

Comprehensive Evaluation of Nearshore Fecal Coliform Distribution in Shellfish Growing Waters

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Compliance Monitoring Division



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Introduction:

A shift in the shellfish industry in the mid-Atlantic states from deep water harvest to nearshore, shallow water float aquaculture has raised public health concerns for the environmental agencies and individuals that have been responsible for regulating the industry. Historically, the establishment of bacterial water sample monitoring locations, in addition to characterizing surrounding water quality, has been decided on the distribution of natural shellfish beds as well as practical aspects including water depths suitable for navigation. The bacterial data (fecal coliform) generated from the monitoring stations are then used to classify the shellfish harvesting waters.

The concentration of shellfish nearshore, and its association with a dock or pier, presents unique problems for consideration. Due to the shallow water and the close proximity to potential pollution sources, the classification of shellfish harvesting waters using data from the current, offshore stations may not be representative of the water quality nearshore. Any pollution event occurring on land will have an immediate and demonstrative impact on the nearshore water quality, which may not necessarily be captured by the current monitoring regime.

Recent studies have demonstrated that nearshore zones within approved shellfish harvesting waters can be areas of elevated bacteria levels (Beatty et al., 2000). Due to a limited assimilative capacity and proximity to bacteria sources such as urban and agricultural run-off, failing onsite waste disposal systems, storm water run-off, and wildlife that inhabit surrounding rivers and streams, nearshore zones may degrade rapidly. A more thorough investigation of the distribution of bacteria within these zones was needed to provide an understanding of the potential impact to the shellfish being grown in these areas, as well as the possible public health implications of a subsequent harvest. The present study selected an assortment of sites that captured a wide cross section of these unique characteristics typically found throughout shellfish harvesting areas and attempted to characterize the fecal coliform bacteria levels in those nearshore zones.

The intent of this study was to determine whether current monitoring sites in approved shellfish harvesting waters are reflective of the water quality nearshore. This investigation also attempted to delineate at what distance from the shoreline the water quality consistently met the criteria for approved status for those sites that have nearshore zones with elevated bacteria.

Study Methods:

A water quality study was conducted in order to evaluate the bacteriological characteristics of nearshore waters in the Maryland portion of the Chesapeake Bay and Coastal Bays. Twenty-three nearshore sites were chosen (see Figure 1) to include a range of physical conditions such as open and confined watersheds, developed and undeveloped shorelines, variable land uses, assorted shoreline characteristics, and high and low flushing tributaries. Additionally, sites were selected in approved or

conditionally approved shellfish waters, within areas of active harvesting (oyster and/or clam), and were closely associated with a regularly monitored sampling station that was used to classify the water body in which the nearshore study sites were located.

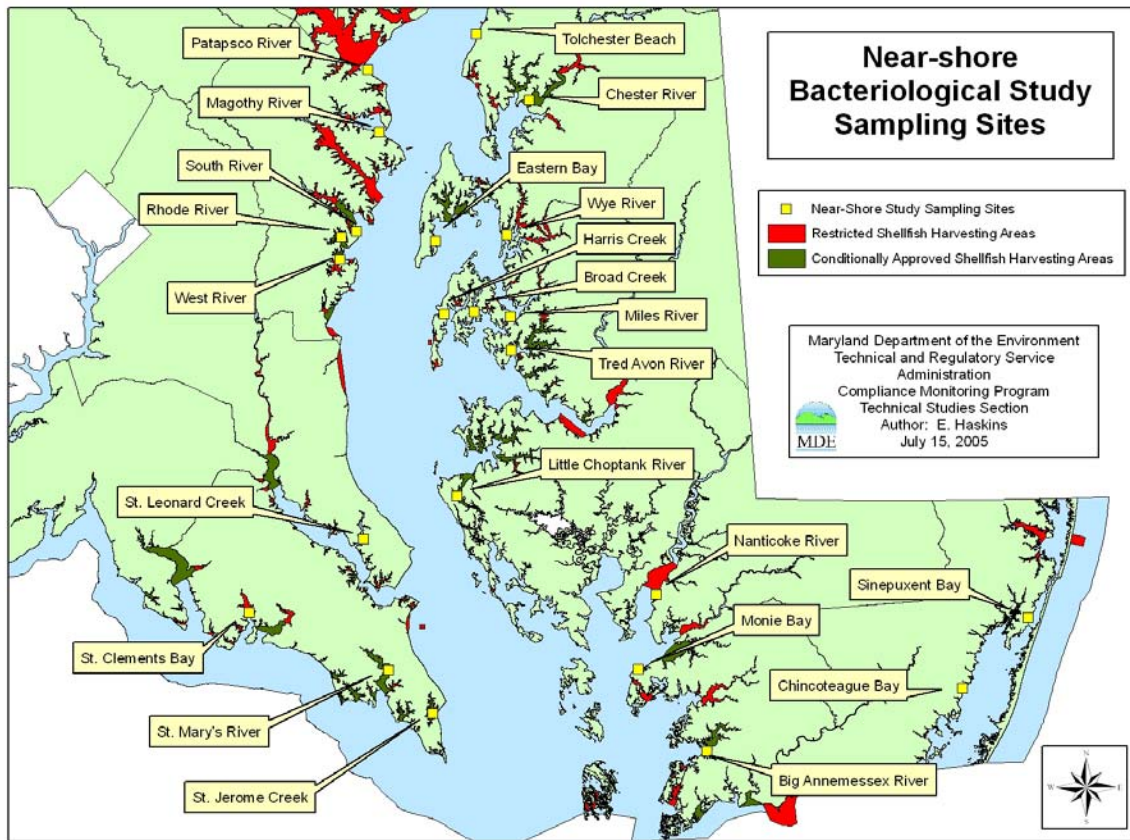


Figure 1. Locations of nearshore study sites

Sample stations at each study site were distributed perpendicular from the shoreline and extended to 150 feet (ft) offshore. Bacteriological water samples were collected from each sample site dock at the following intervals beginning at the mean high water mark: 5 ft, 10 ft, 15 ft, 25 ft, 35 ft, 50 ft, 75 ft, 100 ft, 125 ft, and 150 ft for a total of 10 samples per site. Each station was marked with Geographic Positioning System (GPS) coordinates and the surfaces of the docks were marked so that sample collections could be replicated at an exact location during each sampling event. Site characteristic profile forms were developed and utilized to obtain standardized information for each site including location and bathymetry data. Appendix A contains a compilation of the data generated from the site profile forms. In addition, measurements of physical water quality parameters were collected at the 5 ft, 75 ft, and 150 ft station locations using Hach Environmental's Hydrolab Quanta multi-probe meters (calibrated weekly according to manufacturer's specifications). Parameters included air and water temperature, pH, dissolved oxygen, salinity, and Secchi disk readings.

Each site was monitored approximately twice monthly for four months between August and December 2003 and between April and September 2004. All established shellfish monitoring stations associated with the study sites were sampled in accordance with the National Shellfish Sanitation Program (NSSP) systematic random sampling strategy that is designed to capture all possible water conditions. The Maryland Department of Health and Mental Hygiene's Eastern Shore Regional Laboratory and Baltimore Central Laboratory analyzed the collected samples for fecal coliform, using the 3-tube decimal dilution test.

In addition to the bacterial water sampling and physical parameter measurements, an intensive localized shoreline survey was conducted for each study site. These surveys were conducted in order to identify all potential or real pollution sources that may influence the bacterial results at each study site. These surveys were also used to document geographically accurate land use, public accessibility, recreational usage, and existing commercial fishery activities in each area. Geographic Information System (GIS) technology was used to manage and analyze information collected from the shoreline surveys, highlight potential pollution sources, and delineate watershed characteristics such as land use, size (acreage), bathymetry, and soil types.

