7-2006

Status of the Major Oyster Diseases in Virginia 2005 A Summary of the Annual Monitoring Program

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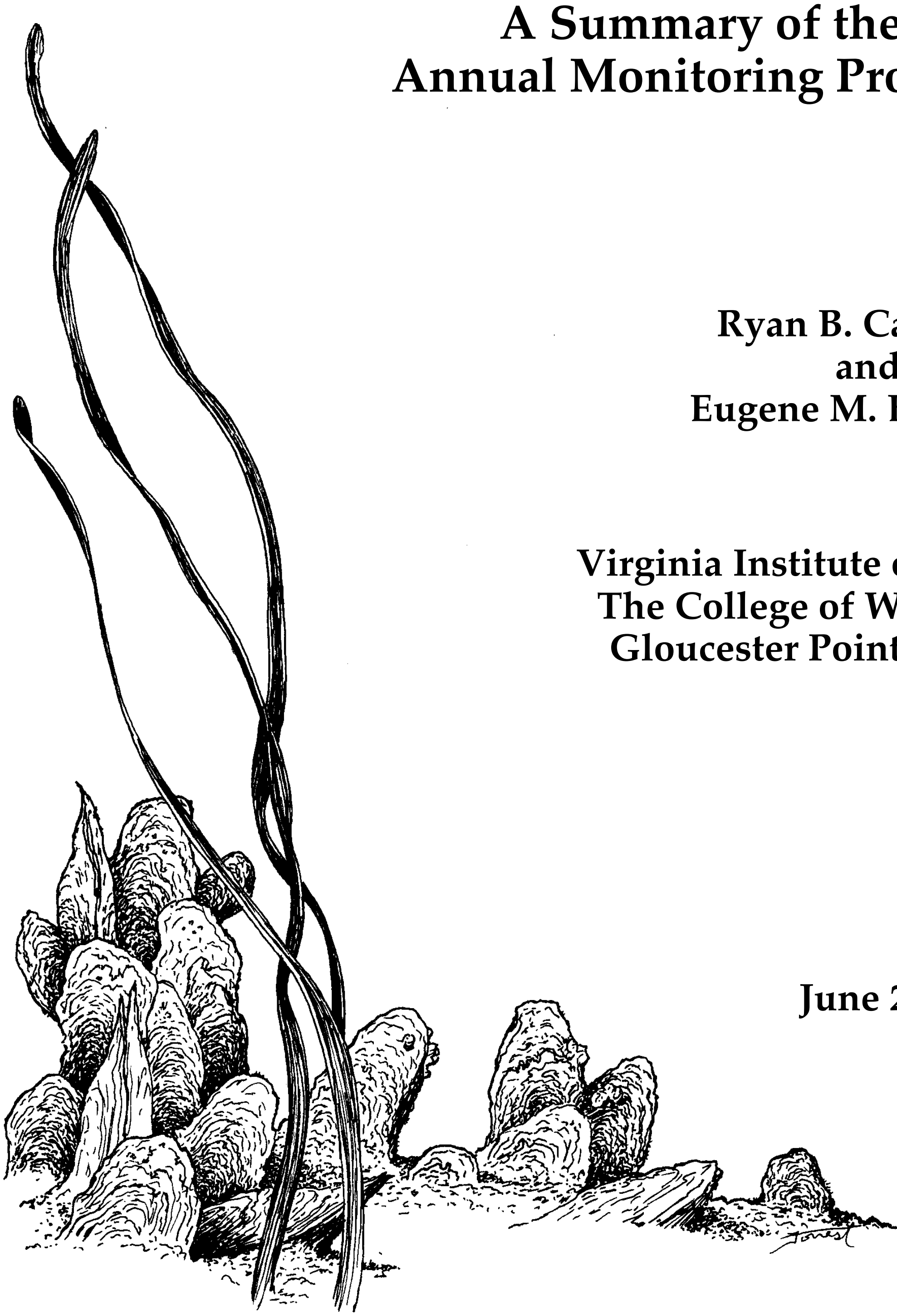

