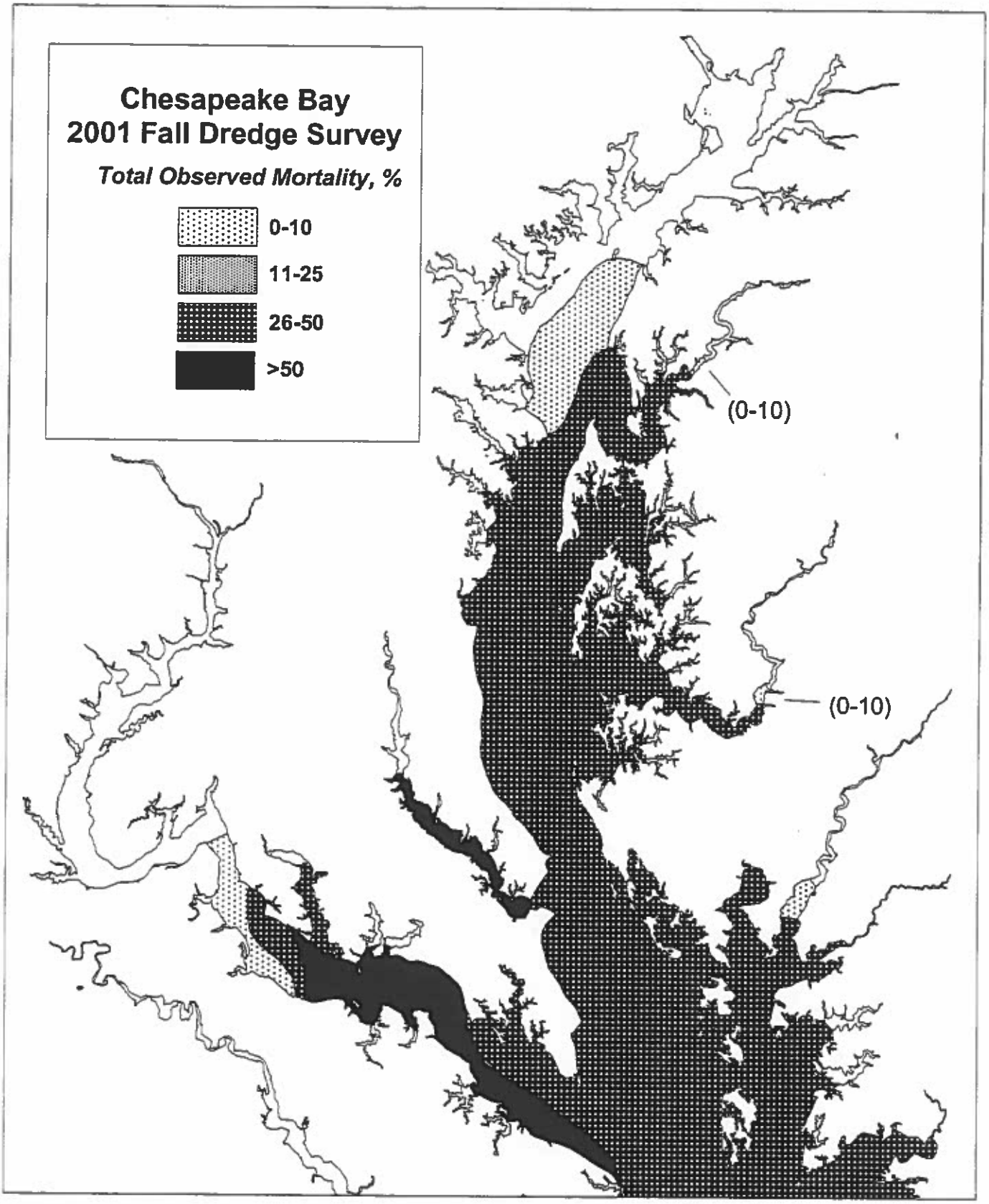

Figure 8. Total observed mortality, 2001.

