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STATUS OF THE MAJOR OYSTER DISEASES IN VIRGINIA—1995.

A SUMMARY OF THE ANNUAL MONITORING PROGRAM.

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EXECUTIVE SUMMARY

Weather. The winter and spring of 1995 were relatively warm and water temperature was generally above the long-term average. Average weekly water temperatures in January were above 5°C and were about 2-4°C above average. In February water temperatures were lower and slightly below average with temperatures less than 5°C recorded for 3 consecutive weeks. Monthly James River streamflow was slightly above average in January but below average from February to May. The high spring runoffs typically observed in the James River did not occur in 1995. A short-term period of high rainfall and intense flooding in late June and early July resulted in James River streamflows well above the long-term average. More typical James River streamflows were observed during August and September and salinity in the upper James River was relatively high. Water temperature remained relatively high during October, generally about 2°C above average. Below average temperatures and normal streamflows were observed in November and December.

***Haplosporidium nelsoni* (MSX).** The abundance of *H. nelsoni* was relatively high in 1995. *Haplosporidium nelsoni* was present in the fall in oysters from the Piankatank River at Burton's Point (8%), the Rappahannock River at Parrot Rock (21%), the Corrotoman River at Middle Ground (4%), and Pocomoke Sound at Byrd Rock (36%). In the James River at Wreck Shoal, the parasite was present at relatively high prevalences during the winter and spring of 1995. A record high prevalence (80%) was observed at Wreck Shoal in May. Numerous advanced infections were observed in May and oyster mortality resulted. Depressed salinities in late June and early July resulted in elimination of the parasite and prevalence decreased to 0% in August. Reinfection, which normally occurs in late summer, was delayed in 1995. Prevalence was 0% from August to November and 8% in December.

Haplosporidium nelsoni was also abundant in the lower York River. VIMS tray oysters, which were transplanted from Ross Rock to the lower York River site on 1 May 1995, had high prevalences (60%) of *H. nelsoni* on 1 July 1995. Prevalence progressively increased from September to December to a maximum prevalence of 74%. *Haplosporidium nelsoni*-associated mortality was nearly 40% by 1 August. Relative to prior years, in 1995 the acquisition of *H. nelsoni* by the transplanted oysters was early and the maximum prevalence and intensity were about average. Prevalence and intensity did not decline during November and December as typically observed.

***Perkinsus marinus* (Dermo).** Our fall survey of Virginia oyster bars indicated that *P. marinus* was present at all western shore oyster bars. Abundances of the parasite were at or

INTRODUCTION

The protozoan parasites *Haplosporidium nelsoni*, popularly known as MSX, and *Perkinsus marinus*, popularly known as Dermo, are serious pathogens of oysters in the Chesapeake Bay. MSX first appeared in Chesapeake Bay in 1959 and in the early 1960s killed millions of bushels of oysters on lower Bay oyster grounds. The continued presence of the parasite has discouraged use of these prime growing areas since that time.

The infection period for *H. nelsoni* begins in early May each year with peak mortality in the lower Bay from these early summer infections during August and September. However, infections acquired during late summer and fall may overwinter if salinity remains high and develop as soon as water temperature increases in early spring. These overwintering infections may cause oyster mortality as early as June. In the major tributaries, normal spring runoff usually causes expulsion of overwintering *H. nelsoni* infections by May, but the pathogen may reinvade an area by fall if salinity is favorable during summer. Oyster mortality is reduced under these circumstances because *H. nelsoni* is present mainly during winter when cold water temperature slows development of the parasite.

Historically, *P. marinus* has been present at low levels in the lower portions of all Virginia rivers, but the parasite increased in abundance and spread throughout all public oyster beds during the late 1980s. Until that time *P. marinus* was not as serious a pathogen as *H. nelsoni* because *P. marinus* spread slowly within an oyster bed and between adjacent beds, and required three years to cause significant mortality. However, because of the increase in the distribution and abundance of *Perkinsus*, this parasite is now more important than *H. nelsoni* as an oyster pathogen in the Bay. The population dynamics of *P. marinus* are complex and not entirely understood. Most mortality occurs during late summer and early fall, but it may begin as early as June following warm winters that allow more overwintering infections.

The distribution and pathogenicity of both diseases are limited by salinity and, in a very general sense, neither parasite causes serious mortality in areas where the salinity remains below about 12 ppt. *Haplosporidium nelsoni* is eliminated from oysters after about 10 days below 10 ppt; however, *P. marinus* may persist for years at low salinity although it is not pathogenic.

Because of the detrimental effect of these diseases on the Virginia oyster industry, the Virginia Institute of Marine Science has been monitoring the prevalence of both parasites since 1960. Information on disease severity and distribution each year is provided to management agencies and the oyster industry through publications and special advisories of the Marine Advisory Service office. The results of disease monitoring for the calendar year 1995 are presented in this report.

