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MARINA CONTRIBUTION TO BACTERIAL WATER QUALITY POLLUTION IN KENT ISLAND NARROWS, MARYLAND

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MARINA IMPACT ON WATER QUALITY IN KENT ISLAND NARROWS, MARYLAND

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Environmental Health Administration
Maryland Department of Health and Mental Hygiene

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INTRODUCTION

The actual impact on water quality caused by the overboard discharge of sewage wastes from boats in marinas is an issue that has been debated for many years. This issue is of particular interest in the Kent Island Narrows where many commercial fishing boats and recreational vessels are located in a small geographical area. Bacteriological water quality in Kent Island Narrows has been unsatisfactory for many years resulting in the restriction of valuable shellfish growing waters by the Maryland State Department of Health and Mental Hygiene.

No previous studies or data have been generated to determine the impact marinas may have on bacterial water quality in the Kent Island Narrows. Additional sampling stations were added to the routine water quality monitoring network already established in this area. Data generated from these additional stations were used to study the impact boating activity may have on bacterial water quality in Kent Island Narrows.

STUDY AREA DESCRIPTION

Kent Island Narrows is a small body of water separating Kent Island on the west from the Eastern Shore mainland on the east. Both Kent Island and Kent Narrows are located in Queen Anne's County (Figure 1). The Narrows, as it is commonly known, is navigable to vessels with entrances from the Chester River to the north and Eastern Bay to the south. It is approximately one mile long and one hundred and seventy yards wide with a dredged deep water channel running the entire length of the Narrows near the east shoreline. The channel ranges from eight to eighteen feet in depth. Good tidal exchange occurs in the Narrows because the tides in Eastern Bay and the Chester River are out of phase.

The topography of Kent Island is an almost level plain less than twenty feet above sea level in most places and barely above high tide near the Narrows. Few streams dissect the surface of this plain, but small bays branching off from the Chesapeake Bay indent the shores and create many narrow peninsulas.

The tide and current movement through Kent Island Narrows can be described as a driving force acting on a relatively small body of water. Regular tidal motion in the Narrows consists of water entering the Narrows as a broadly distributed flow and exiting as a high velocity jet confined by the channel.[1] On flood tide, the water moving into the Narrows from Eastern Bay is probably concentrated on the eastern side of the channel off Wells Cove as a deep moderated velocity flow. The water exiting the Narrows at the northern end into the Chester River is concentrated into a narrow high velocity jet along the dredged channel. During the ebb tide, a broadly distributed flow of water enters the narrows from the Chester River following the boundaries of the channel and exits as a high velocity jet into Prospect Bay. The flood tide is stronger on the eastern side of the Narrows; the ebb tide shows a stronger flow on the west side. It has been suggested that this difference is probably a result of the curvature in the channel. The strong tidal current flow occuring in the Narrows is attributed to the 1.5 hours phase difference between the tidal flows in the Chester River and Eastern Bay.[2]

The concentration of the exiting flow into a high velocity jet allows the water to travel some distance into the Chester River on the flood tide or Eastern Bay on the ebb tide before it slows and spreads into a broad plume. This further dispersal presumably results in less return flow and hence less pollutant accumulation in the Narrows. Because of the 1.5 hours phase difference between the tidal flows in Eastern Bay and the Chester River, the flood tide in the Chester River occurs later than the flood tide through the Narrows. The delay results in the water exiting northward through the Narrows being carried up the Chester River on the flood tide. This in turn causes less return flow and presumably lower pollutant concentrations in the Narrows region.

The wind can alter or impede the flow of water through the Narrows. A strong wind driven flow of water can dominate the flow overriding the semidiurnal tide.[3]

The shellfish waters of Kent Island Narrows have been closed for extended periods of time by the Department of Health and Mental Hygiene in the past ten years because of excessive fecal coliform bacteria levels. Six hundred and sixty-five (665) acres of surface waters and sixty-six (66) acres of public oyster bars are currently restricted for shellfish harvesting (Figure 2). This shellfish harvesting area is extremely important to the shellfish industry as it is sheltered from winter winds. In addition, since the swift tidal action impedes ice formation, shellfish harvesting can continue here when other areas are closed by inclement weather conditions. Restriction of this area because of poor water quality causes economic hardship to the industry.

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1. W. C. Boicourt, *Measurement of Tides and Currents in Kent Island Narrows,* Open File Report No. 11, Chesapeake Bay Institute, Johns Hopkins University, February, 1978.
2. Ibid.
3. Ibid.

