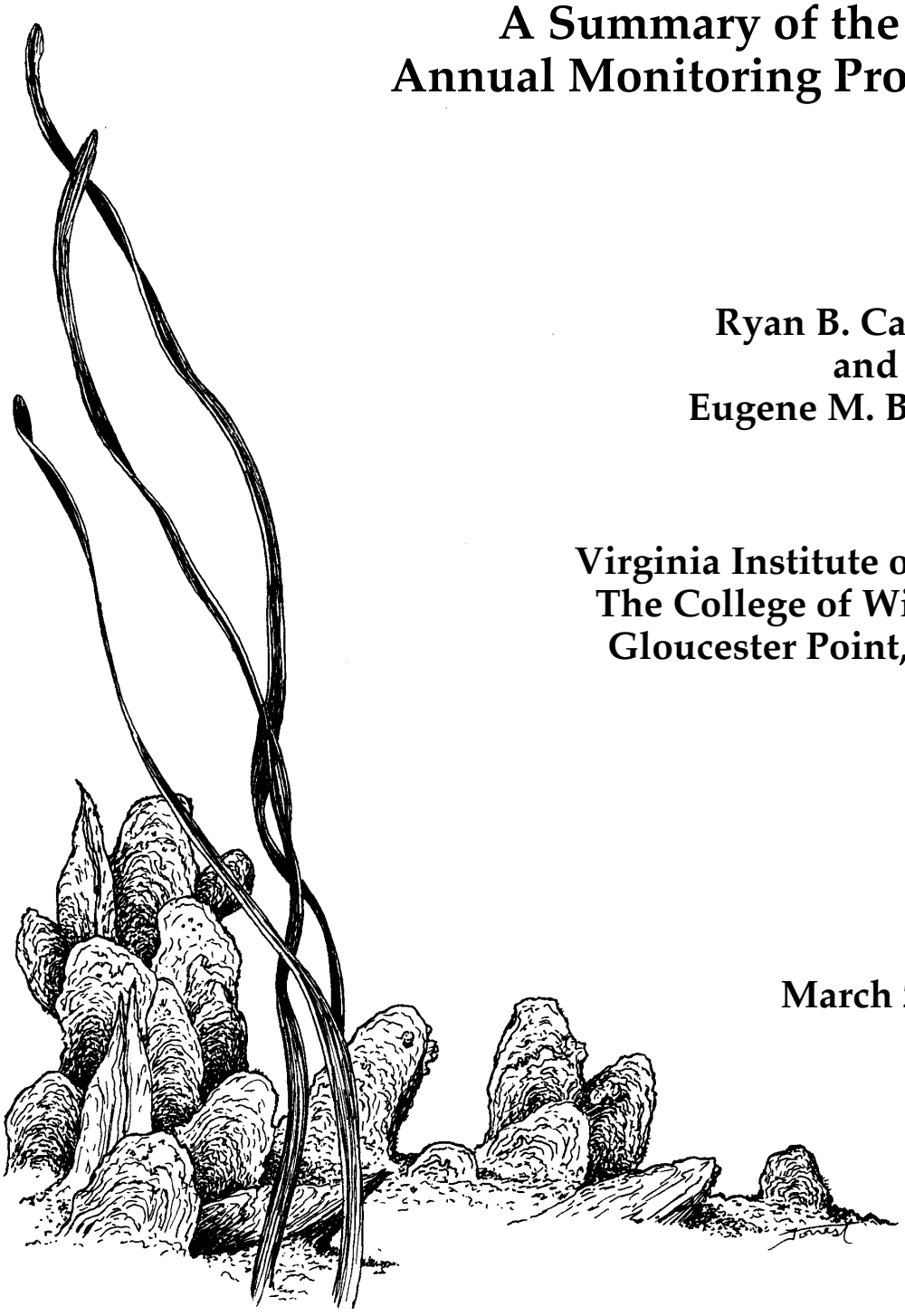
Status of the Major Oyster Diseases in Virginia 2004

A Summary of the Annual Monitoring Program



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Executive Summary

2004 was the second very wet year in a row. While rainfall and streamflows were normal in winter and early spring, and just slightly above average during the summer, the fall of 2004 was nearly as wet as the year before. Salinities were again depressed throughout the lower Bay. Water temperatures were below normal during the winter, but typical otherwise. Low salinities and, in the winter, temperatures brought continued abatement in the oyster diseases caused by *Perkinsus marinus* (Dermo) and *Haplosporidium nelsoni* (MSX). Among quarterly James River Survey sites, maximum annual *P. marinus* prevalences were the lowest they had been since before 1992. In summer and fall, when *P. marinus* is normally most prevalent, it was found in a maximum of 68% of oysters at Wreck Shoal and in no more than 20% of the oysters anywhere else. Advanced infections were rare, and limited to Wreck Shoal. *H. nelsoni* was found in a single oyster, at Wreck Shoal in July.