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Executive Summary

More normal riverflows and salinities returned in 2005 after two very wet years. Temperatures were somewhat colder than normal during the winter, and warmer during the summer. The physical environment was generally more favorable for parasite activity, and thus brought a slight increase in prevalence and intensity of the oyster diseases caused by *Perkinsus marinus* (Dermo) and *Haplosporidium nelsoni* (MSX). Among quarterly James River Survey sites, maximum annual *P. marinus* prevalences returned to levels typical of the mid-1990s, before the years of drought. *P. marinus* prevalence reached 92% at Wreck Shoal, 56% at Point of Shoal, 68% at Horsehead Rock, and 8% at Deepwater Shoal, where *P. marinus* was observed for the first time since early 2003. More advanced, heavy infections became more numerous, but were limited to Wreck Shoal. *H. nelsoni* was restricted to Wreck Shoal, where it increased in maximum prevalence from 4% to 20%.

Fall Survey samples revealed a general but slight intensification of both oyster diseases. *P. marinus* was already ubiquitous, but it increased in prevalence throughout much of the lower Bay, with the upper Rappahannock River being the primary exception. Infection intensities followed a similar trend, but advanced, heavy infections were rare except in the lower James, the Piankatank, and at Parrot Rock in the Rappahannock. *H. nelsoni* activity increased only slightly. It was found at a few more stations than in 2004—at Broad Creek and Middle Ground in the Rappahannock, Tow Stake in Mobjack Bay, Aberdeen Rock in the York, and at Dry Shoal, Wreck Shoal, Thomas Rock, and Nansemond Ridge in the James—but still at low prevalences and intensities. The impact of *H. nelsoni* on oysters in Virginia waters continues to be light.

Taken as a whole, the data suggest that neither parasite had a widespread serious impact on oyster populations in the survey area in 2005, and that mortality caused by these parasites was probably low, with the lower James and Rappahannock Rivers, and the York and Piankatank Rivers being the only exceptions. Disease pressure and mortality may increase, however, in 2006, as the warm winter of 2005/6 allowed *P. marinus* in particular to overwinter at high levels.

Introduction

The protozoan parasites *Haplosporidium nelsoni* (causative agent of "MSX" disease) and *Perkinsus marinus* (causative agent of "dermo") are serious pathogens of oysters in 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 2005 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 2005, 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 the York River at Yorktown 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) was obtained from the United States Geological Survey (http://waterdata.usgs.gov/nwis).

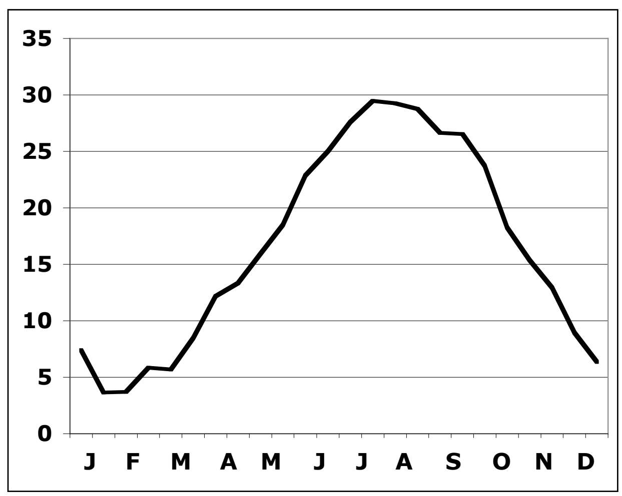

Figure 1. Semi-monthly average water temperature (°C) at Yorktown, on the York River, in 2005.

Results

I. Environmental Conditions

Both winter and summer water temperatures (Figure 1) were more extreme than normal in 2005, but for relatively short durations. Weekly average winter water temperatures in the York River typically fall below 5°C for about six weeks. Normally, they do not fall below 4°C. In 2005, temperatures were below 5°C for only about a month (mid-January to mid-February), but were below 3°C for two weeks. Weekly average summer temperatures typically exceed 20°C for 21 weeks, but do not reach 28°C. In 2005, temperatures were above 20°C for only 18 weeks, but were over 28°C for three of these.

