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Field-testing of disease resistant eastern oysters in Chesapeake Bay

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NARRATIVE:

Restoring water quality within Chesapeake Bay will be greatly aided by biological filtration as performed by filter feeding organisms in addition to chemical and physical treatments. Oysters are a prime candidate to fill the role of reducing the effects of excess phytoplankton and associated eutrophication due to their high capacity for fitration. This "top-down" as opposed to the traditional "bottom-up" strategy can be highly cost effective. For example, conservative estimates of expenditures by participants in the Chesapeake Bay Program during the period 1984 - 1993 totalled $2.3 billion for nutrient reductions that included point and non-point source and combined sewer overflow. While "bottom-up" measures have significantly reduced phosphorus, they have done little to reduce nitrogen which is a primary cause of eutrophication in the Bay. Near the turn of the century, prior to being overharvested and stressed by pollution and disease, oysters are estimated to have had the capacity to filter the entire volume of Chesapeake Bay in approximately 1 week, removing 20-40% of the daily carbon. No technological achievement can rival this level of cleansing! Recent estimates by VMRC indicate that it requires between $6,000 - 65,000 per acre to construct viable reefs depending on the types of materials used. Assuming that 5% of the Bay's 11.5 billion m^2 surface area is amenable to oyster survival, then reefs could conceivably cover 142,080 acres of the Bay. Further assuming that the cost to construct reefs is midway within the estimated range, say $20,000 per acre, then the same 10 year expenditure devoted to oysters and other living resources would have had a much greater effect by promoting the removal of particulate carbons from the system, contributing to improved clarity of the water column, and enhancing SAV.

Unfortunately, the oysters currently residing in the Bay are a mere vestige of the once abundant population. Those that remain are intolerant of the exotic diseases Dermo and MSX that now threaten the remaining native Chesapeake oysters. Some individuals who are unaware of the negative consequences of introducing exotic species have suggested introducing the Japanese oyster *Crassostrea gigas* to fill the ecological void. The known negatives associated with such a proposal include gametic competition with the indigenous *C. virginica*, the fact that *C. gigas* does not prosper under the low salinity conditions that prevail in the majority of the Bay, and infestation of *C. gigas* with pests, parasites, and viral diseases that are not native to Chesapeake Bay. There is hope, however, for eventually restoring oysters to Chesapeake Bay and reaping the free filtration services a flourishing oyster population would provide. Other geographic strains of the indigenous eastern oyster, *C. virginica*, have been demonstrated to tolerate the challenge of disease while continuing to grow and reproduce at some Bay sites. For example, we know that some oysters that demonstrate outstanding performance at low salinity may perish at high salinity due to the effects of disease.

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Likewise, an oyster strain that performs well at high salinity may perish when subjected to synergistic stresses of low salinity and low temperature. In fact, it is likely that introduction of several strains of oyster will be required for the most effective restoration and culture of oysters in the wide variety of lower Chesapeake regions. This study involves testing of disease tolerant oyster stocks best suited to the lower Bay and will identify several optimum locations of suitable habitat for aquaculture and restoration purposes. Growth, disease tolerance, and survival are being assessed monthly for each of six oyster strains cultivated under three salinity regimes: low, moderate, and high.

The specific objectives of this project are fourfold:

① Evaluate several potentially suitable oyster strains for aquaculture and replinishment programs in lower Chesapeake Bay;

② Evaluate growth rates, disease tolerance, and survivability of various oyster stocks over an 18 month period;

③ Identify oyster strains most suited for culture in the wide range of salinities that occur in the lower coastal zone; and

④ Demonstrate the beneficial economic application of aquaculture to restoration of this local resource.

Experimental Design:

Broodstock oysters were collected from geographically distinct eastern oyster populations (Table 1). They were conditioned and spawned at Horn Point Environmental Laboratory in Maryland by cooperative agreement and disease-free spat were shipped directly to the Ecological Genetics Lab at VCU. Spat from each group were deployed in the Fall of 1995 at three coastal zone sites in lower Chesapeake Bay. The sites were selected by accessibility and salinity (low: 10 °/oo, moderate: 20 °/oo, and high: 32 °/oo). Growth rates, disease tolerance and survivability of six strains have been monitored monthly and will continue for a total of approximately 18 months.