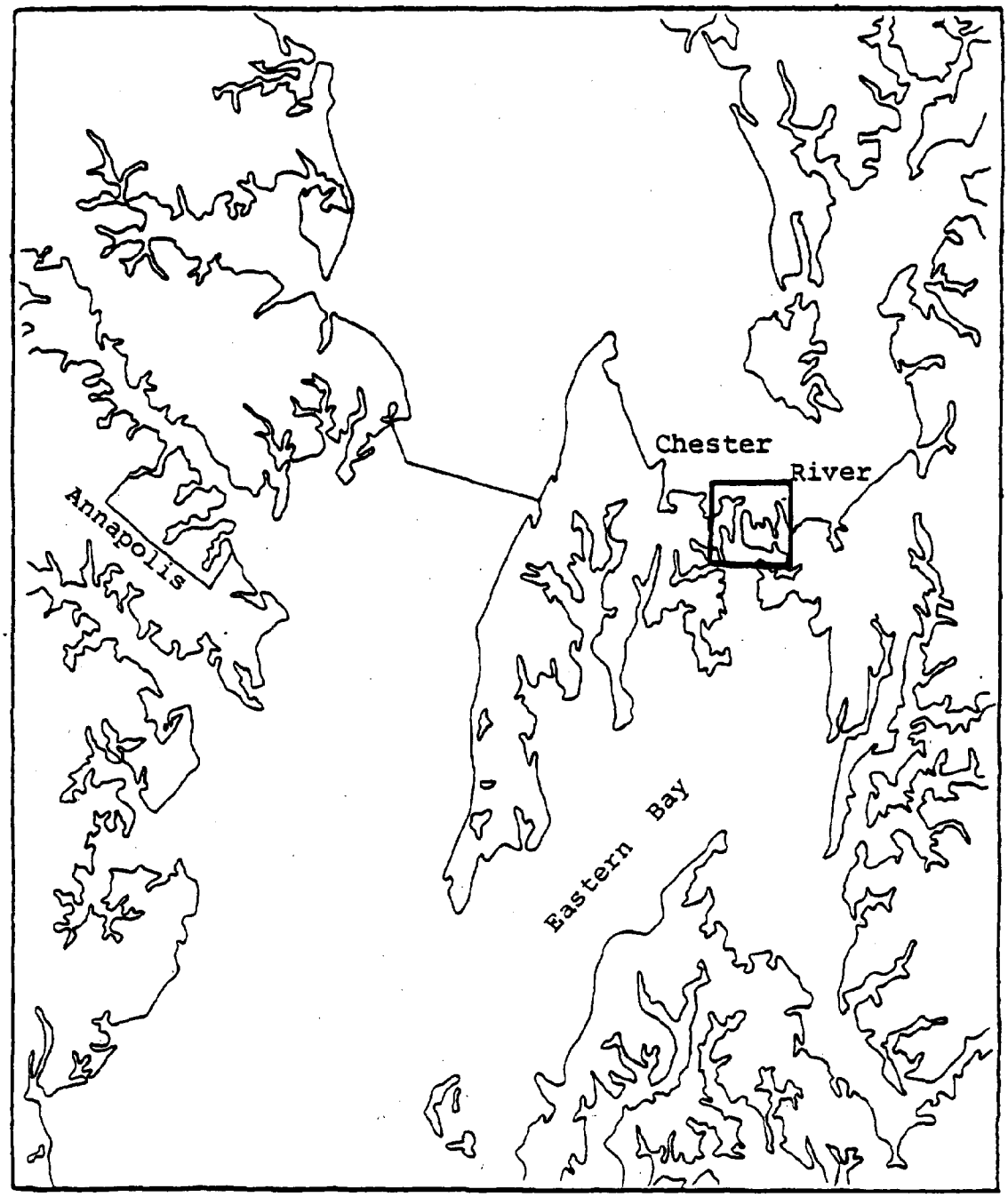

Figure 1 — Chesapeake Bay with Kent Island Narrows Region Enclosed

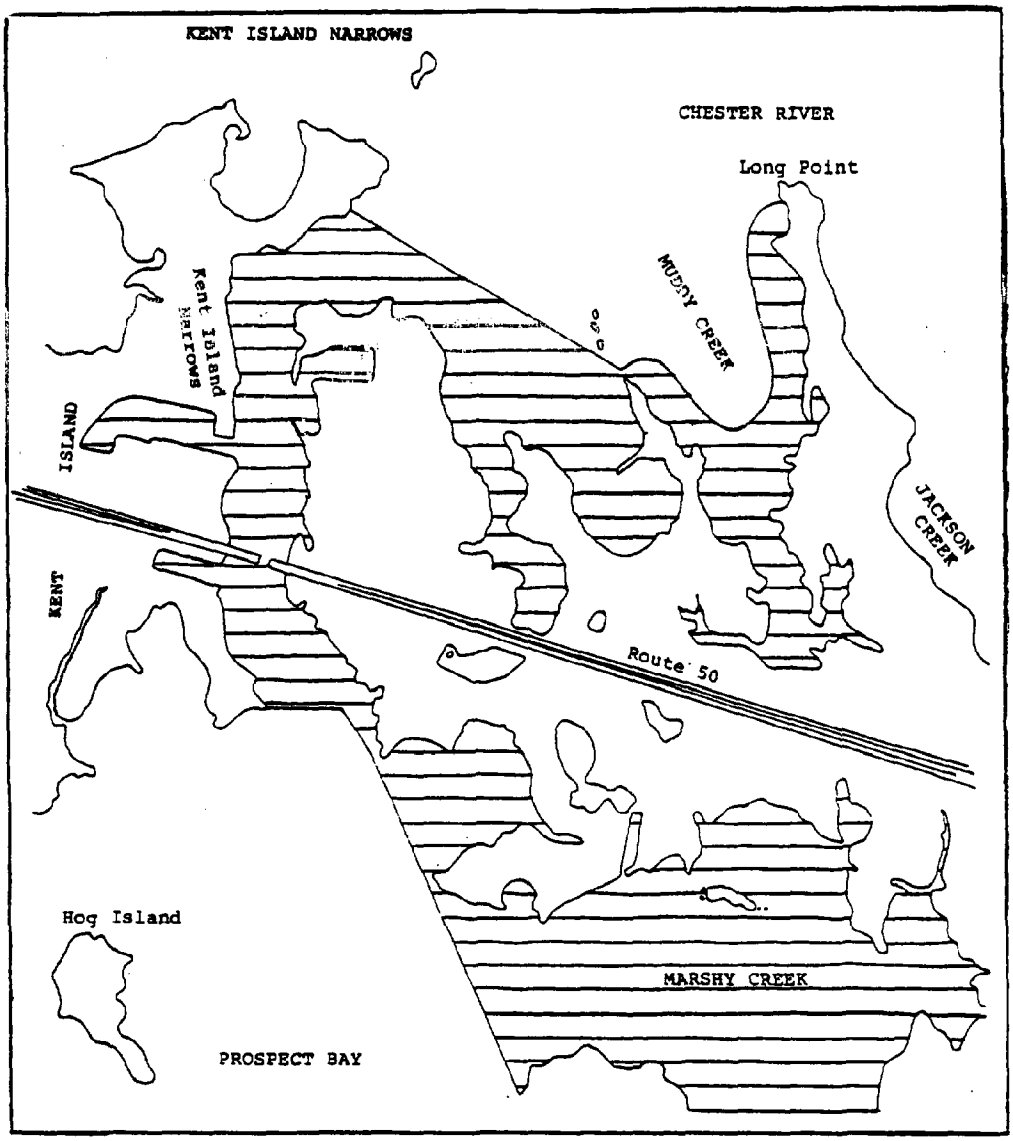

Figure 2 — Restricted Shellfish Harvesting Area in Kent Islands Narrows and Prospect Bay

IDENTIFICATION OF POTENTIAL POLLUTION SOURCES

Possible sources of bacterial pollution in Kent Island Narrows include seafood processing plants, failing septic systems and marinas. No one source has been identified as the principal cause of problems in the area.

