

MARYLAND

OYSTER POPULATION STATUS REPORT

1996-2000 FALL SURVEYS



PREPARED BY

STAFF FROM THE MARYLAND DEPARTMENT OF NATURAL RESOURCES,
SARBANES COOPERATIVE LABORATORY

&

SHELLFISH PROGRAM

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Prepared By
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INTRODUCTION

ince 1939, various state agencies in Maryland have conducted annual dredge-based surveys of oyster bars. These assessments have provided biologists and managers with data on oyster spatfall intensity, observed mortality, and more recently, parasitic infection status in Maryland's Chesapeake Bay. Sites monitored 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 in order to allow the development of structured indices and statistical frameworks while preserving the continuity of the long-term data set. In 1974, 53 sites known 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 both provide adequate geographical coverage and continuity with data going back to 1939. An oyster parasite diagnosis component was added to the annual survey 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 overlap with the 53 spatfall index oyster bars.

METHODS

The 1996-2000 Annual Fall Dredge Surveys were conducted by Shellfish Division staff from the Maryland Department of Natural Resources' (MDDNR) Fisheries Service between early October and mid-November. Oyster parasite diagnostic tests were performed by staff located at the Sarbanes Cooperative Oxford Laboratory (SCOL). Between 270 and 300 oyster bars were surveyed during each year using a standard oyster dredge. Along with natural oyster bars and the Key and Disease Bar sets (Figures 1(a) and 1(b)), contemporary seed oyster planting sites, shell planting locations, and seed production sites were also surveyed (data on seed and shell plantings are in Hess (1996-2000)). At each of the 53 Key Bar sites and the 43 Disease Bars, two replicate 0.5 bushel samples were collected. On State seed production grounds, five 0.2 bushel subsamples were taken from replicate dredge tows. At all other locations, one 0.5 bushel subsample is collected from an oyster dredge tow. A list of data recorded from each sample appears in Appendix 1.

Representative subsamples of 30 oysters, ≥ 40 mm in shell height, were taken at each of the 43 Disease Bar sites. (There have been years where less than 43 sites were reported because an adequate sample of oysters could not be obtained. These sites are indicated in the appropriate

tables). Additional parasite 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 are from hemolymph and, starting in 1999, rectal Ray's fluid thioglycollate culture (RFTM) assays for *Perkinsus marinus* (dermo disease) and blood cytology and, beginning in 1999, tissue histology for *Haplosporidium nelsoni* (MSX disease). Prior to 1999, oyster tissue samples were examined for *H. nelsoni* only from selected sites.

In this report, prevalence refers to the percentage of oysters in a sample having any level of parasite infection. Intensity refers to the mean infection stage or parasite concentration in sampled oysters. An index, ranging from zero to seven, based on blood/tissue pathogen concentration is used to classify intensity information. (See Giesecker 2001 for a complete description of parasite diagnostic techniques and calculations).

Total observed mortality (small and market oysters combined) was calculated as the number of boxes¹ and gapers 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 of 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 $\alpha=0.5$.

To quantify annual relationships, a distribution-free multiple comparison procedure, based on Friedman's Rank Sum Test, was used

¹ A box is a dead bivalve still retaining articulated valves, but with no body tissue remaining.

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, allow the result interpretations as hypothesis tests. Multiple comparisons were evaluated using “yardsticks” developed from experimentwise error rates of $\alpha=0.15$.

RESULTS

Freshwater Discharge Conditions

Between 1996 and 2000, there were two periods, 1996 and 1998, of unusually high freshwater discharge into the Chesapeake Bay, its Maryland tributaries, and the Potomac River (Section “C” in Bue 1968; USGS 2000) (Figure 2). Prior to 1996, and going back to 1985, significant freshets occurred in 1990, 1993, and 1994. The 1990 event had little impact on oyster populations, while the 1993 freshet primarily affected the Potomac River drainage and resulted in substantial oyster mortality (Table 1). 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 2000).

Moderate to severe low freshwater flows

into the Chesapeake Bay elevated salinities during 1997, 1999, and 2000. Since 1985, low flows were particularly severe ($\leq 80\%$ of the 50 year average) in 1988, 1991, 1995, 1997, and 1999.

Spatfall Intensity

Baywide spatfall intensity data, as number of spat per bushel of shell, are given in a series of maps (Figures 3(a)-3(f)). Table 2 lists spatfall intensity data from the Key Bar set for the period 1996-2000. These data are repeated in Appendix 2 in which the Key Bar spatfall intensity index is given for the period from 1985 through 2000. Figure 4 charts the spatfall intensity index from 1985 through 2000 and gives groupings of years as determined from a multiple comparison procedure associated with Friedman's Two-Way Rank Sum Test.

The period from 1985-2000 (Figure 4; Appendix 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 1996-2000 included the lowest on record (1996) and the second highest (1997).

Friedman's Two-Way Rank Sum Test, results gave three groupings of spatfall intensity data, given in Figure 4 from greatest to least. These produced what appears to be an anomaly, with the extremely high index year of 1997

grouped in the middle tier. However, as may be noted in Figures 3(b) and 3(c), 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. Only five of the 53 Key Bars contributed to over 75% of the 1997 index, while ten comprised 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. As 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 Parasite Diagnoses

Oysters were tested for the presence/absence of *P. marinus* and *H. nelsoni*, yielding sample parasite prevalence. Those oysters infected with *P. marinus* were staged for infection intensity, giving mean sample infection. Results of these diagnoses from the Disease Bar set are given in Figures 5(a)-5(e) for 1996-2000, and in Tables 3 and 4 for the period 1996-2000. These data are included in a list of test results for

the period 1990 through 2000 given in Appendix 3 for *P. marinus* and Appendix 4 for *H. nelsoni*. Mean annual *P. marinus* prevalence (arithmetic mean of the 43 Disease bars) is presented in Figure 6 along with *H. nelsoni* percent frequency (percentage of the 43 Disease Bars showing positive for *H. nelsoni*). Mean *P. marinus* intensity from 1985-1999 is given in Figure 7. Friedman's Test and associated multiple comparison procedure were applied to *P. marinus* prevalence and intensity data, and the results are summarized in Figures 6 and 7 as described in Figure 4. Because these procedures require equal sample sizes, data from nearby sites were used when the targeted site could not yield an adequate sample for parasite (both *P. marinus* and *H. nelsoni*) diagnostic tests.

From 1996 to 1998, baywide *P. marinus* prevalence was relatively low, within the 1990-2000 data set, ranging from 61 to 67%. But in 1999, the single highest baywide mean prevalence was recorded, 90% (Figure 5; Appendix 3). Of the 42 sites examined for *P. marinus* in 1999, 32 showed prevalence increases from 1998 by an average of 32%, while only 4 sites decreased in prevalence, by an average of 8%. Six oyster bars showed no change (Table 3). Annual mean prevalence in 2000 was only slightly lower, 81%, than in 1999. Friedman Test and multiple comparison results (Figure 6) indicated three groupings of mean *P. marinus*

prevalence within the 1990-2000 period. The lowest tier included 1994, 1996, 1997, and 1998, the middle tier contained 1990 and 1995, and the upper tier consisted of 1991, 1992, 1993, 1999, and 2000.

Perkinsus marinus mean intensity data (Table 3; Figure 7; Appendix 3) gave a relational pattern similar to that described for prevalence. The 1999 mean intensity of *P. marinus*, 3.5, represents the highest level reached over the 1990-2000 period.

Perkinsus marinus mean prevalence and intensity data patterns generally followed patterns of freshwater flow. The only exceptions occurred with comparing data from 1993 and 1997 (Figures 2, 6, and 7). As previously mentioned, the 1993 freshet was primarily 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 infection progressively increased between 1996 and 1999 (Figures 5(a)-5(e); Table 4). Primarily situated in Tangier and Pocomoke Sounds during 1996-1998, the geographic distribution of *H. nelsoni* increased substantially in 1999 and 2000. Between 1996 and 1998, *H. nelsoni* was found on only eight or fewer of the 43 Disease Bar set. In 1999 and 2000, however, 28 and 27 oyster

bars were infected with *H. nelsoni* from Eastern Bay south into Tangier and Pocomoke Sounds and from Holland Point south into the lower Potomac River (Figures 5(a)-5(e)). Prevalence substantively increased in 1999 from the previous three years, with a small decline subsequently observed in 2000. Since 1990, there have been three *H. nelsoni* epizootics: 1991-1992, 1995, and 1999-2000. 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 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 recession of the geographical distribution of *Haplosporidium nelsoni* in 1993 and in 1996 (Appendix 4). Percent frequency of occurrence of MSX disease among the Disease Bar set exceeded 60% in both 1999 and 2000, the second and third highest frequencies found during the 1990-2000 period (Figure 6; Appendix 4).

Oyster Mortality

Baywide observed oyster mortality is given in Figures 8(a)-8(e) and in Table 5 developed from the 43 Disease Bar set. These data are also included in Appendix 5, in which mortalities are listed for the 43 bar set from 1985 through 2000.

Total observed mortality steadily

increased from 1997 through 2000 (Table 5; Figure 9). In addition, the number of sites with total observed mortality of 30% or greater increased substantially between 1996 and 2000. 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 (42 in 2000) had mortalities of 30% and greater (Table 5). Mean observed total mortality in 2000 ranked third highest over the 1985-2000 period (Appendix 5).

Friedman's Two-way Rank Sum test results indicated three associations of observed mortality, from highest to lowest: 1987, 1991, 1992, 1993, 1995, 1999 and 2000; 1986, 1988, 1990, 1994, 1996, 1997, and 1998; 1985 and 1989. Observed total mortality averages and rank sums are shown in Figure 9.

Commercial Harvest²

The 1999-2000 harvest of 380,000 bushels was about 10% less than that of the 1998-99 season (Table 6; Figure 10), but considerably greater than those of the three preceding seasons. During the 1999-2000 season, almost one-third of the harvest came from Eastern Bay. The Chester River (18%), the Choptank River (15%), and the Upper Bay

region (15%) also made significant contributions.

Regional harvest summaries from the 1985-86 season through the 1999-2000 season are given in Appendix 6. Over this period, harvesters have become increasingly dependent on the lower salinity zones such as the Chester River and the Upper Bay. The mid to higher salinity areas have become increasingly less reliable with respect to consistent, relatively high zones of commercial oyster production.

1996-2000 SUMMARY

It is clear that oyster mortality since the late 1980s has been strongly influenced by levels of freshwater discharge into the Chesapeake Bay. During this period, the temporal pattern of *P. marinus* infection changed from acute (epizootic) to chronic 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 and their periodicity largely controlled by freshwater discharge into the Bay (Ford and Tripp 1996). Since oysters situated in the lower salinity zones have been

² Harvest data presented in this report are rounded off. Exact information can be obtained from the MDDNR Fisheries Service, Resource Management Division.

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 from the 1993, 1994, 1996, and 1998 freshets (Table 1). Given the chronic nature of *P. marinus* infections, low and even average freshwater discharges into the Chesapeake Bay tend to exacerbate oyster infection levels. In addition, low flow conditions have generally resulted in *H. nelsoni* epizootics. This parasite can cause more rapid mortality in oysters than does *P. marinus*, 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 1996-2000 period included three of the lowest spatfall intensity indices on record and 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 signature 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 1996-2000 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 parasite 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 *P. marinus* population infection levels of 3.0 or greater, over 67% of oyster bars had infection levels of 3.0 or greater in 1999 and 2000.

A severe *H. nelsoni* epizootic occurred in 1999, the second such since 1990. Unlike the 1992 outbreak, however, the 1999 epizootic persisted through 2000. The brevity of the 1992 infection 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 (MDDNR 1988; Krantz 1990).

Compared to the 1985-2000 mean observed total mortality, the 1996-2000 mortality levels were not unusually high. However, the Baywide mean mortality (less fishing mortality) average from 1985-2000 was substantially greater than those that may be found in records from previous periods (MDDNR 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 1996 through 2000 indicated no change in this pattern.

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Table 1. Oyster population mortality estimates from sites influenced by the 1990, 1993, 1994, 1996, and 1998 freshet events.

Region	Oyster Bar	Total Observed Mortality (%) in Low Salinity Areas										
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Upper Bay	Flat Rock	12	0	0	13	29	10	100	---	100	0	0
	Deep Shoals	4	2	4	5	13	2	11	9	3	---	0
	Tolchester	0	5	0	5	13	0	21	3	0	4	4
	Hodges	2	4	3	5	27	0	31	8	6	3	5
	Swan Point	2	4	9	5	35	2	43	6	6	7	13
	Mountain Point	3	4	0	7	15	4	12	3	8	3	3
Chester River	Shippen Creek	---	---	---	5	72	0	33	0	0	0	0
	Sheep	---	---	0	0	42	42	34	13	5	0	28
	Emory Hollow	---	3	9	4	26	0	4	0	3	6	4
	Cliff	8	14	3	8	26	5	31	3	4	4	10
	Spaniard Pont	2	2	14	3	20	13	13	6	5	9	19
Choptank River	Drum Point	2	1	4	3	90	35	17	7	26	0	5
	Cabin Creek	5	10	4	7	21	4	12	2	20	2	9
	Tanners Patch	---	1	5	11	36	9	17	8	20	26	55
Wicomico River (Western Shore)	Key	---	2	---	71	22	3 ¹	9 ¹	---	---	---	---
	Stoddard	1	1	6	78	42	1	8	1	15	---	---
	Cohouck	---	2	---	37	16	7 ¹	14 ¹	---	---	---	39
Potomac River	Beacons	1	2	5	58	64	4	40 ¹	27	22	0	0
	Popes Creek	1	0	7	70	75	3	17	18	23	0	7
	Pascahanna	6	2	6	71	40	4	19	3	22	6	9
	Lower Cedar Point	18	11	4	91	38	6	15	4	11	8	0

¹ Data from 8/96.

Table 2. Spatfall intensity data, number per bushel, from the 53 "key" bar set, 1996-2000.

Region	Oyster Bar	Spatfall, Number Per Bushel				
		1996	1997	1998	1999	2000
Upper Bay	Mountain Point	0	1	0	0	0
	Swan Point	0	0	0	0	0
	Brickhouse	0	0	0	1	1
	Hacketts Point	0	0	0	0	1
	Tolly Point	0	0	0	2	2
	Three Sisters	0	0	0	0	0
Mid Bay	Holland Point	0	0	0	0	0
	Stone Rock	0	18	0	3	34
	Flag Pond	0	7	0	1	5
	Hog Island	0	5	2	6	1
Lower Bay	Butlers	1	8	0	6	1
Chester River	Buoy Rock	0	8	0	0	0
Eastern Bay	Parsons Island	0	3,375	3	6	6
	Wild Ground	0	990	0	2	5
	Hollicutts Noose	0	56	0	6	2
Wye River	Bruffs Island	0	741	4	5	9
Miles River	Ash Craft	1	2,248	0	14	2
	Turtleback	0	3,368	5	13	4
Poplar Island Narrows	Shell Hill	0	19	1	4	4
Choptank River	Sandy Hill	0	55	0	4	0
	Royston	0	289	0	39	0
	Cooks Point	0	20	0	1	5
Harris Creek	Eagle Point	0	168	2	16	0
	Tilghman Wharf	0	472	0	49	1
Broad Creek	Deep Neck	3	788	1	211	3
Tred Avon River	Double Mills	0	40	0	1	0
Little Choptank River	Ragged Point	0	106	0	43	3
	Cason	5	228	4	53	5
Honga River	WindMill	2	5	1	37	0
	Normans Addition	0	8	0	31	1
Fishing Bay	Goose Creek	0	5	0	0	0
	Clay Island	1	20	2	5	4
Nanticoke River	Wetipquin	0	0	10	0	0
	Middleground	6	27	0	9	1
Wicomico River (Eastern Shore)	Evans	1	5	0	1	0
	Mount Vernon Wharf	0	0	1	0	0
Manokin River	Georges	0	8	6	50	6
	Drum Point	10	16	11	157	27
Tangier Sound	Sharkfin Shoal	0	7	0	9	5
	Turtle Egg	35	70	3	180	33
	Piney Island East	25	45	16	118	28
	Great Rock	7	0	1	82	6
Pocomoke Sound	Gunby	9	0	24	54	32
	Marumsco	0	0	57	27	27
Patuxent River	Broomes Island	0	0	1	7	0
	Back of Island	0	3	0	22	9
St. Mary's River	Chicken Cock	2	36	10	132	16
	Pagan	0	1,390	6	95	42
St. Clements Bay and Breton Bay	Black Walnut	0	2	0	3	0
	Blue Sow	0	0	0	11	0
	Dukehart	0	0	0	1	0
Potomac River	Ragged Point	0	2	0	1	1
	Cornfield Harbor	0	4	11	25	5
Spat Index		2.0	277.0	3.5	29.1	6.4

Table 3. The prevalence and intensity of *Perkinsus marinus* among oyster bars in the 43 Disease Bar set, 1996-2000. ND indicates insufficient quantity for analytical sample.

