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# Status of the Major Oyster Diseases in Virginia 1997 A Summary of the Annual Monitoring Program

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## EXECUTIVE SUMMARY

**Environmental factors.** The winter of 1997 was unusually warm and water temperature was consistently above the long-term average. Average weekly water temperatures remained above 5°C for all but a two week period. Typically, based on long-term averages, water temperatures remain below 5°C for an eight week period. The warm winter was followed by a relatively cold spring and water temperatures remained below 20°C until mid-June, approximately three weeks later than usual. The summer was relatively hot and water temperatures remained above 25°C for 13 weeks. Typically, average weekly water temperatures above 25°C are recorded for 10 weeks. Temperatures during October through December were generally at or above average. Above average streamflows were recorded for the James River during January through March; however, overall, 1997 was a relatively dry year and streamflows were well below normal during the months of April, May, August through October, and December. Increases in salinity caused by the reduced streamflows presented favorable conditions for oyster disease intensification during the late summer and fall.

***Haplosporidium nelsoni* (MSX).** *Haplosporidium nelsoni* was not observed in the James River seed area during the winter and spring of 1997. At Wreck Shoal, this was the first time in 10 years that the average prevalence of *H. nelsoni* during the winter and spring was 0%. In July, the parasite was detected at Wreck Shoal at a prevalence of 4%. Prevalence ranged from 28-44% during the remainder of the year. Although higher fall maximum prevalences have been recorded, the average prevalence at Wreck Shoal for August through December 1997 was the highest ever recorded for this location. The parasite was not detected at Horsehead Rock in 1997.

In the fall, low prevalences of *H. nelsoni* were observed in the Piankatank River at Burton's Point (4%) and Palace Bar (16%). In the lower Rappahannock River the parasite was present at higher prevalences than have been observed in the past, but prevalences were still fairly low—prevalences at Parrot Rock, Broad Creek, and Drummond Ground were respectively 28, 16 and 24%. *Haplosporidium nelsoni* was also present at very low prevalences in the Corrotoman River at Middle Ground (4%) and in the Great Wicomico River at Fleeton Point (8%). On the bayside of the Eastern Shore, *H. nelsoni* was present at Parker Rock (28%) in Pocomoke Sound and at California Rock in Tangier Sound (12%). On the seaside of the Eastern Shore *H. nelsoni* was present at 9-42% prevalence at Fisherman's

Island. In the York River, transplanted susceptible oysters acquired high prevalences (>70%) of *H. nelsoni*, once again, for the sixth consecutive year.

***Perkinsus marinus* (Dermo).** Our fall survey of Virginia oyster bars indicated that *P. marinus* was present at nearly all western shore oyster bars surveyed. The unusually cold winter and high streamflows of 1996 were associated with a significant decline in *P. marinus* activity in the fall and winter of 1996. The low 1996 *P. marinus* levels resulted in reduced overwintering prevalences and intensities in 1997 and a relatively late and slow increase in parasite activity during the summer months. Fall prevalences and intensities of the parasite in areas located in the Great Wicomico River, Piankatank River, Pocomoke Sound and on the seaside of the Eastern Shore were lower or comparable to previous years. In the Rappahannock River prevalences increased in some areas and decreased in others. The parasite was not detected at Ross Rock which is located in the upper Rappahannock River.

In the upper James River, *P. marinus* prevalences and intensities were very low (0-20%) during the winter and spring and slow to increase during the summer months. At Deepwater Shoal disease pressure during the summer was not as low as in 1996 but was still significantly reduced compared to 1991-1995. The maximum prevalence observed at Deepwater Shoal in 1997 was 36%. Prevalences were much higher at seed areas located down river of Deepwater Shoal. Late summer/fall prevalences ranged from 76-100% at Horsehead Rock, 68-100% at Point of Shoals, and 52-100% at Wreck Shoal. Heavy and moderate infections were abundant at all three areas. The average prevalence at Horsehead Rock for the period of August through November was the highest recorded since 1991.

# 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 occurring 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 1997 are presented in this report.

## METHODS

### Sampling.

The oyster disease monitoring program consists of three different sample types—tray samples, native oyster samples and samples provided from private oyster grounds.

**Tray Samples.** In late April each year, oysters are dredged from Ross Rock in the upper Rappahannock River, and placed in 2-foot by 4-foot legged trays in the York River at Gloucester Point. Oysters from the upper Rappahannock River are known to be highly susceptible to *H. nelsoni* and thus they serve as excellent indicators of annual abundance of this parasite when placed in an endemic area such as the lower York River just prior to the normal infection period for *H. nelsoni* that begins in May and continues through July. Historically, *P. marinus* has never invaded the trays during the first year of monitoring so the trays were a good measure of mortality resulting from MSX alone. However, because of the dramatic increase in *P. marinus* abundance since 1987, oysters in the monitoring trays have become infected with this pathogen in recent years. The presence of both *H. nelsoni* and *P. marinus* in the trays has made interpretation of the cause of mortality difficult. In addition, because of its widespread distribution, oysters from the upper Rappahannock River may now be infected with *P. marinus* when they are collected. Nonetheless, these oysters can still be used to monitor *H. nelsoni*, which normally does not occur in the upper reaches of the rivers.

Prior to establishing trays, a sample of 25 oysters is analyzed for *H. nelsoni* and *P. marinus* to determine the level of existing infections at the dredge site. No *H. nelsoni* infections have ever been encountered at these sites during April, but in recent years *P. marinus* has been present at low prevalence (<10%). At least 300 oysters are placed in each of the two York River trays on 1 May each year. Trays are cleaned every week and counts are periodically made of live and dead oysters in each tray. Samples of 25 oysters are removed on about 1 July, 1 August, 1 September, and 1 October for disease determination; final counts are made about 1 December and trays are removed from the river at that time. New trays are established each May to provide a record of disease prevalence and intensity for each year. Because oysters from the same source have been held at the same location each year since 1960 we have a long-term data base on *H. nelsoni* abundance and it is possible to compare years and to relate disease abundance and distribution to various environmental parameters.

**Native Oyster Samples.** In order to determine the annual distribution and severity of both *H. nelsoni* and *P. marinus;* samples of native oysters are collected periodically from most major public harvesting areas in Virginia. Samples of 25 oysters are collected in the fall, approximately 1 October, from many sites in Mobjack Bay, the Rappahannock River, the Great Wicomico River and from other tributaries of the western shore and the seaside of the Eastern

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.

The winter of 1996-1997 was extremely warm and weekly average water temperatures exceeded the long-term average by 1-3°C (Figure 1 and 2). During January and February average weekly water temperatures remained above 5°C for all but a two week period (Figure 1). Normally average weekly water temperatures are below 5°C for a period of 8 weeks.

Above average temperatures prevailed through March and early April (Figure 1); however, this relatively warm period was followed by below average temperatures in mid to late spring. Water temperatures remained below 20°C until mid-June, approximately three weeks later than would be predicted based on the long-term average. During late June water temperatures rapidly warmed to greater than 25°C and remained at this high level until the end of September, a period of 13 weeks. Typically temperatures exceeding 25°C are recorded for only 10 weeks. Temperatures in October through December were at or above average with the exception of a three week cool spell in November during which temperatures below the long-term average were recorded. A comparison of 1987-1997 temperature anomalies (deviations from long-term average temperatures) is shown in Figure 3.

James River streamflows were slightly above average during the months of January through March (Figure 1 and 2). The high flows for these three months continued a trend of above average streamflows which began in September 1996 following Hurricane Fran. A comparison of 1992-1996 streamflow anomalies (deviations from long-term average streamflows) is shown in Figure 3. April and May of 1997 were unusually dry resulting in streamflows that were well below the long-term averages (Figures 1and 2). Heavy rains in June altered this pattern and above average streamflows were recorded. In July more normal streamflows were observed. The months August through October were dry and below average streamflows were observed. Heavy rains in November changed this pattern, but below average streamflows were once again recorded in December.

***Perkinsus marinus* (Dermo).** In the summer and fall of 1996, baywide prevalences of *P. marinus* were reduced in comparison to previous years due to extreme cold temperatures and high streamflows that occurred throughout the year. The depressed 1996 *P. marinus* levels and continuation of relatively high streamflows which caused decreases in salinity during the winter of 1997 had a significant impact on the prevalence and intensity of the parasite in the winter, spring and early summer of 1997. Monthly *P. marinus* prevalences for James River stations and fall survey results for baywide stations are shown in Table 1 and Table 2, respectively.

In the James River prevalences and intensities of the parasite during the months of January through June were among the lowest recorded in the last 10 years. At Wreck Shoal, prevalences ranged from 0-16% during the winter and spring (Table 1, Figures 4 and 5). Compared to previous years, in 1997 *P. marinus* prevalence was slow to increase during the summer months (Figue 5). Prevalence at Wreck Shoal increased to 52% in July and remained the same in August. The warm and dry summer presented conditions conducive to the rapid multiplication of the parasite and infection intensities and prevalences increased to 96% in

September and remained between 96-100% through December (Figure 5). Salinity remained above 15 ppt during this period (Figure 5). Infection intensities in the Wreck Shoal oysters were also very high during this time. Thirty-six to forty percent of the sampled oysters exhibited moderate to heavy infections.