The six oyster groups are being cultivated side-by-side in floating rafts as previously described by Brown *et al*. 1993, 1994, and 1995. Spat were held initially in small-mesh bags within floating trays. As they have grown, they have been transferred to successively larger mesh sizes in the floating trays. Growth is determined monthly by measuring both shell length (mm) and wet/dry tissue weight (g). All measurements except mortality are determined by randomly selecting approximately 25 oysters from each strain at each site. Mortality is recorded monthly for all members of each treatment. Individual representatives of each group at each site are sacrificed monthly for condition assessment and disease analysis according to Paynter and DiMichele (1990). All of these operations are conducted through the Ecological Genetics Lab at VCU.

Table 1. Oyster strains currently being tested in the coastal zone/lower Chesapeake Bay for growth, disease, and survival.

Strain	Origin of Broodstock
1.	Upper Chesapeake Bay
2.	North Carolina
3.	South Carolina
4.	Texas
5.	Louisiana
6.	Louisiana (Triploid)

Progress:

The project was begun by introducing five strains of eastern oyster, *Crassostrea virginica*, during September, October and November 1995 at four lower Chesapeake Bay sites[1]. The geographic range of native *C. virginica* strains tested includes synchronously spawned oysters from Texas, Louisiana, South Carolina, North Carolina, and Chesapeake Bay. Each of the four geographically estranged strains was hybridized to Chesapeake Bay oysters to produce the four hybrid groups and one pure Chesapeake Bay group introduced in September which we are now tracking. A sixth strain, triploid *C. virginica* denoted 3N, was introduced in July 1996. To avoid differential treatment of any one set of oysters, the five strains were identified by the numbers 16, 17, 18, 19, and 20. At present, with the exception of the triploids, the study is blind and we cannot yet determine which of the five strains originated from which geographic location.

Non-disease mortality was noted at various times during the study due to pests and predators, noteably crabs, tunicates, and an as yet unclassified parasitic worm. Crab induced mortality was limited to very small oysters (< 10 mm) at a single site. Tunicates compete with the oysters for space during specific times of the year at one site. Exceedingly high barnacle sets occasionally occur on the trays requiring tray maintenance. The worm infestation, which also occurred at only one site, was terminated by chemical treatment of the oyster shells. This infestation was one of several times that unscheduled (non-monitoring) trips were necessary. Other unscheduled trips have been necessary to retrieve trays that have broken loose from their tethers and to salvage repair damage following Hurricane Fran and other severe storm events.

Evaluation of growth rate, survivability, and disease tolerance began in October 1995. Oyster groups ranged from 7 - 16 mm average length at the time they were deployed. Growth has progressed at each site at anticipated rates resulting in a current range of sizes from 30 mm at the low salinity site to 59 mm at the high salinity site. Growth, condition, disease and survival differences among the groups are minor at this point (Figures 1, 2, 3, and 4). Cumulative non-disease mortality (due to pests and predators; in particular, smothering by tunicates) is currently 30% or less regardless of site. Distinct site-dependent mortality differences became apparent during September 1996, being extremely limited at low salinity

[1] Gloucester County (low salinity), Matthews County (low to moderate salinity) and two sites in Virginia Beach (moderate salinity and high salinity)

sites (< 20%) and increasing rapidly at the moderate and high salinity sites to approximately 60% (Figure 4). Our disease analyses indicate that Dermo is a substantial cause of mortality in the moderate and high salinity sites (Figure 3), as predicted.

Products/Deliverables:

We projected that by the end of year one of the project, several potentially suitable oyster strains would be identified and deployed for use in aquaculture and replenishment in lower Chesapeake Bay regions of various salinities. This has been accomplished for six strains and four sites. Substantial progress has been made toward completing the products and deliverables projected for year two of the project.

COMMENTS:

We had originally created the budget in anticipation that the VIMS disease analysis facility could be contracted to analyze our 375 oysters per month as follows:

> ***F. Contractual:*** Disease analyses (Dermo and MSX) will be contracted to the lowest qualified bidder in accordance with the Virginia Public Procurement Act. The request for bids will be handled by the VCU Procurement Office and will be preapproved by the VCRMP staff prior to execution.