Region	Bar	<i>Perkinsus marinus</i> . Prevalence (%) and Intensity (I)									
		1996		1997		1998		1999		2000	
		%	I	%	I	%	I	%	I	%	I
Upper Bay	Swan Point	0	0.0	3	0.1	43	1.2	97	3.4	80	1.2
	Hacketts Point	30	0.7	43	1.3	43	1.1	97	3.3	97	3.7
Mid Bay	Holland Point	47	1.4	37	1.1	37	0.9	93	2.8	87	3.4
	Stone Rock	93	2.7	90	2.3	100	3.5	100	4.0	93	3.6
	Flag Pond	63	2.0	53	1.2	73	2.3	ND	ND	ND	ND
	Hog Island	43	1.2	47	1.3	97	3.2	93	5.5	83	3.9
Lower Bay	Butlers	60	1.6	57	1.0	97	3.3	93	3.2	83	2.7
Chester River	Buoy Rock	13	0.4	7	0.7	33	0.9	93	3.0	97	3.5
	Oldfield	0	0.0	10	0.2	33	0.8	97	3.0	93	3.0
Eastern Bay	Bugby	80	2.0	70	1.8	60	1.4	100	3.9	100	4.0
	Parsons Island	73	2.8	63	1.4	80	2.5	100	4.7	100	3.5
	Hollicutts Noose	60	1.4	50	1.0	83	2.5	90	3.0	100	4.1
Wye River	Bruffs Island	67	1.4	17	0.2	57	1.6	100	3.7	97	3.2
Miles River	Turtleback	83	2.1	83	1.8	50	1.6	100	4.3	97	3.1
	Long Point	20	0.4	23	0.6	100	2.7	100	3.6	97	3.3
	Cooks Point	60	1.5	70	2.4	87	2.8	93	3.4	40	1.2
Choptank River	Royston	50	1.1	67	1.5	90	2.5	97	3.5	97	4.7
	Lighthouse	77	1.8	57	1.5	43	1.5	87	2.3	100	3.4
	Sandy Hill	30	0.7	60	1.3	40	1.0	97	3.4	87	3.6
	Oyster Shell Point	13	0.2	50	0.9	20	0.3	83	2.3	73	2.2
Harris Creek	Tilghman Wharf	67	1.3	60	1.0	67	2.0	87	2.5	93	3.4
Broad Creek	Deep Neck	83	2.1	100	2.6	97	2.9	97	4.5	100	4.0
Tred Avon River	Double Mills	70	1.2	83	2.0	100	3.0	100	4.8	100	4.7
Little Choptank River	Cason	87	1.9	93	2.4	50	1.4	97	3.8	100	3.6
	Ragged Point	97	2.6	97	2.4	87	1.4	100	4.0	97	3.7
Honga River	Normans Addition	93	2.4	73	1.6	73	2.3	93	3.5	80	3.4
Fishing Bay	Goose Creek	97	4.0	83	2.0	100	3.0	100	5.4	97	3.1
Nanticoke River	Wilson Shoals	83	1.8	80	1.9	70	1.6	100	4.3	70	2.1
Manokin River	Georges	93	2.0	93	2.2	83	2.4	93	3.5	80	2.3
Holland Straits	Holland Straits	83	2.0	67	1.8	57	1.2	80	2.5	30	0.9
Tangier Sound	Sharkfin Shoal	97	2.1	93	2.6	80	2.7	100	4.3	80	2.3
	Back Cove	97	3.2	93	2.9	90	2.3	100	5.5	40	1.2
	Piney Island East	63	1.7	73	2.2	83	1.9	63	2.4	86	2.3
	Old Woman's Leg	80	2.3	57	1.3	90	3.2	87	3.9	70	1.7
Pocomoke Sound	Marumscro	90	2.4	61	2.1	80	2.8	90	3.4	93	2.7
Patuxent River	Broomes Island	17	0.4	83	2.1	93	3.0	100	4.6	93	4.0
St. Mary's River	Chicken Cock	77	1.4	73	1.7	80	1.7	100	5.0	63	1.8
	Pagan	82	1.4	86	1.7	73	1.7	97	3.4	68	1.6
Wicomico River (Western Shore)	Lancaster	56	1.2	80	1.6	37	0.7	83	2.5	90	2.7
	Mills West	60	1.2	77	1.7	20	0.4	90	3.2	97	3.6
Potomac River	Cornfield Harbor	87	2.0	83	1.8	83	2.0	97	3.9	80	2.1
	Ragged Point	7	0.2	0	0.0	0	0.0	17	0.5	13	0.7
	Lower Cedar Point	3	0.3	0	0.0	0	0.0	0	0.0	17	0.5

Table 4. The prevalence of *Haplosporidium nelsoni* on oyster bars among the 43 Disease Bar set, 1996-2000. ND indicates insufficient quantity for analytical sample.

Region	Bar	<i>Haplosporidium nelsoni</i> , Prevalence (%)				
		1996	1997	1998	1999	2000
Upper Bay	Swan Point	0	0	0	0	0
	Hacketts Point	0	0	0	0	0
Mid Bay	Holland Point	0	0	0	0	3
	Stone Rock	0	0	0	30	47
	Flag Pond	0	0	0	ND	ND
	Hog Island	0	0	0	60	27
Lower Bay	Butlers	0	13	3	47	17
Chester River	Buoy Rock	0	0	0	0	0
	Oldfield	0	0	0	0	0
Eastern Bay	Bugby	0	0	0	0	0
	Parsons Island	0	0	0	0	0
	Hollicutts Noose	0	0	0	7	10
Wye River	Bruffs Island	0	0	0	0	0
Miles River	Turtleback	0	0	0	0	0
	Long Point	0	0	0	0	0
Choptank River	Cooks Point	0	3	0	13	33
	Royston	0	0	0	3	7
	Lighthouse	0	0	0	13	7
	Sandy Hill	0	0	0	0	0
	Oyster Shell Point	0	0	0	0	0
Harris Creek	Tilghman Wharf	0	0	0	3	27
Broad Creek	Deep Neck	0	0	0	3	7
Tred Avon River	Double Mills	0	0	0	3	0
Little Choptank River	Cason	0	0	0	7	27
	Ragged Point	0	0	0	20	47
Honga River	Normans Addition	0	3	3	63	37
Fishing Bay	Goose Creek	0	0	0	47	17
Nanticoke River	Wilson Shoals	0	0	0	4	10
Manokin River	Georges	0	0	0	40	20
Holland Straits	Holland Straits	0	20	3	73	40
Tangier Sound	Sharkfin Shoal	7	10	20	53	37
	Back Cove	7	27	10	33	37
	Piney Island East	23	20	17	43	53
	Old Woman's Leg	20	32	23	53	30
Pocomoke Sound	Marumsc	3	25	7	37	30
Patuxent River	Broomes Island	0	0	0	3	10
St. Mary's River	Chicken Cock	0	0	0	77	7
	Pagan	0	0	0	3	13
Wicomico River (Western Shore)	Lancaster	0	0	0	0	0
	Mills West	0	0	0	3	0
Potomac River	Cornfield Harbor	0	0	3	53	17
	Ragged Point	0	0	0	13	10
	Lower Cedar Point	0	0	0	0	0

Table 5. Oyster population mortality estimates from the 43 Disease Bar set, 1996-2000.

Region	Bar	Total Observed Mortality, %				
		1996	1997	1998	1999	2000
Upper Bay	Swan Point	43	20	3	7	13
	Hacketts Point	16	10	26	22	13
Mid Bay	Holland Point	51	36	36	8	33
	Stone Rock	25	15	33	46	66
	Flag Pond	16	13	33	50	ND
	Hog Island	20	16	33	67	67
Lower Bay	Butlers	17	20	20	48	67
Chester River	Buoy Rock	17	7	7	6	25
	Oldfield	17	8	5	8	21
Eastern Bay	Bugby	27	15	8	5	29
	Parsons Island	22	25	8	16	29
	Hollicutts Noose	13	15	14	13	38
Wye River	Bruffs Island	6	6	11	16	33
Miles River	Turtleback	21	9	9	26	38
	Long Point	8	3	9	14	33
Choptank River	Cooks Point	16	11	20	35	63
	Royston	16	9	6	32	31
	Lighthouse	15	5	6	20	33
	Sandy Hill	23	22	4	15	27
	Oyster Shell Point	25	6	2	1	15
Harris Creek	Tilghman Wharf	9	15	6	12	19
Broad Creek	Deep Neck	14	8	13	37	23
Tred Avon River	Double Mills	9	8	10	38	40
Little Choptank River	Cason	12	11	18	28	32
	Ragged Point	12	13	19	34	37
Honga River	Normans Addition	55	31	54	35	38
Fishing Bay	Goose Creek	69	64	20	64	63
Nanticoke River	Wilson Shoals	11	11	9	29	25
Manokin River	Georges	33	36	12	32	60
Holland Straits	Holland Straits	43	20	18	35	35
Tangier Sound	Sharkfin Shoal	59	47	28	62	61
	Back Cove	33	29	50	59	20
	Piney Island East	56	49	67	38	27
	Old Woman's Leg	46	33	38	42	15
Pocomoke Sound	Marumscro	53	49	26	40	22
Patuxent River	Broomes Island	0	13	11	44	25
St. Mary's River	Chicken Cock	10	7	24	82	63
	Pagan	27	15	3	14	35
Wicomico River (Western Shore)	Lancaster	25	8	8	18	48
	Mills West	18	17	16	24	36
Potomac River	Cornfield Harbor	24	7	27	78	62
	Ragged Point	11	4	25	10	8
	Lower Cedar Point	23	3	26	8	0

Table 6. Regional summary of annual oyster harvests in Maryland, 1995-1996 season through 1999-2000 season.

Region/Tributary	1995-96	1996-97	1997-98	1998-99	1999-2000
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., and 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	199,000	178,000	285,000	423,000	380,700

Table 7. History of *P. marinus* prevalence on 15 representative Chesapeake Bay oyster bars, 1985-2000.

Bold values indicate change to chronic infection status. Prevalences in **bold and italics** indicate sites where *P. marinus* was chronic prior to 1985 and ? next to bar name indicates status in flux.

Oyster Bar	Year															
	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00
Broomes Island	16	14	17	33	57	97	100	63	87	40	43	17	83	93	100	93
Bugby	10	34	58	67	100	100	100	73	100	43	83	80	70	60	100	100
Buoy Rock	6	12	4	23	20	23	80	97	93	10	67	13	7	33	93	97
Chicken Cock	70	94	—	100	100	100	97	93	95	40	83	77	73	80	100	63
Cornfield Harbor	88	100	—	—	—	97	83	100	93	77	93	87	83	83	97	80
Deep Neck	2	4	8	96	100	100	100	100	100	67	97	83	100	97	97	97
Flag Pond	4	6	43	—	—	33	97	97	88	30	87	63	53	73	ND	ND
Georges	14	40	93	—	63	83	93	58	30	50	87	93	93	83	93	80
Hacketts Point	—	—	8	0	13	3	27	57	97	23	90	30	43	43	97	97
Hog Island	8	12	0	37	26	90	97	100	93	37	93	43	47	97	93	83
Hollicutt's Noose	4	8	13	0	23	30	73	82	97	70	90	60	50	83	90	100
Lighthouse	2	10	20	20	57	90	100	100	93	47	90	77	57	43	87	100
Lower Cedar Point	—	—	—	—	3	40	10	23	7	7	13	3	0	0	0	17
Marumsco	28	23	90	77	43	93	93	60	87	72	100	90	61	80	90	93
Mills West	—	—	—	—	0	13	80	90	63	20	57	60	60	20	90	97
Oldfield	—	—	—	—	10	17	20	37	83	20	83	0	10	33	97	93
Oyster Shell Point	—	—	0	13	53	3	60	100	93	47	90	13	50	20	83	73
Ragged Point(LC)	36	20	—	23	67	100	100	100	100	87	93	97	97	87	100	97
?Ragged Point(PT)	—	—	—	100	93	97	90	40	50	10	33	7	0	0	17	13
Sandy Hill	—	—	0	7	53	100	100	100	100	83	89	30	60	40	97	87
Sharkfin Shoal	74	80	—	—	10	23	100	97	93	63	90	97	93	80	100	80
Stone Rock	—	—	—	—	27	46	27	100	100	90	87	93	90	100	100	93
Swan Point	—	—	0	0	3	7	27	23	37	3	20	0	3	43	97	80

CHESAPEAKE BAY FALL DREDGE SURVEY

Sampling Stations

★ Fall Survey stations

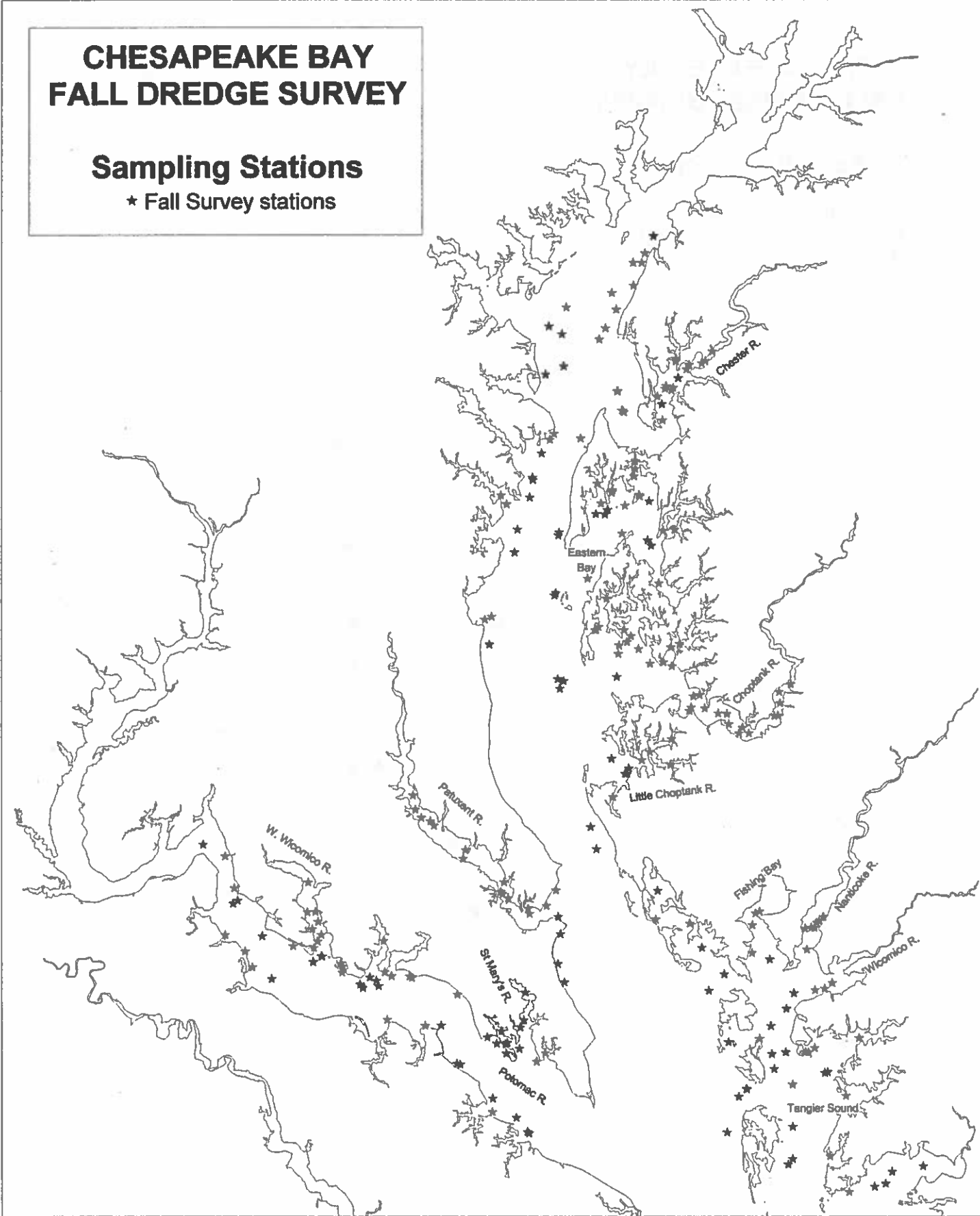


Figure 1(a). Annual Fall Survey station locations.