Results and Discussion:

Approximately two weeks after initiating sampling, a major storm destroyed five study sites. The sampling regime was resumed with the remaining 18 study sites approximately three weeks after the meteorological event.

The shoreline survey assessments documented and evaluated all pollution sources that could potentially affect the surrounding water quality. A potential source identified by the field inspectors at all sites were the docks and piers used for the study. These structures provided a platform where waterfowl and seagulls congregated in large numbers. Also, evidence was observed indicating the presence of mammalian wildlife, such as muskrat and raccoon, accessing these sites for habitat and to forage for food.

The standard for 'approved' status of waters classified for shellfish harvesting includes a fecal coliform median value of <14 Most Probable Number (MPN) per 100ml with an estimated 90th percentile that shall not exceed 49 MPN per 100ml on a minimum of 30 samples in addition to a sanitary survey as required in the U.S. Food and Drug Administration's Interstate Shellfish Sanitation Conference Guide for the Control of Molluscan Shellfish. The present study, due to time constraints, generated a 16-sample set for each station within each study site, which was not enough data to properly classify shellfish water quality under the National Shellfish Sanitation Program (NSSP). With such a small database, the 90th percentile standard could not be calculated. The following discussion only refers to the median value of 14 MPN/100ml portion of the NSSP standard to be met to place the shellfish harvesting waters in the approved status. Also, all sites located in conditionally approved harvesting waters were only monitored when those waters were in the approved status.

The following graph (Figure 2) delineates the calculated results of the Wye River study site. Each vertical bar at the designated distance from the shoreline represents the median fecal coliform value for 16 samples. The horizontal dash line indicates the 14 MPN/100ml portion of standard separating approved waters (below the line) from restricted waters (above the line). In addition, a median was calculated for the 16 samples collected from the associated offshore station during each nearshore sampling effort and is depicted at the end of the x-axis beyond the 150 ft station.

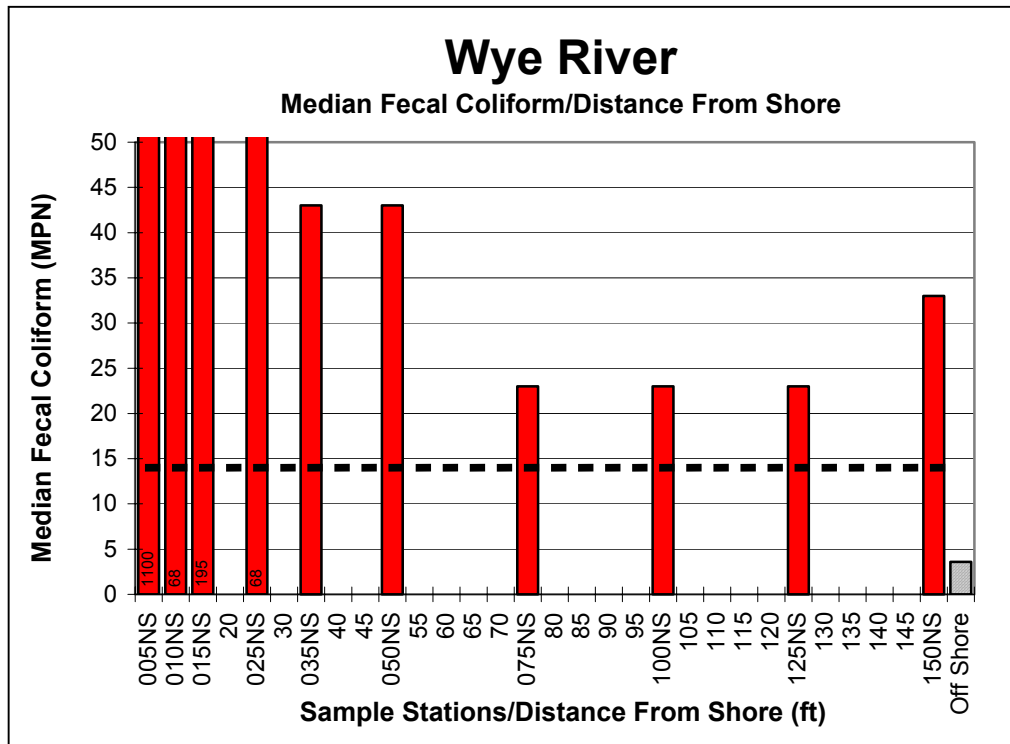


Figure 2. Calculated results of the Wye River study site

Based on the results of the offshore station, the shellfish waters in this region of the Wye River should be (and are) classified as approved for shellfish harvesting. The nearshore data does not support this classification. Within the study design, the data from the nearshore site indicates the waters should be classified as restricted out to 150 ft from the shoreline.

Of the 18 study sites, only four sites (Harris Creek, West River, St. Jerome's Creek, and the Big Annessex River) were correctly classified to the shoreline (for the calculated median portion of the standard) by the offshore shellfish monitoring stations. There were no obvious similarities common to these four sites that would distinguish them from the remaining study sites. Bacterial data from all stations (5 ft to 150 ft) at the two following sites (Figure 3) met the standard for an approved classification (the 5 ft station at the St. Jerome Creek site only slightly exceeded 14 MPN/100ml) and were reflective of the water quality at the associated offshore shellfish monitoring station. The West River site had a bulkhead shoreline within a heavily developed area with a

bathymetric profile range from 1.5 ft to 6.5 ft. The St. Jerome Creek site had an emergent grass shoreline within a rural, undeveloped area with a bathymetric profile range from 1.0 ft to 3.5 ft.