Shore. Since 1987 a more intensive survey has been conducted in the James River, samples are collected monthly at Wreck Shoal, Horsehead Rock and Deep Water Shoal and periodically at Point of Shoal.

Private Oyster Grounds. Private oyster planters submit samples for disease diagnosis and the results are used to make planting and harvesting decisions. In this report these samples are identified by location only and cannot be separated from native oyster samples.

Diagnostic Techniques.

Prevalence of *H. nelsoni* was determined by histological analysis of paraffin–embedded tissue sectioned at 6 µm and stained with hematoxylin and eosin; prevalence of *P. marinus* was determined by thioglycollate culture of mantle, gill and rectal tissue.

Monthly mortality in tray samples was determined by dividing the number of dead oysters by the number of live and dead oysters in the tray. This result was divided by the period in days since the last count to yield percent dead per day. This value was then multiplied by 30 to yield monthly mortality. Cumulative mortality in each tray was calculated using a complex formula that accounts for live oysters removed for disease diagnosis.

Environmental Parameters.

Water temperature for the determination of long-term averages and yearly anomalies is obtained from a continuous monitor at the VIMS pier in the lower York River. Water temperatures were also recorded at the various collection sites on each sample date. Salinity data for the James River is obtained from a variety of sources. The State Water Control Board takes biweekly samples at Wreck Shoal and at Deep Water Shoal from May through October and monthly samples from November through April. The VIMS shellstring survey obtains weekly data at these locations from May through October and the VIMS oyster disease monitoring program obtains monthly samples throughout the year. Riverflow data for the James River and for the entire Chesapeake Bay are obtained from the U. S. Geological Survey.

RESULTS

Temperature and streamflow/salinity.

During the winter, spring and summer months of 1995 water temperatures were generally above the long term average (Figure 1 and 2). In January average weekly water temperature was 2-4°C above average continuing a trend that began in November 1994. Temperatures slightly below average were recorded for three consecutive weeks in February. Weekly once again found at Ross Rock, the uppermost bed sampled. Heavy and moderate infections were numerous in oysters sampled from Long Rock, Morattico Bar, Smokey Point, and Parrot Rock and it is likely that some oyster mortality occurred.

In the James River, *P. marinus* disease pressure was relatively high (Table 1). Summer and fall prevalences and intensities of *P. marinus* exceeded levels recorded during 1992-1994, but remained lower than the record high levels recorded in 1991 (Figure 4, 5, and 6). At Deepwater Shoal a typical decline in detectable infections was observed during the winter and spring and an annual minimum in prevalence was recorded in July (0%) (Figure 4 and 7). Prevalence gradually increased during August through November to an annual high of 64%. Summer salinities of greater than 10 ppt were favorable for development of infections and a low percentage of advanced infections (moderate or heavy intensity) was observed from September to December (Table 1). Heavy and moderate infections are normally absent at Deepwater Shoal.

At Horsehead Rock, *P. marinus* prevalence declined from 40% in January to 4% in March (Table 1, Figure 5 and 7). *Perkinsus marinus* was observed at low prevalences (4-16%) throughout the spring. Typically prevalence decreases to 0% in the spring. An annual minimum prevalence of 0% was observed in July following a decrease in salinity from 9 ppt to 4 ppt (Figure 5). Prevalence sharply increased from 0% in July to 96% in August (Figure 7). This is the highest prevalence and intensity ever recorded for August at Horsehead Rock. Prevalence peaked at 100% in October. Advanced infections were observed in 12-24% of the oysters sampled in August to November (Table 1). Prevalence and infection intensity declined to more typical levels in December.

Record high summer and fall prevalences and intensities were observed at Point of Shoals (Table 1). Following a typical decline in prevalence from 60% in January to an annual minimum of 4% in April, prevalence gradually increased to 32% in June. As salinity decreased prevalence decreased to 16% in July (Table 1). Despite this depression in *P. marinus* activity, prevalence sharply increased to 96% in August. High prevalences (>88%) were maintained from September to December. Moderate and heavy intensity infections were found from August through December, and were particularly numerous (32-44% of sampled oysters) during August through October (Table 1).