CHESAPEAKE BAY FALL DREDGE SURVEY

Sampling Stations

- ◆ "key" bars for spat indexes
- modified Fall Survey disease bars
- overlap of "key" and disease bars

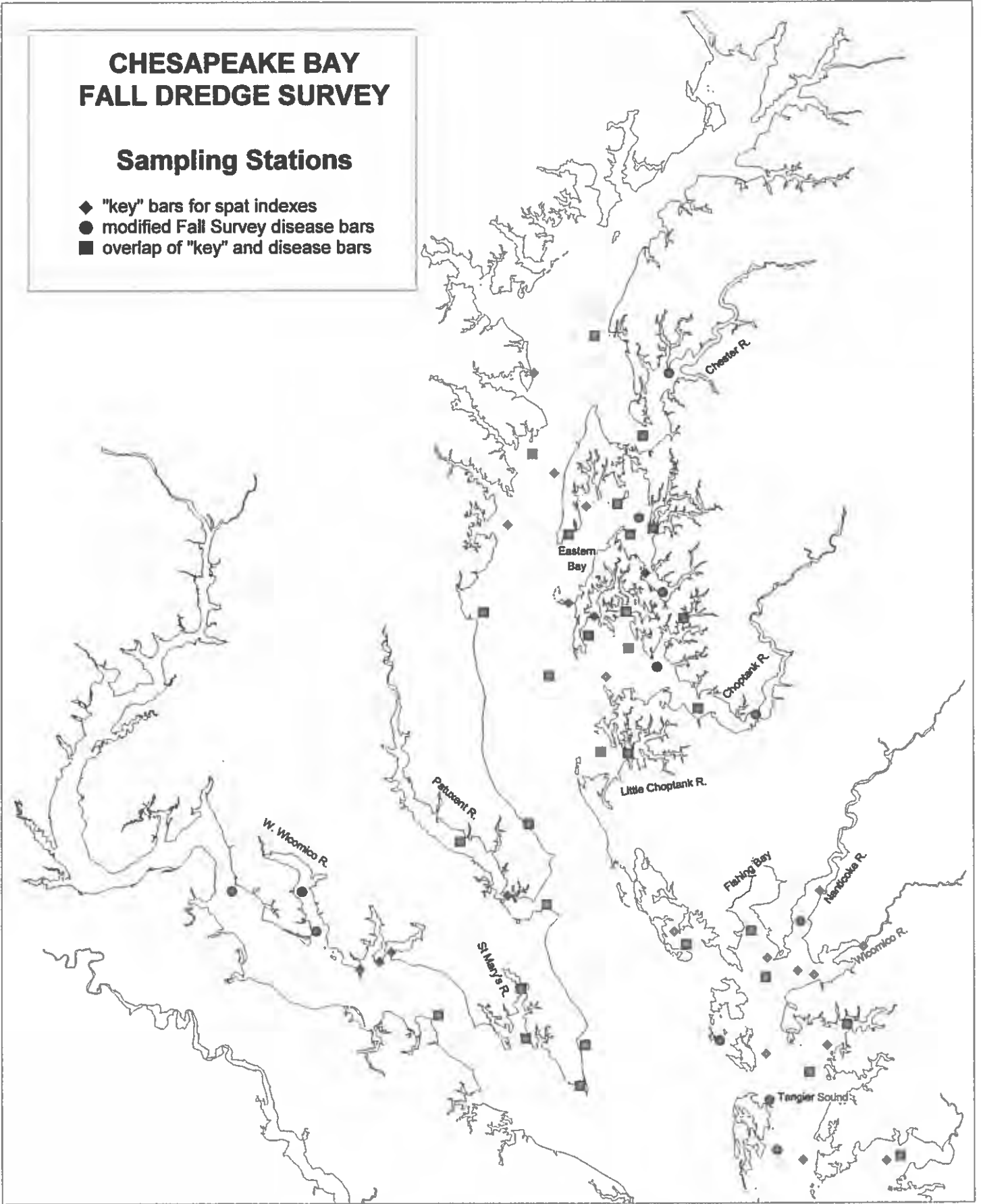


Figure 1(b). Annual Fall Survey station locations for key and disease bars.

Annual Freshwater Flow, Monthly Mean
Chesapeake Bay, USGS Section C

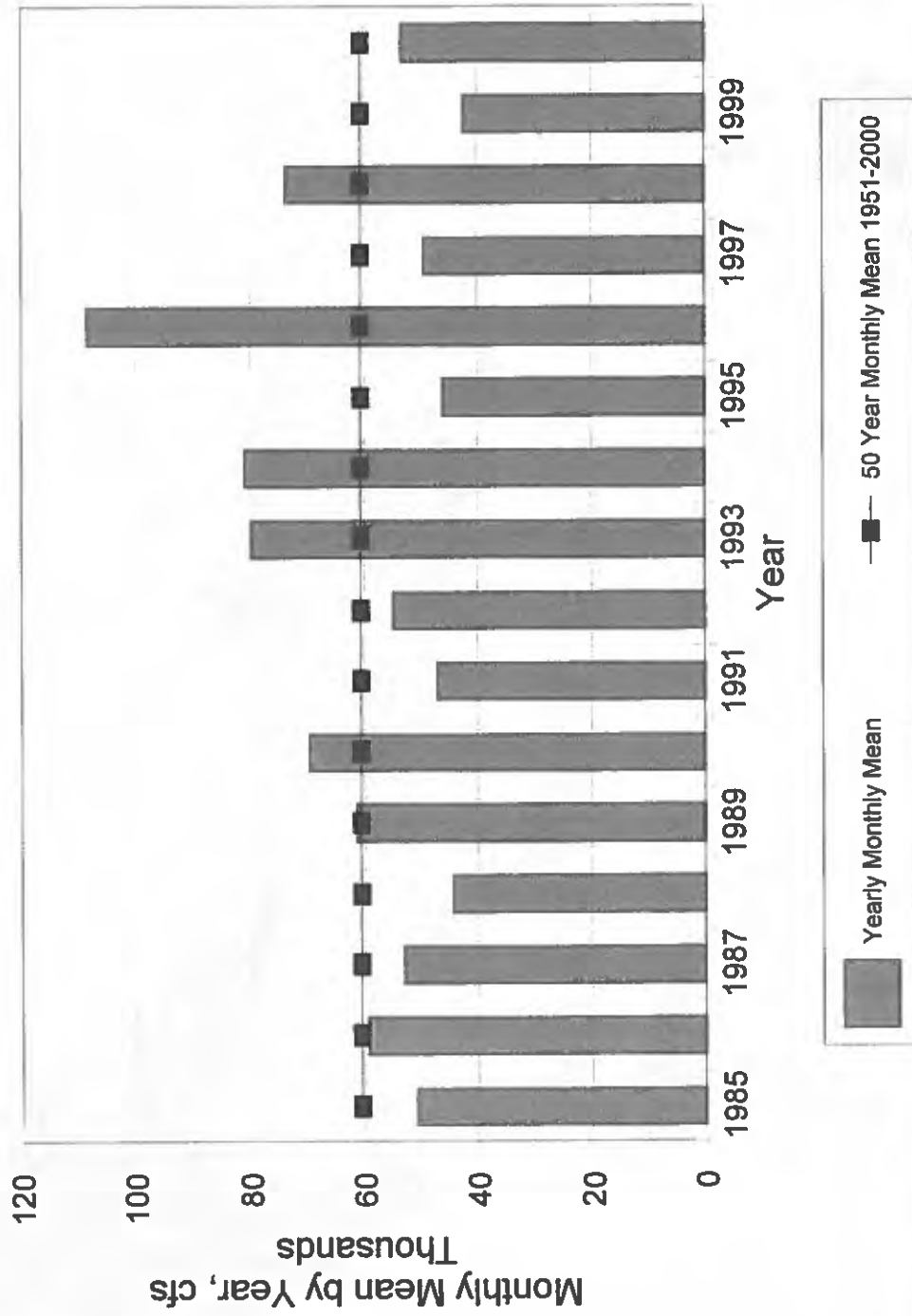
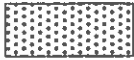


Figure 2. Mean monthly freshwater inflow into the Chesapeake Bay. Section C: all Md tributaries and the Potomac River.

Chesapeake Bay 1996 Fall Dredge Survey

Spat Set



0



1-10



11-50

#Spat per Bushel

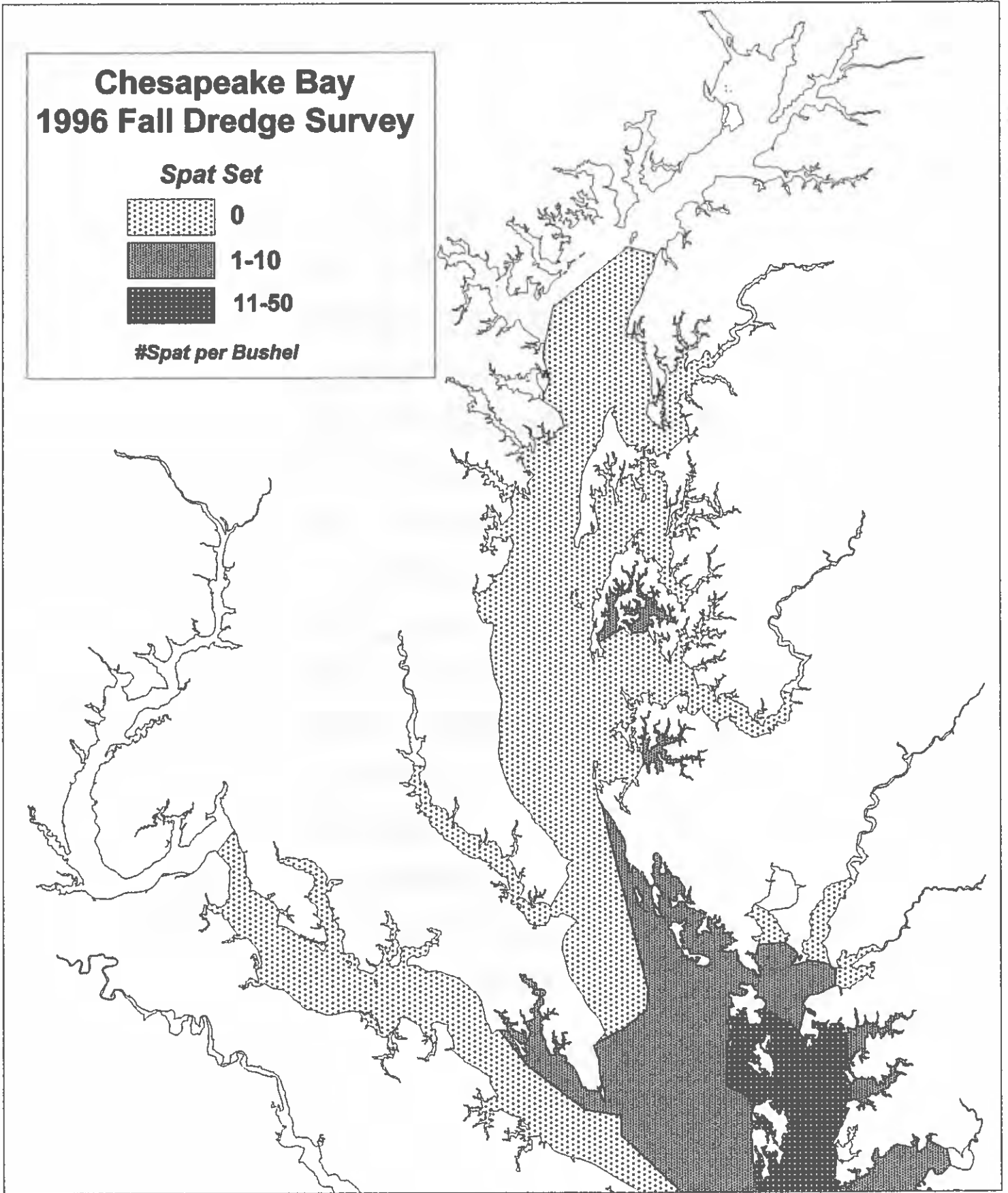
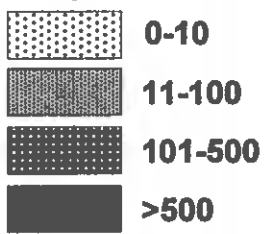


Figure 3(a). Spatfall intensity ranges, 1996.

Chesapeake Bay 1997 Fall Dredge Survey

Spat Set



#Spat per Bushel

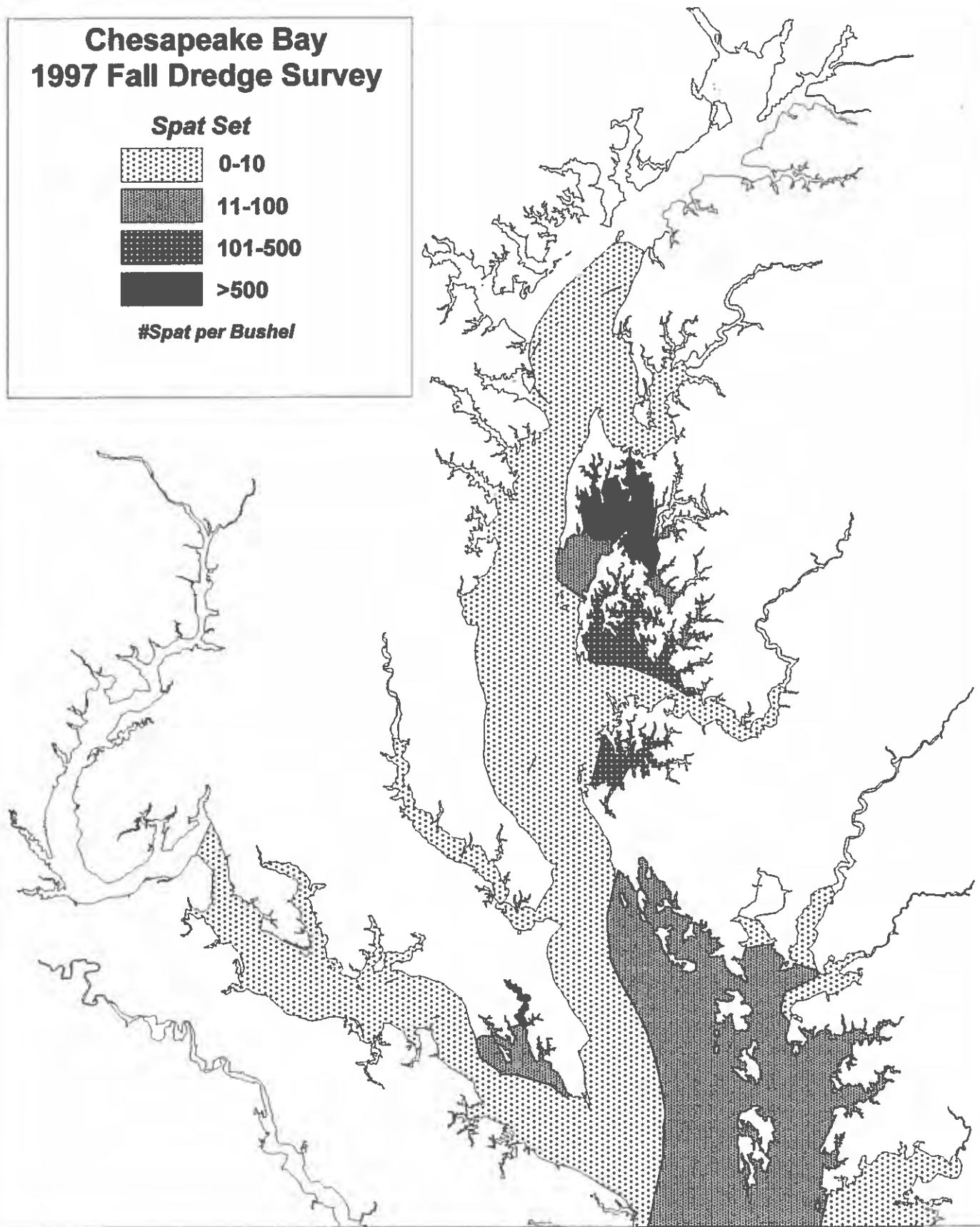


Figure 3(b). Spatfall intensity ranges, 1997.