Seafood Processing Plants

Seafood processing plants have been suspected of contributing to the bacterial pollution load in the Narrows since wastewater from seafood processing operations is discharged directly overboard. No seafood processing plants are located on the western shore of the Narrows although eight seafood processing plants operate along the eastern shore (Figure 3). Oysters, softshell clams and crabs are the main seafood products processed. Softshell clams and crabs are processed on a year-round basis whereas oysters are processed from September through April.

Various amounts of wastewater are produced at the seafood plants during processing and in the cleaning of equipment and work areas at the end of the work day. In seven of the seafood processing plants, the wastewater drains into a single concrete trough running the length of the plant. Twenty mesh screens are placed at several locations in the trough to catch any solid materials that could be discharged with the wastewater. Disinfection of the effluent is accomplished through the use of chlorine tablets placed in the troughs. This straight flow discharge elimination type system results in inadequate disinfection because of limited chlorine contact time and the high organic demand of the effluent. Fisherman's Seafood Market uses a baffled concrete tank to receive wastewater from the plant allowing solids to settle out before the effluent is discharged. Chlorine tablets are also the method of disinfection used with this system. The effluent from all the seafood processing plants is discharged directly into the channel waters of the Narrows.

Effluent data from the Enforcement Division, Water Resources Administration, Department of Natural Resources, indicates that these seafood processing plants discharge effluent which is high in total coliform and fecal coliform bacteria. Eight seafood processing plants were inspected and effluent samples collected for compliance monitoring by the Water Resources Administration, during 1975 and 1976. Effluent data for 1974 was not available. Seven of these plants were not in compliance with the bacteriological requirements of their National Pollution Discharge Elimination System (NPDES) permit most of the time. These permits require that the total coliform level in discharged effluent not exceed 70 MPN/100 ml. Effluent data collected from the sampling of these plants is presented in Table 1.

Seafood processing plants in Kent Island Narrows that discharge effluents high in total coliform and fecal coliform bacteria may be considered as a contributory source toward the overall pollution of waters in the Narrows. The volume of wastewater discharged from these seafood processing plants is based on the daily output of products processed. If a large amount of seafood is processed on a given day then the volume of wastewater produced daily is proportionately large. The opposite is true if a small amount of seafood is processed. Since no data are available on the actual volume of effluent discharged from the seafood processing plants, it is difficult to determine the impact these effluents have on bacteriological water quality in the Narrows.

Two different means of human waste disposal serve the seafood processing plants. Privys and chemical toilets provide the means of human waste disposal for the plant workers while indoor toilet facilities serviced by a septic system serve the needs of the office workers. The outdoor facilities are located inland some distance from the shoreline of the Narrows. Because of their location away from the water, it is not believed that sewage from these privys and chemical toilets would seriously affect the waters of the Kent Island Narrows. The septic systems serving the indoor bathroom facilities of the seafood plants have been known to fail.