River flows in 2005 returned to more normal levels (Figures 2, 3) for the first time since 1997. Measured in the James River at Richmond, streamflow was above average in four months out of twelve (January, April, October, and December), but never by more than 54%. Streamflow was below average in seven months (February, March, May, June, August, September, and November), but never by more than 62%. Measured salinities, depressed in 2003 and 2004, also returned to more normal levels. Relative to 2004, salinity measured during fall survey sampling was higher by 6-8 psu in the James, 11 psu in the York, 4-6 psu in Mobjack Bay, 6 psu in the Piankatank, 5-8 psu in the Rappahannock, and 8-9 psu in the Great Wicomico. James River salinities during spring and summer were close to average.

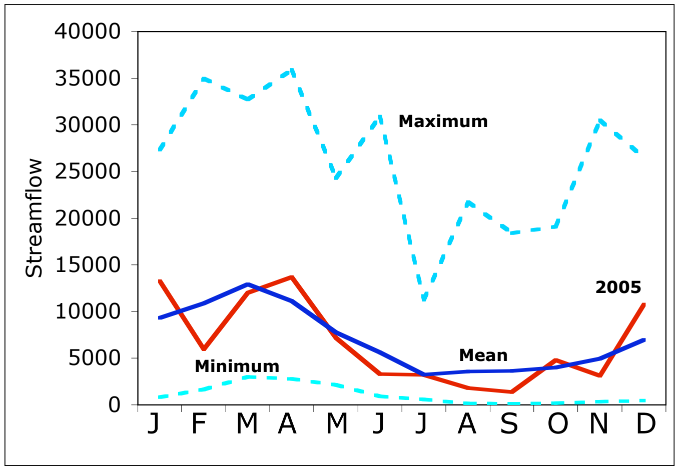

Figure 2. Average monthly streamflow (cu ft/sec) in the James River at Richmond in 2005 relative to the long-term (1935-2004) monthly average and all time maxima and minima.