Fall Survey samples revealed a continued withdrawal of *H. nelsoni* from most of the oyster bars in lower Bay tributaries. *H. nelsoni* was observed only at Thomas Rock and Nansemond Ridge in the lower James, at Page Rock in the lower York, at Hog House Rock in the Rappahannock, and at Whaley's in the Great Wicomico, and always at low prevalence and intensity. *P. marinus* also continued to decrease in prevalence throughout much of the lower Bay, with the lower James River (Dry Shoal, Wreck Shoal, Thomas Rock, and Nansemond Ridge) being the primary exception. Infection intensities, however, increased almost everywhere except in the upper James, though heavy, advanced infections were still relatively rare. Increasing infection intensities in the context of a general decrease in *P. marinus* prevalence probably indicates intensification of pre-existing infections against a backdrop of low parasite transmission and relatively infrequent establishment of new infections.

Taken as a whole, the data suggest that neither parasite is seriously impacting oyster populations in the survey area, and that mortality caused by these parasites in 2004 was probably low. Disease pressure and mortality should continue to be low until at least through summer 2005, and perhaps longer if normal rainfall and streamflow conditions are slow to return.

Introduction

The protozoan parasites *Haplosporidium nelsoni* ("MSX") and *Perkinsus marinus* ("Dermo") are serious pathogens of oysters in the Chesapeake Bay. *H. nelsoni* 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 once-productive 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* in Virginia was limited to the lower river areas, 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, with its increase in abundance and distribution, *P. marinus* is now a more important oyster pathogen than *H. nelsoni*. Most *P. marinus*-associated mortality occurs during late summer and early fall, but it may begin as early as June following warm winters that allow more infections to persist through the winter.

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 12 ppt. *H. 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 at salinities < 12 ppt.

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 2004 are presented in this report.

Methods

Sampling

The oyster disease monitoring program consists of three different components: quarterly **James River Survey** sampling of four historic oyster reefs; yearly **Fall Survey** sampling of oyster reefs in the James, York, Piankatank, Rappahannock, and Great Wicomico Rivers as well as Mobjack Bay; and monthly monitoring of **Spring Imports** from the upper Rappahannock River (Ross Rock) to the York River.

James River Survey and **Fall Survey.** From 1987 to the present the upper James River has been intensively monitored. In January, April, July, and October 2004, samples of 25 oysters were collected from Wreck Shoal, Point of Shoals, Horsehead Rock, and Deep Water Shoal. Between September and October, samples of native oysters (n=25) were collected additionally

from most major public harvesting areas in Virginia. Together, these sampling programs allow us to determine the annual distribution and severity of *H. nelsoni* and *P. marinus* activity.

Spring Imports. Oysters are collected from the upper Rappahannock River at Ross Rock each April or May and held in trays in the lower York River. Ross Rock oysters are highly susceptible to diseases caused by *H. nelsoni* and *P. marinus* and serve as excellent sentinels for the assessment of annual variability in disease pressure.

Prior to deploying trays, 25 oysters are screened 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 Ross Rock during April, but in some years *P. marinus* has been present at low (< 10%) prevalence. Three hundred or more oysters are placed in each of two trays in the York River around 1 May each year. Each month from May through October, mortality (monthly and cumulative) is calculated and samples of 25 oysters are examined histopathologically for disease, with *P. marinus* detection also by RFTM (see below).

New trays are established each May to provide a record of disease prevalence and intensity for each year. Because sentinel oysters have been held at the same location each year since 1960, we have a long-term database on *H. nelsoni* and *P. marinus* abundance. It is possible to compare parasite prevalence and infection intensity between years and to relate disease abundance and distribution to various environmental parameters.

Diagnostic Techniques

Prevalence (percentage of population infected) of *H. nelsoni* was determined by histopathological 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 (RFTM). Infection intensity in each case was rated "heavy", "moderate", "light", or "rare".

Environmental Parameters

Water temperatures for Sewells Point, on the James River, were obtained from the NOAA Center for Operational Oceanographic Products and Services web site (http://co-ops.nos.noaa.gov/). Water temperature and salinity data for James River and Fall Survey sites were obtained at time of collection and from the Virginia DEQ. River flow data for the James (at Richmond), Potomac (near Washington, DC), and Susquehanna (at Harrisburg, PA) Rivers were obtained from the United States Geological Survey (http://waterdata.usgs.gov/nwis).