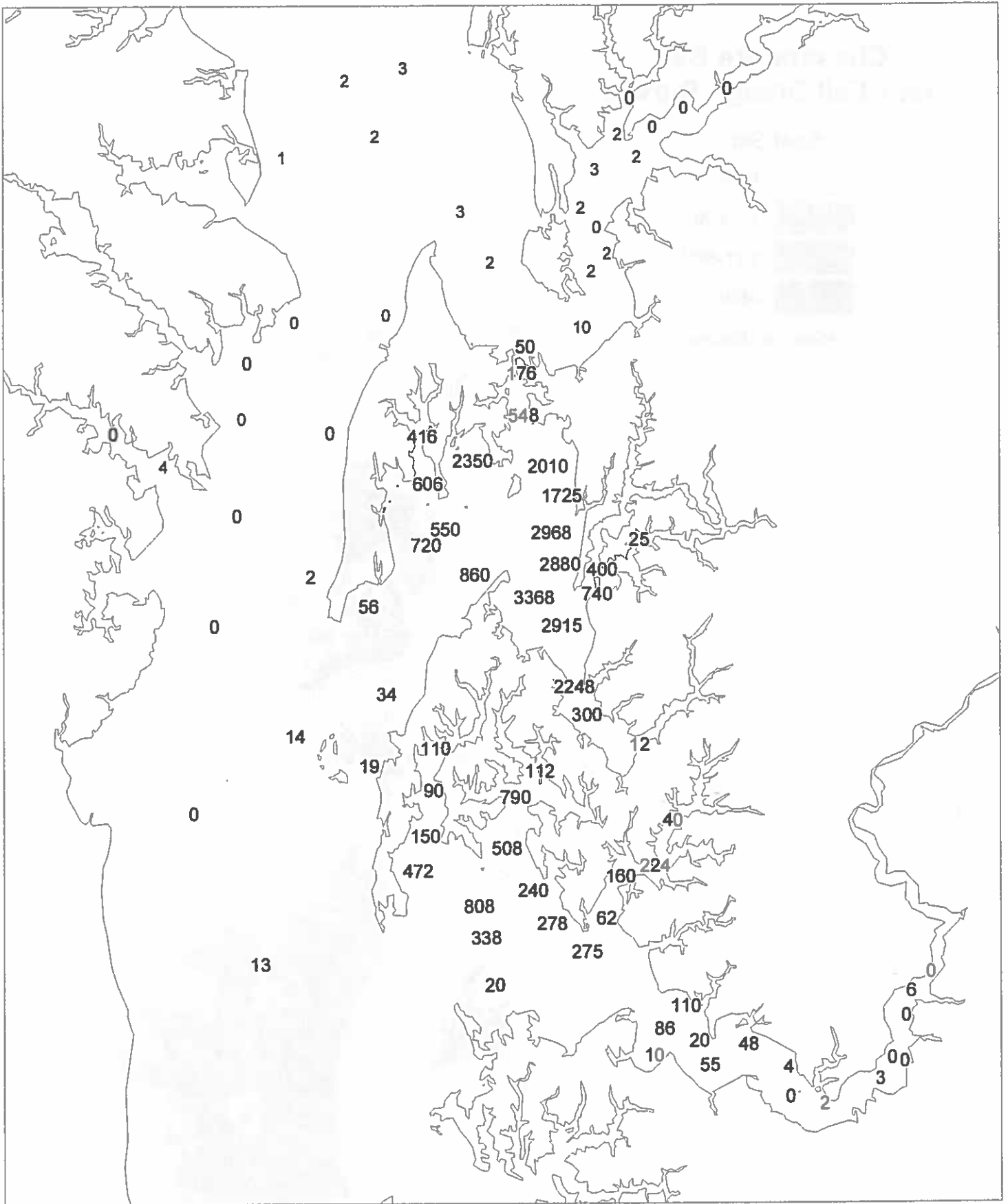
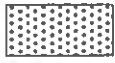


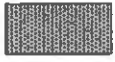
Figure 3(c). Spatfall intensity ranges, spat per bushel, Eastern Bay, 1997.

Chesapeake Bay 1998 Fall Dredge Survey

Spat Set



0



1-10



11-50

Spat per Bushel

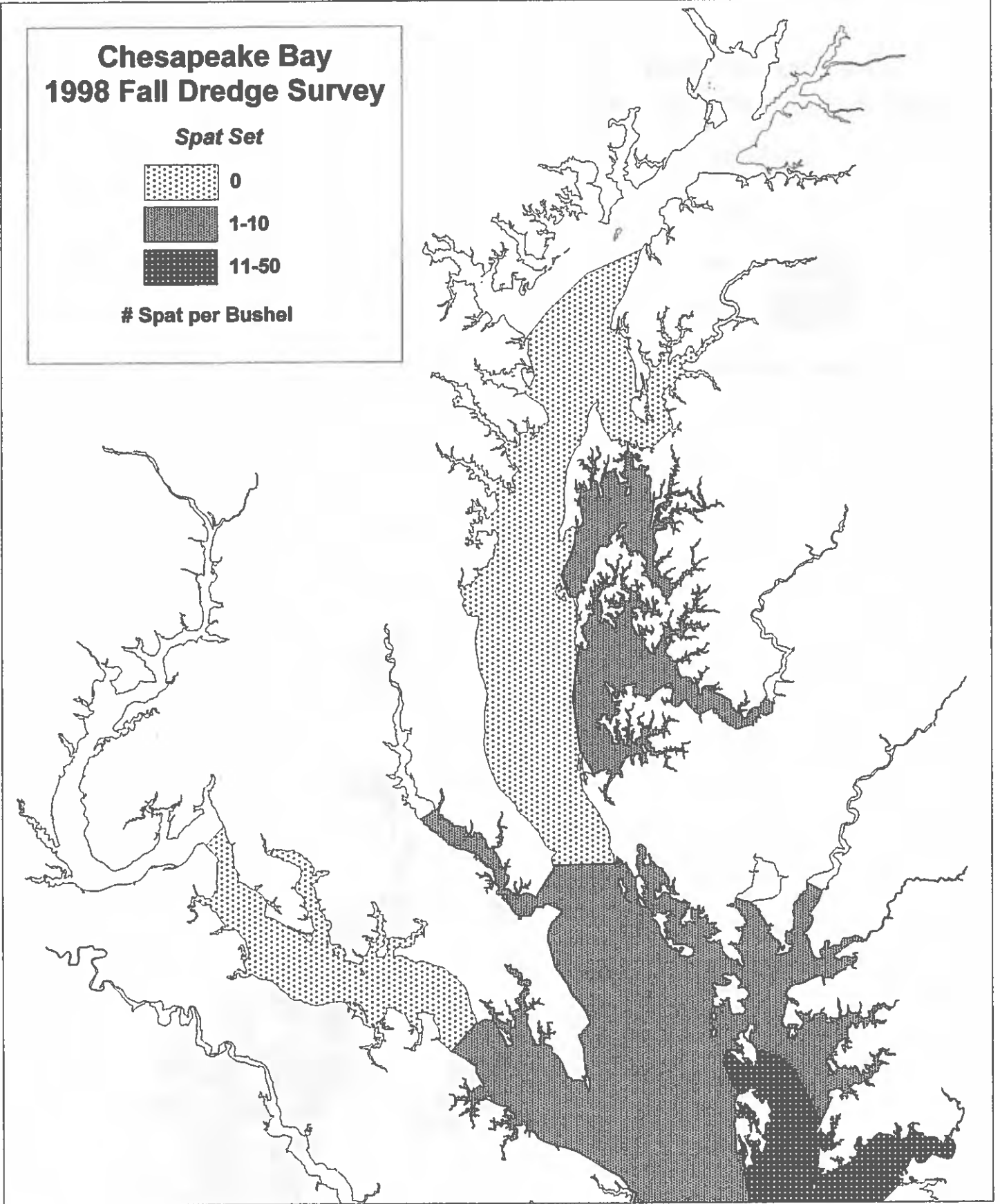
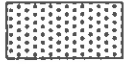


Figure 3(d). Spatfall intensity ranges, 1998

Chesapeake Bay 1999 Fall Dredge Survey

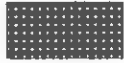
Spat Set



0-10



11-50



51-200

Spat per Bushel

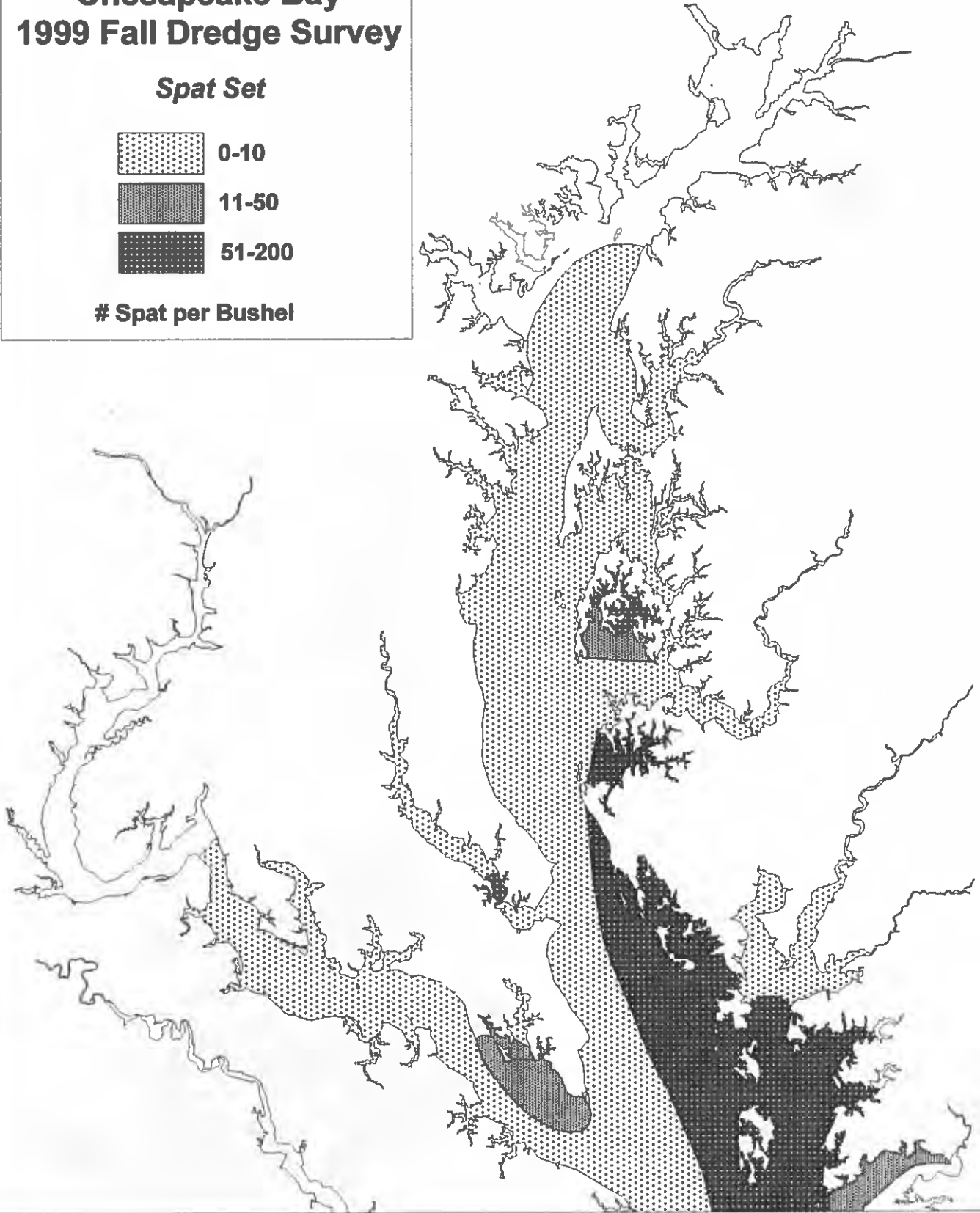
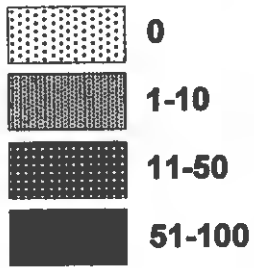


Figure 3(e). Spatfall intensity ranges, 1999.

Chesapeake Bay 2000 Fall Dredge Survey

Spat Set



Spat per Bushel

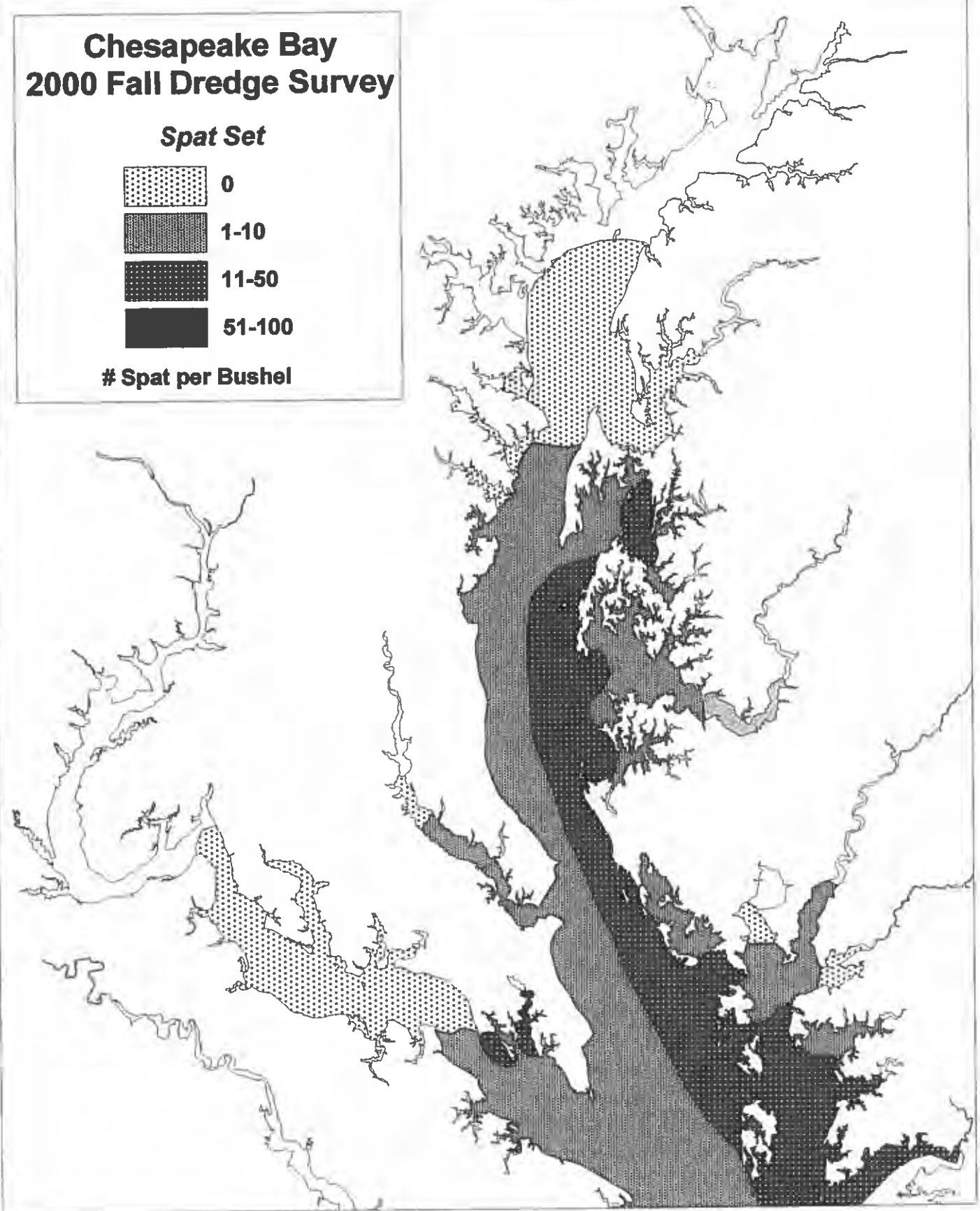


Figure 3(f). Spatfall intensity ranges, 2000.