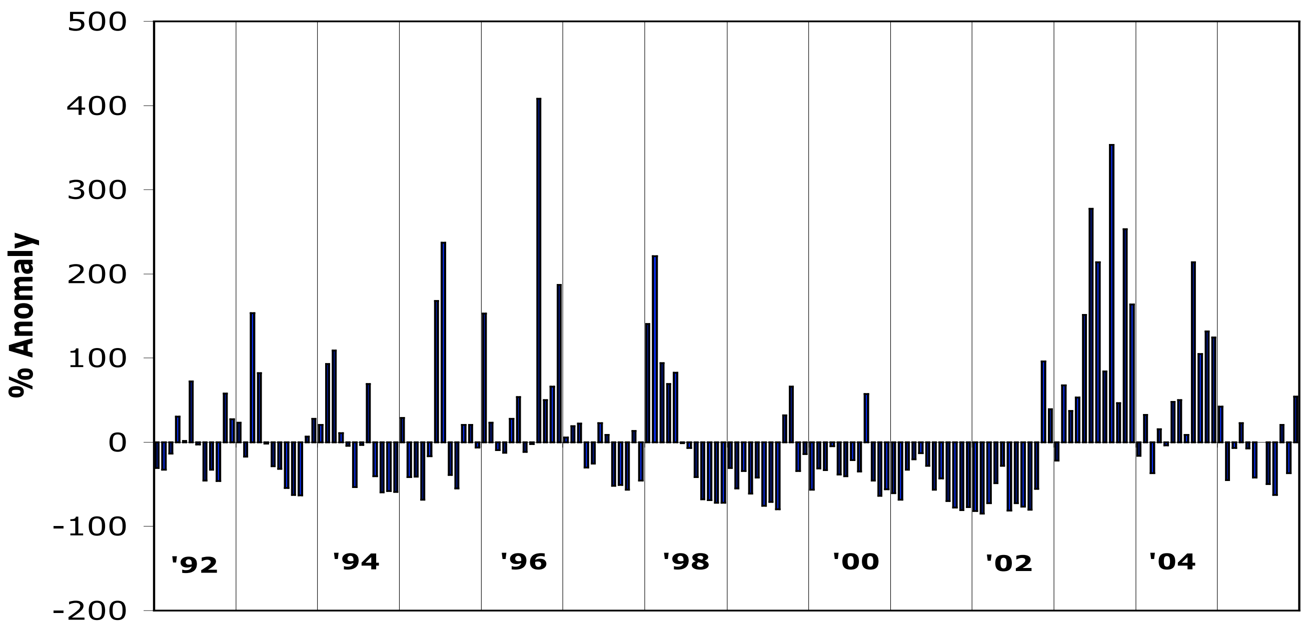

Figure 3. Average monthly streamflow anomaly, expressed in terms of % above or below long-term (1935-2004) average monthly flow in the James River at Richmond.

II. James River Survey

Perkinsus marinus

Prevalence and intensity of *P. marinus* infections increased at all James River quarterly monitoring stations in 2005 (Table 1, Figure 4). Prevalence in October 2005 exceeded 90% at Wreck Shoal, and 50% at Point of Shoal and Horsehead Rock, for the first time since 2002. Infections were observed at Deepwater Shoal for the first time since spring of 2003, but never exceeded 16% prevalence. The increase in *P. marinus* prevalence was accompanied by an increase in infection intensities. In October 2004, moderate to heavy infections were only observed at Wreck Shoal, and accounted for just 29% of infections there. In 2005, moderate to heavy infections increased in frequency at Wreck Shoal (to 48% of October infections), and moderate infections began to reemerge at Point of Shoal (5/14 October infections, 36%) and Horsehead Rock (1/17 October infections, 6%). *P. marinus* activity in the James River has returned to the level of the pre-drought years of 1996 and 1997.

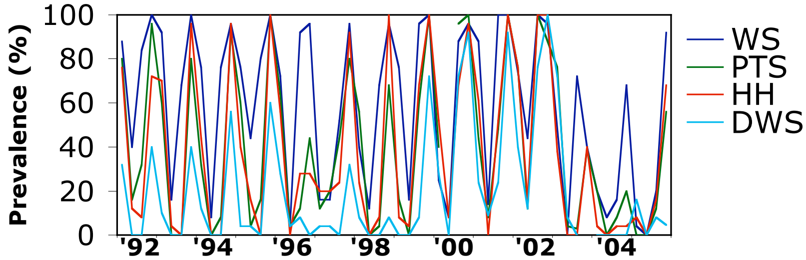

Figure 4. Quarterly prevalence of *P. marinus* in the James River at Wreck Shoal (WS), Point of Shoal (PTS), Horsehead Rock (HH), and Deepwater Shoal (DWS) from 1992-2005.

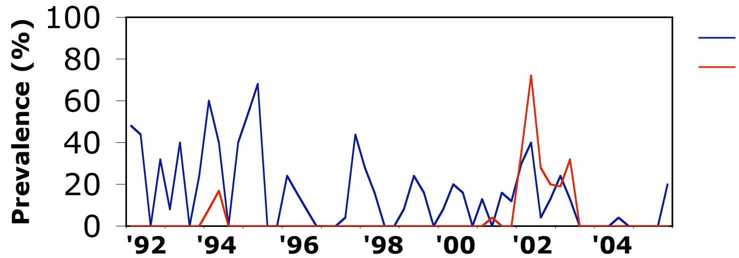

Figure 5. Quarterly prevalence of *H. nelsoni* in the James River at Wreck Shoal (WS) and Horsehead Rock (HH) from 1992-2005.

Haplosporidium nelsoni

Prevalence of *H. nelsoni* increased at Wreck Shoal, from 4% in July 2004 (and 0% in October 2004) to 20% in October 2005. One infection was moderate, three were light, and one was rare in intensity. As in 2004, *H. nelsoni* was not observed at Point of Shoal, Horsehead Rock, or Deepwater Shoal (Table 1, Figure 5).

III. Fall Survey

The fall 2005 oyster disease survey was conducted from 10 October through 11 November. Thirty 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/Corrotoman Rivers, and Great Wicomico River. Results of this survey are presented in Table 2, and described for each tributary below.