With the departure of Dr. Perkins, VIMS experienced a tremendous increase in the numbers of oysters to be analyzed. By the time we received funding approval, VIMS could not accommodate our request. Therefore, VIMS generously trained our own staff to perform the necessary disease analyses. Dermo (*Perkinsus*) analyses are very time-consuming, requiring approximately 2 persons to spend 3.5 - 4 days per month to prepare, incubate, and microscopically examine 375 individual oyster samples. For MSX, duplicates of each sample are being archived for later analysis if it is suspected that *Haplosporidium* might be the cause of any otherwise unexplained mortalities. The necessity of doing disease analyses caused us to spend considerably more than was originally budgeted in the supply and personnel categories during the first and second quarters of the project. The VCU lab is now set up and running smoothly and much less is expected to be spent on supplies during the remainder of the project.

The cost for VCU to perform the disease analyses in our own lab is currently $782 per month ($0.50 per sample in supplies and 64 hours total time spent to perform the analyses) which totals $9390 per year in unanticipated cost to successfully complete the study. As a result of the increased work load, NOAA funds were totally expended as of 1 July 1996 leaving a shortfall of approximately 3 months. To partially address the shortfall, the budget was amended by moving the funds originally budgeted for contracting disease analysis ($2,200) to the personnel category and funds from travel ($1,200) to supplies. The difference has been paid by contributions from Dr. Brown ($11,489) and Chesapeake Scientific ($1200) totalling $12,689 to date. The ammended budget outlines a 1:1 state match for this project. At the completion of year one, state matching has been exceeded by 53%. Without assistance to correct this disparity, it is expected that total state matching funds for the project will exceed $70,261 by the end of the second year. This translates to a 1:1.6 match.