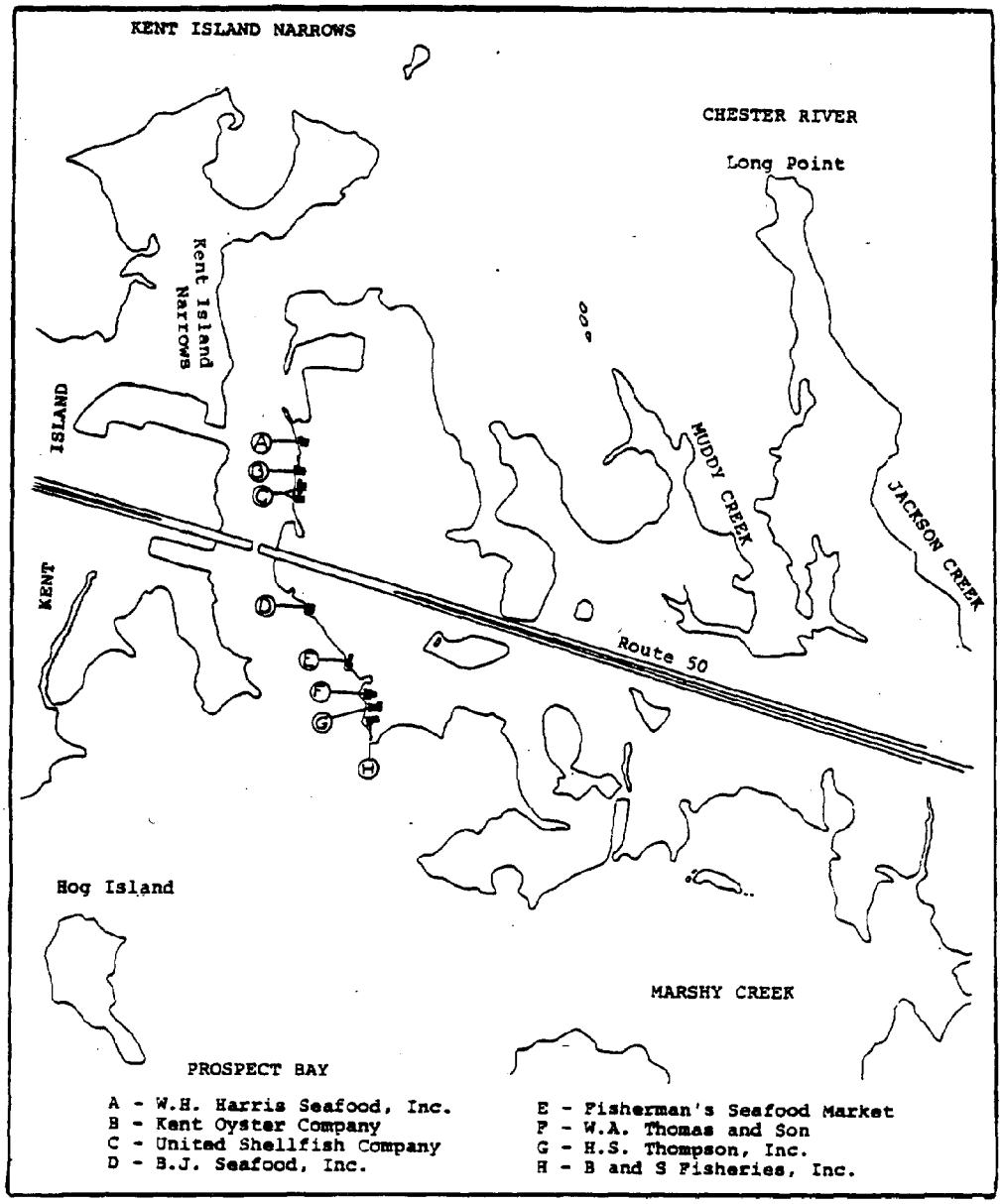

Figure 3 — Location of Seafood Processing Plants in Kent Island Narrows

Table 1 — Seafood Processing Plant Effluent Sample Results

TABLE 1 - Seafood Processing Plant Effluent Sample Results

Seafood Processing Plants		Date	Total Coliform MPN/100 ml	Fecal Coliform MPN/100 ml
Herman D. Thompson	Outfall 1	10/28/75	23,000	430
		10/28/75	240,000	4,300
	Outfall 1	3/16/76	3	3
	Outfall 2	3/16/76	210,000	4,300
	Outfall 1	12/7/76	43,000	93
W.A. Thomas and Sons		3/16/76	3	3
B. and S. Fisheries	Outfall 1	11/24/75	9,300	150
		3/16/76	43,000	430
		8/3/76	3	3
		12/7/76	4	3
Islander Seafood		6/3/75	460,000	930
	Primary Outfall	10/1/75	9,300,000	1,500
		10/1/75	2,300	15
	Outfall 1	11/24/75	15,000	23
United Shellfish Co.	Outfall 2	10/8/75	23,000	430
	Outfall 2	3/16/76	240,000	150
	Outfall 1	5/12/76	3	3
	Outfall 1	8/3/76	2,400,000	240,000
		12/28/76	2,400,000	93
		2/8/77	150,000	3
Fishermans Seafood Market		10/1/75	3	3
	Outfall 1	10/28/75	43,000	930
	Outfall 1	3/16/76	3	3
Kent Oyster Company	Outfall 1	10/8/75	240,000	23,000
W.H. Harris Seafood	Outfall 1	10/8/75	39,000	4,300

SOURCE: Enforcement Division, Water Resources Administration, Department of Natural Resources

Sewage Treatment Plants

An activated sludge sewage treatment plant serving a small condominium housing seventeen people is located on the ground of the Piney Narrows Marina. This plant has a design flow of .024 million gallons per day (MGD). The daily flow from this plant, however, is well below the designed flow and ranges from .001 to .007 million gallons per day. Based on inspections and analyses of effluent samples, the performance rating of this plant is in compliance with its NPDES permit. The treated effluent from this plant is discharged into the Chester River through an unnamed tributary and is not believed to have any effect on water quality in Kent Island Narrows. The location of the Piney Narrows Sewage Treatment Plant and its discharge point is shown in Figure 4.[4]

On-Site Disposal Systems

Failing on-site waste disposal systems have been suspected of contributing to the bacteriological pollution load entering the waters of Kent Island Narrows either by direct discharge or from runoff occurring after heavy precipitation. On-site waste disposal systems in Kent Island Narrows serve several marinas and their offices, most of the seafood processing plant offices, two restaurants (Poiseidon Inn and Fishermans Inn), and a few individual homes.

Soils in the Kent Island Narrows area are classified as Tidal Marsh and Made Land soils with Tidal Marsh being the dominant type. Tidal Marsh soils have severe limitations for disposal of sewage effluent from septic tanks and for use as sewage lagoons because of tidal flooding. Made Land soils consist of areas where the soil material has been disturbed or modified by man and can no longer be identified by soil series or soil type. This soil has no agricultural value and is used for residential and commercial purposes only.

Marinas

There are ten marinas in Kent Island Narrows serving both pleasure and work boats. Three of the marinas are located on the west shore of the Narrows and seven are located on the east shore (Figure 5). The names of these marinas and the number of slips available are listed below.

Name	*Number of Slips*
Hartge Boat Yard	26
Thomas Boat Yard	6
Cedar Point Marina, Inc.	100
Fisherman's Marina, Inc.	45
W. A. Thomas and Son, Inc.	2 (Party Boats)
Kent Narrows Marina	50
Seward's Point Marina	405
Piney Narrows Marina and Yacht Sales	274
Kent Island Yacht Club	41
County Marina	91
TOTAL NUMBER OF SLIPS	1040

Source: *Boating Almanac 1977*, Boating Almanac Company, Volume 4, Severna Park, Maryland, 1977.