At Wreck Shoal *P. marinus* overwintered at high prevalence (Table 1, Figure 6 and 7). Prevalence of the parasite was 76% in January, February and March. Prevalence decreased in April and May to an annual minimum of 24% (Figure 7). Relatively high salinities and warm temperatures resulted in an unusually high increase in prevalence (88%) during June. Depressed salinities in late June and early July resulted in a slight decrease in prevalence and intensity in July, but by August a clear progression in infection intensity was evident and

VIMS Tray Samples

Two trays of Ross Rock, Rappahannock River oysters were established at the VIMS, Gloucester Point, York River site on 1 May 1995. Analyses of a sample of the Ross Rock oysters prior to transplantation indicated that *P. marinus* prevalence was 4% and that the oysters were free of detectable *H. nelsoni* infections. The number of live and dead oysters in each tray was assessed on approximately the first day of each month from June to December and the resulting determinations of percent monthly and percent cumulative mortalities are shown in Table 3. Fewer than 6% of the oysters died between May and the beginning of July, but cumulative mortality increased to 38% by 1 August and was 77% by early October (Table 3). The rate of monthly mortality decreased from the July peak in subsequent months and cumulative mortality totaled 87% on the first of December. Samples for disease diagnoses were also taken at the beginning of each month. *Haplosporidium nelsoni* was not detected in oysters sampled on 1 June but by 3 July 60% of the oysters were infected, 20% of which had advanced infections. Prevalence of *H. nelsoni* decreased to 32% in August but then steadily increased to a maximum of 74% in December. Moderate and heavy infections were continually present from August to December. *Haplosporidium nelsoni* prevalence and oyster mortality in 1995 were slightly lower than in 1994 but remained at high levels. Maximum prevalences of MSX in VIMS tray oysters over a 35 year period are shown in Figure 8.

Perkinsus marinus infections did not appear until early August. In 1995, *P. marinus* acquisition occurred later and prevalences and intensities were lower than in previous years. Prevalence of *P. marinus* increased from 9% on 1 August to 80% on 1 September. Prevalence continued to be high (76-100%) in subsequent samples and advanced infections of *P. marinus* were numerous (28-36%) in oysters sampled in October and November.

Mortality occurring prior to 1 August, and possibly prior to 1 September, may be attributed to MSX. Later mortality was probably caused by a combination of both parasites.

DISCUSSION

***Perkinsus marinus* (Dermo).** *Perkinsus marinus* continues to be present on all oyster beds in Virginia. Prevalences and intensities in 1995 were relatively high compared to previous years. In some areas record high levels were observed. The parasite persisted through the winter of 1994-1995 at high prevalences at Wreck Shoal and probably in most moderate-high salinity areas inhabited by oysters. The predominantly dry and relatively warm conditions in the fall of 1994 and winter/spring of 1995 presented favorable conditions for the parasite. As a consequence of numerous overwintering infections and relatively low streamflows, summer and fall *P. marinus* abundances were at record or near record high levels

Shoal and in the downriver populated beds of Virginia's other major western shore tributaries. The pathogen was also observed at a relatively high prevalence and intensity in Pocomoke Sound at Byrd Rock. While fall prevalences remained below 30% in most areas, infections of moderate and heavy intensity were observed and suggest that the parasite may have caused mortality in the lower tributary regions. In the James River at Wreck Shoal the high abundances of *H. nelsoni* that were observed in the fall of 1994 persisted through May 1995. In most years normal spring runoffs cause an expulsion of *H. nelsoni* by May; however, in 1995 steamflows were well below normal during February to May and the high salinities combined with above average temperatures created favorable conditions for the parasite to persist and intensify. *Haplosporidium nelsoni* prevalence and intensity at Wreck Shoal in May were of record high proportions. It is probable that significant oyster mortalities occurred at Wreck Shoal in late May and early June. Atypically high James River runoffs in June and July resulted in a dramatic decline in *H. nelsoni* prevalence at Wreck Shoal. This decline highlights the profound effect that salinity has on *H. nelsoni*, clearly demonstrating that the parasite can not survive short term exposures to salinities less than 10 ppt. Generally, *H. nelsoni* is eliminated in spring and then reappears in the late summer and fall. In 1995 reinfection was delayed—the parasite was not detected in Wreck Shoal oysters sampled from July to November and only 8% were infected in December. This delay in reinfection should result in much lower prevalences in this area in 1996.

Susceptible oysters that were transplanted to VIMS in May also acquired *H. nelsoni* infections at a relatively high prevalence. Maximum prevalence at the York River site in 1995 was lower than the 1994 peak but the epizootic was still severe. Infections were detected in the tray oysters relatively early in the summer. A prevalence of 60% was observed in early July and by the first of August nearly 40% of the oysters had died from the disease. Prevalence declined to 32% in August and then steadily increased in subsequent months. Prevalence was 74% in December. It was unusual for the prevalence of MSX in the tray transplanted oysters to progressively increase during October through December. Generally, prevalence of spring import oysters peaks in mid summer and declines during the fall. The progressive increase in prevalence during the fall of 1995 probably reflects an abnormally long period of parasite transmission. The factors controlling MSX transmission are largely unknown.