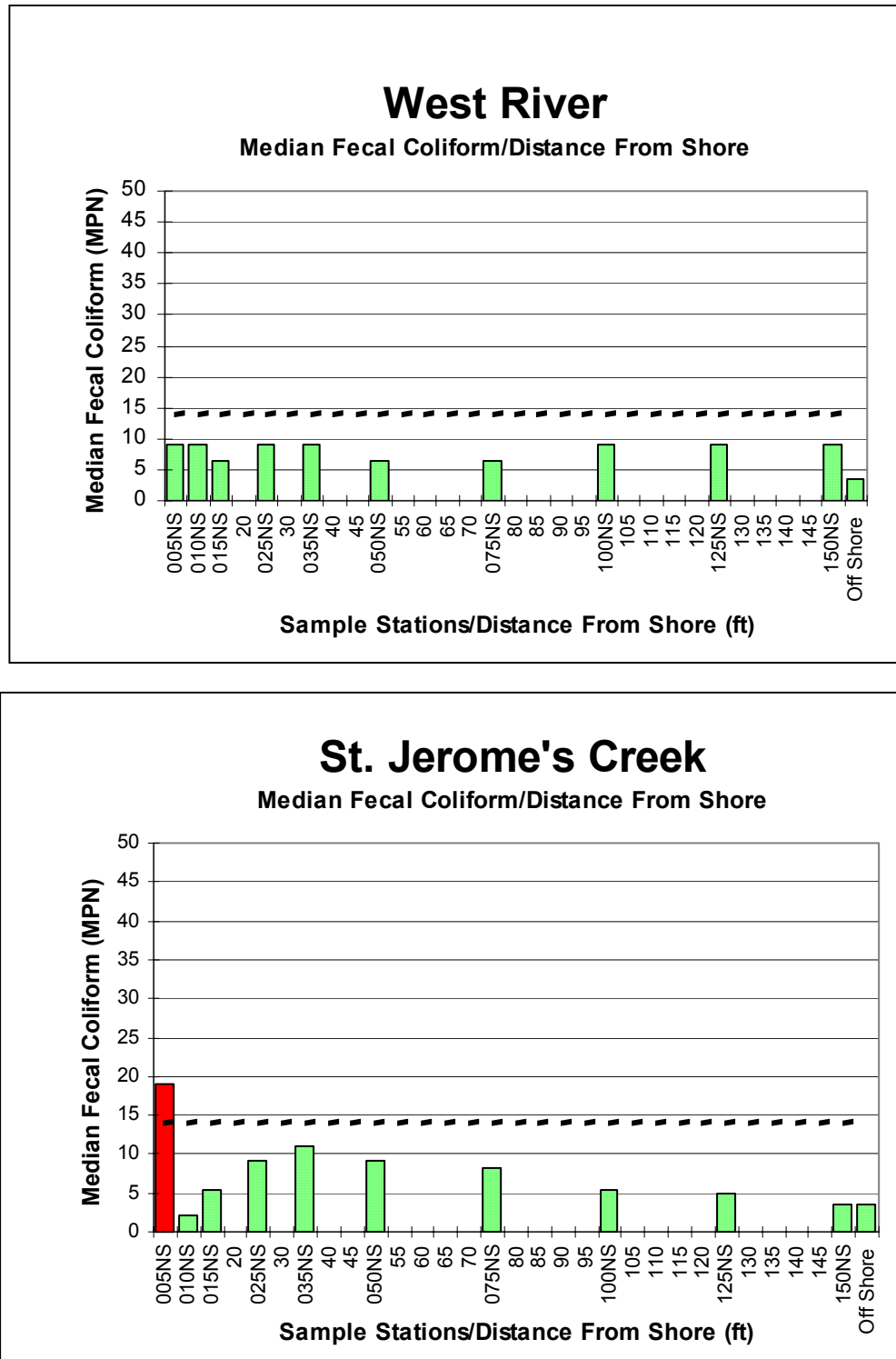


Figure 3. Calculated results of the West River and St. Jerome Creek study sites

The graph shown below (Figure 4) delineates the calculated results of the Monie Bay study site. The first six sampling stations of this study site did not meet the approved criteria but, beyond the 50 ft sampling station, the data supported the offshore, approved classification. Six sites met the approved status for shellfish harvesting at some distance between the shoreline and the 150 ft study limit.

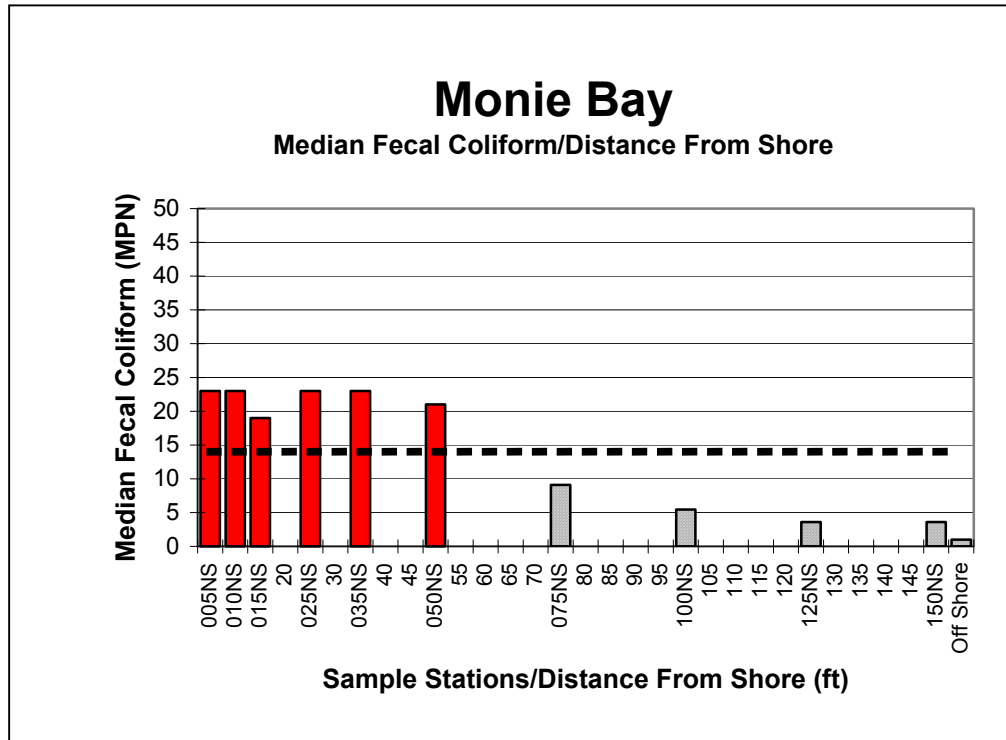


Figure 4. Calculated results of the Monie Bay study site

During the study period, the data generated from the associated offshore shellfish monitoring stations classified all of the nearshore sites as approved. Of the 18 study sites, 14 sites (entirely or at some point from the shoreline) did not meet the median portion of the standard for the approved classification. The selected study sites were to some degree incorrectly classified 77% of the time (See Appendix A).

A statistical analysis of the nearshore data did not produce any significant correlation between fecal coliform levels and any of the variables recorded which included land usage, shoreline type, tidal state, seasonal variations, and water quality parameters. Indeterminate associations between bacterial levels with wind and depth

were indicated, but with such a limited data set, no conclusion can be drawn. The graph below (Figure 5) visually depicts this association by plotting the calculated medians from all samples taken at each study site station (y-axis) against the total water depth (x-axis).

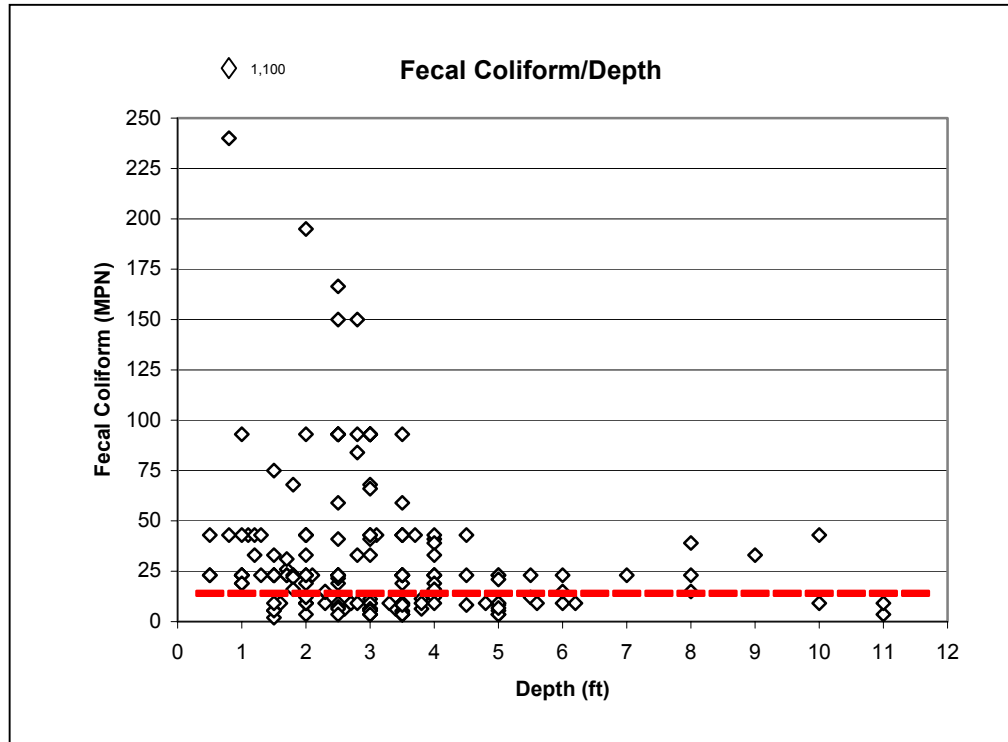


Figure 5 – Median fecal coliform vs. water depth

Conclusions and Recommendations:

Dispersion and dilution of pollutants entering shellfish harvesting waters occurs constantly and progressively through tidal action, wind induced currents, fresh water influx through run-off and the hydrological characteristics unique to each area. The work of Dr. Mark Frana, a researcher at Salisbury University, in bacterial source tracking found elevated levels of fecal coliform in tidal waters ebbing from a marsh environment in a very small, sparsely inhabited creek (Beatty et al, 2000). The associated monitoring from the centerline of the creek produced significantly lower fecal coliform levels.