The actual effects of boating activity on the environment are difficult to isolate and assess. It is generally accepted that high intensity boat activity can result in:

1. Degradation of water quality and aquatic biota due to overboard discharge of human wastes and litter.
2. Reduction of water flushing capabilities due to structure encroachment.
3. Degradation of water quality and aquatic biota due to discharge of engine emissions and unburned fuels.[5]

4. Official Record, Division of Water Supplies, Water and Sewage Control Programs, Environmental Health Administration, Department of Health and Mental Hygiene.
5. Maryland Department of Natural Resources Water Resources Administration, *Chester River Basin Water Quality Management Plan*, Annapolis, Maryland, 1976.

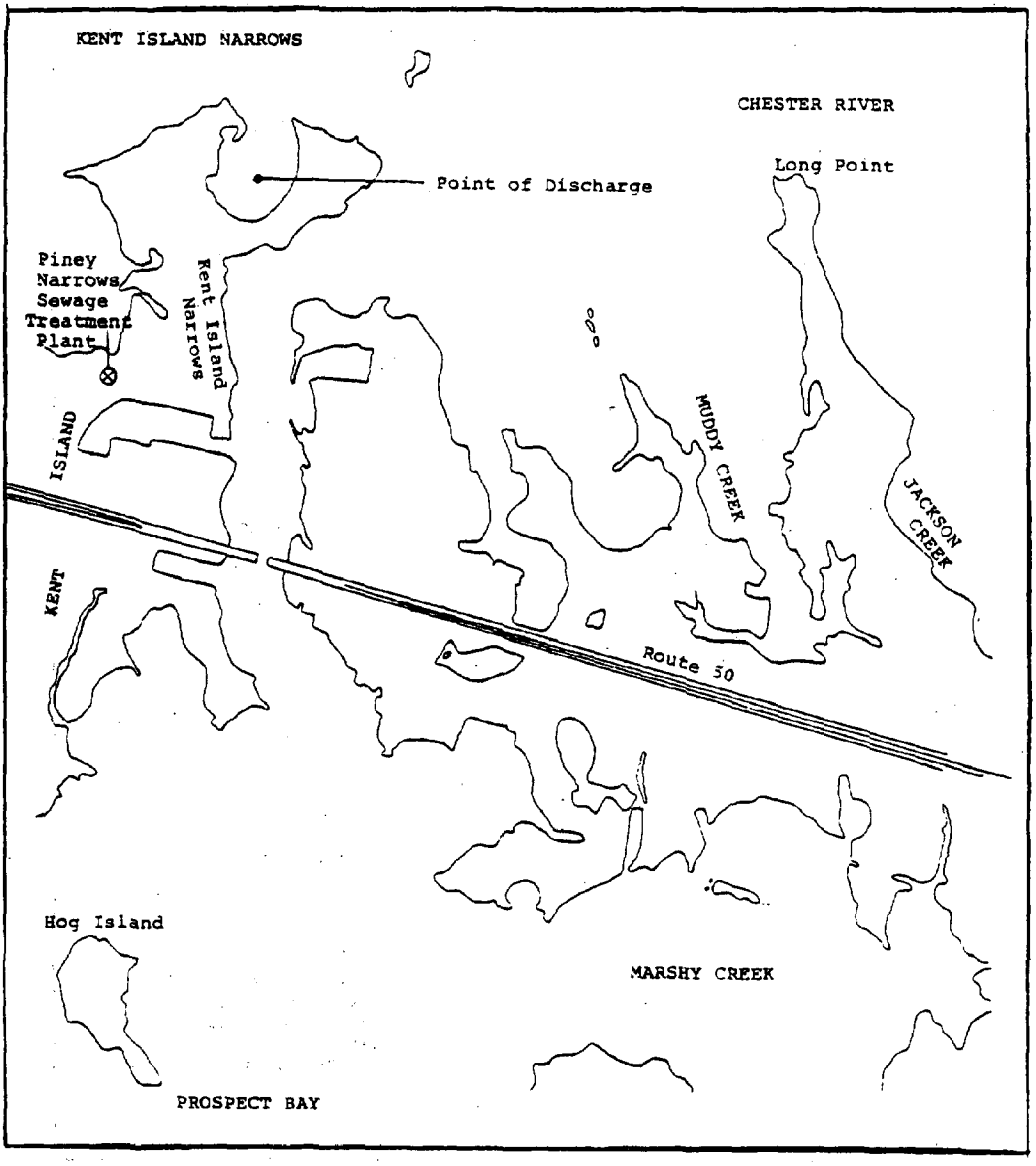

Figure 4 – Piney Narrows Sewage Treatment Plant Location

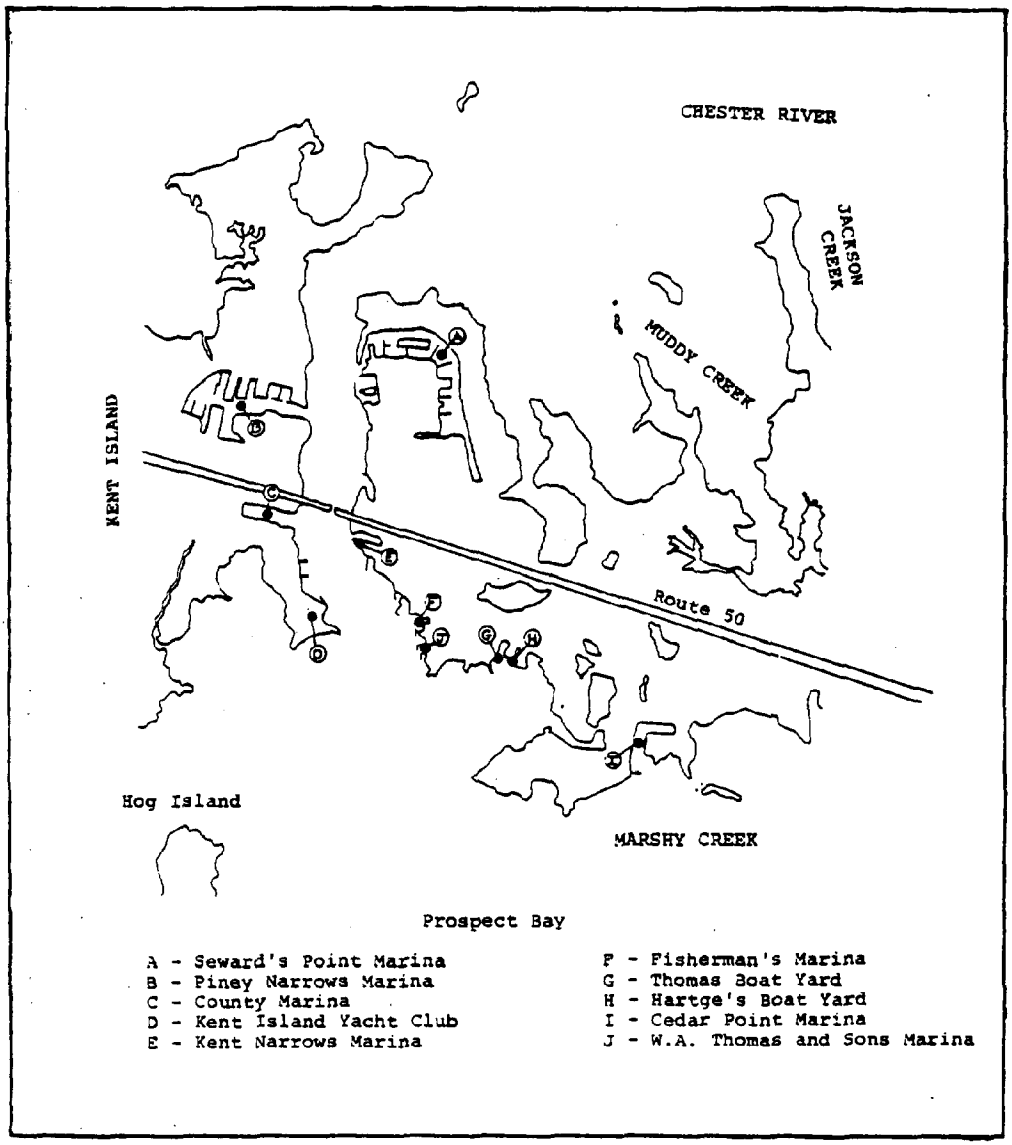

Figure 5 — Kent Island Narrows Marinas

STUDY APPROACH

In April of 1974, personnel from the Division of General Sanitation established a special water sampling program in Kent Narrows at the request of Dr. Roberta Hall, Deputy State and County Health Officer for the Queen Anne's County Health Department. The purpose of the program was to monitor water quality in Kent Island Narrows marinas for the presence of total coliform and fecal coliform organisms as indicators of sewage pollution from boats.

Total coliform and fecal coliform are indicator organisms used in assessing the bacteriological quality of water. The coliform group of bacteria are found in the guts and feces of warmblooded and coldblooded animals, in soils and on many plants. The fecal coliform organisms, however, are usually associated only with the enteric tract of warmblooded animals. The feces of warmblooded animals such as humans, animals and birds may also contain disease producing microorganisms at any time.[6] The coliform group, particularly fecal coliform, are therefore used as an indicator of the possible presence in water of sewage bearing disease-producing microorganisms.