Winter and spring prevalences of *P. marinus* at Point of Shoals and Horsehead Rock were similar to those observed at Wreck Shoal (Table 1, Figure 4). Prevalences remained extremely low in June but increased in July to 24% and 44% at Horsehead Rock and Point of Shoals, respectively. The dry summer resulted in relatively high salinities (10-15.8 ppt) at both Horsehead Rock and Point of Shoals, which promoted high prevalences (68-100%) and intensities of *P. marinus* during the late summer and fall (Figures 6 and 7). Heavy and moderate infections were common at both areas during this time (Table 1). At Horsehead Rock, the 1997 average prevalence for the period August through November was the highest recorded at the site since 1991. At Point of Shoals *P. marinus* average prevalence for the same period ranked as the third most severe since 1987.

At Deepwater Shoals *P. marinus* was nearly eradicated in 1996 as a result of cold temperatures and high streamflows during the winter and summer. Overwintering infection prevalence declined to 4% in April 1996 and failed to increase appreciably in the summer and fall (Figure 8). As a result, extremely low prevalences of the parasite were observed in the winter and spring of 1997 (Figures 4 and 8). Prevalence at Deepwater Shoal remained below 8% through August 1997; however, as salinity increased to 10-12 ppt in September and October, prevalence gradually increased to an annual maximum of 36% in November 1997 (Figure 8). Although the maximum *P. marinus* prevalence at Deepwater Shoal in 1997 was higher than in 1996, it was still lower than the maximum prevalences recorded during the years 1990-1995, which ranged from 40-88%.

Overall, for the second consecutive year baywide fall prevalences of *P. marinus* were reduced compared to 1991-1995 levels. The parasite however, was present at all oyster bars sampled with the exception of Ross Rock, which is located in the upper Rappahannock River and Bells Rock, which is located in the upper York River (Table 2). *Perkinsus marinus* prevalence and infection intensity varied with location, generally decreasing with decreasing salinities as one moves up river. Salinities in the fall were relatively high and moderate and heavy infections were recorded at most sites. Prevalences of *P. marinus* in the Piankatank River were significantly reduced compared to previous years—areas typically having 90-100% prevalence had prevalences of only 36-68%. Prevalences at Ginny Point were 60-65% lower than prevalences recorded during the period 1989-1996 and only light infections were observed. In the Great Wicomico River, prevalences were slightly lower or about the same as in 1996 remaining lower than 1995 levels but not as low as those observed in 1993. Despite

the relatively high salinities (>17 ppt) evident at the time of collection, infection intensities at the Great Wicomico were generally light. In the Rappahannock River, Ross Rock once again returned to a "disease free", or nondetectable disease status. Seven additional Rappahannock River oyster bars, located down river of Ross Rock, were also sampled in the fall. The bars, which were located along a salinity gradient had salinities at the time of collection ranging from 14-18 ppt. *Perkinsus marinus* prevalences ranged from 22-96%. In comparison to 1996 prevalences, three of the bars (Bowlers Rock, Drummund Ground, and Parrot Rock) exhibited an increase in prevalence and the remaining four bars (Long Rock, Morratico Bar, Smokey Point, and Broad Creek) exhibited a decrease in prevalence. Infection intensities were higher than normal at both Bowlers Rock and Parrot Rock. Variability in prevalence among the bars was atypical in that a consistent progressive increase with the progressive down river increase in salinity was not observed. For instance, the prevalence at Broad Creek located at the mouth of the river was equivalent to that at Bowlers Rock which is located in the upper river. In the spring of 1997, large numbers of James River oysters were transplanted into areas of the upper Rappahannock River as part of the Virginia Marine Resources Commission oyster repletion program. The observed atypical disease patterns were likely related to these oyster transplantation.

Prevalences exceeding 90% were also found in adult oysters from the bayside and seaside on the Eastern Shore (Table 2). Prevalences of *P. marinus* in replicate samples of adult oysters from Fisherman's Island were 82 and 93%. Infection levels were particularly high at Tangier Sound (96%) and Pocomoke Sound at Hurley Rock (100%). Much lower infection prevalences were observed in Pocomoke Sound at Parker Rock (28%) and in yearling oysters from Fisherman's Island (40-47%).

***Haplosporidium nelsoni* (MSX).** *Haplosporidium nelsoni* was not observed in the James River seed area during the winter and spring of 1997 (Table 1, Figure 4). At Wreck Shoal, this was the first time in 10 years that the average prevalence of *H. nelsoni* during the winter and spring was 0%. In July, the parasite was detected at a prevalence of 4%. Prevalence increased to 44% in August, peaked at 48% in September, and then gradually declined to 28% in December. Although higher fall maximum prevalences have been recorded, the average prevalence for August through December 1997 is the highest ever recorded for this location (Figure 5). The same can be said for infection intensity. At Horsehead Rock the parasite remained absent or undetectable throughout 1997 (Table 1, Figures 4 and 7).

*Haplosporidium nelsoni* was also observed at relatively low prevalences (<50%) in oysters sampled in the fall from public oyster beds in other Virginia tributaries (Table 2). Low prevalences of *H. nelsoni* were observed in the Piankatank River at Burton's Point (4%) and

Palace Bar (16%). In the lower Rappahannock River the parasite was present at higher prevalences than have been observed in the past, but prevalences were still fairly low. Prevalences at Parrot Rock, Broad Creek, and Drummond Ground were respectively 28, 16 and 24%. *Haplosporidium nelsoni* was also present at very low prevalences in the Corrotoman River at Middle Ground (4%) and in the Great Wicomico River at Fleeton Point (8%). On the bayside of the Eastern Shore, *Haplosporidium nelsoni* was present at Parker Rock (28%) in Pocomoke Sound and at California Rock in Tangier Sound (12%). On the seaside *H. nelsoni* was present at Fisherman's Island (9-42%) (Table 2).

### VIMS Tray Samples

Two trays of Ross Rock, Rappahannock River oysters were established at the VIMS, Gloucester Point, York River site on 7 May 1997. Analyses of a sample of the Ross Rock oysters prior to transplantation indicated that *P. marinus* prevalence was 0% and that the oysters were also free of detectable *H. nelsoni* infections. The number of live and dead oysters in each tray was assessed monthly from June to October and the resulting determinations of percent monthly and percent cumulative mortalities are shown in Table 3. Cumulative mortality was 61% by mid August and was 96% in late October (Table 3). Samples for disease diagnoses were also taken monthly. *Haplosporidium nelsoni* was not detected in oysters sampled on 17 June. Only 8% prevalence was found in the 11 July sample, but by 12 August prevalence increased to 82%. Prevalence remained between 77-83% through October. In August and September 55-60% of the infected oysters had heavy infections (Table 3). The acquisition of *H. nelsoni* was somewhat later than typically occurs but the maximum prevalence attained was among the highest on record (Figure 9).

*Perkinsus marinus* infections first appeared in June (9.5%) but were not detected in July or August (Table 3). In September *P. marinus* prevalence was only 18% and in October prevalence was still only 50%. The acquisition and proliferation of the disease was atypically late and low compared to other years. Given the fact that the onset of *P. marinus* infections was very late and prevalences of the parasite were relatively low it is very likely that most of the mortality observed between July and October was associated with *H. nelsoni.*

## DISCUSSION

***Perkinsus marinus* (Dermo).** *Perkinsus marinus* continues to be present on nearly all oyster beds in Virginia. Overall, prevalences of the parasite were lower than in previous years but there were still some areas that had record high prevalences.

The typical annual cycle of *P. marinus* activity exhibits a pattern in which prevalence and intensity decline during the winter and early spring to an annual minimum in April or May. Prevalence and intensity once again increase in the summer and maximum prevalences are observed in September or October. This cyclic pattern is primarily driven by seasonal temperature changes, but it is also greatly influenced by salinity. Generally, prevalence and intensity rise more rapidly and to a greater degree in high salinity (>15 ppt) areas than in areas with lower salinity. Conversely, prevalence and intensity regress faster and more extensively in low salinity areas than in high salinity areas. In the James River seed area *P. marinus* prevalences and intensities were extremely low during the winter and spring of 1997. This is largely due to the environmental conditions that prevailed in 1996.

In 1996, unusually cold winter temperatures and high streamflows resulting from severe winter storms caused infections to decline to relatively low levels during the spring. The scarcity of overwintering infections combined with relatively wet summer conditions resulted in the lowest prevalences of *P. marinus* at Deepwater Shoal and Horsehead Rock in nearly a decade. Hurricane Fran, which struck the region on 5 September 1996, caused a sharp decline in salinity which greatly depressed *P. marinus* activity and retarded *P. marinus* infection progression in oysters in most upper tributary areas. Prevalences and intensities of *P. marinus* in more down river locations were also reduced relative to previous years; however, the impact of Hurricane Fran was less dramatic in these areas. Although the winter of 1996-1997 was atypically warm, above average streamflows in early 1997 and the reduction of *P. marinus* disease in 1996 resulted in an unusually low proportion of overwintering *P. marinus* infections. The average prevalence of the parasite in the upper James River at Wreck Shoal during the winter and spring of 1997 was the lowest observed since the parasite invaded the seed areas in the late 1980s. Very low winter and spring prevalences were also observed at the up river seed areas—Point of Shoals, Horsehead Rock, and Deepwater Shoal.