ACKNOWLEDGMENTS

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Table 1. Monthly survey of prevalence and intensity of *Haplosporidium nelsoni* (MSX) and *Perkinsus marinus* in oysters from James River harvesting areas in 1995. See accompanying figure for station locations. NA=not analyzed for MSX. NS=not sampled.

Location	Date	Temp. (°C)	Sal. (ppt)	MSX Infect./exam. -%infected	H–M–L*	*Perkinsus* Infect./exam. -%infected	H–M–L*
Deep Water Shoal	17 Jan	7.0	7.0	NA		1/25 (4%)	0-0-1
	14 Feb	3.0	7.0	NA		0/25 (0%)	
	15 Mar	11.5	4.5	NA		1/25 (4%)	0-0-1
	18 Apr	17	7.5	NA		1/25 (4%)	0-0-1
	16 May	21.5	5.0	NA		2/25 (8%)	0-0-2
	15 Jun	24	6.0	NA		0/25 (0%)	0-0-0
	12 Jul	29.4	1.0	NA		0/25 (0%)	0-0-0
	23 Aug	28	10.0	NA		2/20 (10%)	0-0-2
	13 Sep	26	10.0	NA		5/25 (20%)	1-0-4
	12 Oct	22.6	11.0	NA		15/25 (60%)	0-1-14
	17 Nov	10.2	2.5	NA		16/25 (64%)	1-1-14
	13 Dec	NS	NS	NA		13/25 (52%)	0-1-12
Horsehead Rock	17 Jan	9.0	9.0	0/25 (0%)		10/25 (40%)	0-0-10
	14 Feb	3.0	9.5	0/25 (0%)		2/25 (8%)	0-0-2
	15 Mar	11.0	6.5	1/25 (4%)	0-0-1	1/25 (4%)	0-0-1
	18 Apr	16.9	9.5	0/25 (0%)		4/25 (16%)	0-0-4
	16 May	21.5	6.5	0/25 (0%)		1/25 (4%)	0-0-1
	15 Jun	24.0	9.5	0/25 (0%)		1/25 (4%)	0-0-1
	12 Jul	29.0	3.5	0/25 (0%)		0/25 (0%)	0-0-0
	23 Aug	28.0	14.0	0/25 (0%)		24/25 (96%)	3-0-21
	13 Sep	25.9	12.0	0/25 (0%)		23/25 (92%)	3-3-17
	12 Oct	22.1	10.0	0/25 (0%)		25/25 (100%)	2-1-22
	17 Nov	10.5	8.0			17/25 (68%)	1-2-14
	13 Dec	NS	NS			14/25 (56%)	1-0-13
Point of Shoals	17 Jan	9.0	10.5	NA		15/25 (60%)	3-0-12
	14 Feb	3.0	10.0	NA		3/25 (12%)	0-0-3
	15 Mar	12.0	6.5	NA		8/25 (32%)	0-0-8
	18 Apr	17.0	10.5	NA		1/25 (4%)	0-0-1
	16 May	21.0	6.5	NA		4/25 (16%)	0-0-4
	15 Jun	23.9	10.0	0/25		8/25 (32%)	0-0-8
	12 Jul	28.9	3.8	NA		4/25 (16%)	0-0-4
	23 Aug	28.0	14.5	NA		24/25 (96%)	2-9-13
	13 Sep	25.9	12.0	NA		24/25 (96%)	5-3-16
	12 Oct	22.2	12.0	NA		25/25 (100%)	4-7-14
	17 Nov	10.0	6.0	NA		22/25 (88%)	2-4-16
	13 Dec	NS	NS	NA		23/25 (92%)	2-2-19
Wreck Shoal	17 Jan	9.0	18.0	13/24 (54%)	2-2-9	19/25 (76%)	1-1-17
	14 Feb	3.0	15.0	12/25 (48%)	4-1-7	19/25 (76%)	1-2-16
	15 Mar	11.0	12.5	13/25 (52%)	5-2-6	19/25 (76%)	3-0-16
	18 Apr	16.0	16.0	17/25 (68%)	1-0-16	11/25 (44%)	0-1-10
	16 May	21.0	13.0	20/24 (80%)	7-3-10	6/25 (24%)	0-0-6
	15 Jun	23.9	13.0	4/25 (16%)	0-0-4	22/25 (88%)	1-6-15
	12 Jul	28.2	10.0	0/25 (0%)		20/25 (80%)	2-2-16
	23 Aug	28.0	18.0	0/25 (0%)		21/25 (84%)	6-4-11
	13 Sep	25.5	18.0	0/25 (0%)		25/25 (100%)	9-4-12
	12 Oct	22.6	19.0	0/25 (0%)		25/25 (100%)	0-3-22
	17 Nov	11.0	14.5	0/25 (0%)		24/25 (96%)	2-5-17
	13 Dec	NS	NS	2/25 (8%)	0-0-2	22/25 (88%)	6-4-12

*H=number of heavy infections, M=moderate infections, L=light infections.