Spatfall Intensity Index, 1985-2000

Spat Per Bushel

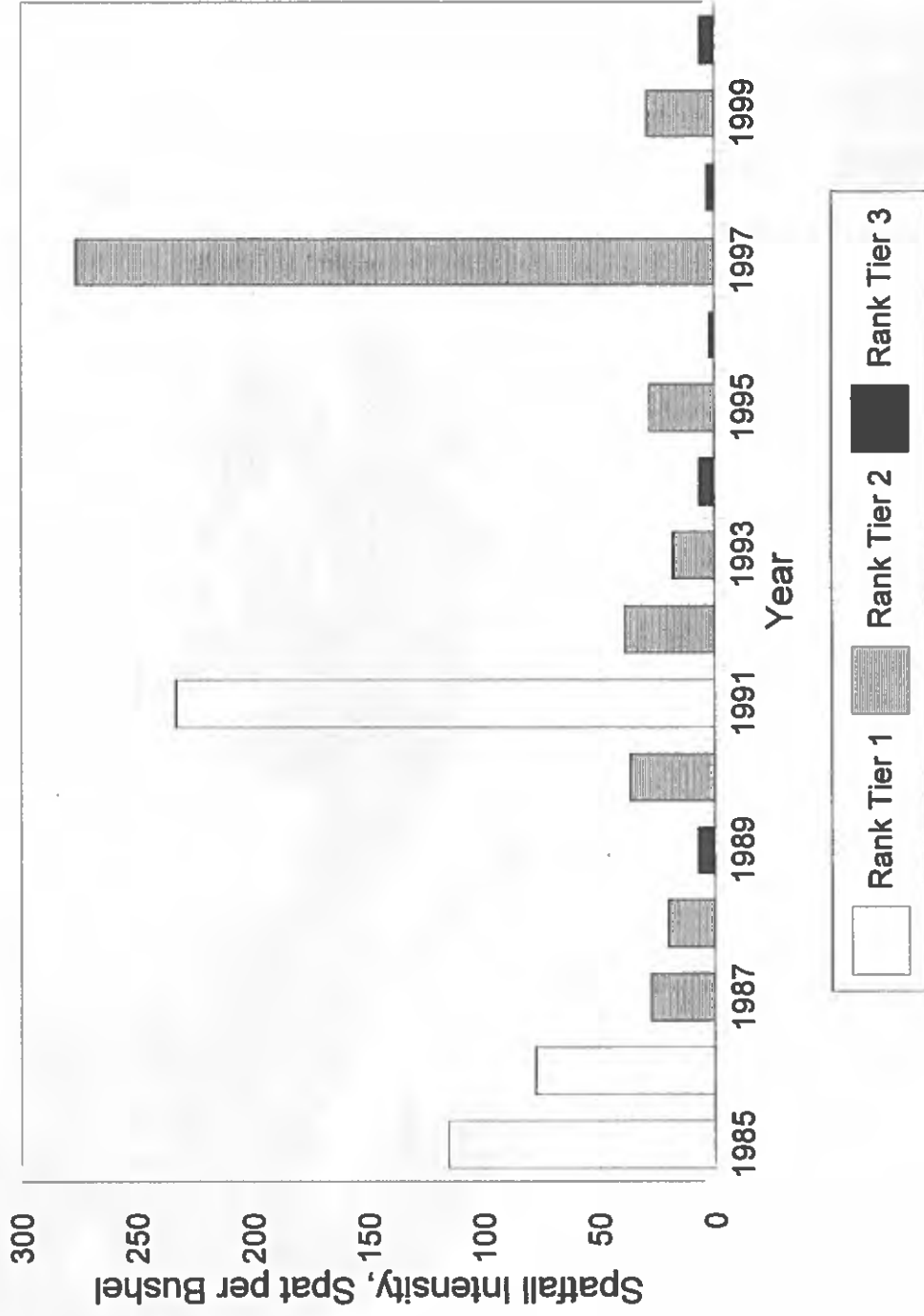


Figure 4. Spatfall intensity in Maryland, spat per bushel, 1985-2000

**Chesapeake Bay
1996 Fall Dredge Survey**

% *P. marinus* Prevalence

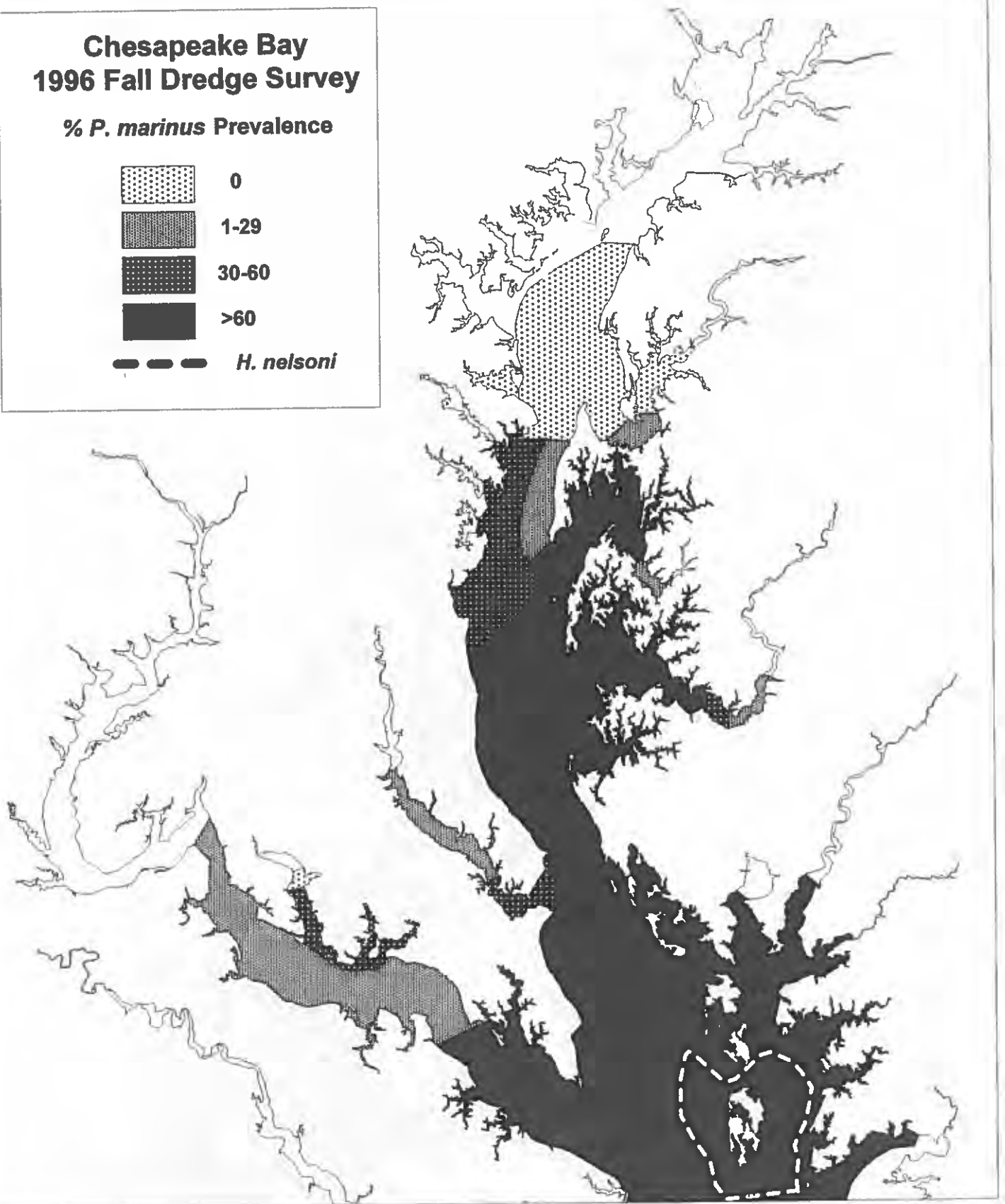
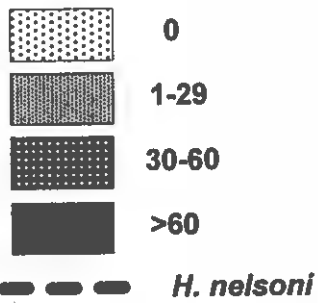


Figure 5(a). *Perkinsus marinus* prevalence ranges and geographical extent of *Haplosporidium nelsoni*, 1996.

Chesapeake Bay 1999 Fall Dredge Survey

% *P. marinus* Prevalence

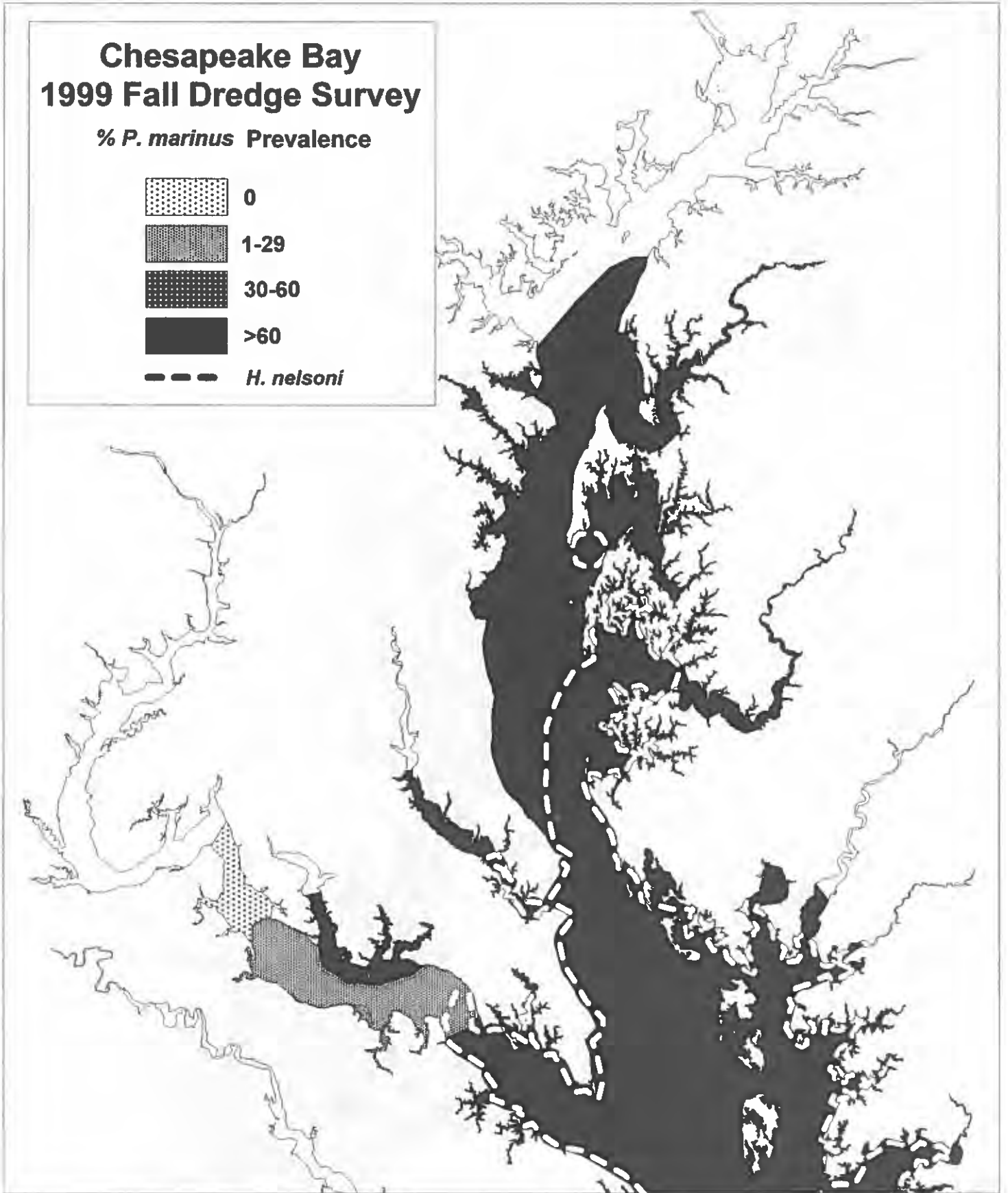
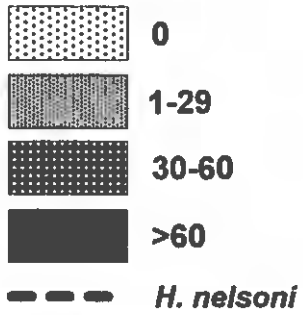


Figure 5(d). *Perkinsus marinus* prevalence ranges and geographical extent of *Haplosporidium nelsoni*, 1999.

Chesapeake Bay 2000 Fall Dredge Survey

% *P. marinus* Prevalence

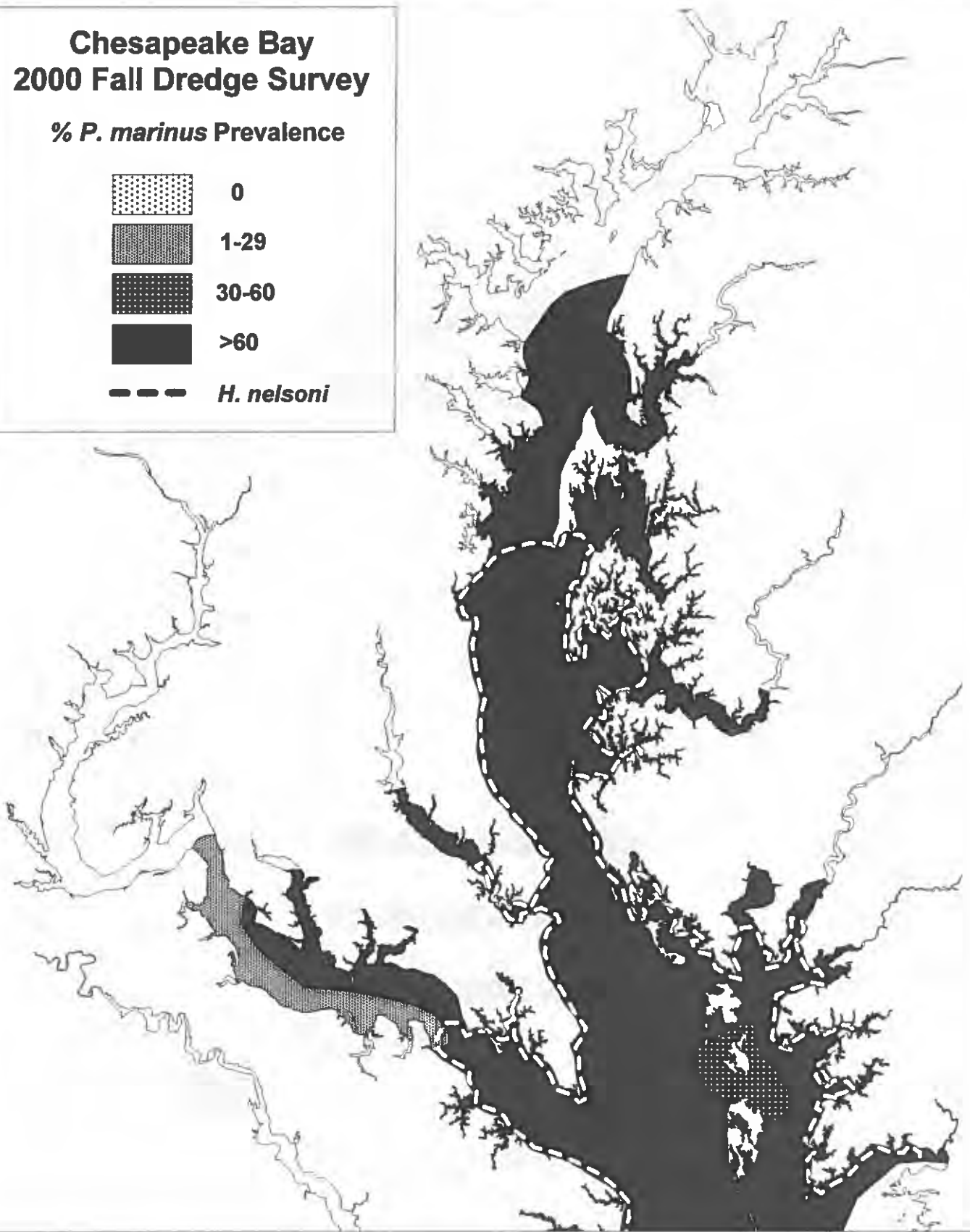
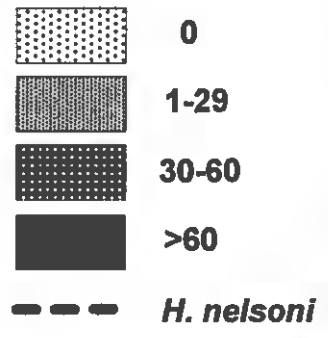


Figure 5(e). *Perkinsus marinus* prevalence ranges and geographical extent of *Haplosporidium nelsoni*, 2000.