Fig 1. Size of oysters at four sites in lower Chesapeake Bay

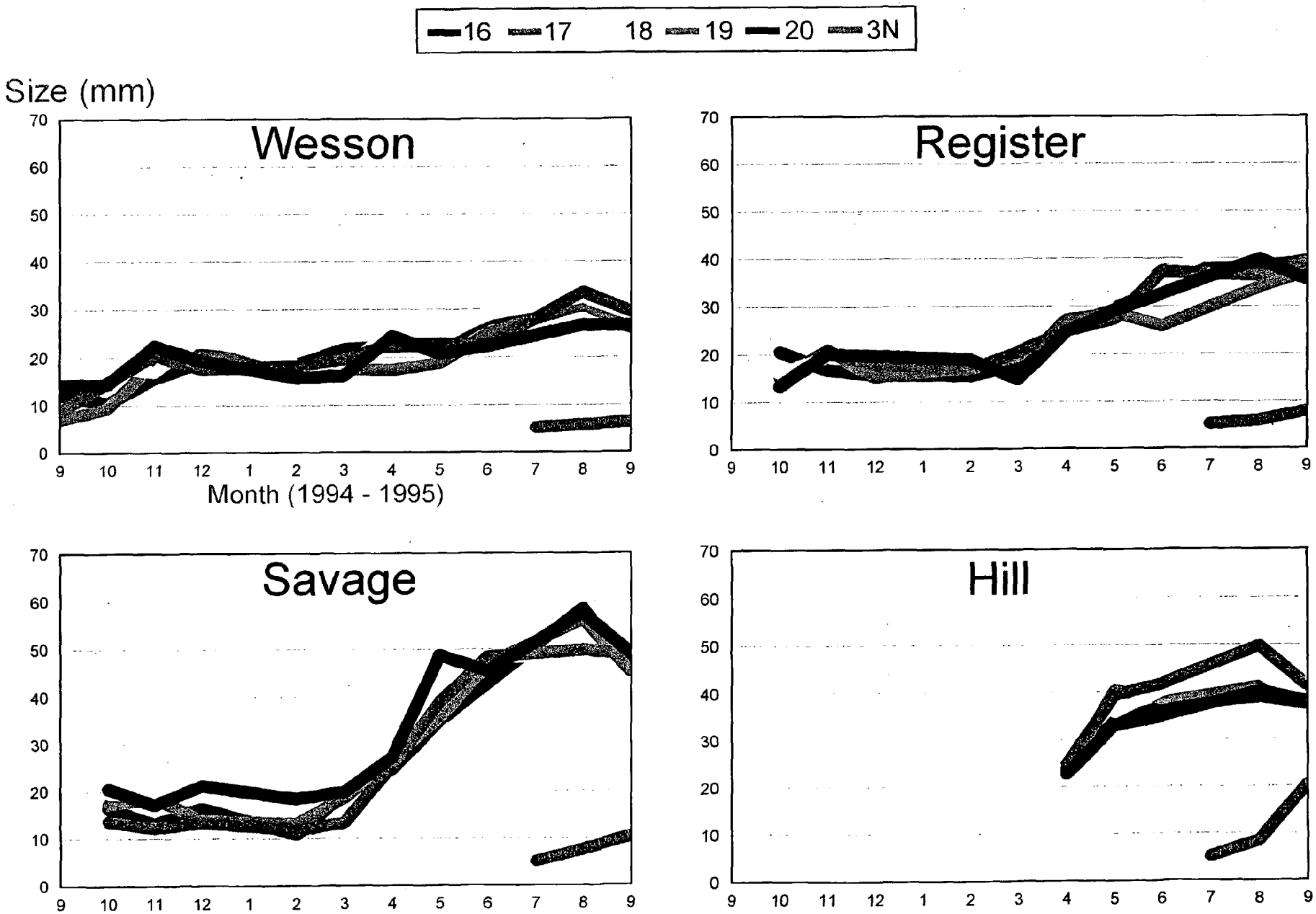


Fig 2. Cumulative disease-induced mortality of oysters at four lower Chesapeake Bay sites