The temporal and spatial separation between run-off containing potential pollutants entering a water body and shellfish beds in deeper water, away from the shoreline, provides a sufficient buffer to protect the health of individuals consuming shellfish from the offshore beds. This separation has provided regulators with a margin of safety when classifying shellfish waters. If water quality degrades, whether gradually or acutely, the

shellstock are sufficiently removed from the pollution sources to provide a low-risk of disease transfer until the waters can be closed or reclassified. The movement of shellfish product into these nearshore areas has eliminated this margin of safety. Pollutants entering a waterway, such as disease causing organisms from a failing septic system, will realize little dilution and have a limited exposure time to the environment before reaching the shellstock. The shellfish could then concentrate the pollutants and pose a health risk to individuals consuming the product.

The present investigation has demonstrated that the monitoring methodology currently used to classify shellfish harvesting waters does not capture nearshore characteristics. In the majority of study sites, the data from the offshore monitoring stations correctly reflected the current classification of the surrounding waters as approved (or conditionally approved) but were not representative of the water quality in the bordering nearshore areas. Nearshore areas are highly variable and bacteria levels cannot be predicted with any certainty.

Contamination of shellfish located nearshore can occur rapidly (U.S. Food and Drug Administration Center for Food Safety and Applied Nutrition, 2003). The water quality of any nearshore site in consideration for the cultivation of shellfish for human consumption cannot be assumed to be correctly classified based on the current classifications derived from the offshore routine monitoring stations. Each site should receive a complete site assessment to include water sample collections for fecal coliform at a minimum of three distances from the shoreline beginning at a point of less than 25 feet, one between 50 and 75 feet and one beyond 100 feet. This should help certify those potential sites that comply with the NSSP shellfish water quality standards at specific distance from the shoreline. Also, due to the potential for an immediate and demonstrative impact on the nearshore water quality from runoff, a shoreline survey should be routinely performed of the surrounding area documenting real and/or potential pollution sources at a frequency to achieve a level of assurance for the regulators protecting public health. Any site containing potential pollution sources of a high-risk nature (i.e. septic systems located between neighboring homes and the waterfront or an animal waste holding lagoon) should not be permitted even if the water quality meets shellfish standards.

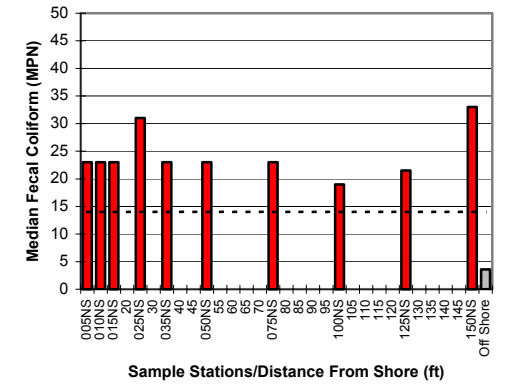
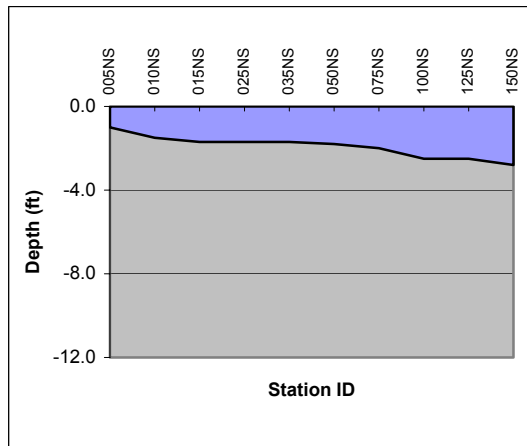
APPENDIX A: SITE CHARACTERISTIC PROFILES

Chester River

Lat: 39° 06' 23.3"
 Long: 76° 08' 28.6"
 Cliff City Public Landing



County: Kent County
 Map: 04 Section: 02
 Nearest Station: 04-02-013A
 Classification: **Cond. Approved**
 Dock Length: 250 ft
 Shoreline: Grasses
 Waste Disposal: Septic
 Surrounding Area: Sparse Residential, Agriculture

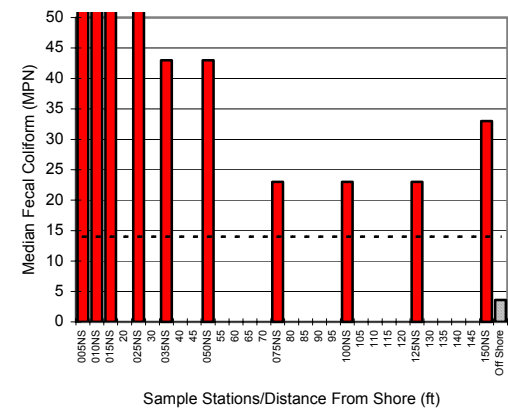
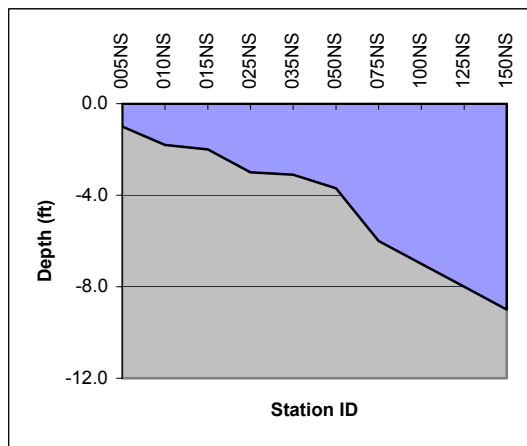


Wye River

Lat: 38° 53' 21.6"
 Long: 76° 11' 16.5"
 Bennett Point Public Landing



County: Queen Anne's County
 Map: 08 Section: 02
 Nearest Station: 08-02-010
 Classification: **Approved**
 Dock Length: 75 ft
 Shoreline: Grasses
 Waste Disposal: Septic
 Surrounding Area: Sparse Residential, Agriculture

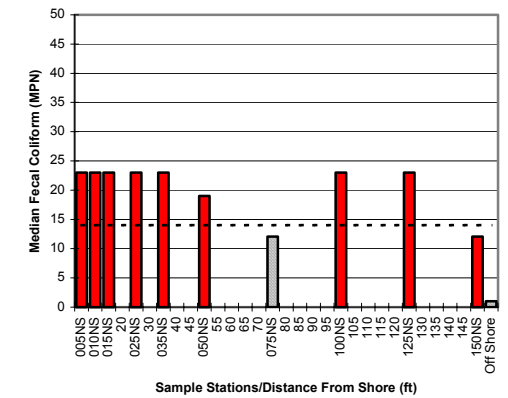
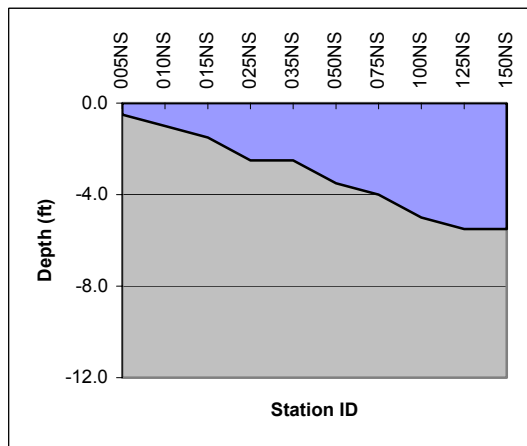