Unfortunately, the low prevalences did not persist through the dry summer months of 1997. Although *P. marinus* prevalences were slow to increase in early summer, prevalences increased to 100% at Wreck Shoal, Point of Shoal, and Horsehead Rock. At Horsehead Rock, the 1997 average prevalence for the period August through November was a record high. The maximum prevalence observed at Deepwater Shoal was 36%. This level increased from the maximum observed in 1996 but remained lower than maximums observed in 1990-1995. While the decline of *P. marinus* prevalence in the upper most seed areas in 1996 was very encouraging, the reintensification observed in 1997 once again indicates that eradication of the disease from this area will be very difficult.

Overall *P. marinus* prevalences in the other major Virginia tributaries were lower or about the same as in 1996; however, there were areas where *P. marinus* prevalences increased in

comparison to previous years. Prevalences in the Piankatank and Great Wicomico Rivers were lower than in 1996 while in the Rappahannock River prevalences increased at some bars and decreased at others. The persistence of relatively low prevalences in many areas is surprising considering that baywide salinities were relatively high during the summer and fall of 1997 presenting favorable conditions for the parasite.

***Haplosporidium nelsoni* (MSX).** Since 1993, *H. nelsoni* has persisted at record high prevalences and intensities in the James River at Wreck Shoal, in the down river populated beds of Virginia's other major western shore tributaries, and in the sounds of Virginia's Eastern Shore. In 1997, *H. nelsoni* was once again observed in these areas. The annual periodicity of *H. nelsoni* prevalence in the James River at Wreck Shoal was somewhat unusual in 1997 in that the parasite was not detected in the area at all during the winter and spring. Generally, *H. nelsoni* infections which were acquired the previous summer or fall persist through the winter and then are subsequently eliminated in spring. Since the parasite is intolerant of salinities at or below 10 ppt, high streamflows which reduce salinity below 10 ppt usually result in parasite expulsion. At Wreck Shoal salinities at or below 10 ppt occurred in the fall and winter of 1996 and then again through June of 1997. This resulted in an early expulsion of the parasite from the area. Typically, the parasite reinvades the area during the summer and fall, once salinity increases to greater than about 10 ppt. This reinvasion was evident at Wreck Shoal in July 1997 and as very dry and warm conditions prevailed in late summer and early fall the disease intensified. Record high MSX levels occurred for the period of August-November, despite an absence of the parasite in the winter and spring. Heavy infection intensities occurring during this period were probably associated with oyster mortality.

Generally, in the other major tributaries fall prevalences and intensities of *H. nelsoni* were lower than at Wreck Shoal. In the Piankatank and Great Wicomico Rivers prevalences were <16%. Somewhat higher prevalences and intensities were found in the lower Rappahannock River; however, prevalences were still < 28%. Prevalences in Pocomoke and Tangier Sounds ranged from 0-18%, while prevalences at Fisherman's Island on the seaside of the Eastern Shore ranged from 9-42%

Susceptible oysters that were transplanted to VIMS in May 1997 also acquired *H. nelsoni* infections at a relatively high prevalence. The transplanted oysters exhibited one of the highest prevalences of *H. nelsoni* ever recorded at the site. Infections were detected in the tray oysters at a relatively low prevalence in July but prevalence increased to 82% in August. *Haplosporidium nelsoni* infections were severe and caused extensive mortality of the transplanted oysters. The MSX disease observed in native oyster populations and that

observed in the VIMS oyster transplant study indicate that MSX remains a serious threat to Virginia's oyster resource.

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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 1997. 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 | 14 Jan | 4.5 | 0 | NA | | 1/25 (4%) | 0-0-1 |
| | 12 Feb | 6.6 | 0 | NA | | 2/25 (8%) | 0-0-2 |
| | 11 Mar | 12.5 | 0 | NA | | 0/25 (0%) | 0-0-0 |
| | 15 Apr | 17.5 | 2.0 | NA | | 1/25 (4%) | 0-0-1 |
| | 19 May | 19.6 | 6.0 | NA | | 0/25 (0%) | 0-0-0 |
| | 11 Jun | 22.3 | 3.0 | NA | | 0/25 (0%) | 0-0-0 |
| | 16 Jul | 30.4 | 6.0 | NA | | 0/25 (0%) | 0-0-0 |
| | 13 Aug | 29.5 | 7.0 | NA | | 1/25 (4%) | 0-0-1 |
| | 17 Sep | 26.0 | 10.0 | NA | | 4/25 (16%) | 0-0-4 |
| | 23 Oct | 16.2 | 12.0 | NA | | 8/25 (32%) | 1-0-7 |
| | 18 Nov | 11.5 | 6.0 | NA | | 9/25 (36%) | 0-0-9 |
| | 10 Dec | 7.5 | 10.0 | NA | | 5/25 (20%) | 0-0-5 |
| Horsehead Rock | 14 Jan | 5.0 | 1.0 | 0/25 (0%) | 0-0-0 | 5/25 (20%) | 0-1-4 |
| | 12 Feb | 6.2 | 0.5 | 0/25 (0%) | 0-0-0 | 0/25 (0%) | 0-0-0 |
| | 11 Mar | 12.0 | 0.0 | 0/25 (0%) | 0-0-0 | 4/25 (16%) | 0-0-4 |
| | 15 Apr | 15.0 | 3.0 | 0/25 (0%) | 0-0-0 | 5/25 (20%) | 0-0-5 |
| | 19 May | 19.4 | 8.0 | 0/25 (0%) | 0-0-0 | 0/25 (0%) | 0-0-0 |
| | 11 Jun | 21.7 | 4.0 | 0/25 (0%) | 0-0-0 | 2/25 (8%) | 0-0-2 |
| | 16 Jul | 29.9 | 9.0 | 0/25 (0%) | 0-0-0 | 6/25 (24%) | 0-0-6 |
| | 13 Aug | 28.0 | 10.0 | 0/25 (0%) | 0-0-0 | 19/25 (76%) | 0-2-17 |
| | 17 Sep | 27.0 | 14.0 | 0/24 (0%) | 0-0-0 | 23/24 (96%) | 2-6-15 |
| | 23 Oct | 14.0 | 15.8 | 0/25 (0%) | 0-0-0 | 23/25 (92%) | 3-3-17 |
| | 18 Nov | 11.0 | 10.0 | 0/25 (0%) | 0-0-0 | 25/25 (100%) | 1-1-23 |
| | 10 Dec | 8.0 | 13.0 | 0/25 (0%) | 0-0-0 | 23/25 (92%) | 2-0-21 |
| Point of Shoals | 14 Jan | 5.0 | 2.0 | NA | | 3/25 (12%) | 0-0-3 |
| | 12 Feb | 6.2 | 0.5 | NA | | 1/25 (4%) | 0-0-1 |
| | 11 Mar | 13.0 | 0.0 | NA | | 2/25 (8%) | 0-0-2 |
| | 15 Apr | 16.0 | 1.0 | NA | | 5/25 (20%) | 0-0-5 |
| | 19 May | 18.0 | 4.0 | NA | | 1/25 (4%) | 0-0-1 |
| | 11 Jun | 22.0 | 4.0 | NA | | 0/25 (0%) | 0-0-0 |
| | 16 Jul | 29.2 | 10.0 | NA | | 11/25 (44%) | 1-1-9 |
| | 13 Aug | 28.3 | 11.0 | NA | | 17/25 (68%) | 2-2-13 |
| | 17 Sep | 27.0 | 14.0 | NA | | 21/25 (84%) | 3-4-14 |
| | 23 Oct | 15.6 | 14.0 | NA | | 20/25 (80%) | 2-1-17 |
| | 18 Nov | 11.0 | 11.5 | NA | | 25/25 (100%) | 1-3-21 |
| | 10 Dec | 8.0 | 14.0 | NA | | 21/25 (84%) | 2-0-19 |
| Wreck Shoal | 14 Jan | 5.0 | 8.0 | 0/25 (0%) | 0-0-0 | 4/25 (16%) | 0-0-4 |
| | 12 Feb | 5.5 | 2.5 | 0/25 (0%) | 0-0-0 | 0/25 (0%) | 0-0-0 |
| | 11 Mar | 12.0 | 4.0 | 0/25 (0%) | 0-0-0 | 1/25 (4%) | 0-0-1 |
| | 15 Apr | 14.5 | 8.0 | 0/25 (0%) | 0-0-0 | 4/25 (16%) | 0-0-4 |
| | 19 May | 19.3 | 10.0 | 0/25 (0%) | 0-0-0 | 2/25 (8%) | 0-0-2 |
| | 11 Jun | 21.2 | 7.0 | 0/25 (0%) | 0-0-0 | 3/25 (12%) | 0-0-3 |
| | 16 Jul | 29.4 | 12.0 | 1/25 (4%) | 0-0-1 | 13/25 (52%) | 2-2-9 |
| | 13 Aug | 29.5 | 13.0 | 11/25 (44%) | 3-0-8 | 13/25 (52%) | 3-1-9 |
| | 17 Sep | 26.5 | 20.0 | 12/25 (48%) | 2-2-8 | 24/25 (96%) | 5-4-15 |
| | 23 Oct | 16.6 | 17.0 | 11/25 (44%) | 3-2-6 | 24/25 (96%) | 6-3-15 |
| | 18 Nov | 12.0 | 15.0 | 9/25 (36%) | 2-1-6 | 25/25 (100%) | 3-7-15 |
| | 10 Dec | 8.5 | 15.0 | 7/25 (28%) | 0-2-5 | 24/24 (100%) | 3-5-16 |