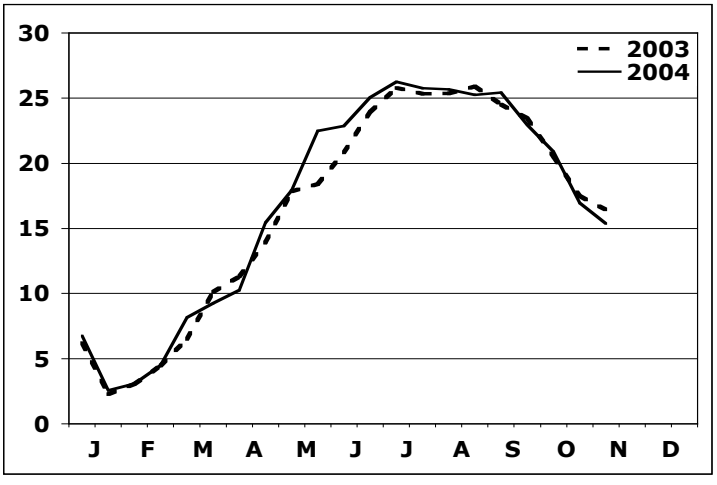

Figure 1. Semi-monthly average water temperature (°C) at Sewell Point, on the James River, in 2003 and 2004.

Results

I. Environmental Conditions

Water temperatures in 2003 were relatively cold during the winter months and cool in late spring, but normal otherwise. In 2004, water temperatures

were similarly cold in winter months, with temperatures below 5°C through most of late January and February, but temperatures were warmer in spring than in 2004 (Figure 1).

2004 was the second very wet year in a row (Figures 2, 3). Measured in the James River at Richmond, resulting streamflow was above average in nine months out of twelve, with the exceptions being January, March, and May. Flows exceeded average rates by over 100% from October-December, and by over 200% in September. High streamflows, particularly in summer and autumn, were not restricted to the lower Bay. In the Potomac River, streamflow was above average in eight of twelve months, exceeding the average rate by 200% in September. In the Susquehanna River, streamflow was above average in nine months, exceeding the average rate by over 100% in July and December, by over 200% in August, and by almost 800% in September, when Susquehanna streamflow set an all-time record for that month. Salinities were depressed throughout Chesapeake Bay. In Fall Survey 2003 sampling, measured salinities relative to 2002 had been 6-10‰ lower in the James River, 6-12‰ lower in the York River, 8-9‰ lower in the Piankatank River, 6-7‰ lower in the Rappahannock River, and 8‰ lower in the Great

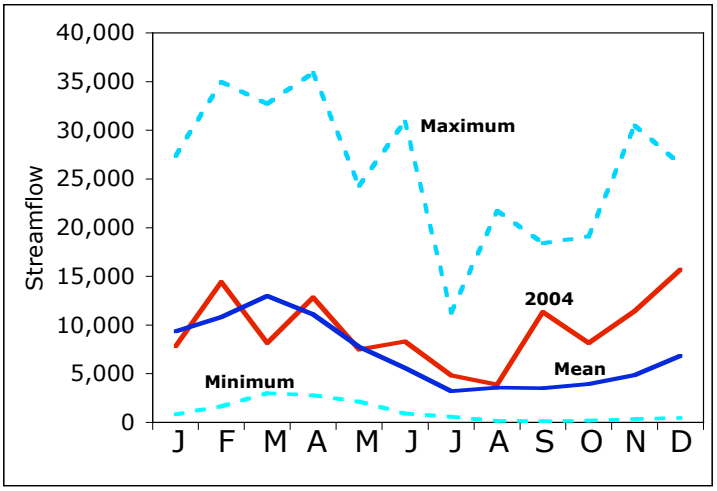

Figure 2. Average monthly streamflow (cu ft/sec) in the James River at Richmond in 2004 relative to the long-term (1935-2003) monthly average and all time maxima and minima.