James River

Eleven James River oyster reefs were surveyed for disease in the fall of 2005. *P. marinus* prevalences increased at every site, by 5% (Deepwater Shoal) to 64% (Horsehead Rock) over

2004 levels. Prevalence reached 100% at two stations, Thomas Rock and Nansemond Ridge. Only at these two stations and Wreck Shoal, however, was serious *P. marinus*-caused mortality likely occurring. Everywhere but Nansemond Ridge, most infections were light-rare in intensity.

H. nelsoni, absent from the James River in 2003 and present at just 4% prevalence at Thomas Rock and Nansemond Ridge in 2004, expanded its range to two additional James River sites in 2005: Dry Shoal, at 16% prevalence, and Wreck Shoal, at 20% prevalence. *H. nelsoni* persisted at Thomas Rock at 8% prevalence and Nansemond Ridge at 16% prevalence. With the exception of one moderate infection at Wreck Shoal and one heavy infection at Nansemond Ridge, all autumn *H. nelsoni* infections in the James River were light-rare in intensity.

York River

Two locations were sampled in the York River: Bell Rock, which had been sampled in 2004, and Aberdeen Rock, which had not. *P. marinus* prevalence increased at Bell Rock by 48%, to 100%, with most infections moderate (two were heavy). At Aberdeen Rock, *P. marinus* prevalence was also 100%, but more infections were moderate-heavy. At both sites, serious *P. marinus*-caused mortality was likely occurring.

H. nelsoni was not observed at Bell Rock, and was present in just a single oyster in the Aberdeen Rock sample. This infection was rare in intensity.

Mobjack Bay

Oysters from only two sites in Mobjack Bay, Tow Stake and Pultz Bar, were examined for disease. *P. marinus* prevalence was 12% at Tow Stake, and 17% at Pultz Bar. Only six oysters were sampled at Pultz Bar, however, and oysters in the samples from both sites were small. Low *P. marinus* prevalences probably reflected low oyster densities at these sites and the sampling of small oysters, which would generally be expected to have lower *P. marinus* levels.

H. nelsoni was not observed in the six oysters sampled from Pultz Bar, but was present in 25% of the sample from Tow Stake, with two infections heavy and one moderate in intensity. Prevalence and intensity of *H. nelsoni* infections were higher at Tow Stake than at any other station during the fall survey.

Piankatank River

Two Piankatank River oyster reefs were sampled in fall 2005: Burton Point and Palace Bar. *P. marinus* prevalence increased from 48% to 76% at Burton Point and from 76% to 100% at Palace Bar, with a majority of infections at both sites moderate-heavy in intensity. Serious *P. marinus*-caused mortality was likely occurring at both sites.

H. nelsoni was not observed in fall survey samples from the Piankatank River.

Rappahannock River

Oysters were sampled from nine Rappahannock River oyster reefs. *P. marinus* prevalence in 2005 continued to decrease, by 4-26% from 2004 levels, at every station above Parrot Rock. From Ross Rock to Hog House Rock, most observed *P. marinus* infections were light-rare in intensity, and *P. marinus*-caused mortality was probably not serious. The only exceptions were Parrot Rock and Hog House Rock, where prevalence increased by 4%. *P. marinus* prevalence increased in the lower Rappahannock, from 92% to 100% at Parrot Rock and from 88% to 96% at Broad Creek. At Broad Creek, however, the proportion of advanced moderate-heavy infections decreased, so *P. marinus*-caused mortality, while still serious, may have decreased as well. Most infections at Parrot Rock were moderate-heavy in intensity, and *P. marinus*-caused mortality here was probably severe.

Among fall survey samples from the Rappahannock River, *H. nelsoni* was only found in a single oyster from Broad Creek. This infection was light in intensity.

Corrotoman River

Middle Ground was the only Corrotoman River location surveyed in 2005. *P. marinus* was slightly less prevalent than in 2004 (73%, versus 84% in 2004), but as in Mobjack Bay, low prevalence here could reflect a low density of larger oysters. All infections were moderate-heavy in intensity.

A light *H. nelsoni* infection was observed in 1/11 oysters sampled.