Table 3. Mean mortality and disease prevalence in upper Rappahannock River seed oysters transplanted to trays at the lower York River, Gloucester Point, VA in May, 1995.

Date-1995	Monthly mortality–%	Cumulative mortality-%	*H. nelsoni* prevalence	Intensity H-M-L*	*P. marinus* prevalence	Intensity H–M–L*
1 May	0.0	0.0	0/25 (0%)		1/25 (4%)	0-0-1
1 Jun	1.9	1.9	0/25 (0%)		0/25 (0%)	
3 Jul	3.4	5.6	15/25 (60%)	3-2-10	0/25 (0%)	
1 Aug	34.6	37.9	7/22 (32%)	3-1-3	2/22 (9%)	0-0-2
1 Sep	22.5	60.4	11/25 (44%)	2-3-6	20/25 (80%)	3-0-17
2 Oct	15.7	76.6	13/25 (52%)	7-4-2	19/25 (76%)	5-2-12
3 Nov	8.5	85.4	13/23 (57%)	3-2-8	23/23 (100%)	5-4-14
1 Dec	1.2	86.6	17/23 (74%)	6-5-6	21/23 (91%)	2-2-17

*H = number of heavy infections, M = moderate infections, L = light infections.

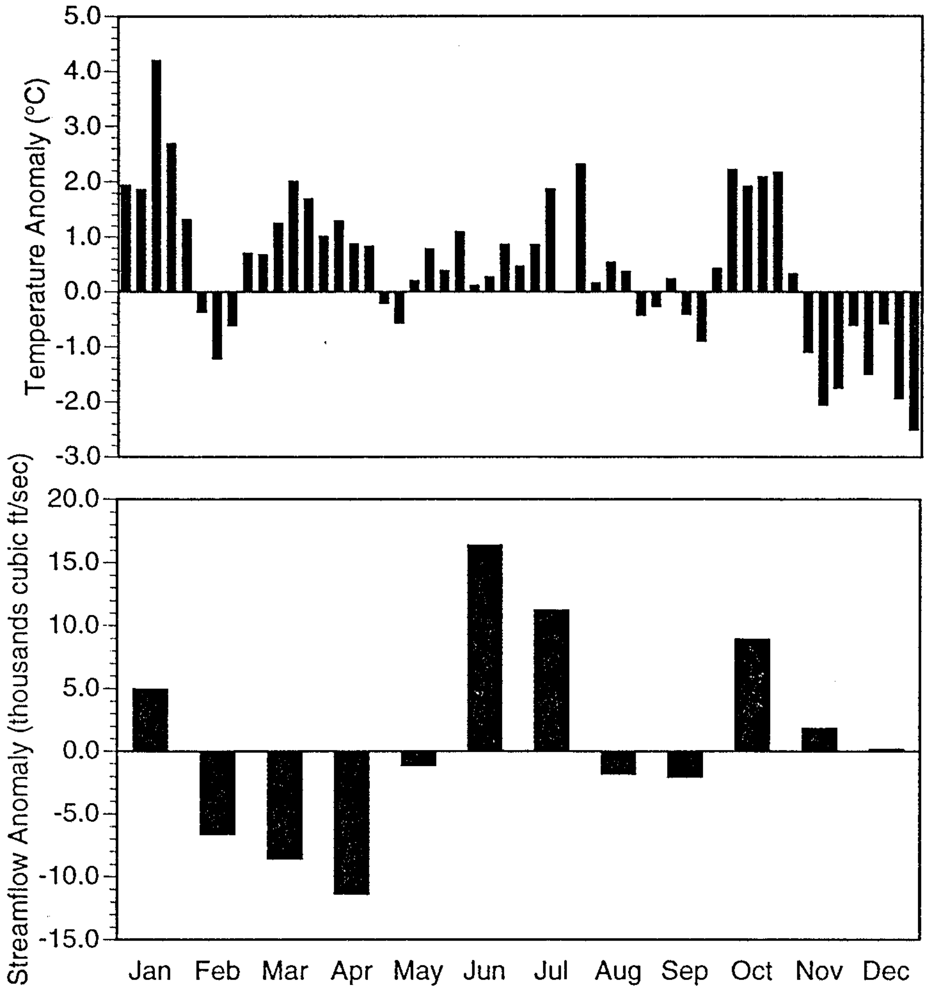


Figure 2. Weekly water temperature anomaly at the VIMS pier, Gloucester Point, VA based on average discharge from 1947-1994 (top) and monthly James River streamflow anomaly based on average discharge from 1951-1994 (bottom) for the calendar year 1995. Anomalies were calculated by subtracting the long term average from the value observed in 1995.