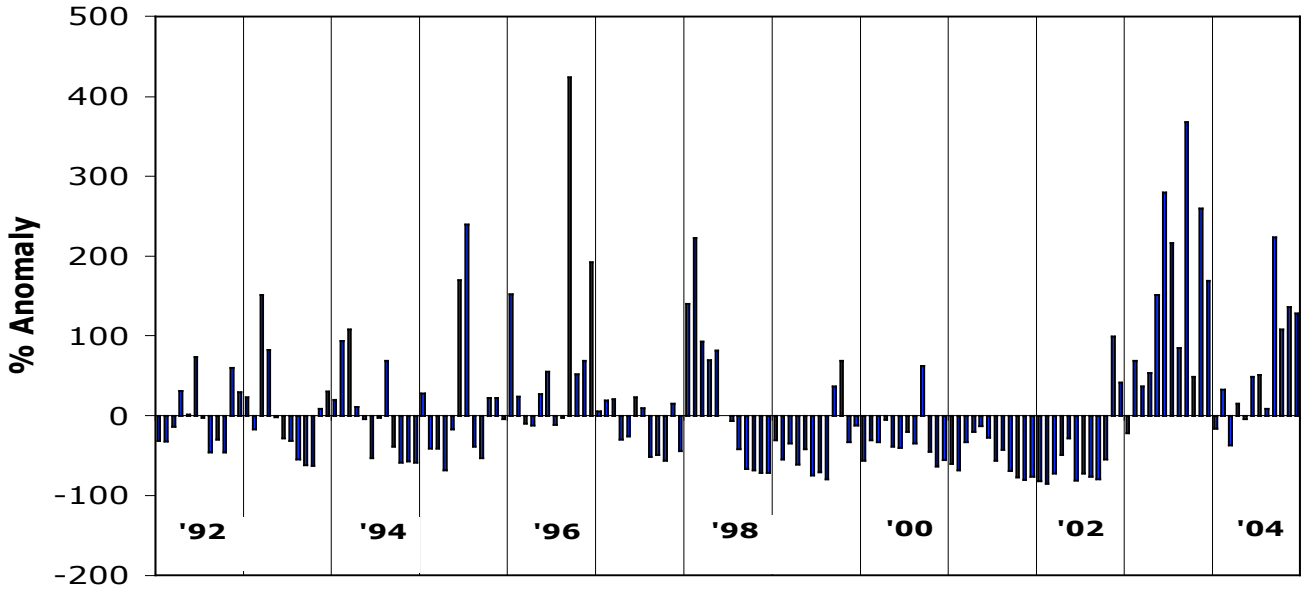

Figure 3. Average monthly streamflow anomaly, expressed in terms of % above or below long-term (1935-2003) average monthly flow, in the James River at Richmond. Flows in 2004 were normal to slightly above normal through August, but far above average through the fall.

Wicomico River than in 2002. Measured salinities were lower still in 2004, by as much as 7‰ in the James and York Rivers, 1‰ in the Piankatank River, and 3‰ in the Rappahannock and Great Wicomico Rivers (Table 2).

II. James River Survey

Perkinsus marinus

Prevalence and intensity of *P. marinus* in the upper James River, at Deepwater Shoal, Horsehead Rock, and Point of Shoals, declined in 2004 for the second year in a row and reached levels not seen since before 1992 (Table 1, Figure 4). *P. marinus* was not detected at all at Deepwater Shoal, and just three oysters were found to be infected at Horsehead Rock, one each in January, July, and October. *P. marinus* was observed slightly more frequently at Point of Shoals, but *P. marinus* prevalence here still reached levels that were the lowest (April, 0%; October, 20%), second-lowest (January, 20%) or third-lowest (July, 8%) in the 1992-2004 period. Prevalence levels at Wreck Shoal in 2004 were at or near 13-year minima in January (20%), April (8%), and July (16%), but increased by 28% from 2003 in October (68%).

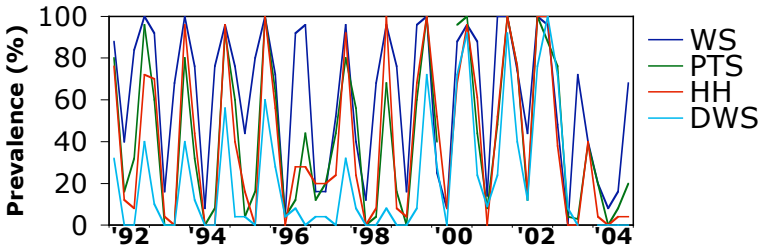

Figure 4. Quarterly prevalence of *P. marinus* in the James River at Wreck Shoal (WS), Point of Shoal (PTS), Horsehead Rock (HH), and Deepwater Shoal (DWS) from 1992-2004.

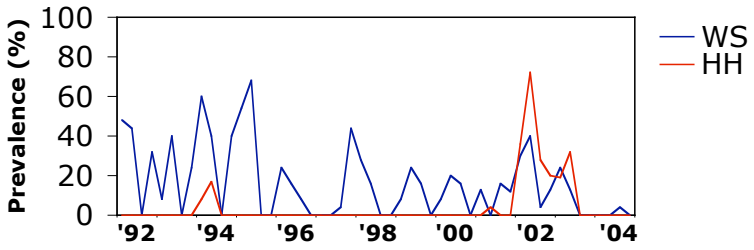

Figure 5. Quarterly prevalence of *H. nelsoni* in the James River at Wreck Shoal (WS) and Horsehead Rock (HH) from 1992-2004.

Intensity of *P. marinus* infections in the upper James River in 2004 was also lower than in 2003, with the single exception of Wreck Shoal in October (Table 1). In 2002, 75% of all *P. marinus* infections in July and October were at least moderate in intensity, with 24% heavy; just 25% of infections were light. In 2003, 71% of July-October infections were light, and just a single heavily infected oyster was observed after January, in October at Wreck Shoal. In 2004, 80% of July-October infections were "light", but the proportion of moderate-heavy infections increased in October at Wreck Shoal, from 2/25 (one heavy, one moderate) in 2003 to 5/25 (two heavy, three moderate) in 2004.

Haplosporidium nelsoni

After disappearing from quarterly James River Survey samples after March 2003, *H. nelsoni* was observed in a single Wreck Shoal oyster in 2004, a July infection "rare" in intensity (Table 1, Figure 5).