Chesapeake Bay


Lat: 38° 12' 48.1"
 Long: 76° 14' 48.6"
 Tolchester Beach



County: Kent County
 Map: 02 Section: 01
 Nearest Station: 02-01-007
 Classification: **Approved**
 Dock Length: N/A
 Shoreline: Beach with grass
 Waste Disposal: Sewer
 Surrounding Area: Forested, Residential, Commercial



Eastern Bay
Lat: 38° 52' 49.9"
Long: 76° 19' 55.4"
 Romaneoke Public Pier




Map: 08 **Section:** 04
Nearest Station: 08-04-019
Classification: Approved
Dock Length:
Shoreline: Grasses
Waste Disposal:
Surrounding Area: Scattered homes

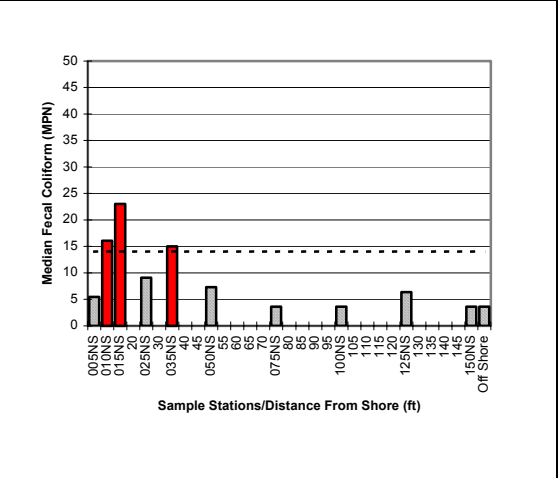
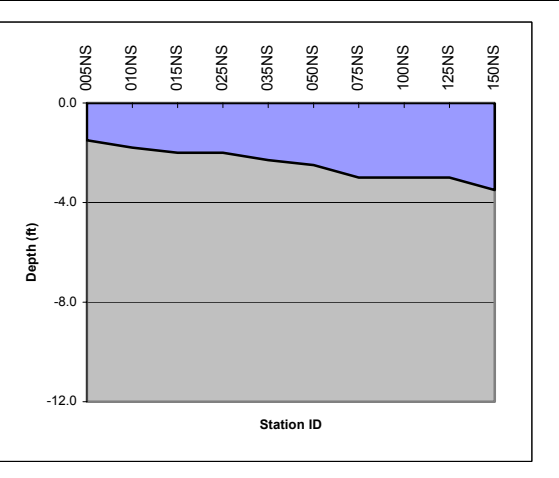
PIER DESTROYED AND NO LONGER AVAILABLE FOR USE DUE TO HURRICANE ISABEL.

PIER DESTROYED AND NO LONGER AVAILABLE FOR USE DUE TO HURRICANE ISABEL.


Broad Creek
Lat: 38 45.957
Long: 76 15.385
 Private Dock



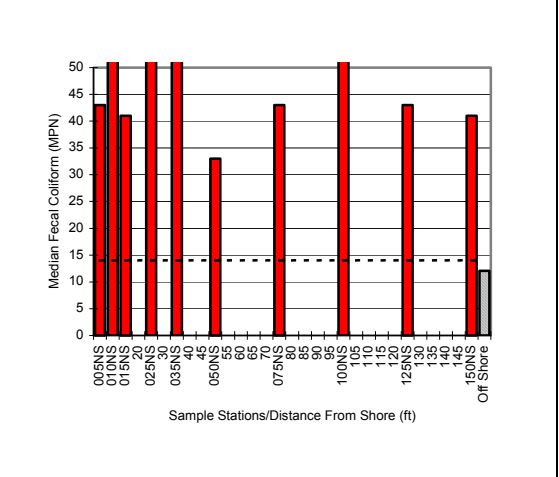
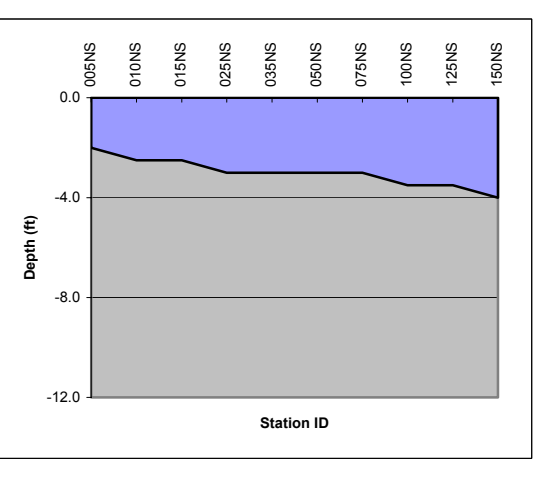
County: Talbot County
Map: 08 **Section:** 07
Nearest Station: 08-07-007
Classification: Approved
Dock Length: 85 ft
Shoreline: Beach with grass
Waste Disposal: Septic
Surrounding Area: Wooded lots with scattered homes



Tred Avon River
Lat: 38° 42' 24.9"
Long: 76° 10' 52.9"
 Bellevue Ferry Pier



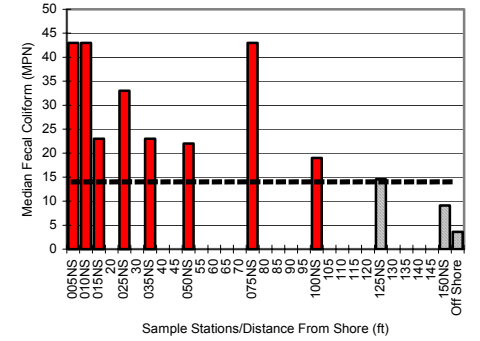
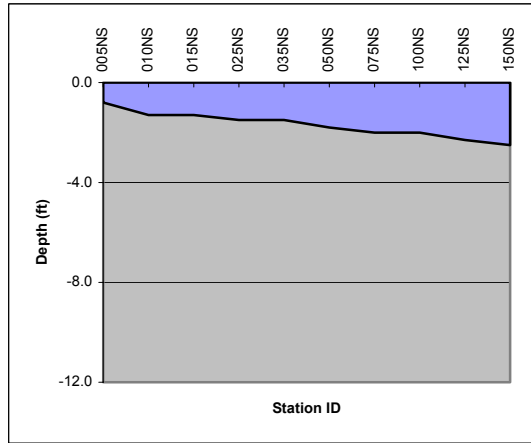
County: Talbot County
Map: 08 **Section:** 06
Nearest Station: 08-06-025
Classification: Approved
Dock Length: 250 feet
Shoreline: Riprap
Waste Disposal: Septic
Surrounding Area: Residential & Agricultural