Perkinsus marinus Prevalence and H. nelsoni % Frequency, 1990-2000

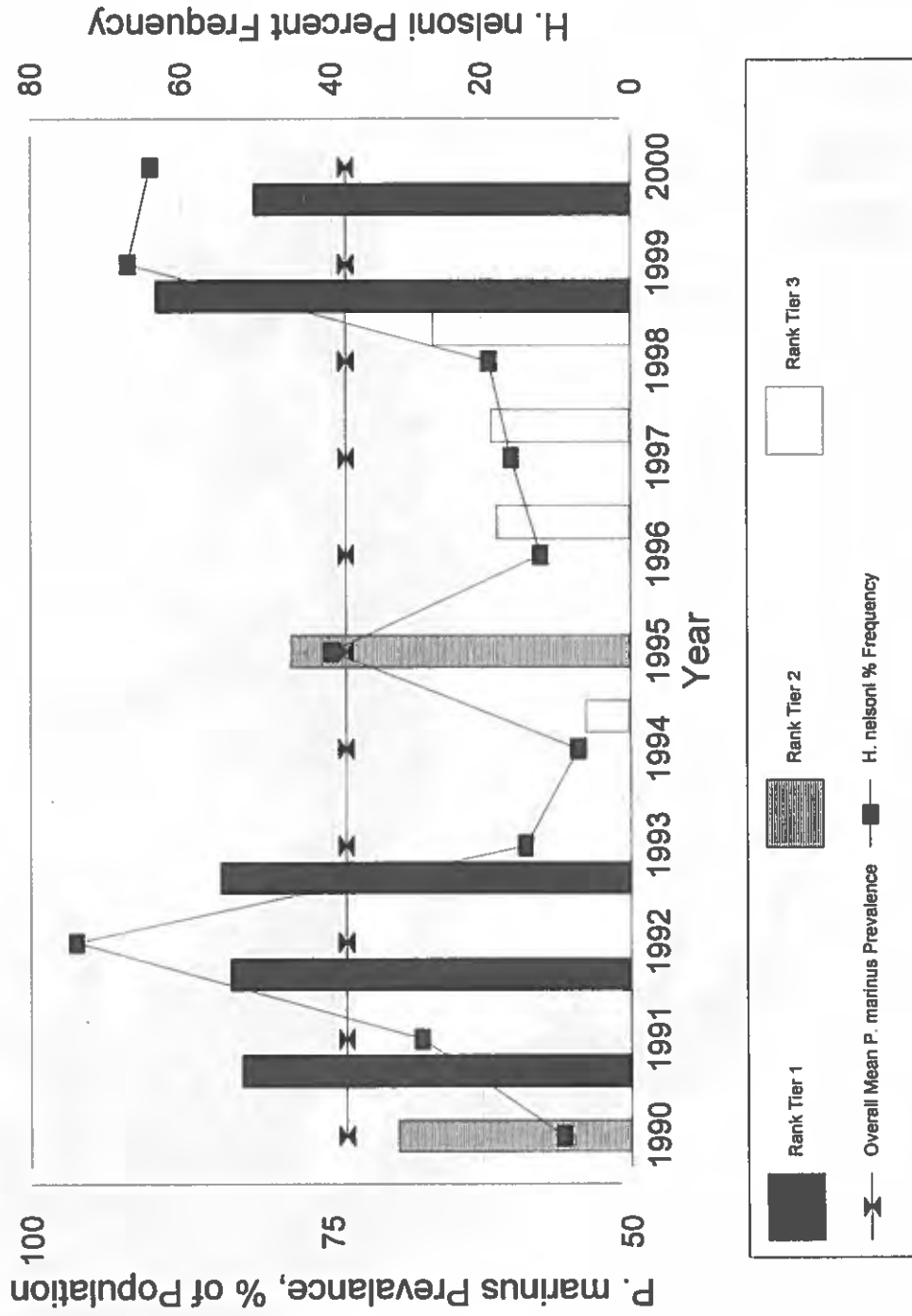


Figure 6. Prevalence of *P. marinus* and % Frequency, of Disease Bars, of *H. nelsoni*, 1990-2000.

Perkinsus marinus Intensity 1990-2000

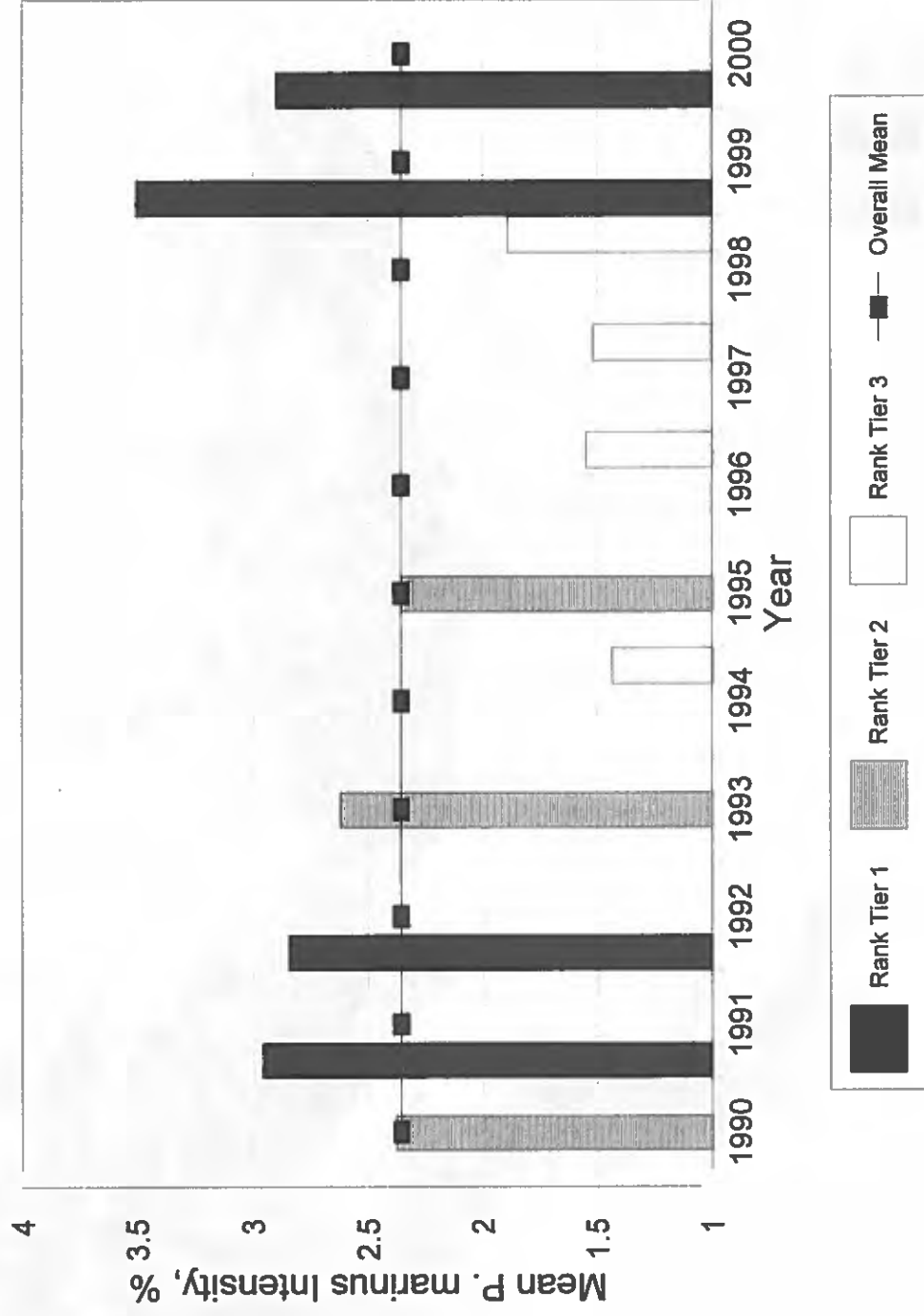


Figure 7. Mean Perkinsus marinus intensity, 1990-2000.

**Chesapeake Bay
1996 Fall Dredge Survey**
Total Observed Mortality, %

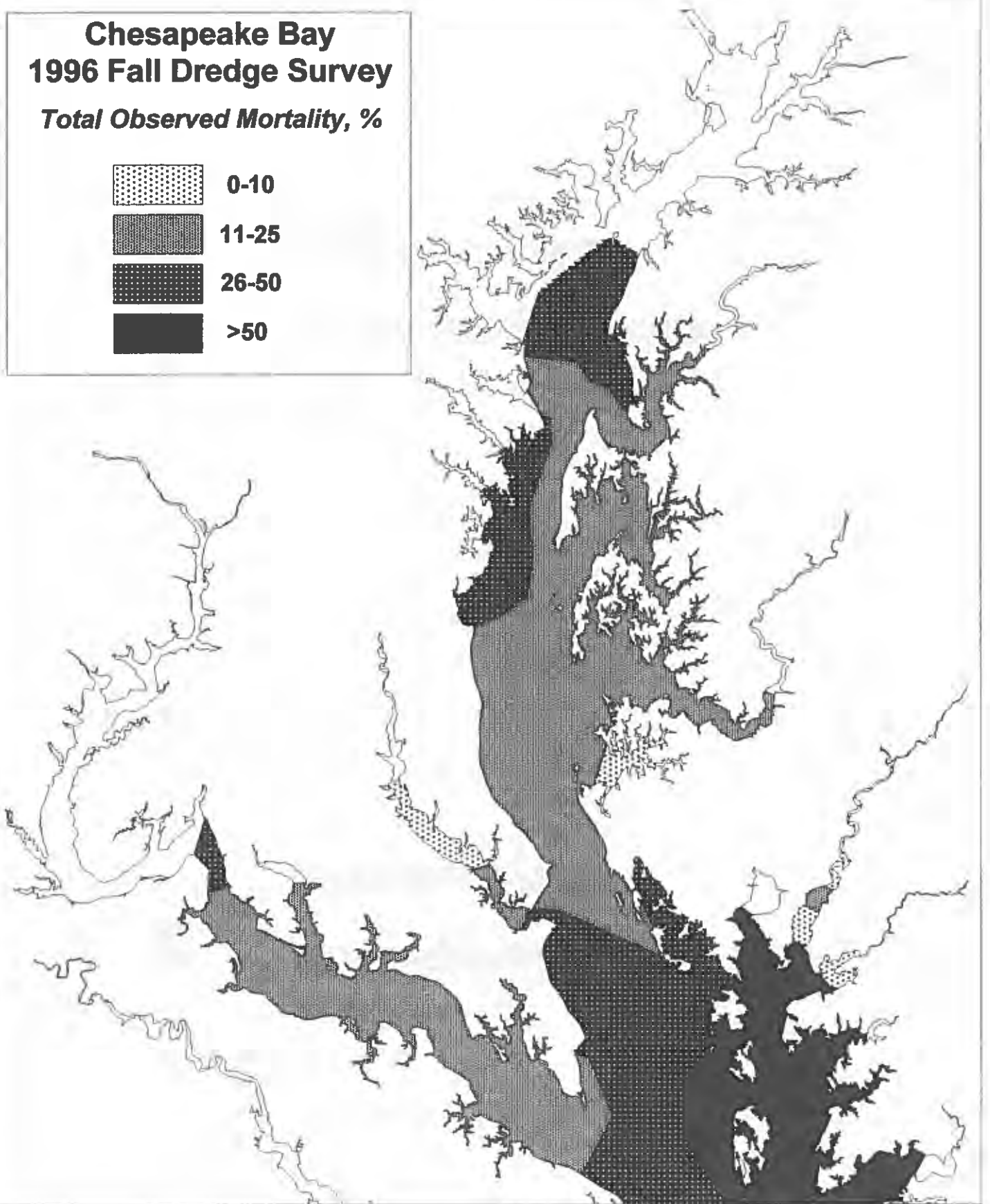
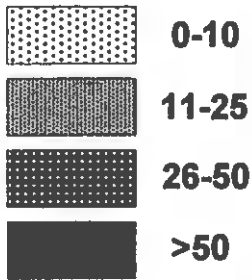


Figure 8(a). Total observed mortality ranges, 1996.

**Chesapeake Bay
1997 Fall Dredge Survey**

Total Observed Mortality, %

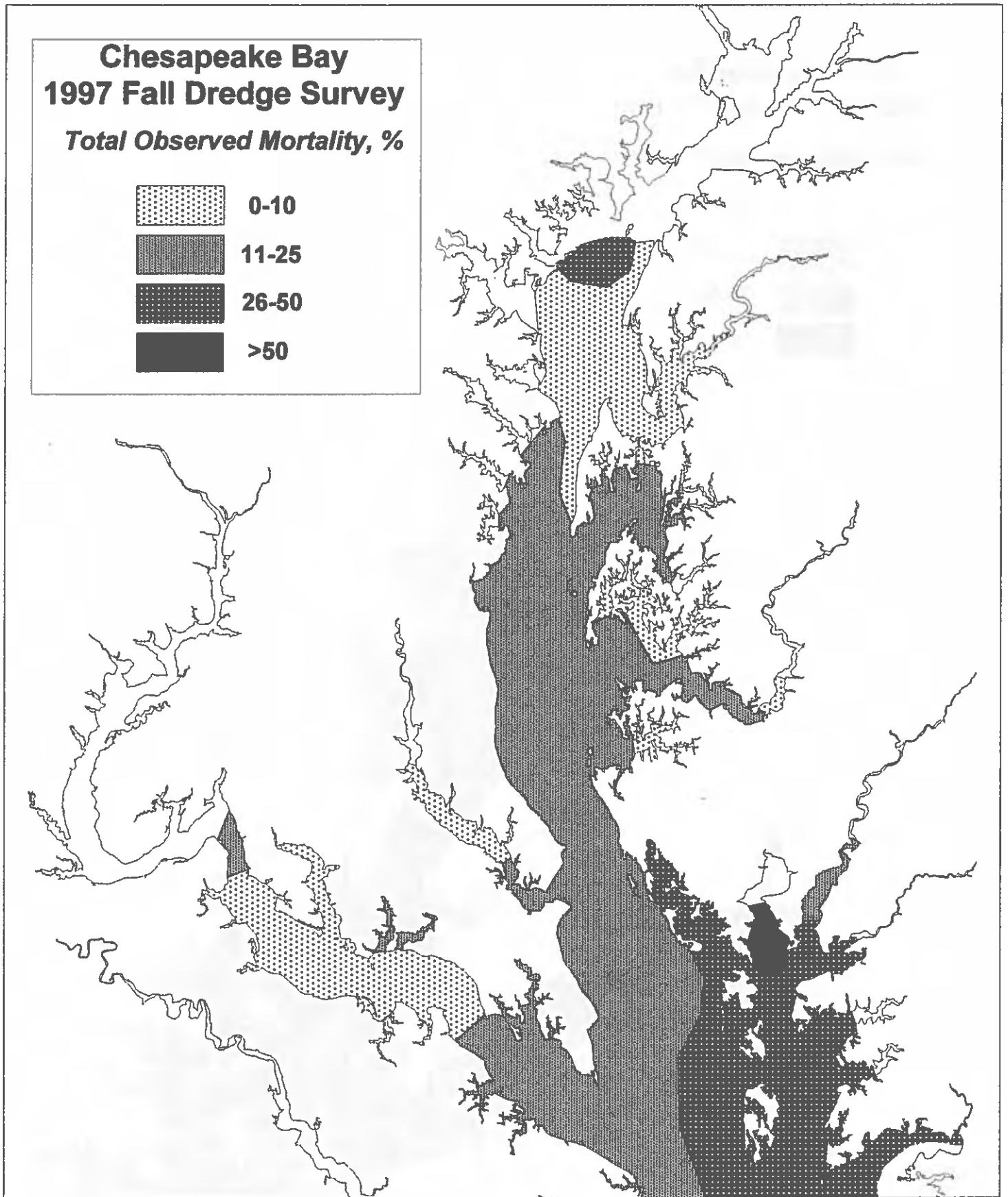
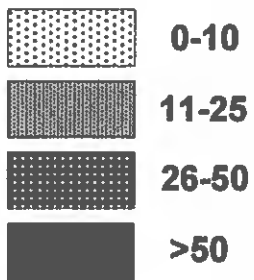


Figure 8(b). Total observed mortality ranges, 1997.

Chesapeake Bay 1998 Fall Dredge Survey

Total Observed Mortality, %

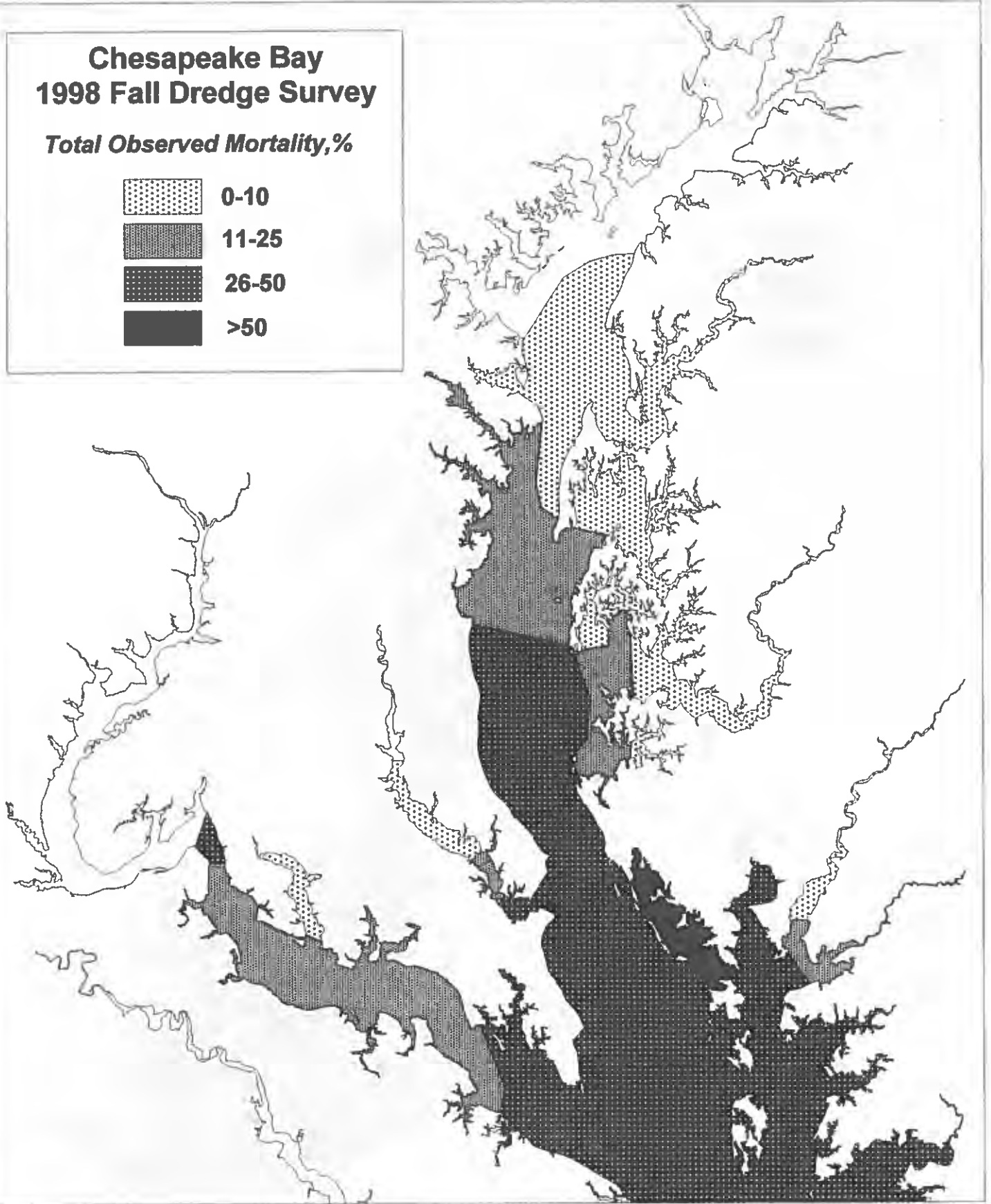
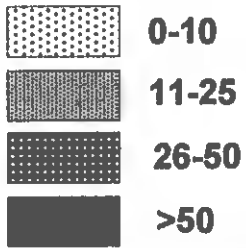


Figure 8(c). Total observed mortality ranges, 1998.