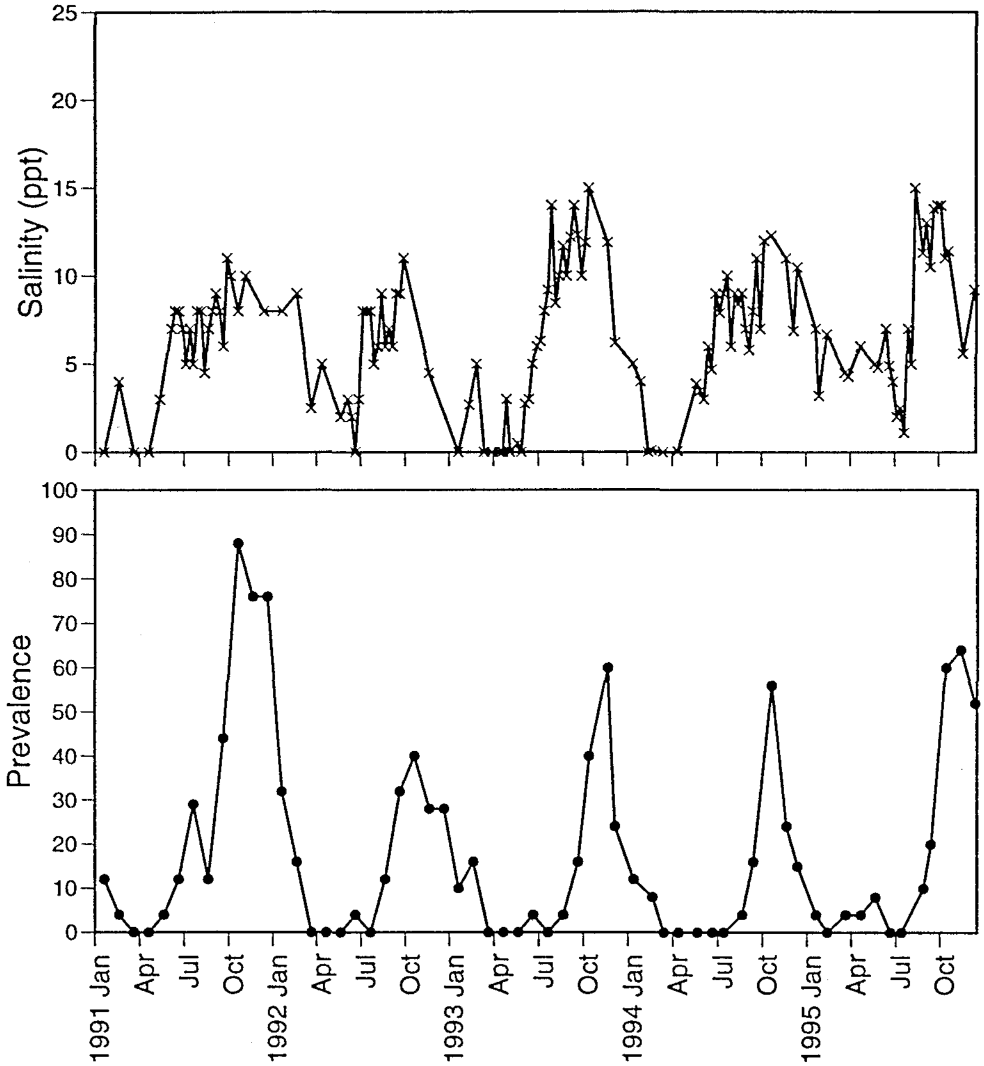


Figure 4. Salinity (top) and *P. marinus* prevalence (bottom) at Deepwater Shoal, James River, VA for the years 1991-1995.