The waters in Kent Island Narrows are classified as shellfish growing waters and are highly productive for oyster shellstock. Oysters are filter feeders that strain detritis and phytoplankton from the water for food. If harmful bacteria or viruses are present in the growing waters, they are concentrated within the oysters. When the oysters are consumed in a raw or partially cooked state by humans, the harmful microorganisms concentrated within the oyster may produce illness. Where concentrations of boats equipped with toilets discharging untreated wastes overboard occur, a potential hazard to human health exists if the receiving waters are used for growing shellfish such as clams, oysters or mussels.

At the beginning of the program, twenty-three sampling stations were randomly established at various locations in and around Kent Island Narrows. Upstream and downstream locations were included to monitor the extent of bacteriological loading leaving or entering the Narrows during tidal changes and current flows. Figure 6 shows the sampling station locations in Kent Island Narrows and Prospect Bay. Figure 7 shows sampling station locations in the Chester River.

Ten sampling stations were established in the waters of six marinas to study the effect boating activity may have on water quality in the Narrows. Sampling stations were located as follows:

Piney Narrows Marina — 3 sampling stations
Seward's Point Marina — 3 sampling stations
County Marina — 1 sampling station
Kent Narrows Marina — 1 sampling station
Hartge Boat Yard and Thomas Boat Yard — 1 sampling station
Cedar Point Marina — 1 sampling station

Figure 6 shows the sampling station location in or adjacent to these marinas.

On February 14 and 15, 1974, a special shoreline survey of properties in the Kent Island Narrows area was done by personnel from the Division of General Sanitation. Thirty (30) commercial and residential properties were inspected for possible sanitary violations including failing septic systems, kitchen waste and laundry waste discharges. Ten (10) violations were discovered and reported to the Queen Anne's County Health Department for correction. All of the violations were corrected by March 15, 1974, prior to the initiation of the study. Spot checks were made throughout the study on properties with a history of failures. No additional sanitary violations were found.

6. E. E. Geldreich, *Sanitary Significance of Fecal Coliform in the Environment*, U.S. Department of the Interior, November 1966.