Chesapeake Bay 1999 Fall Dredge Survey

Total Observed Mortality, %

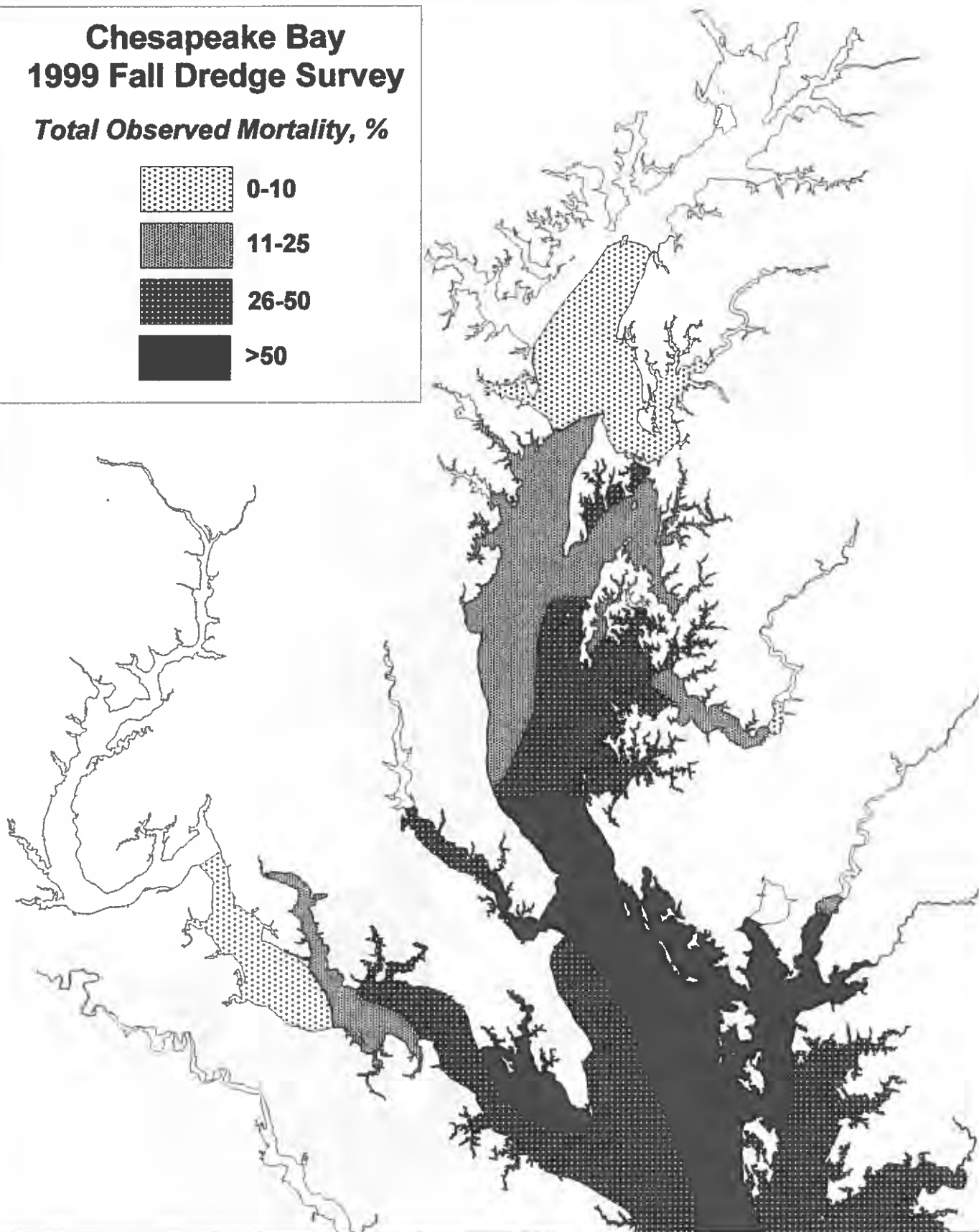
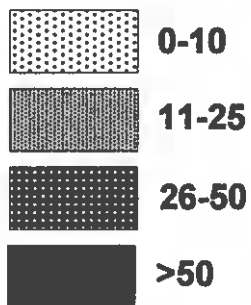


Figure 8(d). Total observed mortality ranges, 1999.

Chesapeake Bay 2000 Fall Dredge Survey

Total Observed Mortality, %

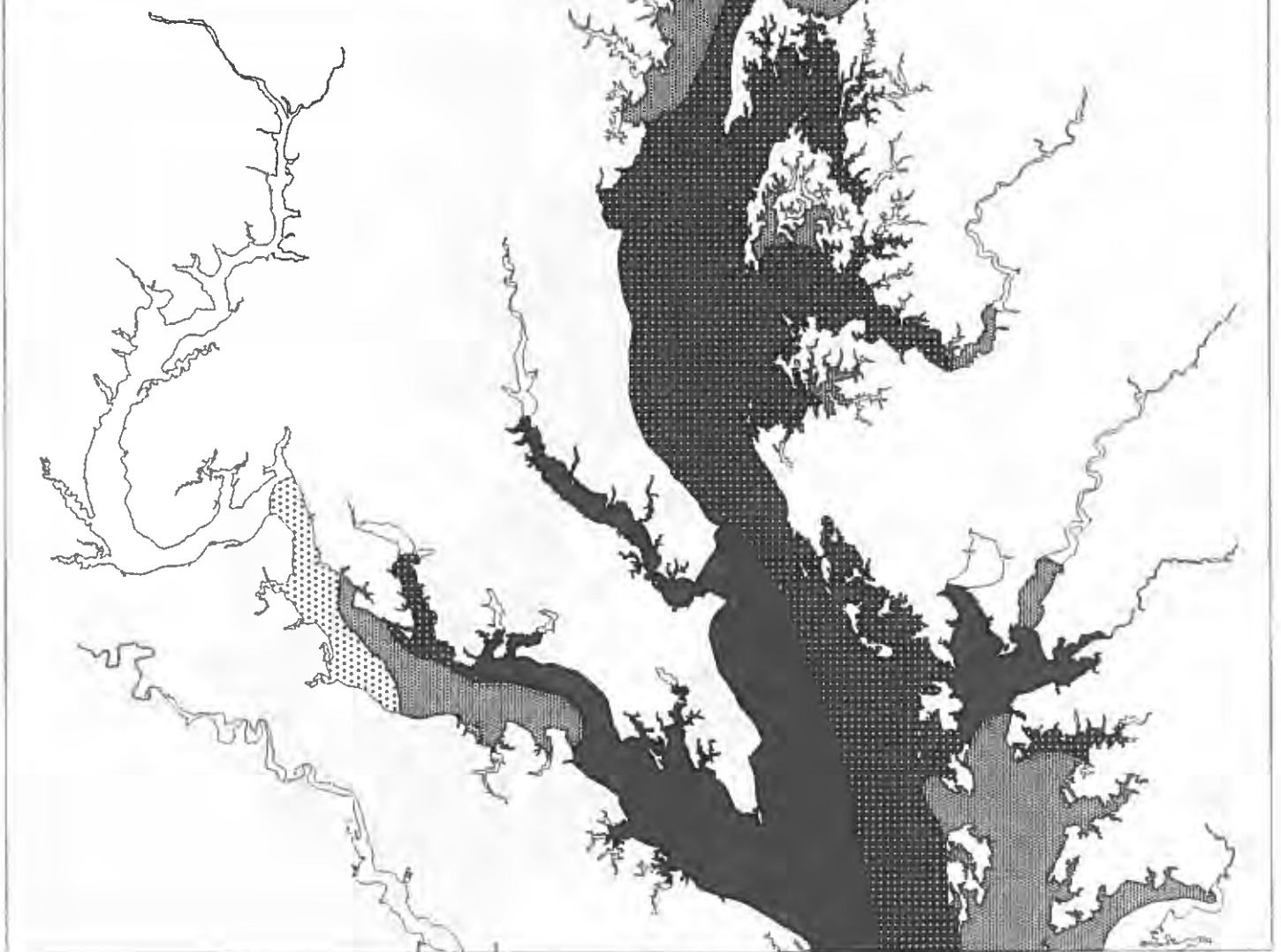
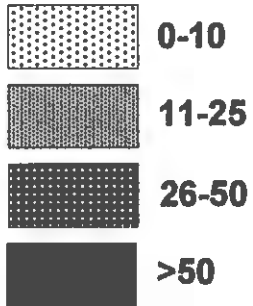


Figure 8(e). Total observed mortality ranges, 2000.

Observed Oyster Mortality, 1985-2000
 Total Mortality Smalls+Markets

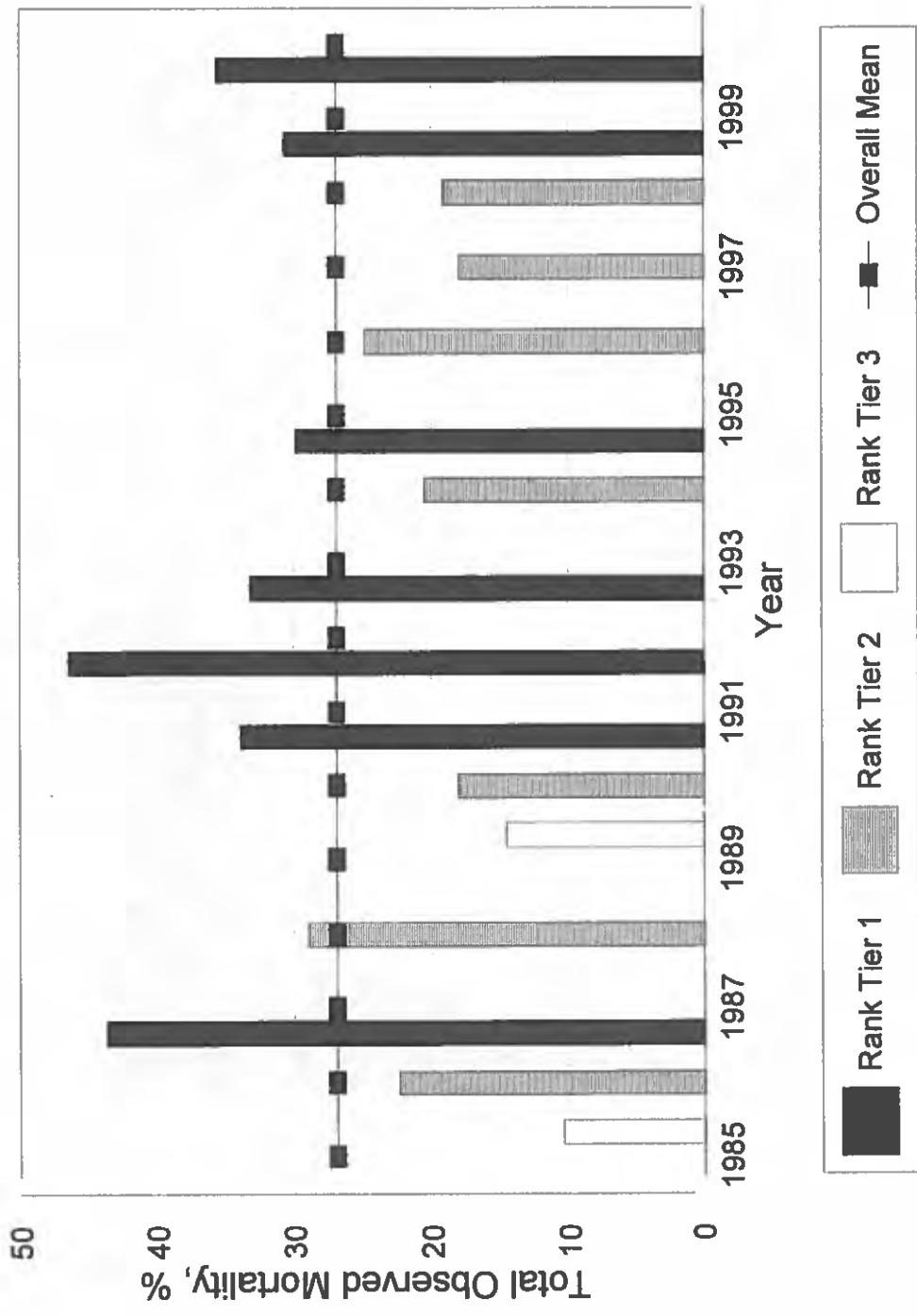


Figure 9. Mean annual total observed mortality, smalls plus markets, 1985-2000.

Maryland Oyster Harvest
1985-1986 Through 1999-2000 Seasons

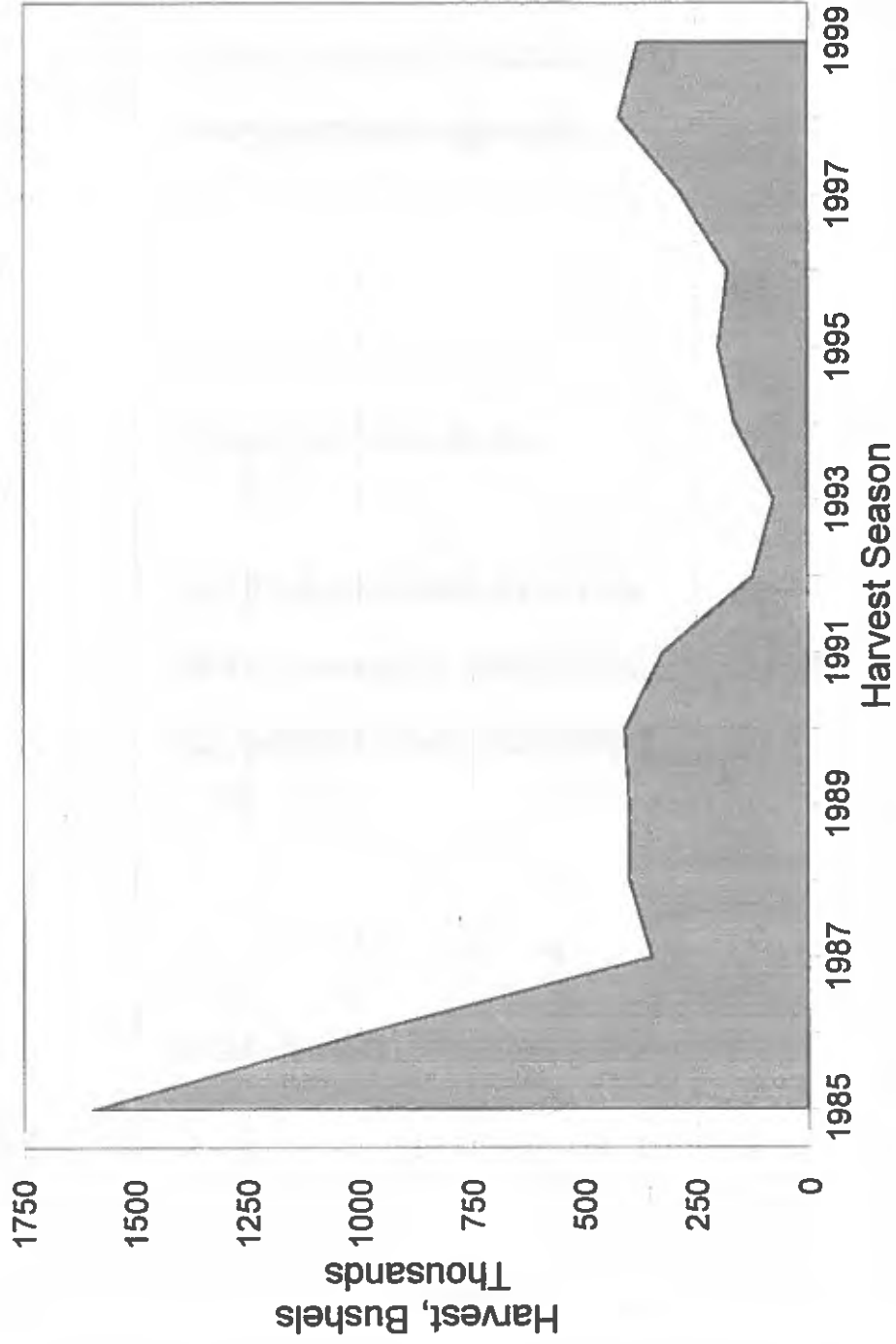


Figure 10. Maryland oyster landings, bushels, 1985-86 season through the 1999-2000 season.