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

Table 2. Fall survey of prevalence and intensity of *Haplosporidium nelsoni* (MSX) and *Perkinsus marinus* in oysters from Virginia oyster beds in 1997. See accompanying figures for station locations. NA=not analyzed for MSX.

| Location | Date | Temp. (°C) | Sal. (ppt) | MSX Infect./exam. -%infected | H–M–L* | *Perkinsus* Infect./exam. -%infected | H–M–L* |
|---|---|---|---|---|---|---|---|
| **James River** | | | | | | | |
| Deep Water Shoal | 23 Oct | 16.2 | 12.0 | NA | | 8/25 (32%) | 1-0-7 |
| Horsehead Rock | 23 Oct | 15.8 | 14.0 | 0/24 (0%) | 0-0-0 | 23/25 (92%) | 3-3-17 |
| Point of Shoals | 23 Oct | 15.6 | 14.0 | NA | | 20/25 (80%) | 2-1-17 |
| Wreck Shoal | 23 Oct | 16.6 | 17.0 | 11/25 (44%) | 3-2-6 | 24/25 (96%) | 6-3-15 |
| Dry Shoals | 29 Oct | 14.6 | 14.7 | 9/25 (36%) | 0-1-8 | 22/25 (88%) | 7-2-13 |
| **York River** | | | | | | | |
| Bell Rock | 27 Oct | 15.5 | 16.4 | 9/25 (36%) | 6-0-3 | 0/25 (0%) | 0-0-0 |
| **Piankatank River** | | | | | | | |
| Ginney Point | 17 Oct | 19.4 | 17.7 | 0/25 (0%) | 0-0-0 | 9/25 (36%) | 0-0-9 |
| Burton's Point | 17 Oct | 18.8 | 18.7 | 1/25 (4%) | 0-0-1 | 17/25 (68%) | 2-3-12 |
| Palace Bar | 17 Oct | 19.4 | 18.3 | 4/25 (16%) | 3-0-1 | 17/25 (68%) | 2-0-15 |
| **Rappahannock River** | | | | | | | |
| Ross Rock | 14 Oct | 21.7 | 12.2 | 0/25 (0%) | 0-0-0 | 0/25 (0%) | 0-0-0 |
| Bowlers Rock | 14 Oct | 22.2 | 13.9 | 0/25 (0%) | 0-0-0 | 13/25 (52%) | 5-3-5 |
| Long Rock | 14Oct | 22.0 | 14.9 | 0/25 (0%) | 0-0-0 | 11/25 (44%) | 1-2-8 |
| Marratico Bar | 14 Oct | 22.0 | 16.1 | 0/25 (0%) | 0-0-0 | 10/25 (40%) | 1-0-9 |
| Smokey Point | 14 Oct | 22.2 | 16.3 | 0/23 (0%) | 0-0-0 | 5/23 (22%) | 1-0-4 |
| Drummond Ground | 14 Oct | 21.2 | 17.8 | 6/25 (24%) | 0-0-6 | 17/25 (68%) | 0-2-15 |
| Parrot Rock | 14 Oct | 21.1 | 18.1 | 7/25 (28%) | 3-0-4 | 24/25 (96%) | 6-3-15 |
| Broad Creek | 22 Oct | 16.5 | 18.0 | 4/25 (16%) | 1-1-2 | 13/25 (52%) | 1-1-11 |
| **Corrotoman River** | | | | | | | |
| Middle Ground | 14 Oct | 21.3 | 17.0 | 1/25 (4%) | 0-0-1 | 25/25 (100%) | 7-5-13 |
| **Great Wicomico River** | | | | | | | |
| Haynies Bar | 22 Oct | 15.5 | 17.9 | 0/25 (0%) | 0-0-0 | 19/25 (76%) | 1-1-17 |
| Whaley's East | 22 Oct | 15.8 | 18.2 | 0/25 (0%) | 0-0-0 | 20/25 (80%) | 0-1-19 |
| Fleeton Point | 22 Oct | 16.0 | 17.9 | 2/25 (8%) | 1-0-1 | 16/25 (64%) | 0-2-14 |
| **Eastern Shore** | | | | | | | |
| Fishermans Island (1995 Plant) | 27 Oct | 18.0 | 32.0 | 1/11 (9%) | 0-1-0 | 9/11 (82%) | 3-1-5 |
| Fishermans Island (1995 Plant) | 27 Oct | 18.0 | 32.0 | 2/15 (14%) | 0-0-2 | 14/15 (93%) | 2-1-11 |
| Fishermans Island (1996 Plant) | 27 Oct | 18.0 | 32.0 | 2/20 (10%) | 0-0-1 | 8/20 (40%) | 2-0-6 |
| Fishermans Island (1996 Plant) | 27 Oct | 18.0 | 32.0 | 6/15 (42%) | 2-3-1 | 7/15 (47%) | 1-1-5 |
| Tangier Sound California Rock | 17 Sept | | | 3/25 (12%) | 1-0-2 | 24/25 (96%) | 3-2-19 |
| Pocomoke Sound Hurley Rock | 17 Sept | | | 0/25 (0%) | 0-0-0 | 25/25 (100%) | 5-5-15 |
| Pocomoke Sound Parker Rock | 17 Sept | | | 7/25 (28%) | 0-2-5 | 7/25 (28%) | 1-0-6 |

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

Table 3. Mean mortality and disease prevalence in upper Rappahannock River oysters transplanted to trays at the lower York River, Gloucester Point, VA in May, 1997.

| Date–1997 | Monthly mortality--% | Cumulative mortality-% | *H. nelsoni* prevalence | Intensity H-M-L* | *P. marinus* prevalence | Intensity H--M--L* |
|---|---|---|---|---|---|---|
| 7 May | 0 | 0 | 0/23 (0%) | 0-0-0 | 0/23 (0%) | 0-0-0 |
| 17 Jun | 17.0 | 23.3 | 0/21 (0%) | 0-0-0 | 2/21 (9.5%) | 0-0-2 |
| 11 Jul | 6.5 | 28.5 | 2/24 (8%) | 0-1-1 | 0/25 (0%) | 0-0-0 |
| 12 Aug | 30.7 | 61.2 | 18/22 (82%) | 12-2-4 | 0/22 (0%) | 0-0-0 |
| 15 Sep | 17.8 | 81.4 | 16/21 (77%) | 12-0-4 | 4/22 (18%) | 2-1-1 |
| 29 Oct | 10.0 | 96.0 | 5/6 (83%) | 1-1-3 | 3/6 (50%) | 0-1-2 |

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

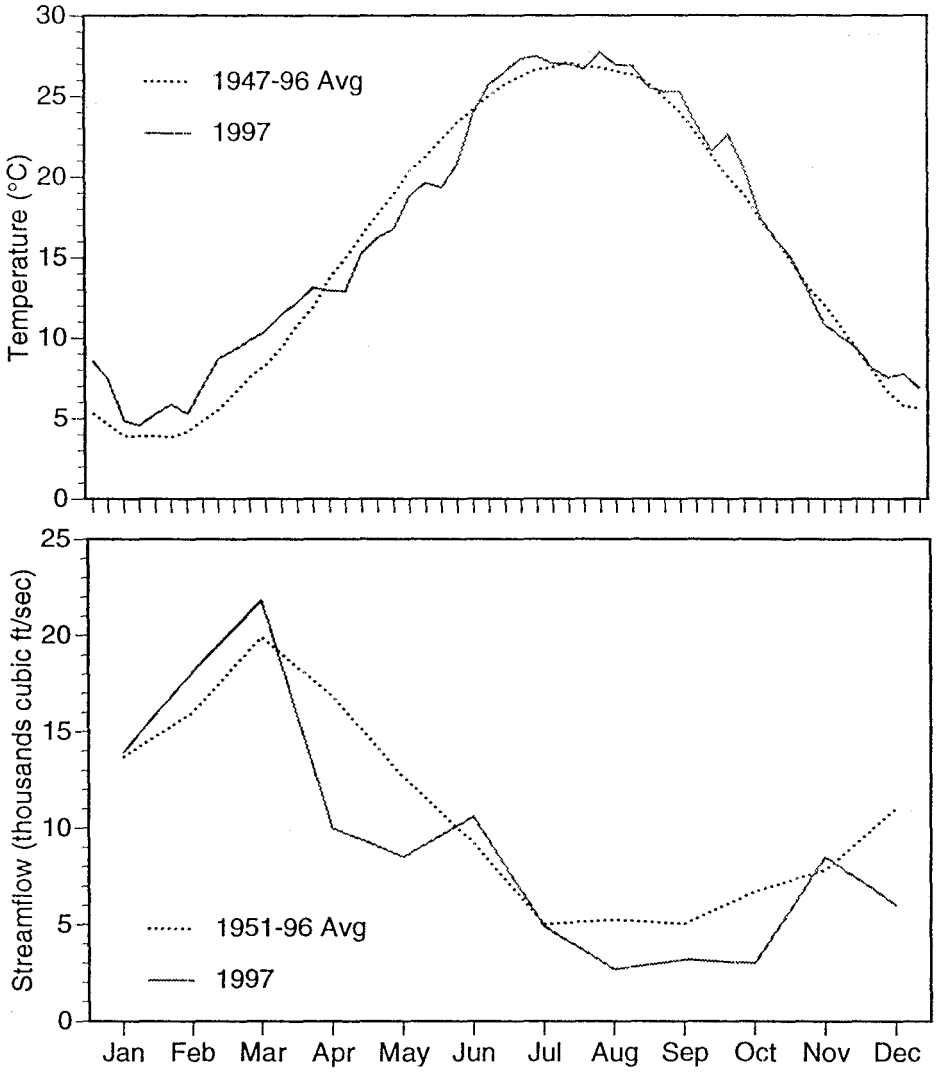



Figure 1. Average weekly water temperature at VIMS, Gloucester Point, VA (top) and monthly James River, VA streamflow (bottom). Long-term averages (dashed lines) are contrasted with 1997 values (solid lines). Long-term temperatures are for years 1947-1996 and long-term streamflows are for 1951-1996.