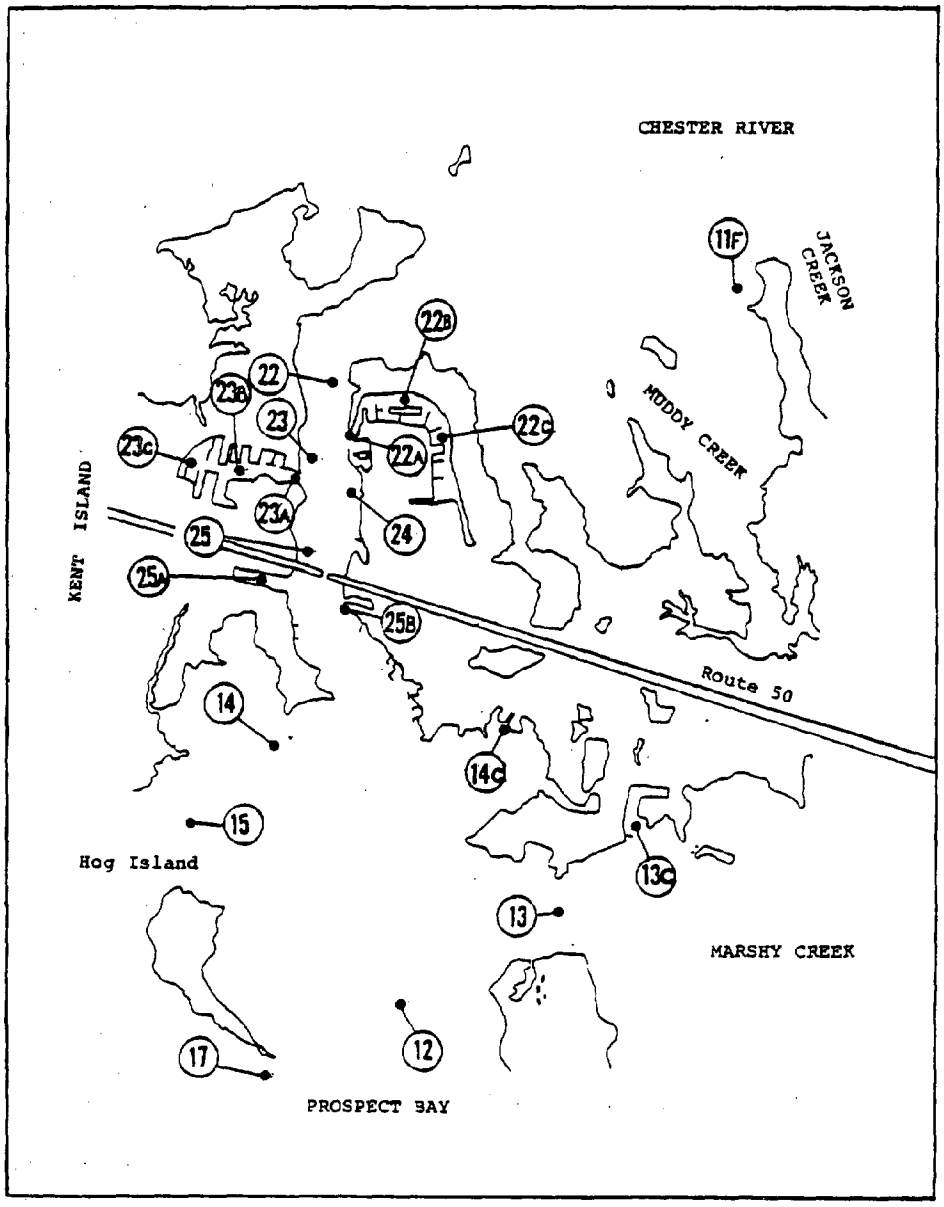

Figure 6 — Sampling Station Locations in Kent Island Narrows and Prospect Bay

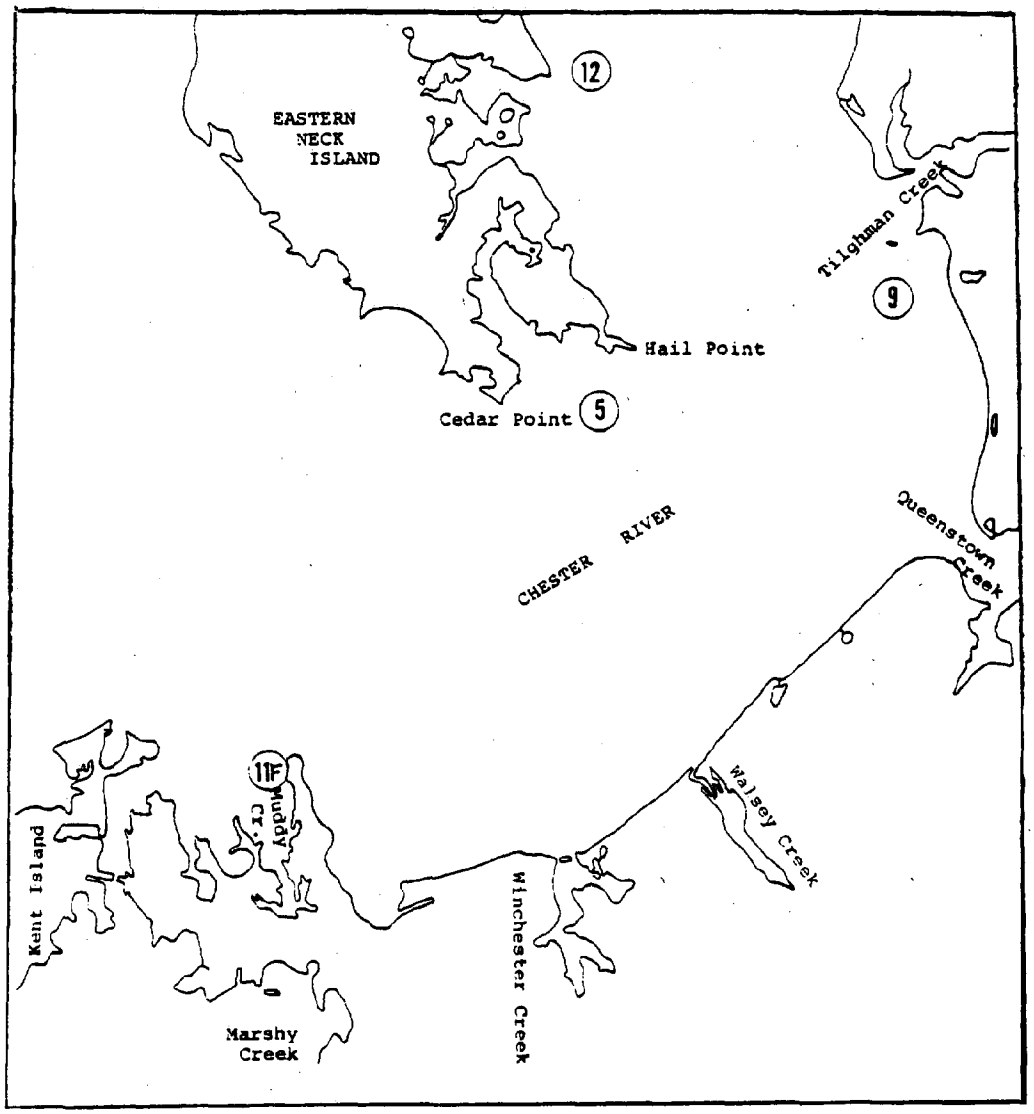

Figure 7 — Sampling Station Locations in the Chester River

METHODOLOGY

Sample Collection and Analysis

Surface water samples for coliform and fecal coliform analysis were collected monthly or more frequently at all established stations for a period of two years. Surface water samples were collected by securing a bottle to the base of a dipstick and lowering it over the side of a boat. All samples were collected in sterile bacteriological bottles using aseptic techniques. All water samples were iced and delivered to the Department of Health and Mental Hygiene's Regional Laboratory in Easton, Maryland. All sampling and examination procedures were conducted in accordance with *Recommended Procedures for the Examination of Sea Water and Shellfish*, 4th Edition, 1970. No samples were collected for chemical analysis.

All water samples collected in the course of the study were analyzed for the presence of the total coliform group and the fecal coliform group using a three-tube/three-dilution Most Probable Number Test. Results of tests for coliform organisms or for various members of the coliform group by the multi-tube dilution method are reported in terms of the "Most Probable Number" (MPN) index. The MPN is not a precise enumeration of the numbers of bacteria in any given sample volume. The precision and confidence limits of the test using any given number of tubes and of the MPN method of estimating densities have been determined and are available in the *Recommended Procedures*. The accuracy of the result is dependent upon the number of portions of each dilution planted in the multi-tube fermentation test.

Statistical Analysis

To adjust the data to a common scale, the total coliform and fecal coliform MPN values were transformed by $\log_{10}$. Data spanning a 2 year period from April of 1974 through May of 1976 were used and results from stations within marinas were combined to establish one mean for each marina. Data from the same period were used to establish a mean for each of the control areas. Results from monitoring stations 12, 13, 14, 15, and 17 were combined to obtain the mean for Prospect Bay waters. Stations 11F, 5, 9 and 12 were combined to obtain a mean for Chester River waters and stations 22, 23, 24, and 25 were used to obtain a mean for the Kent Island Narrows.

Comparisons were made between total coliform and fecal coliform levels in marina waters and the waters in Prospect Bay, Chester River and the Kent Island Narrows (controls). The total coliform and fecal coliform levels from these three control areas were also compared to one another. In addition, fecal coliform levels within marina waters on the first day following a weekend or holiday were compared to levels within marina waters on weekdays.

Dunnett's procedure[7] of comparing all means with a control was used to compare levels of total coliform and fecal coliform in the waters of each marina with levels in each control water. A separate analysis of variance was performed for marina waters versus Kent Island Narrows (control); marina waters versus Prospect Bay waters (control) and marina waters versus the Chester River (control).