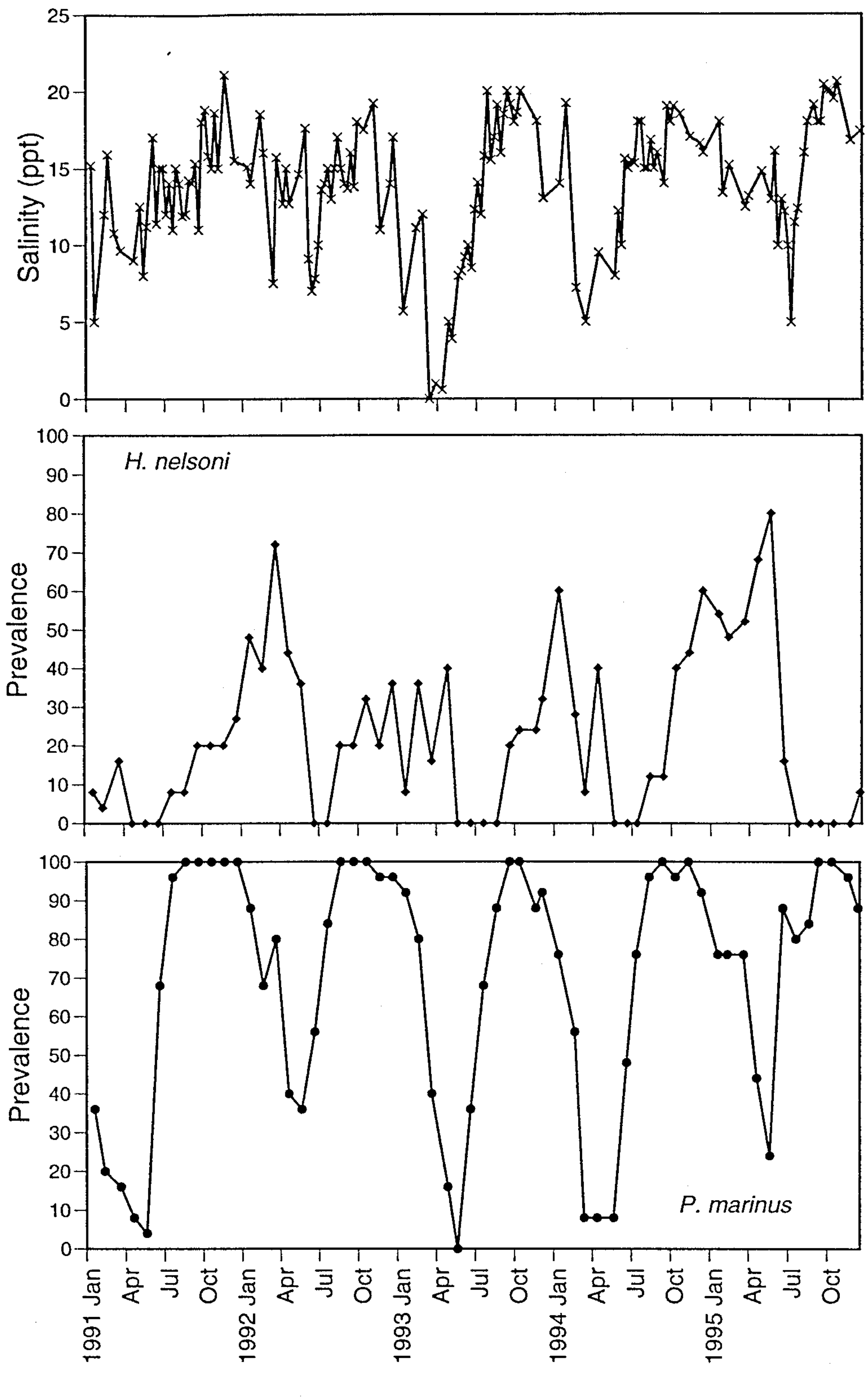


Figure 6. Salinity (top) and prevalence of *P. marinus* (bottom) and *H. nelsoni* (middle) at Wreck Shoal, James River, VA for the years 1991-1995.