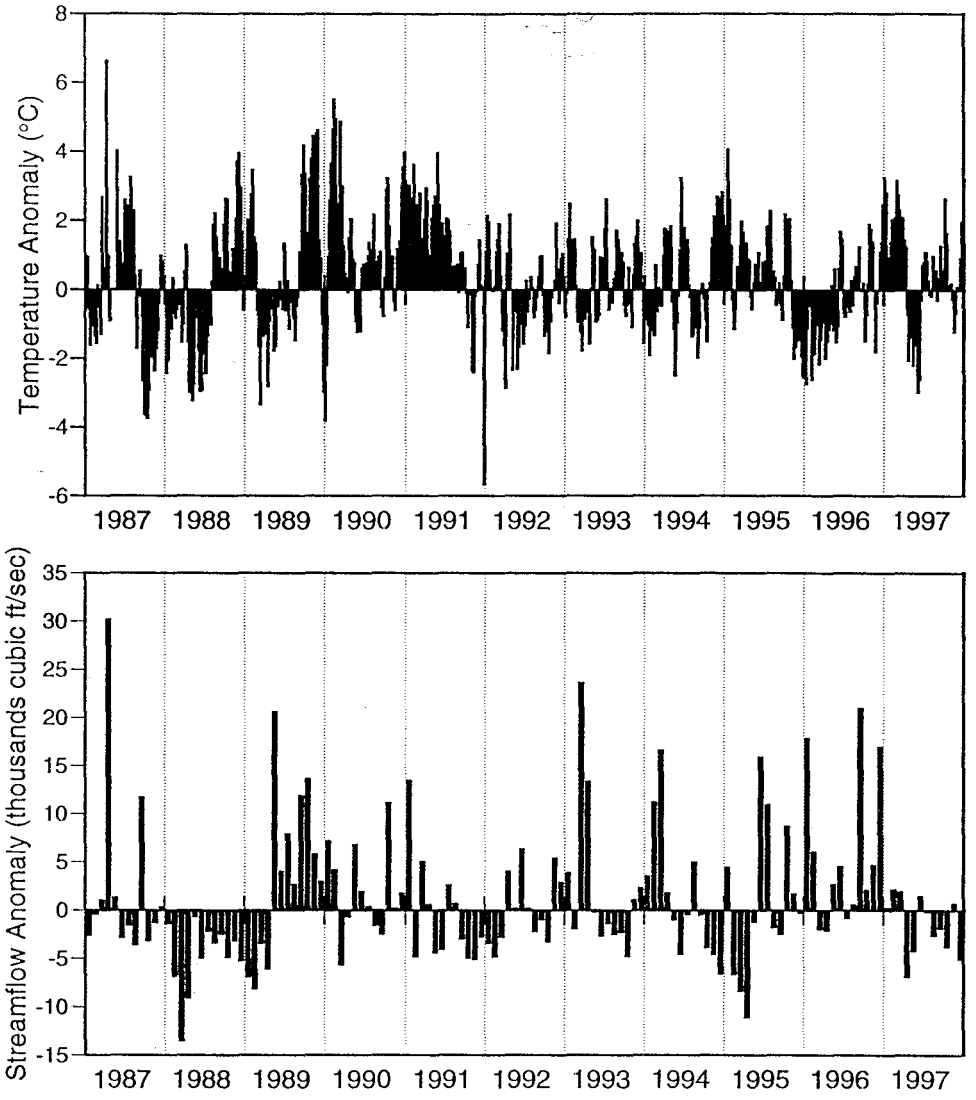



Figure 3. Mean weekly VIMS pier water temperature anomaly from long-term (1947-1996) average (top). Mean monthly James River streamflow anomaly from long-term (1951-1996) average (bottom).

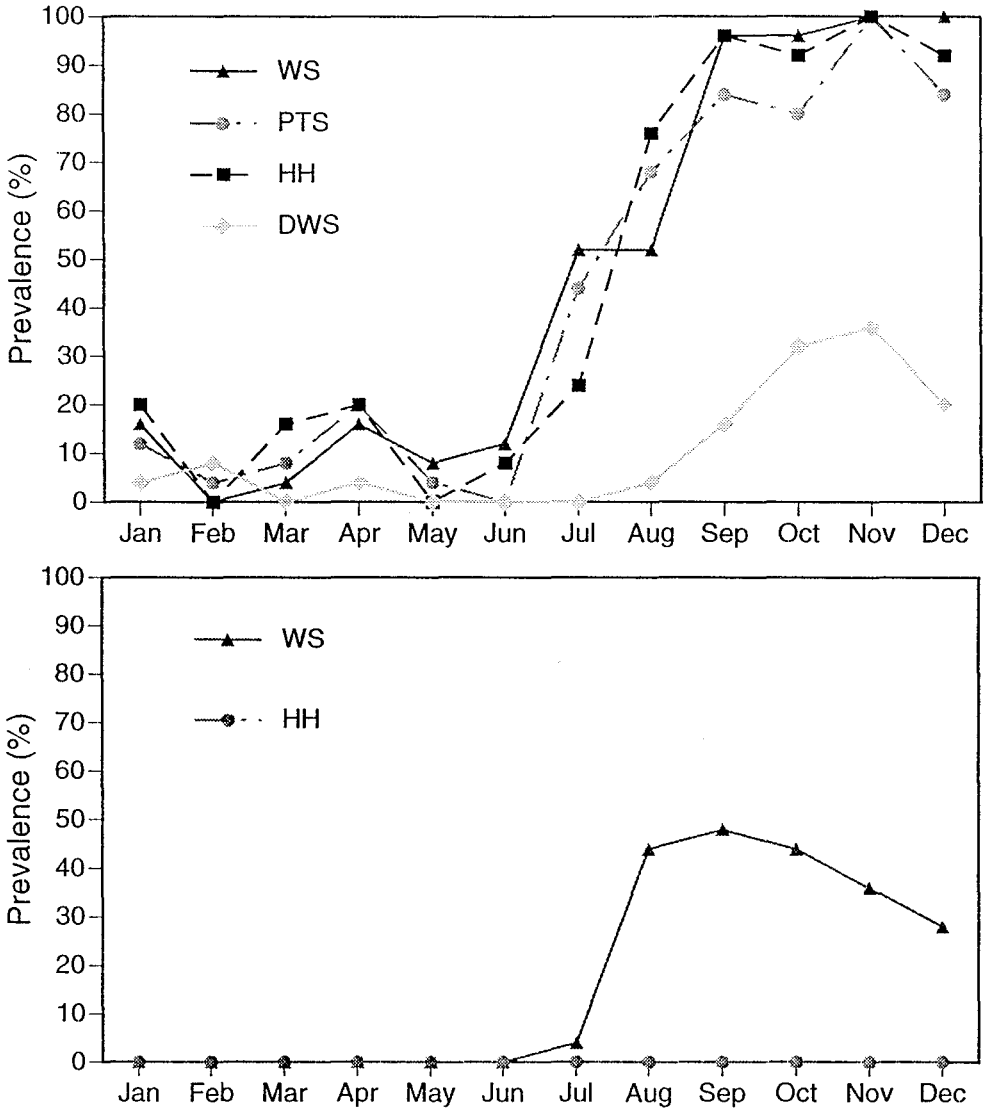



Figure 4. Prevalence of *P. marinus* (top) and *H. nelsoni* (MSX) (bottom) in James River oysters from Wreck Shoal (WS), Horsehead Rock (HH), Point of Shoals (PTS) and Deepwater Shoal (DWS) in 1997. DWS and PTS oysters were not analyzed for MSX.