Great Wicomico River

Three Great Wicomico oyster bars were sampled in the fall of 2004: Haynie Bar, Whaley's/East Crane's Creek, and Fleet Point. *P. marinus* prevalence fell at Whaley's/East Cranes Creek, from 52% to 43%, but only fourteen oysters were sampled, and the low *P. marinus* prevalence could reflect the paucity of larger, older oysters. *P. marinus* prevalence increased from 71% to 76% at Fleet Point, and from 56% to 88% at Haynie Bar. Infection intensities were generally light-rare, and the *P. marinus*-caused mortality in the Great Wicomico River in 2005 was probably not serious.

H. nelsoni infection was not observed in fall survey samples from the Great Wicomico River in 2005.

IV. Spring Imports

In order to assess inter-annual variation in disease pressure, replicate trays of Ross Rock (Rappahannock River) oysters were established in the lower York River at VIMS on 25 April 2005 and subsequently monitored for disease through October. 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 June-October; the resulting determinations of percent monthly and percent cumulative mortalities are shown in Table 3. Onset and degree of mortality through August were not different from 2004. Cumulative mortality was low (< 13%) through early July but increased steadily to 75% by October.

Samples for disease diagnoses were also taken monthly. *P. marinus* was first observed in the transplanted oysters in early June, a month earlier than in 2004 and two months earlier than in 2003. Prevalence of *P. marinus* at that time was 17%, 11% lower upon first appearance than in 2004. Second-month *P. marinus* prevalence was only 12%, versus 100% in 2004. Heavy *P. marinus* infections first appeared in September, one month later than in 2004.

The first 2005 observation of *H. nelsoni* was in July, the same month it first appeared in 2004. The prevalence of *H. nelsoni* upon its initial discovery in the York River in 2005 was 28%, far below the levels of first appearance in 2004 (60%) and 2003 (92%). Infection intensities were also relatively lower than in previous years. The frequency of moderate-heavy *H. nelsoni* infections never exceeded 50% of all infections, or 25% of a sample.

Discussion

P. marinus was distributed only slightly more widely in 2005 than in 2004: reappearing at Mulberry Point and Deepwater Shoal in the James River, while disappearing from Ross Rock in the Rappahannock. Still, *P. marinus* is essentially ubiquitous in Virginia waters, with Ross Rock being the only location in which *P. marinus* was not observed. With the return of normal river flows and thus salinities, however, prevalence of *P. marinus* in Virginia waters once again generally began to rise. Figure 6 shows average maximum annual prevalence from 1992-2005 at oyster bars in the James, Rappahannock, Great Wicomico, and Piankatank Rivers. During the drought years, *P. marinus* prevalence converged upon 100% at all locations surveyed. The wet years of 2003 and 2004 brought *P. marinus* prevalences to record lows. In 2005, prevalences climbed once again to pre-drought levels. The only exception to this trend was the upper Rappahannock. P. marinus prevalence decreased at stations above Parrot Rock.

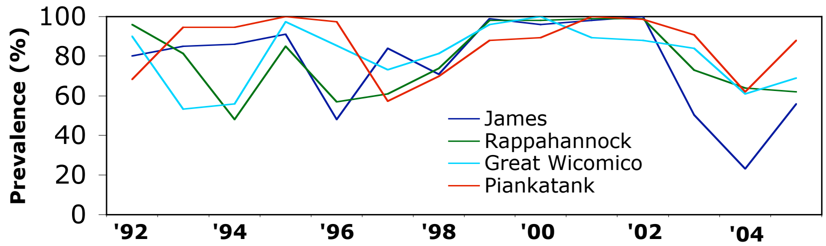

Figure 6. Mean autumn prevalence of *P. marinus* at oyster bars in four Virginia rivers, 1992-2005.

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 2005, after declining sharply in 2003 and stabilizing in 2004 (Figure 7).

The impact of *H. nelsoni* on oyster populations in lower Chesapeake Bay was minimal for the third 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 were widespread in Chesapeake Bay over the two years (2003-2004) of abundant rainfall and high streamflows. *H. nelsoni* retreated from most of the oyster bars it colonized through four and a half years of drought during this time. In 2005, *H. nelsoni* become somewhat more abundant, but its range was still restricted to the lower parts of the major Virginia rivers (the James, York, and Rappahannock), as well as the Lynnhaven River, Mobjack Bay, and the Eastern Shore. Increasing natural resistance to *H. nelsoni* is likely contributing to its diminished disease impact.