Perkinsus marinus Intensity, 1990-2000

43 Disease bar Set

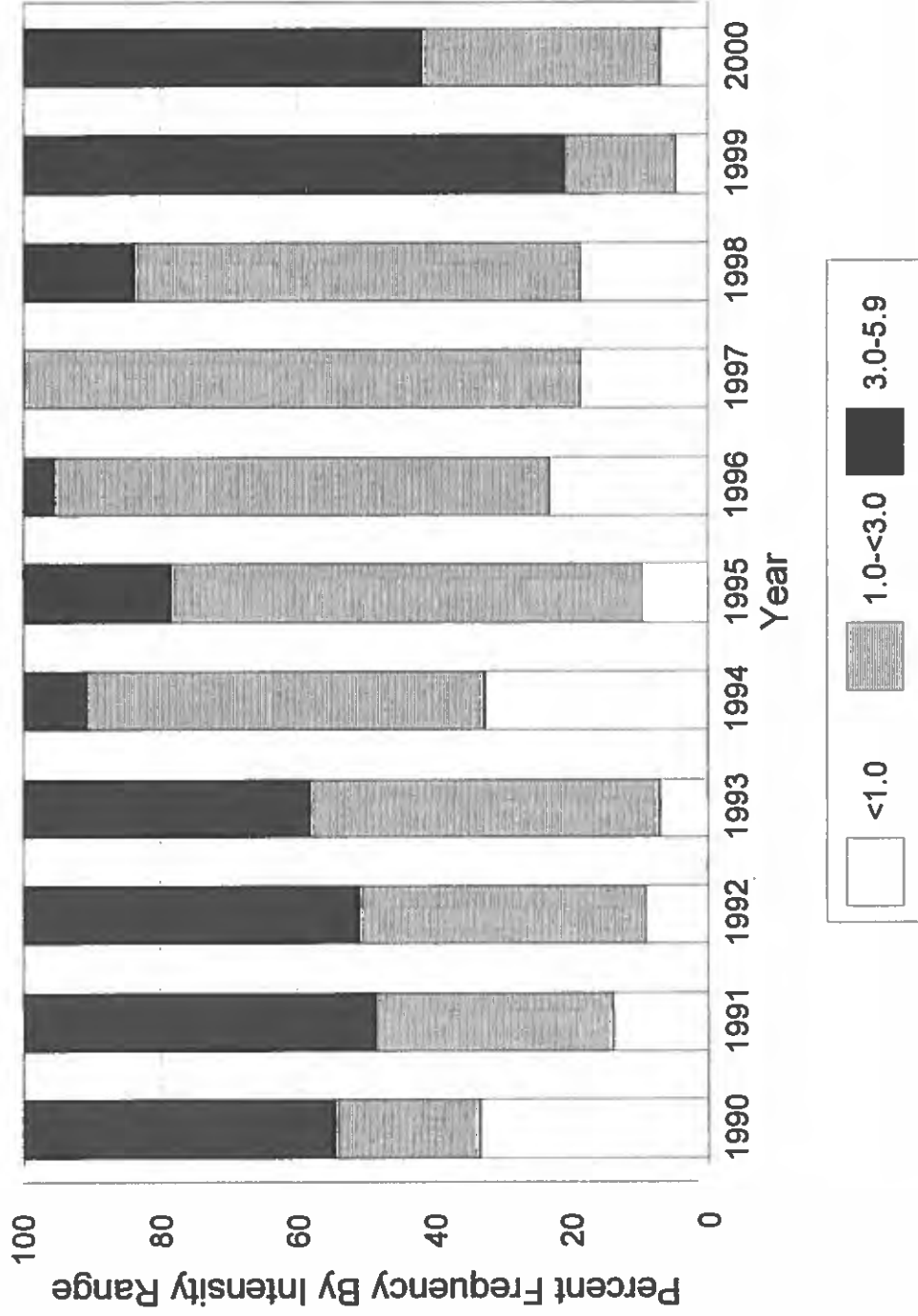


Figure 11. Perkinsus marinus intensity ranges, percent frequency by year and range, 1990-2000.

Appendix 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

Appendix 2. Spatfall intensity from the 53 "Key" bar set, 1985-2000.

Oyster Bar	Spatfall Intensity, Number Per Bushel			
	1985	1986	1987	1988
Mountain Point	6	0	0	0
Swan Point	4	0	2	2
Brickhouse	78	0	4	8
Hacketts Point	0	4	0	0
Tolly Point	2	2	2	0
Three Sisters	10	2	8	0
Holland Point	6	2	0	0
Stone Rock	136	150	20	30
Flag Pond	98	306	128	98
Hog Island	116	32	58	35
Butlers	418	196	171	16
Buoy Rock	16	0	6	0
Parsons Island	78	2	4	2
Wild Ground	46	8	4	8
Hollicutts Noose	24	8	12	6
Bruffs Island	82	0	0	2
Ash Craft	10	2	0	10
Turtleback	382	40	12	34
Shell Hill	50	10	0	6
Sandy Hill	74	16	2	0
Royston	440	8	8	0
Cooks Point	64	82	4	28
Eagle Point	255	28	2	6
Tilghman Wharf	156	128	38	4
Deep Neck	566	114	6	22
Double Mills	332	24	2	0
Ragged Point	134	118	34	112
Cason	400	24	46	50
Windmill	34	112	43	22
Normans Addition	56	214	38	17
Goose Creek	34	79	16	18
Clay Island	4	78	14	48
Wetipquin	34	10	0	0
Middleground	18	12	26	9
Evans	16	10	12	14
Mt. Vernon Wharf	0	0	0	0
Georges	26	97	14	4
Drum Point	48	186	48	90
Sharkfin Shoal	18	44	22	24
Turtle Egg	160	90	12	26
Piney Island East	182	384	50	160
Great Rock	2	6	4	6
Gunby	124	88	50	9
Marumsco	29	50	18	3
Broomes Island	34	0	0	0
Back of Island	42	0	8	4
Chicken Cock	620	298	96	62
Pagan	140	34	52	36
Black Walnut	16	6	0	0
Blue Sow	34	35	0	0
Dukehart	21	4	2	0
Ragged Point	69	66	4	0
Cornfield Harbor	383	908	362	28
Spat Index	115.6	77.7	27.6	20.0

Appendix 2. (Continued).

Oyster Bar	Spat Set, Number Per Bushel			
	1989	1990	1991	1992
Mountain Point	0	0	0	0
Swan Point	0	0	2	0
Brickhouse	0	3	0	0
Hacketts Point	0	0	0	0
Tolly Point	0	0	0	0
Three Sisters	0	0	0	0
Holland Point	0	0	0	2
Stone Rock	5	37	355	15
Flag Pond	0	4	330	8
Hog Island	2	7	169	2
Butlers	2	24	617	3
Buoy Rock	0	1	0	0
Parsons Island	0	7	127	18
Wild Ground	0	18	205	8
Hollicutts Noose	0	1	11	1
Bruffs Island	0	1	12	8
Ash Craft	0	2	12	0
Turtleback	6	11	168	15
Shell Hill	0	0	79	0
Sandy Hill	0	28	179	2
Royston	0	57	595	10
Cooks Point	0	17	171	1
Eagle Point	6	18	387	4
Tilghman Wharf	2	109	719	10
Deep Neck	4	48	468	22
Double Mills	0	1	129	0
Ragged Point	0	65	1036	53
Cason	0	143	1839	43
Windmill	16	155	740	46
Normans Addition	34	82	1159	53
Goose Creek	4	4	153	41
Clay Island	18	12	256	46
Wetipquin	0	3	3	6
Middleground	14	40	107	63
Evans	9	2	20	27
Mt. Vernon Wharf	0	0	15	0
Georges	16	4	52	42
Drum Point	72	16	140	185
Sharkfin Shoal	2	16	43	97
Turtle Egg	26	204	289	591
Piney Island East	74	64	429	329
Great Rock	10	12	208	44
Gunby	8	21	302	156
Marumsco	12	6	142	34
Broomes Island	0	3	12	0
Back of Island	4	15	49	5
Chicken Cock	18	29	182	5
Pagan	6	613	190	62
Black Walnut	0	1	6	0
Blue Sow	0	1	22	0
Dukehart	0	2	19	0
Ragged Point	0	2	14	0
Cornfield Harbor	14	26	212	2
Spat Index	7.2	36.7	233.5	38.8

Appendix 2. (Continued).

Oyster Bar	Spat Set, Number Per Bushel			
	1993	1994	1995	1996
Mountain Point	13	0	0	0
Swan Point	3	0	1	0
Brickhouse	0	0	5	0
Hacketts Point	1	0	0	0
Tolly Point	0	0	0	0
Three Sisters	0	0	1	0
Holland Point	0	0	1	0
Stone Rock	4	4	29	0
Flag Pond	0	0	10	0
Hog Island	2	0	24	0
Butlers	2	1	7	1
Buoy Rock	0	0	6	0
Parsons Island	2	0	57	0
Wild Ground	4	0	68	0
Hollicutts Noose	0	0	7	0
Bruffs Island	0	1	15	0
Ash Craft	0	0	60	1
Turtleback	0	0	194	0
Shell Hill	0	0	15	0
Sandy Hill	0	0	4	0
Royston	8	0	14	0
Cooks Point	0	2	16	0
Eagle Point	15	0	67	0
Tilghman Wharf	59	4	64	0
Deep Neck	94	12	294	3
Double Mills	13	0	15	0
Ragged Point	10	3	16	0
Cason	37	28	48	5
Windmill	20	19	13	2
Normans Addition	33	17	25	0
Goose Creek	43	27	3	0
Clay Island	58	31	11	1
Wetipquin	1	4	1	0
Middleground	14	28	2	6
Evans	7	30	2	1
Mt. Vernon Wharf	18	0	3	0
Georges	19	9	16	0
Drum Point	45	13	14	10
Sharkfin Shoal	18	11	6	0
Turtle Egg	37	31	7	35
Piney Island East	22	25	23	25
Great Rock	27	11	3	7
Gunby	176	7	35	9
Marumsco	55	5	6	0
Broomes Island	0	0	58	0
Back of Island	0	1	17	0
Chicken Cock	45	4	78	2
Pagan	15	7	54	0
Black Walnut	1	0	1	0
Blue Sow	1	0	5	0
Dukehart	2	0	0	0
Ragged Point	3	0	20	0
Cornfield Harbor	29	0	49	0
Spat Index	18.0	6.3	28.1	2.0

Appendix 2. (Continued).

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

Appendix 3. *Perkinsus marinus* prevalence and intensity results for the 43 Disease bar set, 1990-2000.

Bar	<i>Perkinsus marinus</i> 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
<i>P. marinus</i> Indices	70	2.3	83	3.0	83	2.8	84	2.6

Appendix 3. (Continued).

Bar	<i>Perkinsus marinus</i> 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
Marumsc	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
<i>P. marinus</i> Indices	54	1.4	78	2.3	61	1.5	62	1.5

Appendix 3. (Continued).

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

Appendix 4. *Haplosporidium nelsoni* test results for the Disease Bar set, 1990-2000.

Bar	<i>Haplosporidium nelsoni</i> 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 Frequency¹	9	28	74	14	7	40

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

Appendix 4. (Continued).

Bar	<i>Haplosporidium nelsoni</i> Prevalence (%)				
	1996	1997	1998	1999	2000
Swan Point	0	0	0	0	0
Hacketts Point	0	0	0	0	0
Holland Point	0	0	0	0	3
Stone Rock	0	0	0	30	47
Flag Pond	0	0	0	NA	NA
Hog Island	0	0	0	60	27
Butlers	0	7	3	47	17
Buoy Rock	0	0	0	0	0
Oldfield	0	0	0	0	0
Bugby	0	0	0	0	0
Parsons Island	0	0	0	0	0
Hollicutts Noose	0	0	0	7	10
Bruffs Island	0	0	0	0	0
Turtleback	0	0	0	0	0
Long Point	0	0	0	0	0
Cooks Point	0	3	0	13	33
Royston	0	0	0	3	7
Lighthouse	0	0	0	13	7
Sandy Hill	0	0	0	0	0
Oyster Shell Pt	0	0	0	0	0
Tilghman Wharf	0	0	0	3	27
Deep Neck	0	0	0	3	7
Double Mills	0	0	0	3	0
Cason	0	0	0	7	27
Ragged Point	0	0	0	20	47
Normans Add	0	0	3	63	37
Goose Creek	0	0	0	47	17
Wilson Shoals	0	0	0	4	10
Georges	0	0	0	40	20
Holland Straits	0	10	3	73	40
Sharkfin Shoal	0	0	20	53	37
Back Cove	3	3	10	33	37
Piney Isl East	7	13	17	43	53
Old Woman's Leg	20	4	23	53	30
Marumsc	0	11	7	37	30
Broomes Island	0	0	0	3	10
Chicken Cock	0	0	0	77	7
Pagan	0	0	0	3	13
Lancaster	0	0	0	0	0
Mills West	0	0	0	3	0
Cornfield Harb.	0	0	3	53	17
Ragged Point (Potomac)	0	0	0	13	10
Lower Cedar Pt.	0	0	0	0	0
Percent Frequency²	7	16	19	67	64

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

Appendix 5. Oyster population mortality estimates on the 43 Disease Bar set, 1985-2000.

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

Appendix 5. (Continued).

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

Appendix 5. (Continued).

Bar	Total Observed Mortality, Percent			
	1993	1994	1995	1996
Swan Point	5	35	18	43
Hacketts Point	18	30	30	16
Holland Point	43	42	35	49
Stone Rock	30	29	40	25
Flag Pond	43	28	24	16
Hog Island	76	16	45	20
Butlers	66	37	63	17
Buoy Rock	51	33	22	17
Oldfield	8	12	8	17
Bugby	29	18	18	27
Parsons Island	29	18	36	22
Hollicutts Noose	29	32	30	13
Bruffs Island	47	47	33	6
Turtleback	24	40	51	21
Long Point	44	8	28	8
Cooks Point	63	40	22	16
Rovston	37	10	17	9
Lighthouse	57	27	18	15
Sandy Hill	45	36	29	23
Oyster Shell Point	20	14	18	25
Tilghman Wharf	36	6	10	9
Deep Neck	32	1	23	14
Double Mills	24	10	20	9
Cason	53	6	7	12
Ragged Point	71	17	16	12
Normans Addition	51	28	39	55
Goose Creek	38	7	38	69
Wilson Shoals	23	10	17	11
Georges	16	0	55	33
Holland Straits	18	16	45	43
Sharkfin Shoal	16	7	66	59
Back Cove	4	6	46	33
Piney Island East	13	20	65	56
Old Woman's Leg	15	25	63	46
Marumsco	21	8	78	53
Broomes Island	53	27	8	0
Chicken Cock	33	28	15	10
Pagan	17	11	9	27
Lancaster	7	4	19	25
Mills West	2	4	21	18
Cornfield Harbor	47	25	56	24
Ragged Point	28	35	8	11
Lower Cedar Point	47	28	5	23
Mortality Index	33	20	30	25

Appendix 5. (Continued).

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

Appendix 6. Regional summary of oyster harvests in Maryland, 1985-1986 season through the 1999-2000 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

Appendix 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	411,000	323,000	123,000	80,000	164,000

Appendix 6 (continued).

Region/Tributary	1995-96	1996-97	1997-98	1998-99	1999-2000
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	199,000	178,000	285,000	423,000	380,700