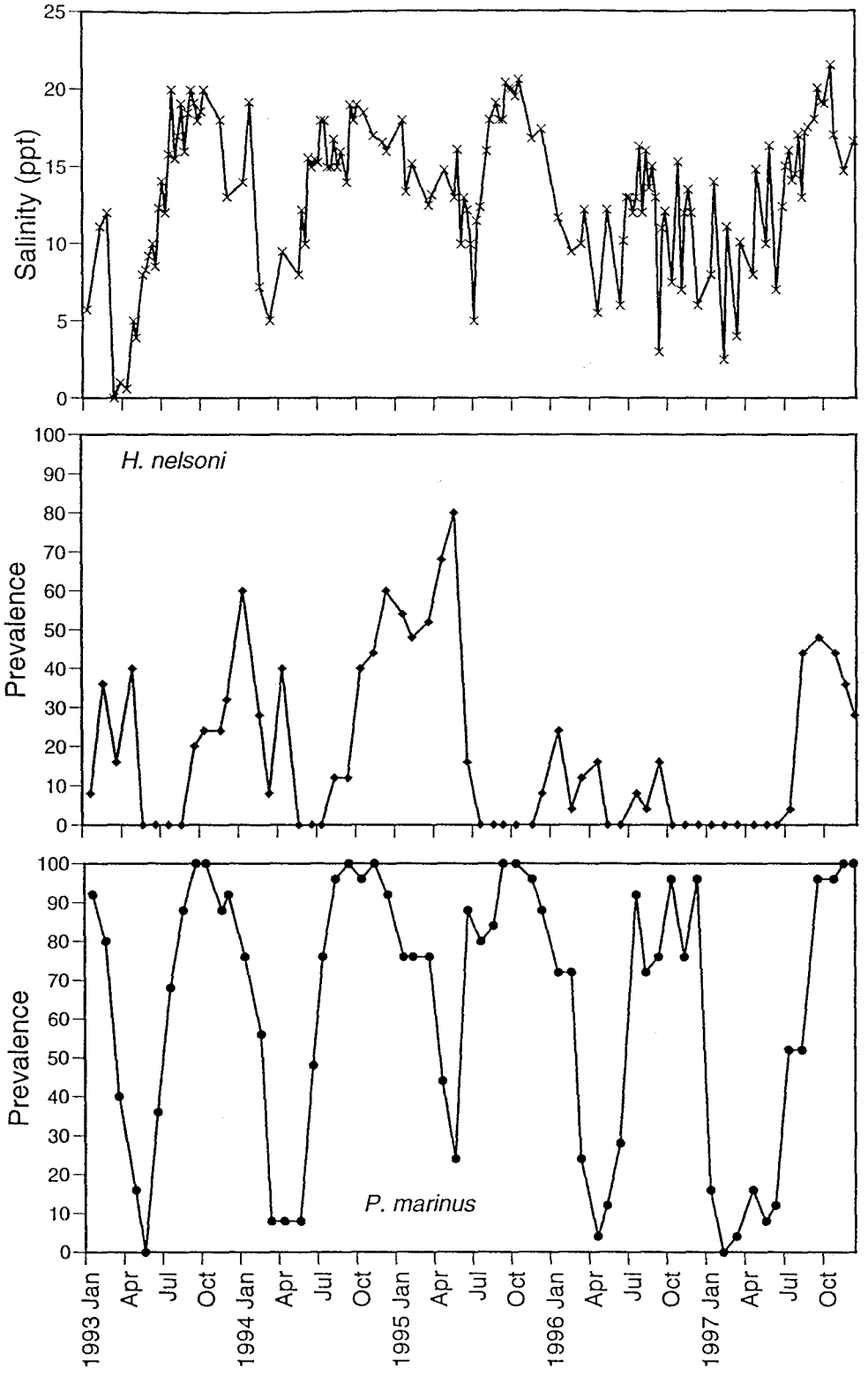



Figure 5. Salinity (top) and prevalence of *P. marinus* (bottom) and *H. nelsoni* (middle) at Wreck Shoal, James River, VA for the years 1993-1997.

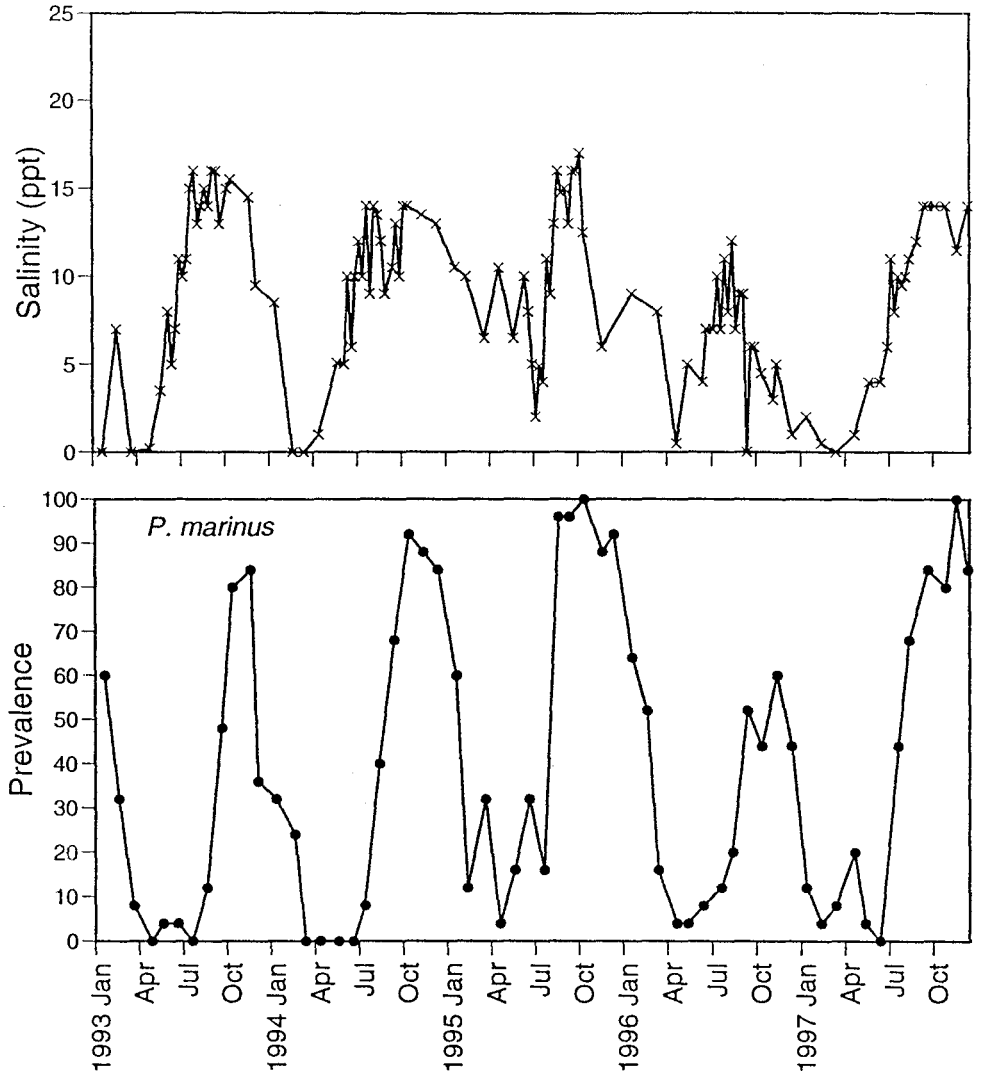



Figure 6. Salinity (top) and prevalence of *P. marinus* (bottom) at Point of Shoals, James River, VA for the years 1993-1997.

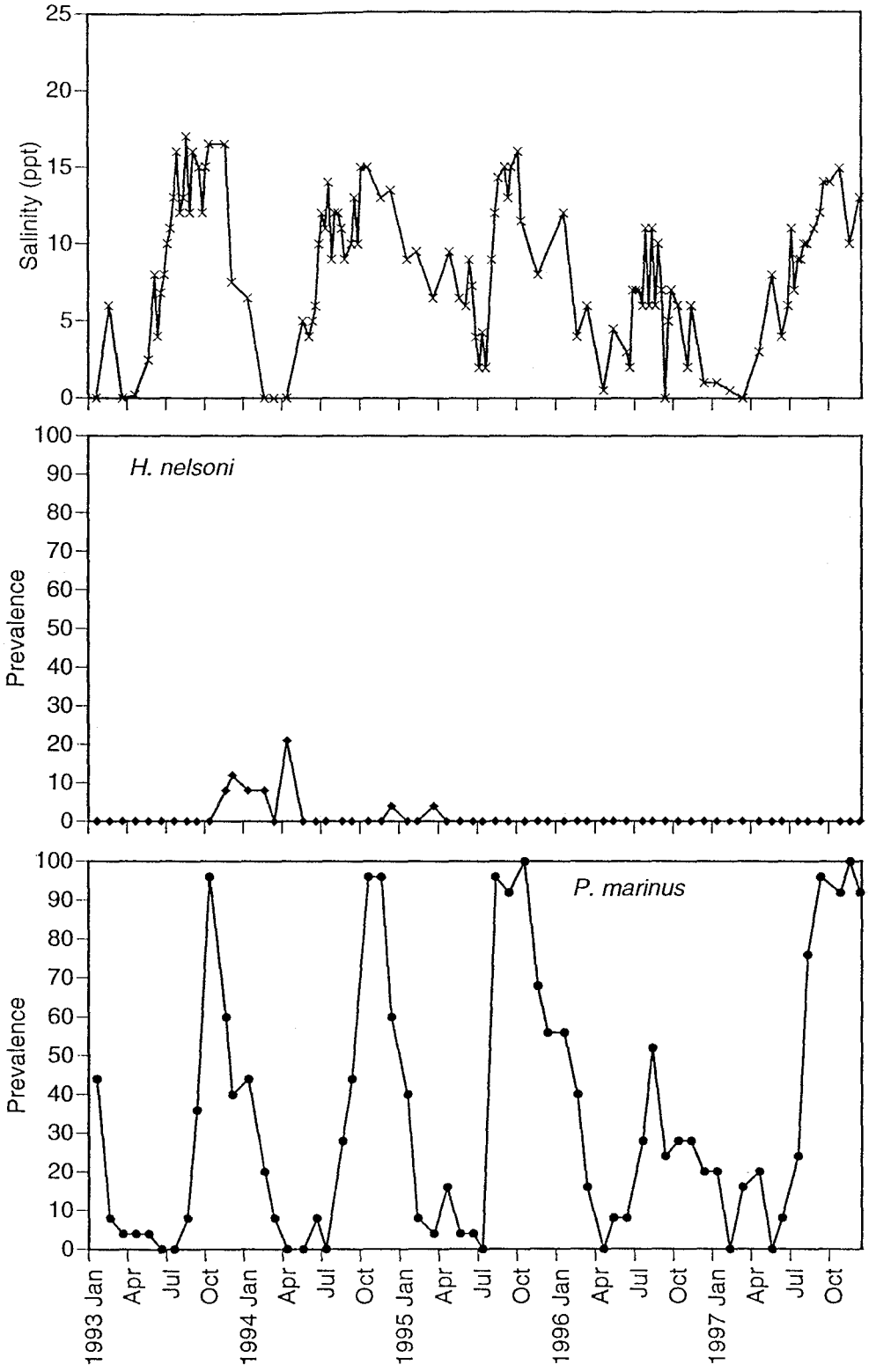



Figure 7. Salinity (top) and prevalence of *P. marinus* (bottom) and *H. nelsoni* (middle) at Horsehead Rock, James River, VA for the years 1993-1997.