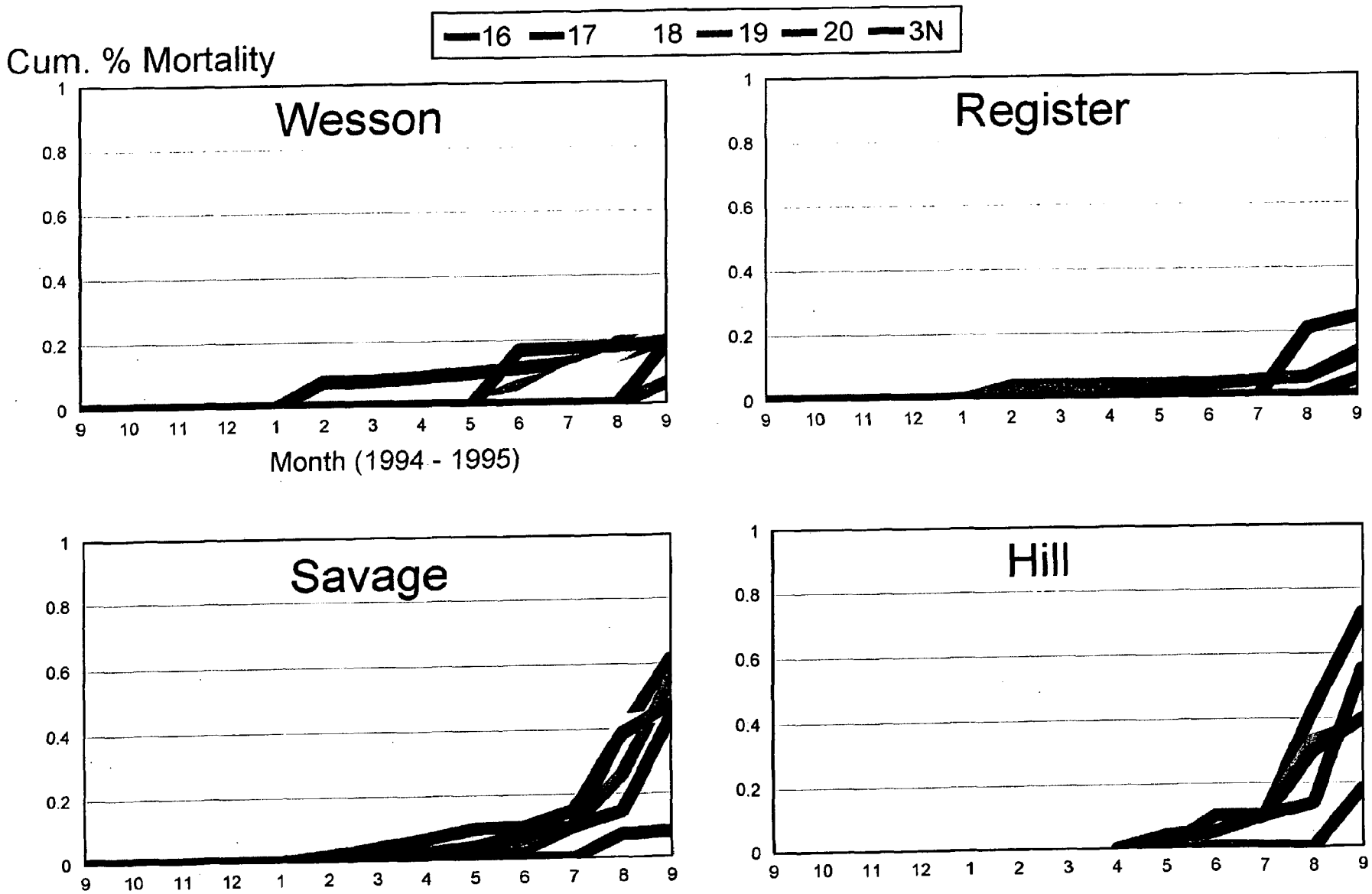


Fig 3. Condition index at four lower Chesapeake Bay sites

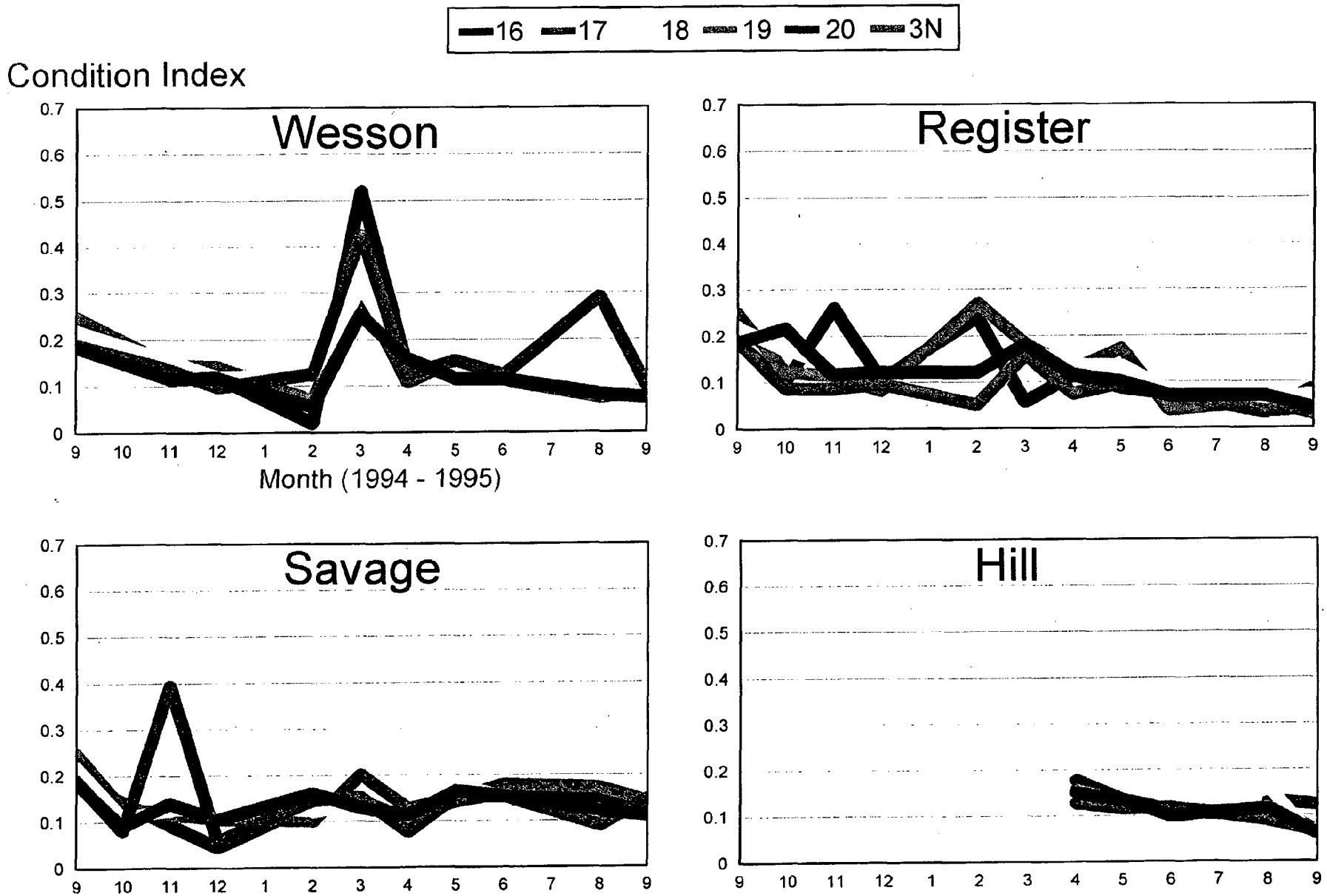