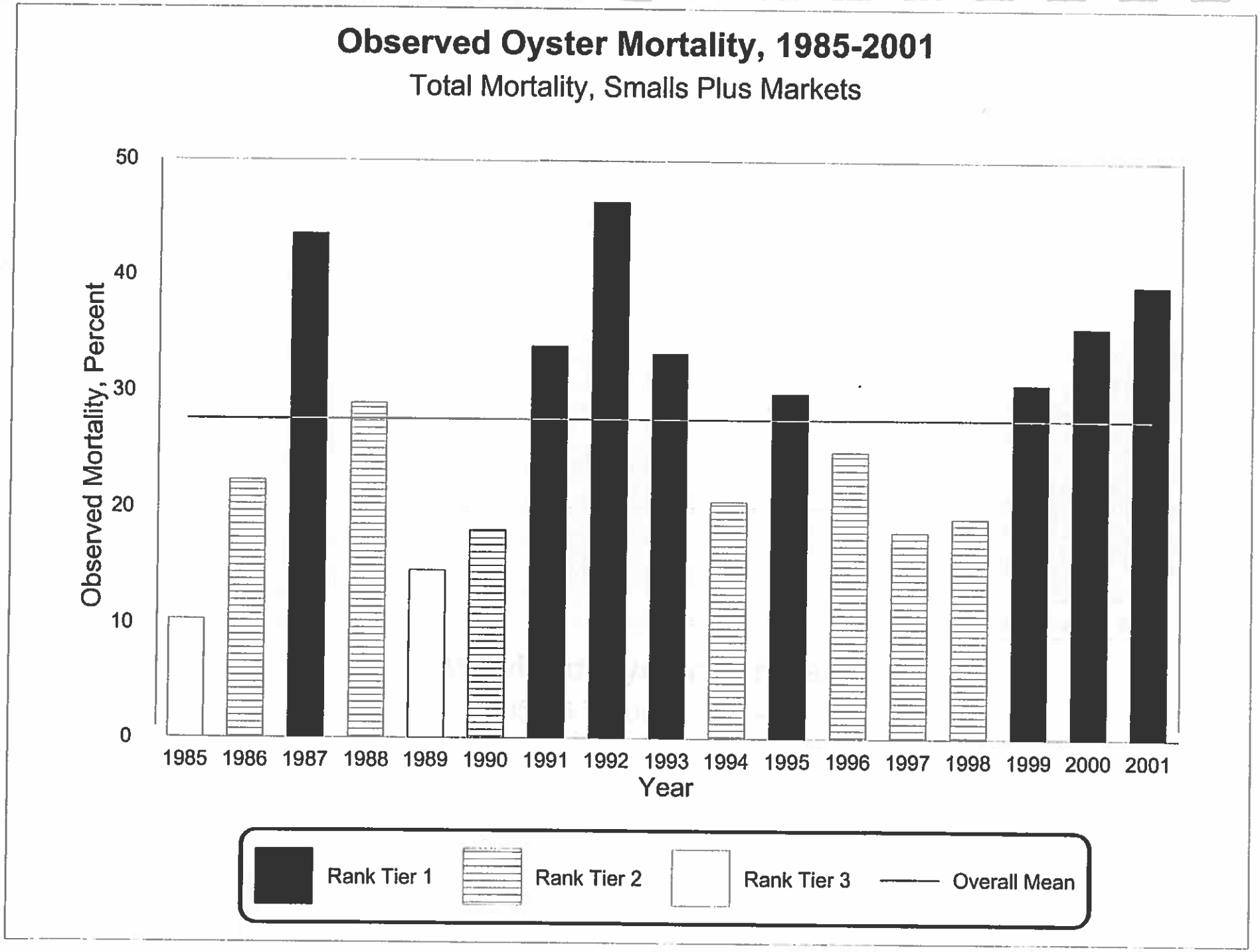

Figure 9. Mean annual total observed mortality, small and market oysters combined.