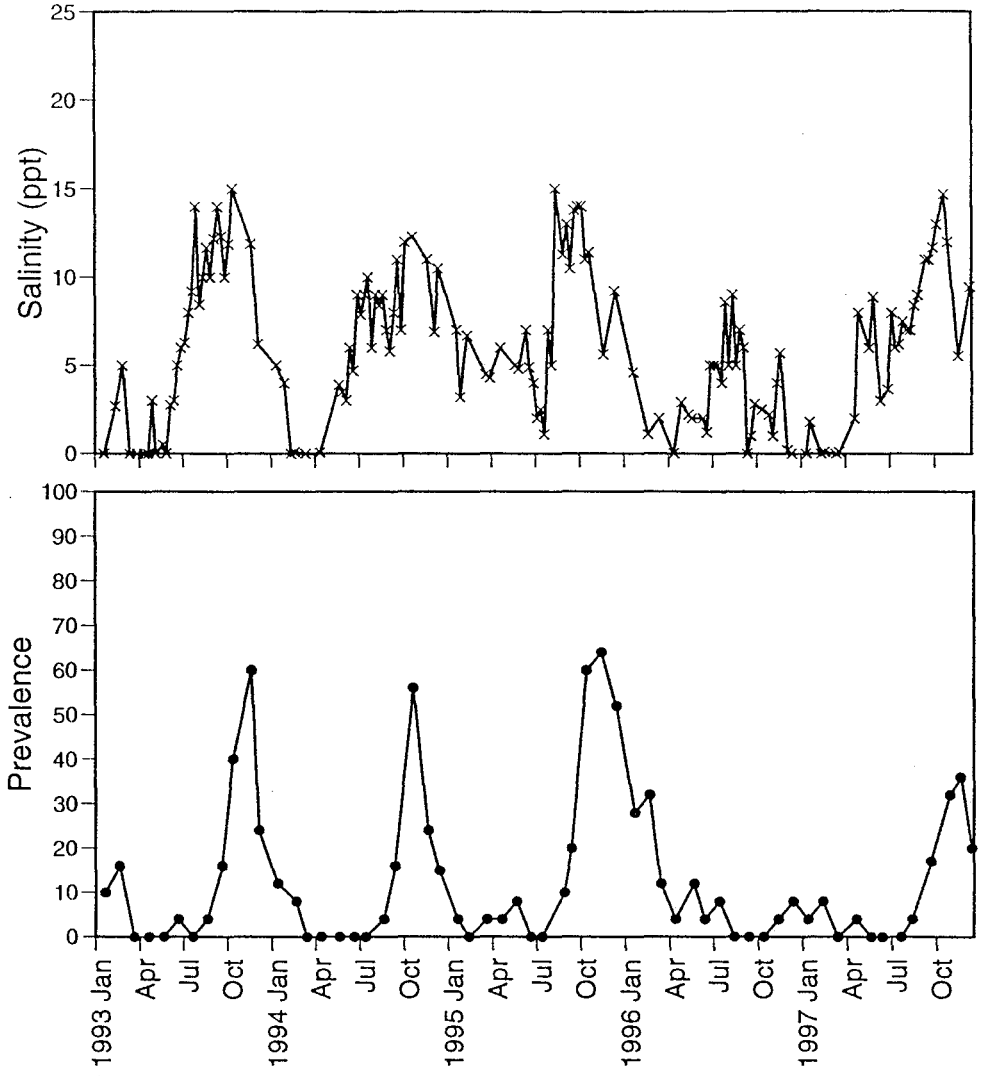



Figure 8. Salinity (top) and *P. marinus* prevalence (bottom) at Deepwater Shoal, James River, VA for the years 1993-1997.