III. Fall Survey

The fall 2004 oyster disease survey was conducted from 27 September through 19 October. Twenty-nine oyster populations were sampled for disease analysis. Oysters were collected from natural oyster reefs in tributaries of the western shore of the Chesapeake Bay, including the James River, York River, Mobjack Bay, Piankatank River, Rappahannock River, Corrotoman River, Great Wicomico River, and Potomac River. Results of this survey are presented in Table 2, and described for each tributary below.

James River

Ten James River oyster reefs were surveyed for disease in the fall of 2004. *P. marinus* prevalences declined for the second year in a row at the upriver oyster reefs, including Horsehead Rock (-36% from 2003), Mulberry Point (-8%, *P. marinus* no longer detected), Swash (-16%), Long Shoal (-40%), and Point of Shoals (-19%). (*P. marinus* was also undetected at Deepwater Shoal after no live oysters were found there in 2003.) *P. marinus* prevalences *increased* for the second year in a row at the two reefs furthest downstream, Thomas Rock (+12%) and Nansemond Ridge (+24%). In between, one-year declines were reversed, with *P. marinus* prevalence increasing at Dry Shoal (+13%) and Wreck Shoal (+28%). Infection intensities followed a similar trend, with declines at upriver beds from Horsehead Rock to Point of Shoals, and increases at downriver beds from Dry Shoal to Nansemond Ridge. Just two infections among the upper reefs reached moderate intensity (both at Swash). Among the lower reefs, moderate-heavy infections occurred much more frequently, accounting for 46% of all infections (versus 23% in 2003).

H. nelsoni, present at all Fall Survey sites in the James River in fall 2002 at prevalences ranging from 4-28% but absent in fall 2003, was recorded in October 2004 only at Thomas Rock (one light infection) and Nansemond Ridge (one rare infection).

York River

Two locations were sampled in the York River: Bell Rock, which had been sampled in 2003, and Page Rock, which had not. *P. marinus* prevalence in fall 2004 was 52% at Bell Rock and 68% at Page Rock. In 2003, prevalence had been 88% at both Bell and Aberdeen Rocks. While *P. marinus* prevalence in the York may have decreased, the mean intensity of infections increased at Bell Rock, where 69% of infections were moderate-heavy in intensity (in 2003, 50% were).

H. nelsoni was unrecorded at Bell Rock for the second year in a row, but 17% of the Page Rock sample was infected. One infection was moderate, two were light, and one was rare.

Mobjack Bay

Oysters from only two sites in Mobjack Bay, Tow Stake and Pultz Bar, were examined for disease. *P. marinus* prevalence was 63% at Tow Stake, and 78% at Pultz Bar. Only Tow Stake had been sampled in 2003. As in the York, *P. marinus* prevalence decreased in Mobjack Bay at Tow Stake (from 83% in 2003), but mean intensity increased as the proportion of moderate-heavy infections increased from 42 to 50%.

H. nelsoni was again not observed in Mobjack Bay.

Piankatank River

Two Piankatank River oyster reefs were sampled in fall 2004: Burton Point and Palace Bar. *P. marinus* prevalence was 48% at Burton and 76% at Palace, decreases of 40% and 16%, respectively. Infections were slightly less intense at Burton Point, with the number of heavy

infections falling from five in 2004 to zero in 2004, but more intense at Palace Bar, with more than half of the infections now moderate or heavy.

H. nelsoni was again not observed in the Piankatank River.

Rappahannock River

Oysters were sampled from nine Rappahannock River oyster reefs. *P. marinus* prevalence in 2004 decreased nearly everywhere, by 4-28%, from 2003 levels. The only exceptions were Parrot Rock and Hog House Rock, where prevalence increased by 4%. Infection intensities, on the other hand, generally increased everywhere except at Smokey Point and Drumming Ground. Heavy infections were more numerous, and were observed as far upriver as Long Rock.

For the second year in a row *H. nelsoni* was found in the Rappahannock River only at Hog House Rock, where it increased in prevalence in 2004. Three infections were observed here in October 2004, two light and one rare.

Corrotoman River

Middle Ground was the only Corrotoman River location surveyed. *P. marinus* was slightly less prevalent than in 2003 (84%, versus 92% in 2003), and fewer oysters had advanced infections. *H. nelsoni* was again not observed in the Corrotoman River.

Great Wicomico River

Three Great Wicomico oyster bars were sampled in the fall of 2004: Haynie Bar, Whaley's, and Fleet Point. *P. marinus* prevalence fell at all three sites, by 17-32% from 2003 levels. Infection intensities increased, though, with moderate-heavy infections now predominating at all three sites.

A single *H. nelsoni* infection was observed this year, a light infection in a Whaley's oyster.