Miles River
 Lat: 38° 11' 20.8"
 Long: 76° 26' 01.1"
 Private Dock



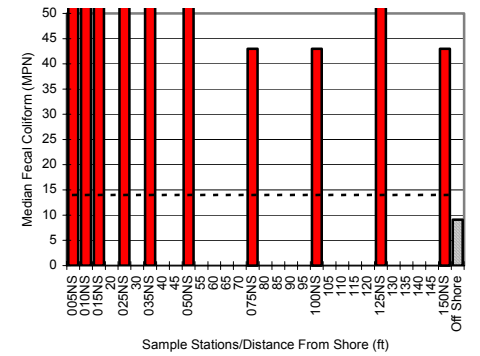
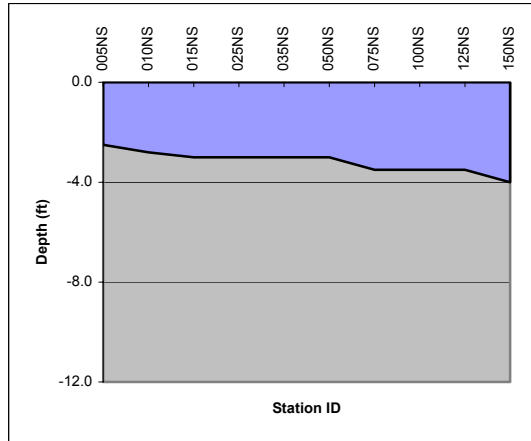
County: Talbot County
Map: 08 **Section:** 01
Nearest Station: 08-01-030
Classification: Approved
Dock Length: 150 feet
Shoreline: Beach/Grasses
Waste Disposal: Septic
Surrounding Area: Residential



Little Choptank River
 Lat: 38° 28' 10.6"
 Long: 76° 17' 35.7"
 Slaughter Cr./Taylor Island Bridge



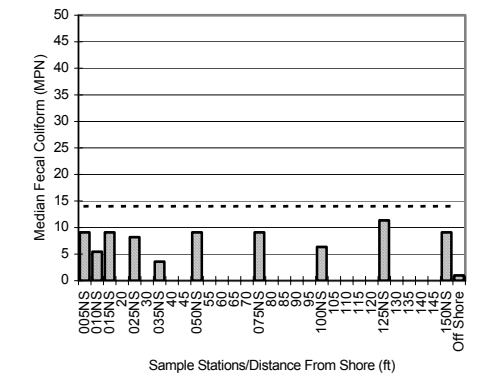
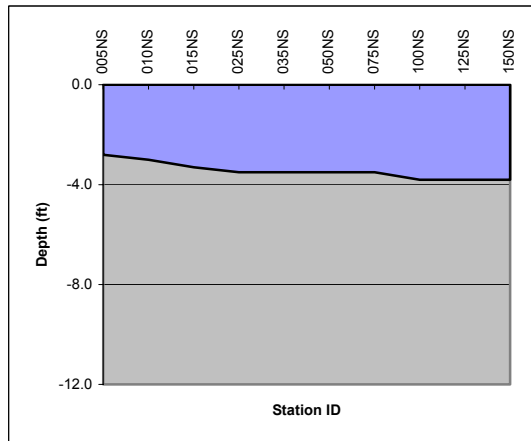
County: Dorchester County
Map: 10 **Section:** 06
Nearest Station: 10-06-010C
Classification: Cond. Approved
Dock Length: N/A - Bridge
Shoreline: Bulkhead
Waste Disposal: Septic
Surrounding Area: Residential/Agricultural



Harris Creek
 Lat: 38° 45' 43.8"
 Long: 76° 19' 01.2"
 Sherwood Pier



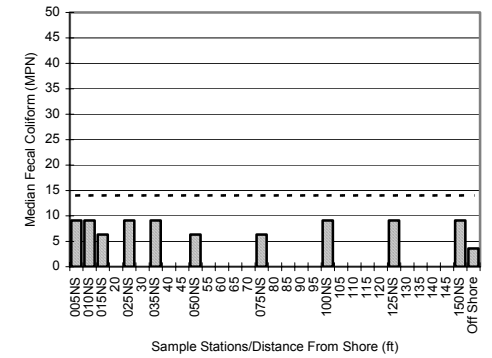
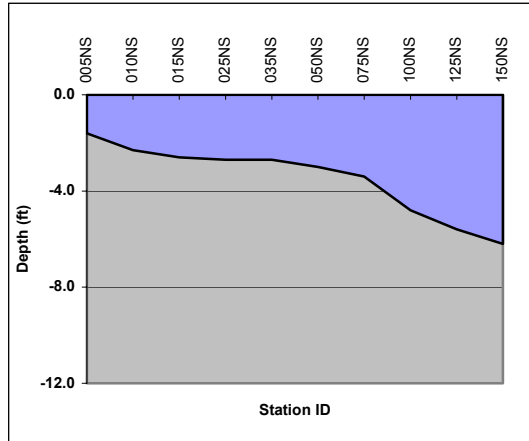
County: Talbot County
Map: 08 **Section:** 08
Nearest Station: 08-08-044
Classification: Approved
Dock Length: 284 feet
Shoreline: Bulkhead
Waste Disposal: Septic
Surrounding Area: Residential



West River
 Shady Side
 Lat: 38.85110
 Long: 76.52692



County: Anne Arundel County
Map: 03 **Section:** 07
Nearest Station: 03-07-204
Classification: Approved
Dock Length: 100 ft
Shoreline: Riprap
Waste Disposal: Septic Systems
Surrounding Area: Residential



South River
 Turkey Point
 Lat: 38.90961
 Long: 76.49588



Map: 03 **Section:** 06
Nearest Station: 03-06-017
Classification: Approved
Dock Length:
Shoreline:
Waste Disposal:
Surrounding Area:

PIER DESTROYED AND NO LONGER AVAILABLE FOR USE DUE TO HURRICANE ISABEL.

PIER DESTROYED AND NO LONGER AVAILABLE FOR USE DUE TO HURRICANE ISABEL.



Magothy River
 Lat: 39.06083
 Long: 76.45939

Map: 03 **Section:** 01
Nearest Station: 03-01-005A
Classification: Approved
Dock Length:
Shoreline:
Waste Disposal:

PIER DESTROYED AND NO LONGER AVAILABLE FOR USE DUE TO HURRICANE ISABEL.

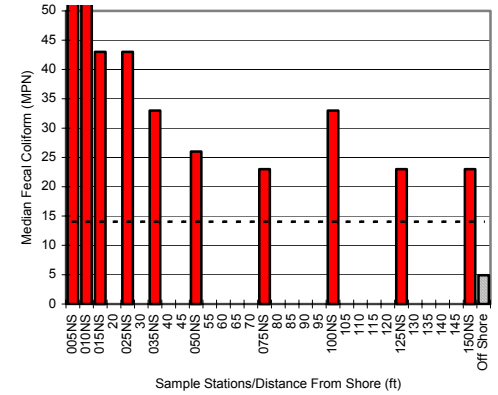
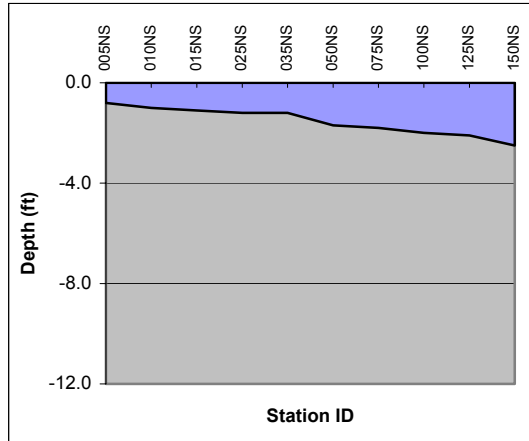
PIER DESTROYED AND NO LONGER AVAILABLE FOR USE DUE TO HURRICANE ISABEL.