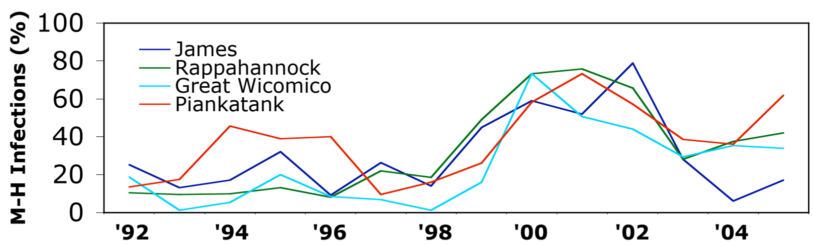

Figure 7. Mean maximum autumn percentage of more advanced, moderate to heavy *P. marinus* infections at oyster bars in four Chesapeake Bay tributaries, 1992-2005.

P. marinus activity in 2006 may be heavy, in particular because the warm winter of 2005/6 translated to high overwintering levels of this parasite. If the generally droughty conditions of the spring of 2006 continue through the summer, heavy *P. marinus* activity may extend into upstream areas normally free of serious dermo disease. *H. nelsoni* activity should continue to be light in 2006. The very heavy rains throughout the region in late June 2006 greatly increased river flows and decreased salinities, which should ensure that extensive colonization of upstream oyster beds by *H. nelsoni* will not occur this year.

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 and Melissa Southworth collected oysters for the Fall Survey; and Rita Crockett, Susan Denny, Nancy Stokes, Kristina Hill, and Corinne Audemard from the VIMS Shellfish Pathology Laboratory, with workship assistance from Jessica Moss and Margaret Fagan, performed all the processing and diagnostics.

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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 2005. 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									
	25 Jan	4	7	0/25	0%	0-0-0-0	4/25	16%	0-0-0-4
	11 Apr	17	0	0/7	0%	0-0-0-0	0/7	0%	0-0-0-0
	11 Jul	31	5	0/25	0%	0-0-0-0	2/25	8%	0-0-0-2
	26 Oct	16	10	0/22	0%	0-0-0-0	1/22	5%	0-0-1-0
Horsehead Rock									
	25 Jan	4	11	0/25	0%	0-0-0-0	2/25	8%	0-0-0-2
	11 Apr	17	0	0/25	0%	0-0-0-0	0/25	0%	0-0-0-0
	11 Jul	30	7	0/25	0%	0-0-0-0	4/25	16%	0-2-0-2
	26 Oct	16	12	0/26	0%	0-0-0-0	17/25	68%	0-1-14-2
Point of Shoals									
	25 Jan	4	11	0/25	0%	0-0-0-0	0/25	0%	0-0-0-0
	11 Apr	16	0	0/25	0%	0-0-0-0	0/25	0%	0-0-0-0
	11 Jul	29	9	0/25	0%	0-0-0-0	3/25	12%	0-1-1-1
	26 Oct	16	12	0/25	0%	0-0-0-0	14/25	56%	0-5-5-4
Wreck Shoal									
	25 Jan	4	15	0/25	0%	0-0-0-0	1/25	4%	0-1-0-0
	11 Apr	15	3	0/25	0%	0-0-0-0	0/25	0%	0-0-0-0
	11 Jul	29	12	0/25	0%	0-0-0-0	5/25	20%	0-1-2-2
	24 Oct	18	17	5/25	20%	0-1-3-1	23/25	92%	5-6-12-0

Table 2.