IV. Spring Imports

In order to assess inter-annual variation in disease pressure, replicate trays of Ross Rock oysters (Rappahannock River) were established in the lower York River at VIMS on 27 April 2004 and subsequently monitored for disease through August. No infections of *H. nelsoni* or *P. marinus* were detected in oysters sampled at the time of transplantation. The number of live and dead oysters in each tray was assessed monthly from late May-August; the resulting determinations of percent monthly and percent cumulative mortalities are shown in Table 3. Relative to 2003, significant mortality began a month earlier in 2004 and increased more gradually. Cumulative mortality was low (< 12%) through early July but increased to 51% in August. Subsequent data unfortunately could not be collected, as the experimental trays were beached and buried in an early September storm, with most remaining oysters killed.

Samples for disease diagnoses were also taken monthly. *P. marinus* was first observed in the transplanted oysters in early July, a month earlier than in 2003. Prevalence of *P. marinus* at that time was 28%, 4% lower upon first appearance than in 2003. It reached a higher second-month prevalence, 100%, than in 2003, but intensity was about the same. Intensity would likely have increased in September and October samplings.

The first 2004 observation of *H. nelsoni*, in July, was also a month earlier than in 2003. The prevalence of *H. nelsoni* upon its initial discovery in the York River in 2004 was 60%, much lower than the level (92%) observed upon its first appearance in 2003. Infection intensity was also relatively lower than in 2003, when half of all infections were heavy in intensity in the first month that *H. nelsoni* was observed. *H. nelsoni* infections became more prevalent and intensified by the second month, August, when 76% of oysters were infected and most infections were moderate-heavy.

Discussion

P. marinus was distributed about as widely in lower Chesapeake Bay in 2004 as in 2003. With salinity depressed once again throughout the lower Bay and its tributaries, however, *P. marinus* prevalence continued to decline to levels not seen since 1992 or earlier. The single major exception was the lower James River, where at Dry Shoal, Wreck Shoal, Thomas Rock, and Nansemond Ridge *P. marinus* prevalence increased in October by 12-28% over October 2003. (*P. marinus* prevalence also increased slightly, by 4% over 2003, in the lower Rappahannock at Hog House Rock and Parrot Rock). Figure 4 illustrates quarterly *P. marinus* prevalence at four James River oyster bars from 1992-2004. During a period of reduced rainfall and streamflow and thus higher salinities from mid-1998 through 2002, the maximum annual prevalence of *P. marinus* converged upon 100% at all four oyster bars. In 2003, however, prevalence peaked at just 68% at Wreck Shoal, in October, and never exceeded 20% anywhere else in the James River. *P. marinus* prevalence in the other rivers followed a similar trend. Figure 6 shows average maximum annual prevalence from 1992-2004 at oyster bars in the James River, Rappahannock River, Great Wicomico River, and Piankatank River. As in the James River, *P. marinus* prevalence in the Rappahannock, Great Wicomico, and Piankatank Rivers surpassed 85% in 1999 and remained high through 2002 before declining over the last two years.

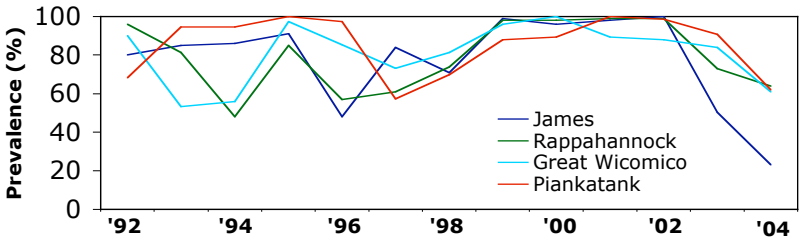

Figure 6. Mean maximum annual prevalence of *P. marinus* at oyster bars in four Chesapeake Bay tributaries, 1992-2004.

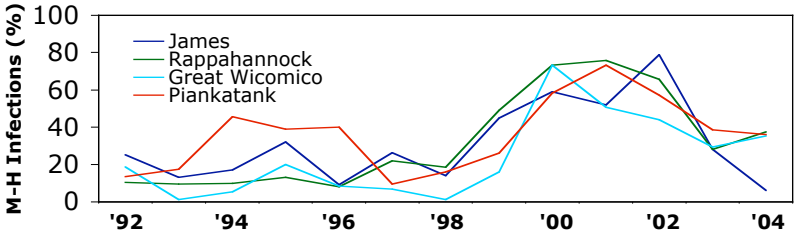

Figure 7. Mean maximum annual percentage of more intense, moderate to heavy *P. marinus* infections at oyster bars in four Chesapeake Bay tributaries, 1992-2004.

The mean maximum annual percentage of more advanced, moderate to heavy infections is another indicator of the intensity of *P. marinus* activity. The proportion of moderate-heavy infections increased at many oyster reefs in 2003, after a sharp decline in 2002 (Figure 7). The major exception to this trend was the upper James River, from Deepwater Shoal to Point of Shoals. Only two moderate infections were found in October 2004 among these six reefs, both at Swash. Increasing mean infection intensities in the context of a general decrease in *P. marinus* prevalence probably indicates intensification of pre-existing infections against a backdrop of low parasite transmission and relatively infrequent establishment of new infections.