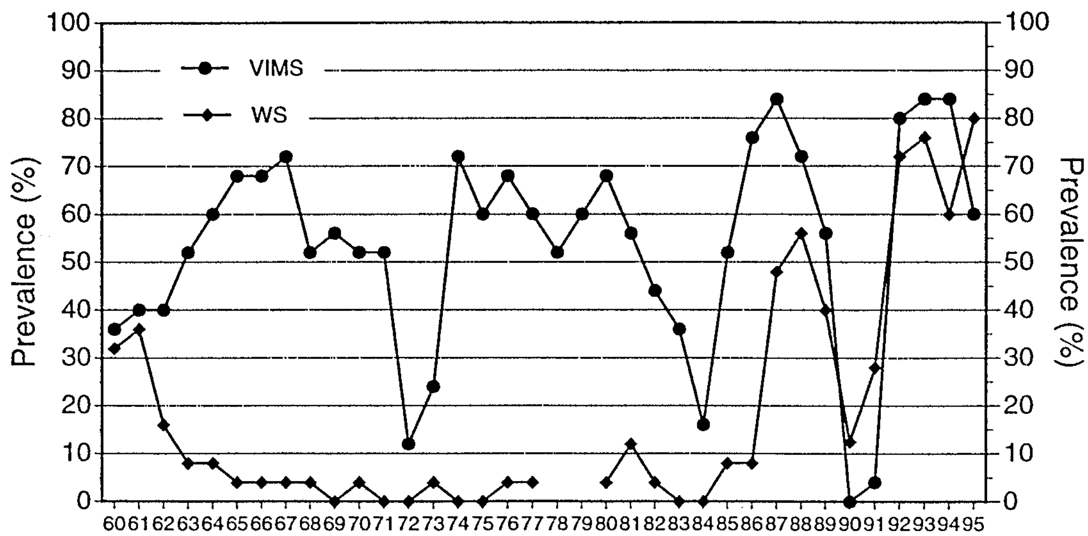
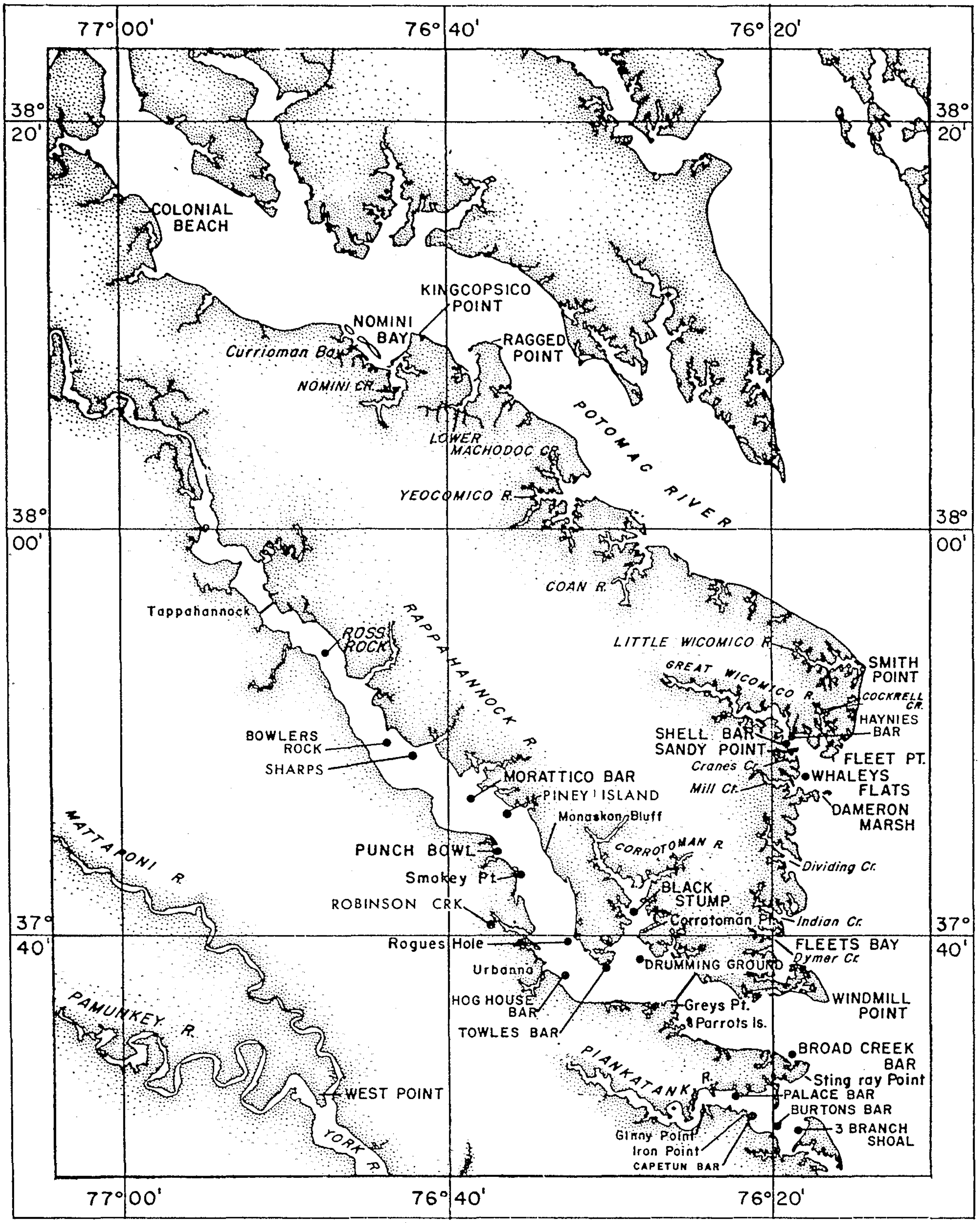


Figure 8. Maximum annual prevalence of *Haplosporidium nelsoni* (MSX) in imported monitoring tray oysters at VIMS and in native oysters at Wreck Shoal (WS), James River, 1960–95.



Names of oyster rocks, geographical points, towns and bodies of water in Rappahannock and Potomac rivers.