Rhode River

Crab Pier
 Lat: 38.88781
 Long: 76.52339



County: Anne Arundel County
 Map: 03 Section: 07
 Nearest Station: 03-07-120
 Classification: **Cond. Approved**
 Dock Length: 200 ft
 Shoreline: Marsh Grass
 Waste Disposal: Septic
 Surrounding Area: Residential and Commercial

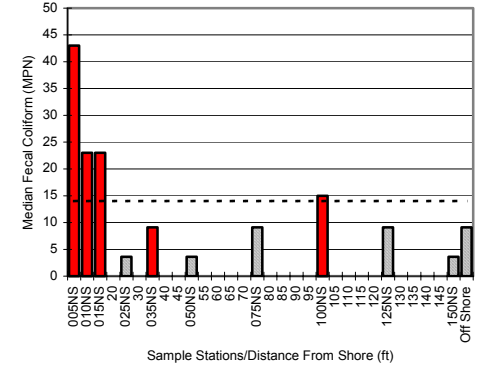
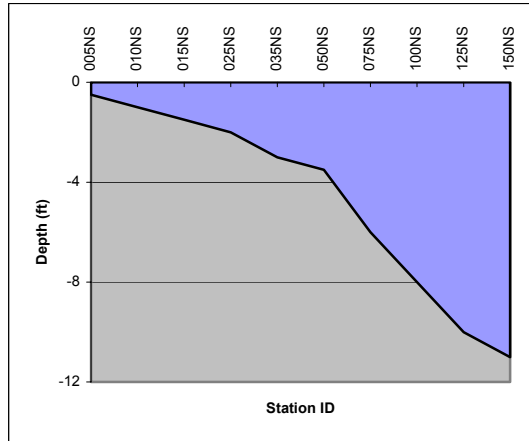


St. Leonard Creek

Lat: 38° 24' 03.2"
 Long: 76° 28' 55.8"
 Private Dock



County: Calvert
 Map: 09 Section: 03
 Nearest Station: 09-03-107
 Classification: **Approved**
 Dock Length: 85 ft
 Shoreline: Beach with grass
 Waste Disposal: Septic
 Surrounding Area: Wooded lots with scattered homes



St. Clements Bay

Lat: 38° 16' 50.7"
 Long: 76° 42' 37.3"
 Private Community Dock



Map: 13 Section: 02
 Nearest Station: 13-02-004
 Classification: **Approved**
 Dock Length: 220 ft
 Shoreline: Beach/Bulkhead w/ grass
 Waste Disposal: City Sewer
 Surrounding Area: Highly concentrated houses

PIER DESTROYED AND NO LONGER AVAILABLE DUE TO HURRICANE ISABEL

PIER DESTROYED AND NO LONGER AVAILABLE DUE TO HURRICANE ISABEL.

St. Mary's River

Lat: 38° 11' 20.8"

Long: 76° 26' 01.1"

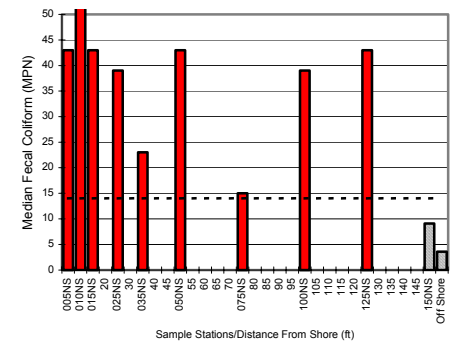
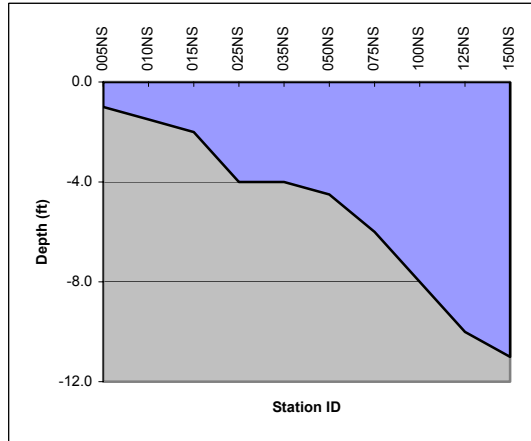
Private College dock



County: St. Mary's
Map: 11 Section: 04
Nearest Station: 11-04-022A

Classification: **Cond. Approved**

Dock Length: ≈ 175 ft
Shoreline: Beach with grass
Waste Disposal: Campus
Municipal Sewer



St. Jerome Creek

Lat: 38° 07' 06.9"

Long: 76° 20' 45.5"

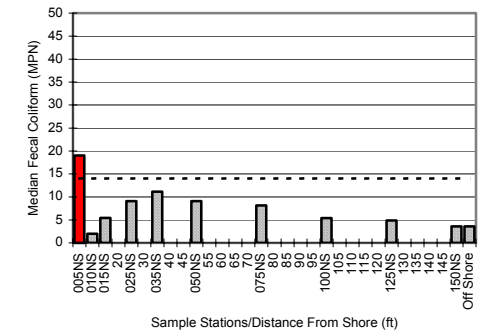
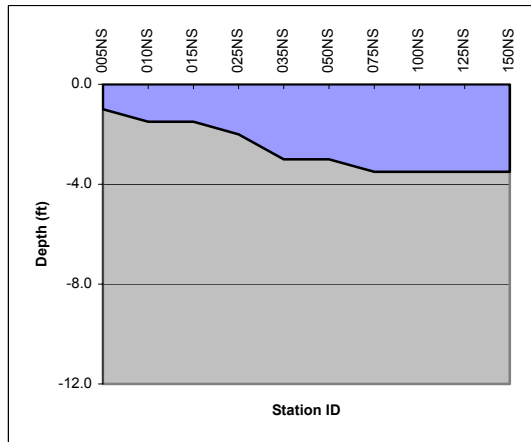
Private Dock



County: St. Mary's
Map: 11 Section: 05
Nearest Station: 11-05-701

Classification: **Cond. Approved**

Dock Length: 200 ft
Shoreline: Beach with grass
Waste Disposal: City Sewer
Surrounding Area: Scattered homes



Sinepuxent Bay

Lat: 38° 15' 39.3"

Long: 75° 09' 03.4"

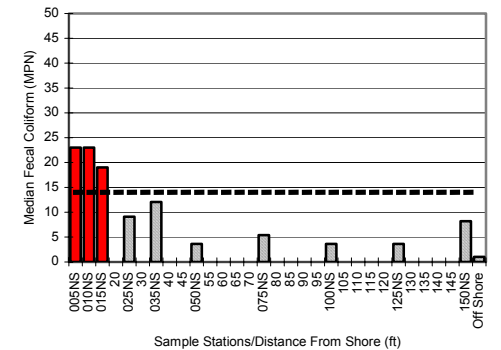
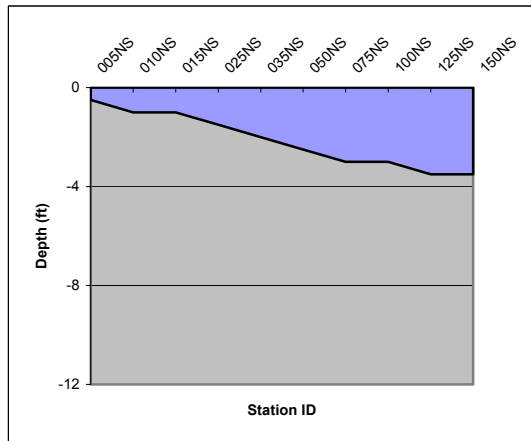
Private Dock



County: Worcester County
Map: 20 Section: 01
Nearest Station: 20-01-004

Classification: **Approved**

Dock Length: 150+ ft
Shoreline: Bulkhead
Waste Disposal: Septic
Surrounding Area: Sparse Residential