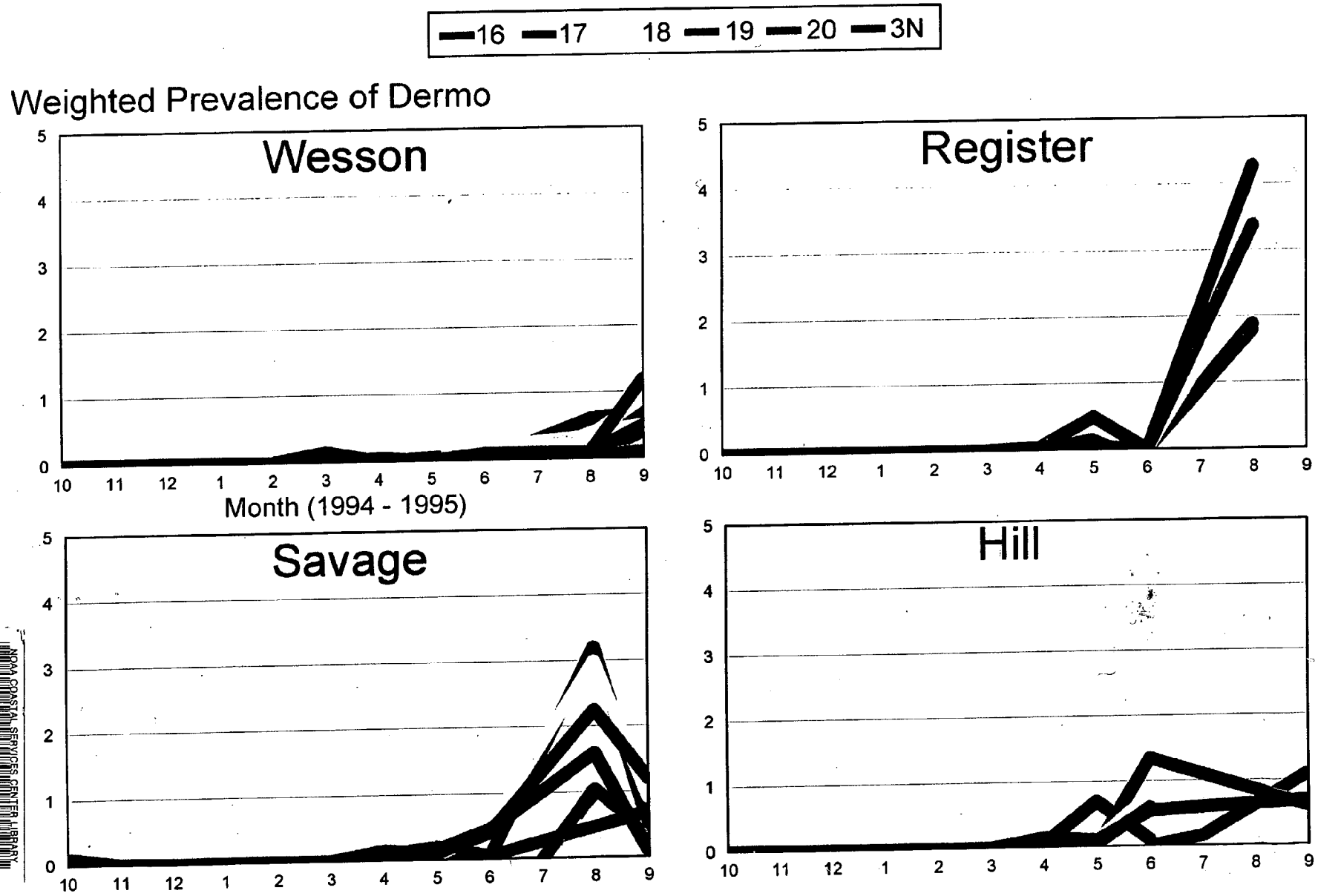


Fig 4. Incidence of disease (Dermo) at four lower Chesapeake Bay sites



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