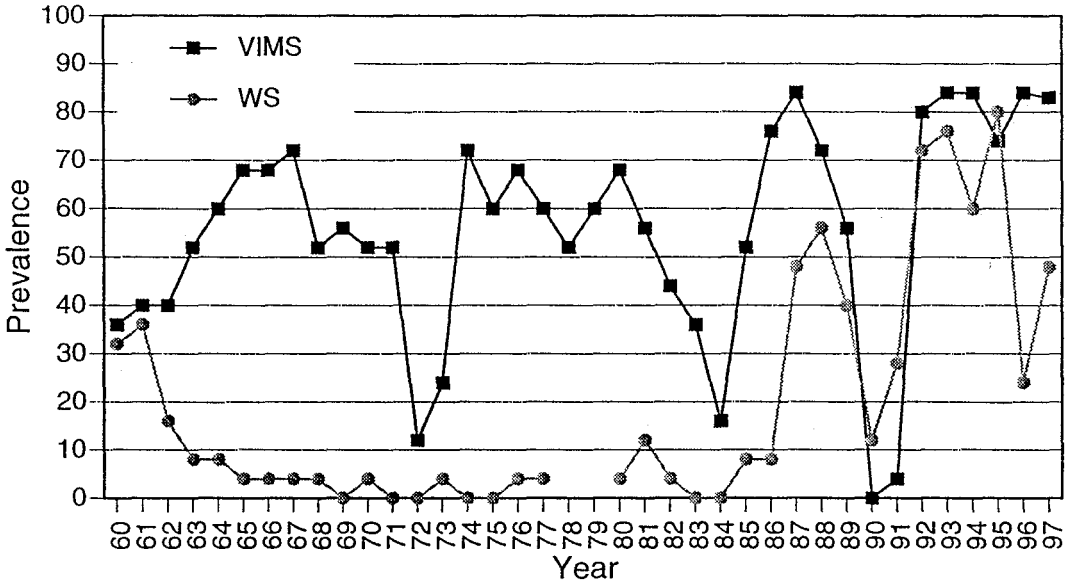
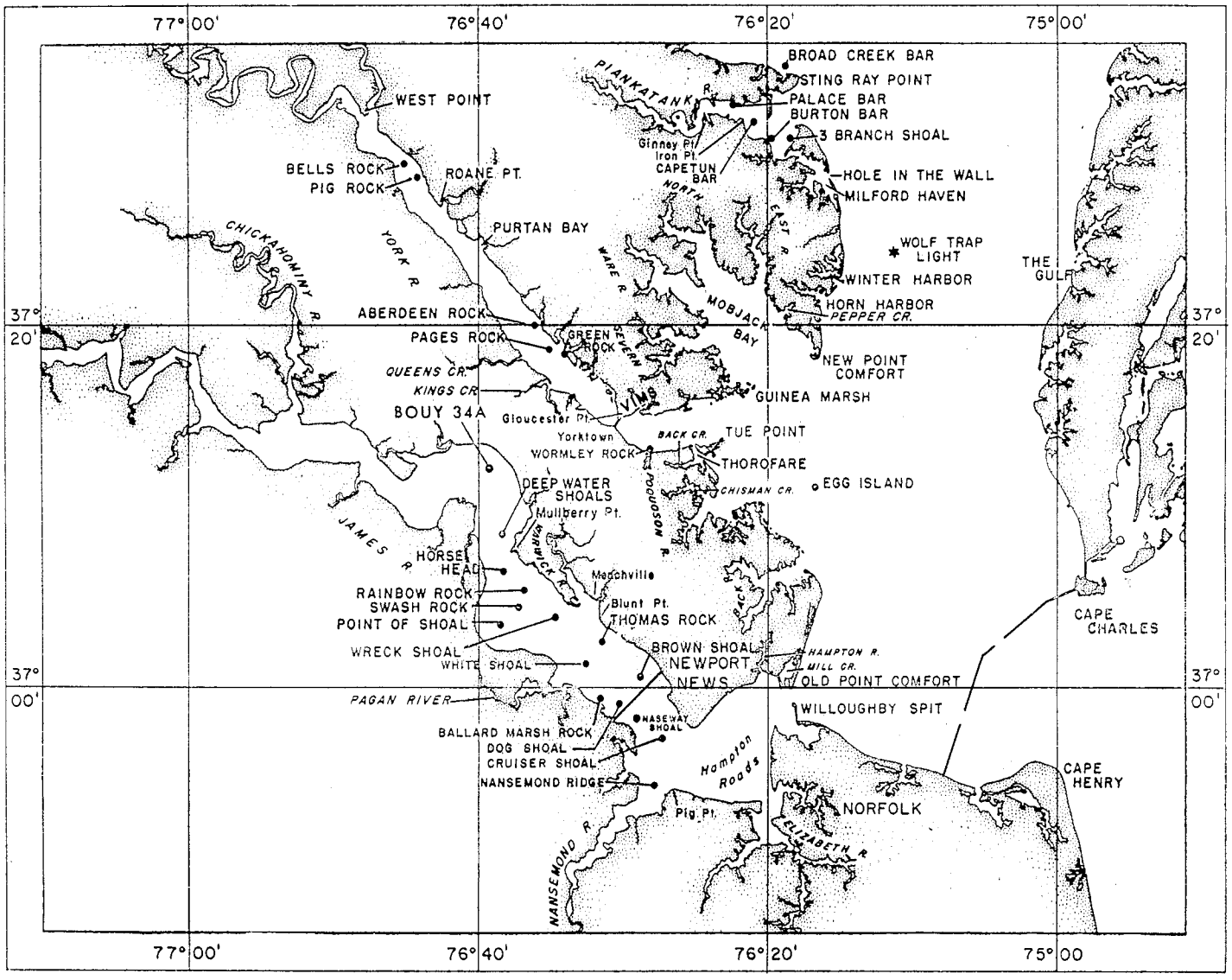
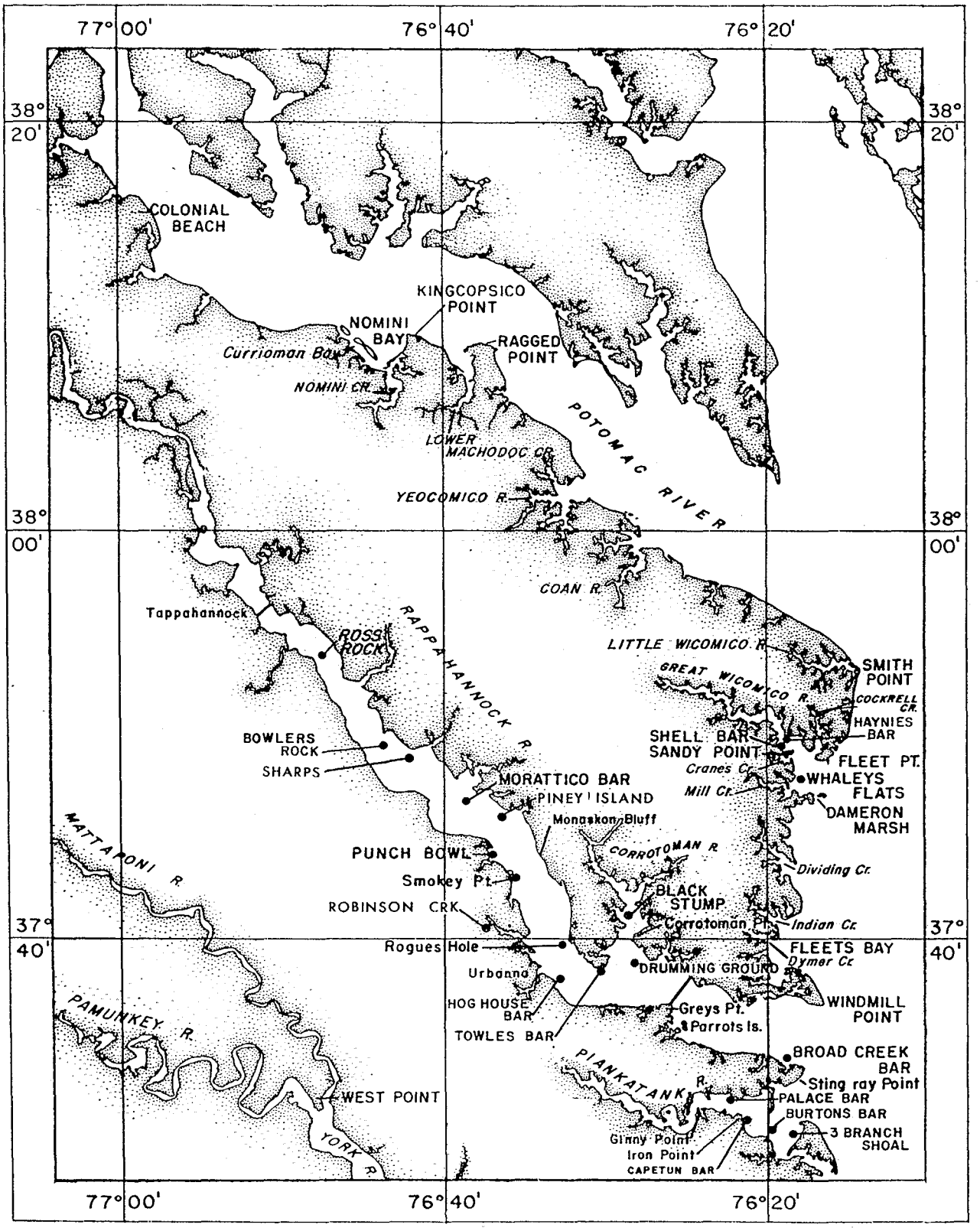


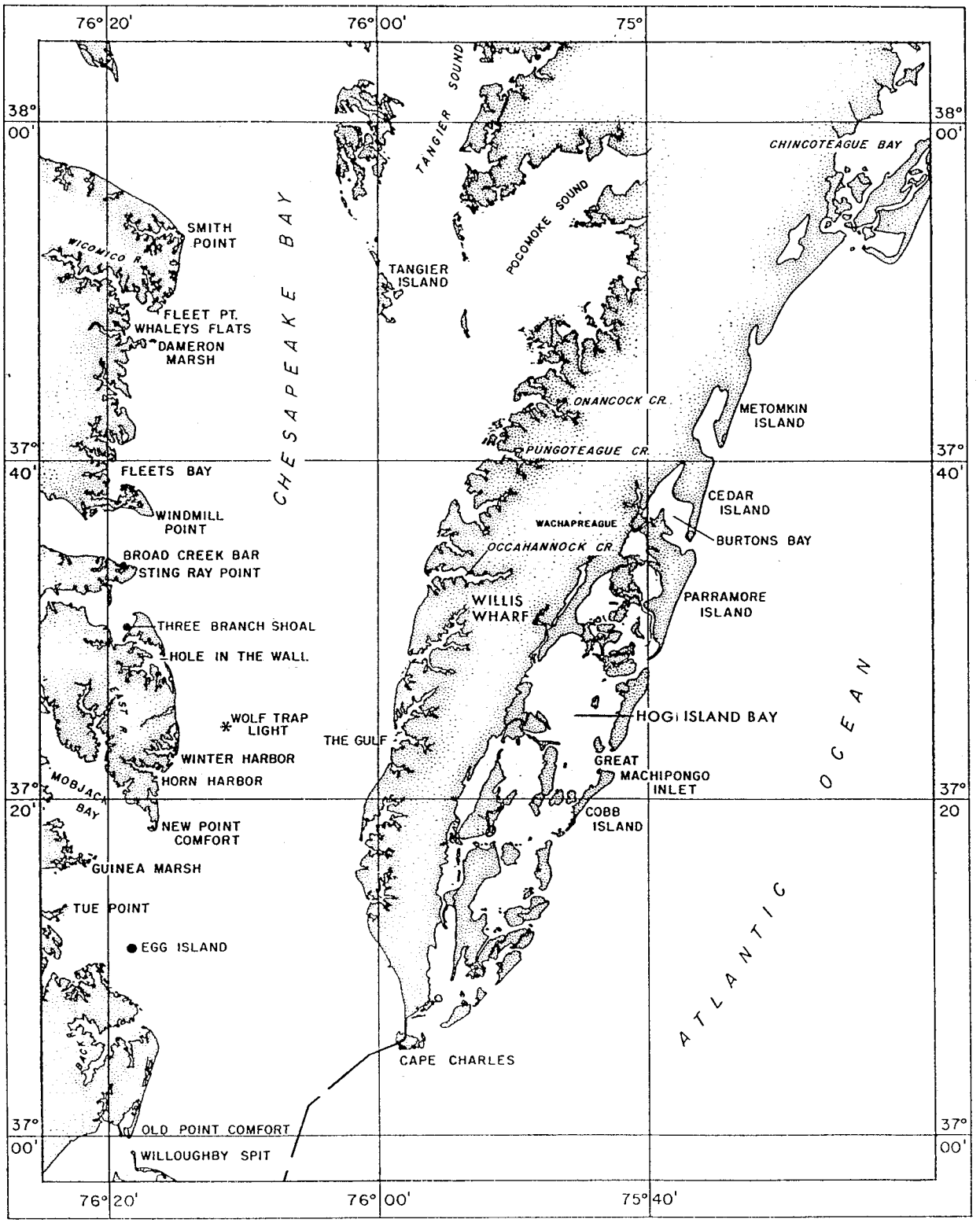

Figure 9. Maximum annual prevalence of *Haplosporidium nelsoni* (MSX) in imported monitoring tray oysters at VIMS and in native oysters at Wreck Shoal (WS), James River, 1960-1997.




Names of oyster rocks, geographical points, towns and bodies of water in James and York rivers.




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




Names of oyster rocks, geographical points, towns and bodies of water on Eastern Shore of Virginia.