Fall survey of prevalence and intensity of *Haplosporidium nelsoni* and *Perkinsus marinus* in oysters from Virginia oyster populations in 2005. 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	26 Oct	16	10	0/25	0%	0-0-0-0	1/22	5%	0-0-1-0
Mulberry Point	26 Oct	16	11	0/25	0%	0-0-0-0	9/25	36%	0-0-8-1
Horsehead Rock	26 Oct	16	12	0/26	0%	0-0-0-0	17/25	68%	0-1-14-2
Moon Rock	11 Nov	ND	ND	0/25	0%	0-0-0-0	13/25	52%	0-2-11-0
Point of Shoals	26 Oct	16	12	0/25	0%	0-0-0-0	14/25	56%	0-5-5-4
Swash	26 Oct	16	12	0/25	0%	0-0-0-0	16/25	64%	0-1-14-0
Long Shoal	26 Oct	16	13	0/24	0%	0-0-0-0	17/24	71%	1-9-6-1
Dry Shoal	26 Oct	16	14	4/25	16%	0-0-4-0	22/25	88%	1-13-8-0
Wreck Shoal	24 Oct	18	17	5/25	20%	0-1-3-1	23/25	92%	5-6-12-0
Thomas Rock	24 Oct	18	19	2/25	8%	0-0-1-1	24/24	100%	4-6-14-0
Nansemond Ridge	24 Oct	18	19	4/25	16%	1-0-2-1	25/25	100%	5-11-9-0
York River									
Bell Rock	11 Oct	22	17	0/25	0%	0-0-0-0	25/25	100%	2-16-5-2
Aberdeen Rock	11 Oct	23	21	1/25	4%	0-0-0-1	25/25	100%	4-18-3-0
Mobjack Bay									
Tow Stake	10 Oct	23	22	7/25	28%	2-1-3-1	3/25	12%	0-0-3-0
Pultz Bar	10 Oct	22	21	0/6	0%	0-0-0-0	1/6	17%	0-1-0-0
Piankatank River									
Palace Bar	12 Oct	22	18	0/25	0%	0-0-0-0	25/25	100%	3-11-8-3
Burton Point	12 Oct	22	19	0/25	0%	0-0-0-0	19/25	76%	6-11-2-0
Rappahannock River									
Ross Rock	14 Oct	20	10	0/25	0%	0-0-0-0	25/25	100%	0-0-0-0
Bowlers Rock	14 Oct	20	13	0/25	0%	0-0-0-0	3/25	12%	0-0-1-2
Long Rock	14 Oct	21	15	0/25	0%	0-0-0-0	10/25	40%	2-6-1-1
Morattico	14 Oct	21	17	0/25	0%	0-0-0-0	12/24	50%	1-2-6-3
Smokey Point	14 Oct	21	16	0/25	0%	0-0-0-0	11/25	44%	0-7-3-1
Hog House Rock	14 Oct	20	16	0/20	0%	0-0-0-0	14/20	70%	1-5-3-5
Drumming Ground	14 Oct	21	18	0/25	0%	0-0-0-0	18/25	72%	4-2-10-2
Parrot Rock	12 Oct	22	18	0/25	0%	0-0-0-0	25/25	100%	8-14-3-0
Broad Creek	12 Oct	22	19	1/25	4%	0-0-1-0	24/25	96%	1-12-9-2
Corrotoman River									
Middle Ground	14 Oct	21	18	1/11	9%	0-0-1-0	8/11	73%	1-7-0-0
Great Wicomico River									
Haynie Bar	17 Oct	19	18	0/25	0%	0-0-0-0	22/25	88%	1-12-6-3
Whaley's/E. Cranes	17 Oct	19	19	0/14	0%	0-0-0-0	6/14	43%	0-3-3-0
Fleet Point	17 Oct	19	19	0/25	0%	0-0-0-0	19/25	76%	1-6-9-3

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, 2005. 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**
25 Apr			0/25	0%	0-0-0	0/25	0%	0-0-0-0
1 June	5.1%	5.1%	0/23	0%	0-0-0	4/23	17%	0-0-0-4
6 July	8.1%	12.9%	7/25	28%	0-1-1-5	3/25	12%	0-1-0-2
5 Aug	15.6%	26.4%	20/25	80%	2-2-14-2	14/25	56%	2-3-7-2
8 Sept	31.0%	46.5%	12/24	50%	1-5-5-1	24/24	100%	4-17-3-0
6 Oct	57.3%	75.1%	10/25	40%	1-3-7-0	25/25	100%	7-18-0-0