The impact of *H. nelsoni* on oyster populations in lower Chesapeake Bay was minimal for the second year in a row. At the end of 2002, *H. nelsoni* was ubiquitous and probably causing intense disease in most of the oyster bars in Virginia. The parasite continued to be very prevalent in the James River in January 2003. However, *C. virginica* can purge *H. nelsoni*

infections at salinities below 10‰, which have been widespread in Chesapeake Bay over the last two years of abundant rainfall and high streamflows. *H. nelsoni* has retreated from most of the oyster bars it colonized during four and a half years of drought. Only a few light-rare *H. nelsoni* infections were observed anywhere. Along the western shore of the Chesapeake, *H. nelsoni* may only be generally enzootic in the lower James and York Rivers.

While *P. marinus* activity may have been reduced in 2004 by an extended period of low salinities, this does not necessarily bode well for 2005; infection prevalence and intensity of *P. marinus* will be strongly influenced by water conditions this summer. *P. marinus* persists in almost every bar oyster surveyed, and while overwintering, January 2005 prevalences were very low (≤ 16% in the James River) and intensities generally light-rare, an extended period of very warm water and high salinities could result in intense disease activity by late summer. A cooler, rainier summer, on the other hand, would probably result in another year of relatively low *P. marinus* activity.

H. nelsoni activity should be light in 2005. Unless expelled by low salinities, *H. nelsoni* normally peaks in prevalence and infection intensity in spring, as late summer-acquired, overwintering infections develop into advanced cases with resulting mortality, and again in late summer-early fall, as spring-acquired infections become advanced. With so few oysters infected by *H. nelsoni* in the fall of 2004, however, overwintering infections were probably rare to non-existent, so oyster mortality in the spring and *H. nelsoni* transmission throughout 2005 should be low. *H. nelsoni* was not observed at all in the James River this past January, and the only other years in the last thirteen in which *H. nelsoni* was not observed in January were also the only years in which spring infections were absent. In 1997 and 2004, overwintering *H. nelsoni* infections were undetectable in the James River, and the parasite did not appear until July those years at any oyster bar in the James.

Acknowledgments

This work would not have been possible without the assistance of many people. Among them, Captain Paul Oliver operated the vessels collecting quarterly James River oyster samples and the Rappahannock River spring imports; the Virginia Marine Resources Commission collected oysters for the Fall Survey; Rita Crockett, Susan Denny, Martin Wunderly, and Lauren Martin performed all the histological processing and RFTM culturing, and read the slides.

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Table 1.

Monthly survey of prevalence and intensity of *Haplosporidium nelsoni* (MSX) and *Perkinsus marinus* (Dermo) in oysters from James River harvesting areas in 2004. Inf/Ex = number infected/number examined. Infection intensity was ranked as heavy (H), moderate (M), light (L) , and rare (R) (presented as H-M-L-R).

				H. nelsoni			*P. marinus*		
Location	Date	Temp	Sal	Inf/Ex	Prev	Intensity	Inf/Ex	Prev	Intensity
Deepwater Shoal									
	21 Jan	3	14	0/9	0	0-0-0-0	0/9	0	0-0-0-0
	16 Apr	14	10	0/23	0	0-0-0-0	0/23	0	0-0-0-0
	21 Jul	30	2	0/24	0	0-0-0-0	0/24	0	0-0-0-0
	18 Oct	23	2	0/25	0	0-0-0-0	0/25	0	0-0-0-0
Horsehead Rock									
	21 Jan	3	7	0/25	0	0-0-0-0	1/25	4	0-0-0-1
	16 Apr	14	2	0/25	0	0-0-0-0	0/25	0	0-0-0-0
	21 Jul	30	4	0/25	0	0-0-0-0	1/25	4	0-0-0-1
	18 Oct	23	3	0/25	0	0-0-0-0	1/25	4	0-0-1-0
Point of Shoals									
	21 Jan	3	8	0/25	0	0-0-0-0	5/25	20	0-0-3-2
	16 Apr	14	2	0/25	0	0-0-0-0	0/25	0	0-0-0-0
	21 Jul	30	5	0/25	0	0-0-0-0	2/25	8	0-1-0-1
	18 Oct	20	5	0/25	0	0-0-0-0	5/25	20	0-0-3-2
Wreck Shoal									
	21 Jan	5	6	0/25	0	0-0-0-0	5/25	20	0-0-1-4
	16 Apr	14	1	0/25	0	0-0-0-0	2/25	8	0-0-1-1
	21 Jul	29	11	1/25	4	0-0-0-1	4/25	16	0-0-2-2
	18 Oct	20	10	0/25	0	0-0-0-0	17/25	68	2-3-11-1

Table 2.