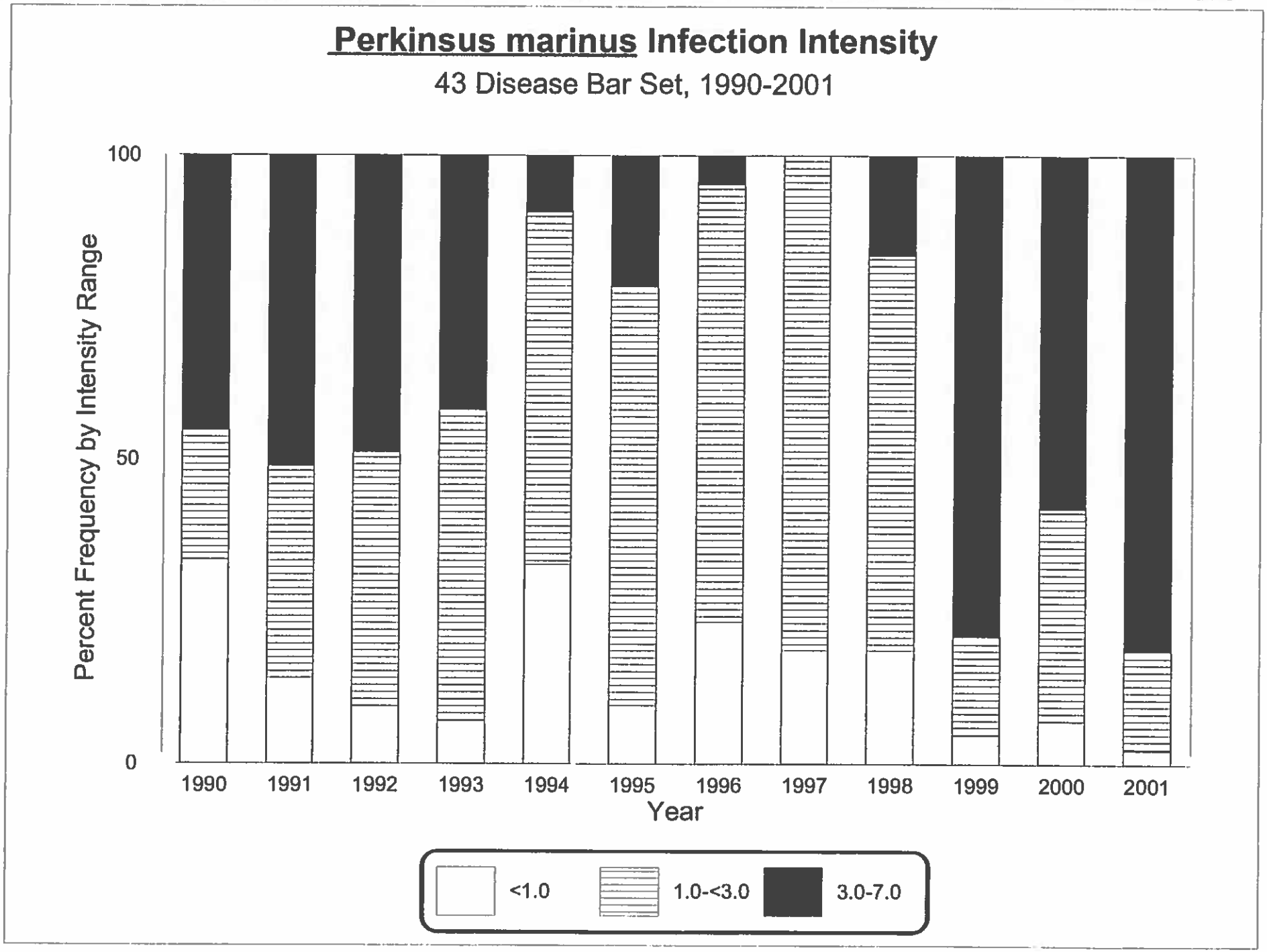

Figure 11. Perkinsus marinus infection intensity ranges, percent frequency by year and range.