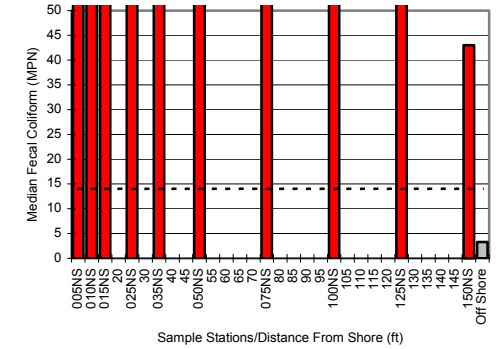
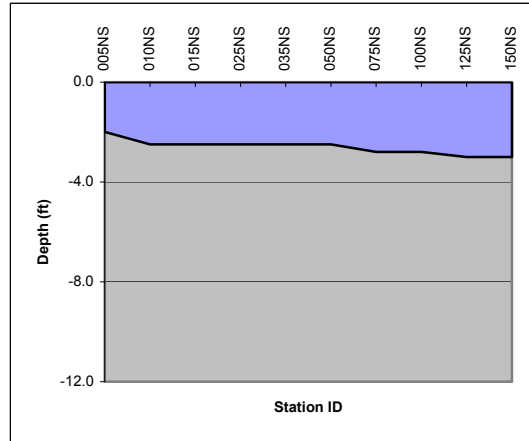


Chincoteague Bay

Lat: 38° 08' 55.0"
 Long: 75° 17' 09.4"
 Public Landing



County: Worcester County
 Map: 20 Section: 02
 Nearest Station: 20-02-008
 Classification: **Approved**
 Dock Length: 300 ft
 Shoreline: Bulkhead
 Waste Disposal: Septic
 Surrounding Area: Sparse Residential

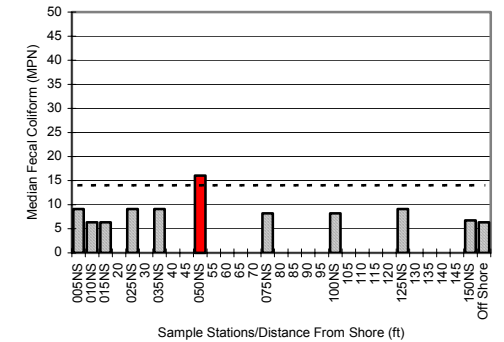
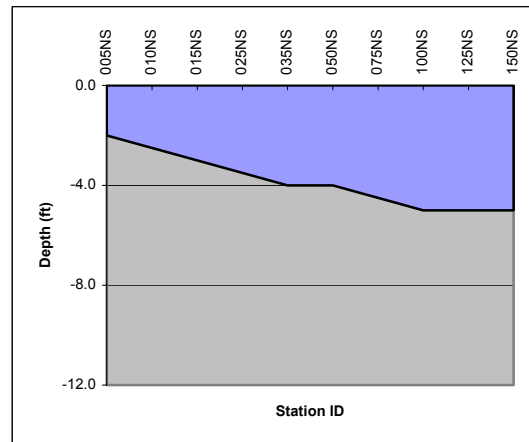


Big Annessex River

Lat: 38° 03' 12.5"
 Long: 75° 47' 57.5"
 Private Pier



County: Somerset County
 Map: 18 Section: 04
 Nearest Station: 18-04-008
 Classification: **Cond. Approved**
 Dock Length: 150+ ft.
 Shoreline: Riprap
 Waste Disposal: Septic

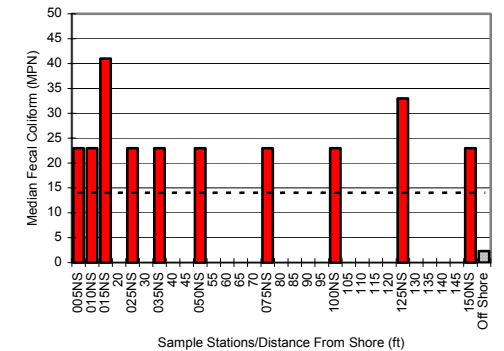
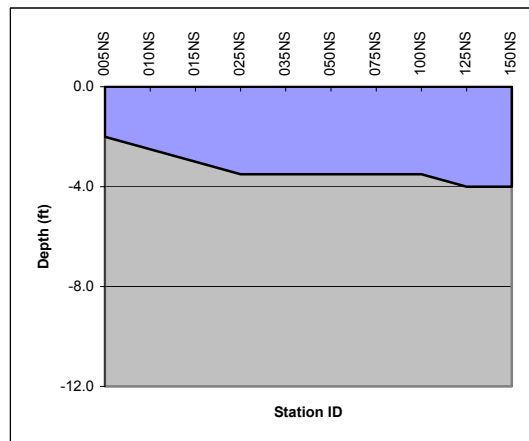


Nanticoke River

Lat: 38° 18' 24.5"
 Long: 75° 53' 45.3"
 Public Dock



County: Wicomico County
 Map: 14 Section: 05
 Nearest Station: 14-05-702
 Classification: **Approved**
 Dock Length: 150+ ft
 Shoreline: Riprap/beach
 Waste Disposal: Septic
 Surrounding Area: Residential

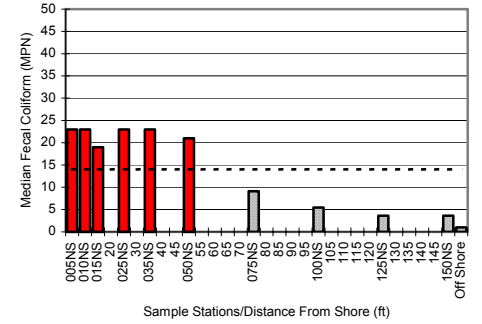
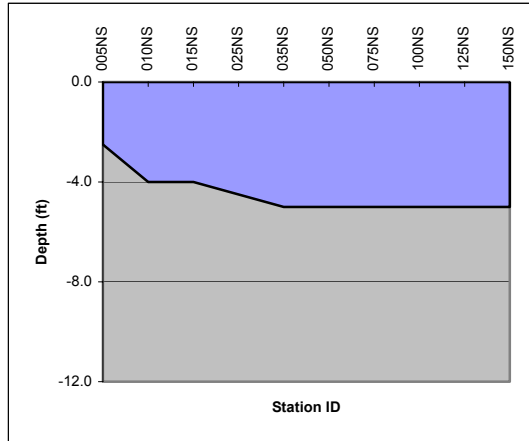


Monie Bay

Lat: 38° 11' 24.1"
Long: 75° 56' 01.2"
 Private Pier



County: Somerset County
Map: 18 Section: 01
Nearest Station: 18-01-701
Classification: Approved
Dock Length: 125 ft
Shoreline: Grasses/beach
Waste Disposal: Septic
Surrounding Area: Sparse Residential/Ag; Marsh



Patapsco River
 Kurtz's Beach
Lat: 39.15393
Long: -76.46883



Map: 03 Section: 02
Nearest Station: 03-02-006B
Classification: Approved
Dock Length:
Shoreline:
Waste Disposal:
Surrounding Area:

PIER DESTROYED AND NO LONGER AVAILABLE FOR USE DUE TO HURRICANE ISABEL

PIER DESTROYED AND NO LONGER AVAILABLE FOR USE DUE TO HURRICANE ISABEL

References

Beatty, W., Brohawn, K., Ellwanger, M., Evans, W., Frana, M.F., Phipps-Dickerson, M., Venso, E.A. (2000). Pilot Study: Fecal Coliform Fingerprints from Nonpoint Source Pollution in Two Eastern Shore Watersheds (Final Report for FFY99CWAP Incremental Section 319(h) Grant 14.00.483.EPA.035).

U.S. Food and Drug Administration Center for Food Safety and Applied Nutrition, (2003). National Shellfish Sanitation Program Guide For the Control of Molluscan Shellfish, Public Health Reasons and Explanations: Chapter VII: Wet storage in approved and conditionally approved growing areas. Retrieved Aug. 08, 2005, from U.S. Food and Drug Administration Center for Food Safety and Applied Nutrition Web site: <http://www.cfsan.fda.gov/~ear/nss2-3.html>.

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