Fall survey of prevalence and intensity of *Haplosporidium nelsoni* and *Perkinsus marinus* in oysters from Virginia oyster populations in 2004. Inf/Ex = number infected/examined. Infection intensity as heavy (H), moderate (M), light (L), and rare (R) (H-M-L-R).

				H. nelsoni			*P. marinus*		
Location	Date	Temp	Sal	Inf/Ex	Prev	Intensity	Inf/Ex	Prev	Intensity
James River									
Deepwater Shoal	18 Oct	23	2	0/25	0	0-0-0-0	0/25	0	0-0-0-0
Horsehead Rock	18 Oct	23	3	0/25	0	0-0-0-0	1/25	4	0-0-1-0
Mulberry Point	18 Oct	23	3	0/25	0	0-0-0-0	0/25	0	0-0-0-0
Swash	18 Oct	23	5	0/25	0	0-0-0-0	11/25	44	0-2-8-1
Long Shoal	18 Oct	23	5	0/25	0	0-0-0-0	2/25	8	0-0-1-1
Point of Shoals	18 Oct	20	5	0/25	0	0-0-0-0	5/25	20	0-0-3-2
Dry Shoal	18 Oct	20	7	0/25	0	0-0-0-0	20/25	80	1-7-8-4
Wreck Shoal	18 Oct	20	10	0/25	0	0-0-0-0	17/25	68	2-3-11-1
Thomas Rock	18 Oct	20	12	1/25	4	0-0-1-0	17/25	68	2-9-5-1
Nansemond Ridge	18 Oct	20	13	1/25	4	0-0-0-1	18/25	72	4-5-9-0
York River									
Bell Rock	8 Oct	22	6	0/25	0	0-0-0-0	13/25	52	1-8-4-0
Page Rock	8 Oct	21	10	4/24	17	0-1-2-1	17/25	68	0-8-8-1
Mobjack Bay									
Tow Stake	27 Sep	25	16	0/19	0	0-0-0-0	12/19	63	1-5-5-1
Pultz Bar	27 Sep	25	17	0/9	0	0-0-0-0	7/9	78	0-1-4-2
Piankatank River									
Palace Bar	12 Oct	22	12	0/25	0	0-0-0-0	19/25	76	2-9-8-0
Burton Point	12 Oct	22	13	0/25	0	0-0-0-0	12/25	48	0-7-4-1
Rappahannock River									
Ross Rock	15 Oct	22	5	0/25	0	0-0-0-0	1/25	4	0-0-0-1
Bowlers Rock	15 Oct	22	7	0/25	0	0-0-0-0	7/25	28	0-2-3-2
Long Rock	19 Oct	22	7	0/25	0	0-0-0-0	12/25	48	2-6-3-1
Morattico	15 Oct	22	9	0/25	0	0-0-0-0	19/25	76	3-6-8-2
Smokey Point	15 Oct	22	10	0/25	0	0-0-0-0	16/25	64	0-7-5-4
Hog House Rock	15 Oct	22	10	3/25	12	0-0-2-1	20/25	80	4-7-7-2
Drumming Ground	15 Oct	21	10	0/25	0	0-0-0-0	20/25	80	0-11-8-1
Parrot Rock	15 Oct	21	10	0/24	0	0-0-0-0	22/24	92	1-12-8-1
Broad Creek	15 Oct	21	11	0/25	0	0-0-0-0	22/25	88	6-8-8-0
Corrotoman River									
Middle Ground	15 Oct	21	10	0/25	0	0-0-0-0	21/25	84	1-8-11-1
Great Wicomico River									
Haynie Bar	12 Oct	20	10	0/25	0	0-0-0-0	14/25	56	0-8-6-0
Whaley's	12 Oct	21	10	1/25	4	0-0-1-0	13/25	52	0-8-5-0
Fleet Point	12 Oct	20	10	0/24	0	0-0-0-0	17/24	71	2-8-4-3

Table 3.

Mean mortality and parasite prevalence in upper Rappahannock River oysters transplanted to trays at the lower York River, Gloucester Point, VA in April, 2003. Inf/Ex = number infected/examined. Infection intensity as heavy (H), moderate (M), light (L), and rare (R) (H-M-L).

	Monthly	Cumulative	*H. nelsoni*			*P. marinus*		
Date	mortality-%	mortality%	Inf/Ex	Prev	Intensity	Inf/Ex	Prev	Intensity
27 Apr			0/25	0	0-0-0	0/25	0	0-0-0
31 May	8.44	8.44	0/25	0	0-0-0	0/25	0	0-0-0
6 July	3.42	11.58	15/25	60	1-4-8-2	7/25	28	0-1-4-2
4 Aug	44.25	50.70	19/25	76	4-7-7-1	25/25	100	6-4-13-2