The significant difference $d' = ts\sqrt{\left(\frac{1}{n_i} + \frac{1}{n_j}\right)}$, where t is from Dunnett's table, s equals the square root of the error mean square and $\left(\frac{1}{n_i} + \frac{1}{n_j}\right)$ is a correction factor for variable replication where n_i and n_j are the number of observations in the two means being compared, was calculated for each comparison. The difference between the means being compared $(\bar{x}_i - \bar{x}_j)$, in this case $\bar{x}_i$ being the marina mean and $\bar{x}_j$ being the control mean, was declared significant if the difference was greater than the significant difference d' that was calculated for that particular comparison.

7. R. Steel and J. Torrie, *Principles and Procedures of Statistics*, McGraw Hill Book Company, Inc., New York, 1960.

Student's one-tailed t-test was used to compare the total and fecal coliform levels in the three control areas (Prospect Bay, Chester River and the Kent Island Narrows).

The Student's one-tailed t-test was used to compare total and fecal coliform levels in the waters of a marina on a day following a weekend or holiday with levels in the waters of the same marina during the week. Data from 1974 and 1975 were used. Data from stations within each marina were combined to obtain one representative mean for weekdays or for the days following a weekend or holiday.

RESULTS

The Kent Island Narrows Marina study began in April 1974 and ended in May 1976. All water quality monitoring stations were sampled monthly or more frequently. During this time period, six hundred and thirty-six (636) water samples were collected from 23 locations. The total and fecal coliform data generated over the two year period are presented in the Appendix. Samples of effluent from seafood processing houses were collected by the Water Resources Administration, Department of Natural Resources.

Seafood Processing Plants

Results of bacterial analyses of the effluents from eight of the seafood processing plants indicate that seven of these plants discharge effluents which exceed their NPDES limits of 70 MPN/100ml for total coliform most of the time. All of the seafood processing plants discharge treated effluent directly into Kent Island Narrows. No known direct discharges from the processing plants enter the marina basins. No data are available on the actual volume of effluent discharged by these plants and it is, therefore, difficult to quantify the impact of these effluents on bacteriological water quality in the Narrows.

Since the water quality in Kent Island Narrows was used as a control for comparison purposes with water quality in the marina basins and since the control includes the effects of the seafood processing plants, any elevated total or fecal coliform levels found in the marina basins should be related to marina activity and not to seafood processing plant wastes.

On-Site Waste Disposal Systems

Failing on-site waste disposal systems have been suspected of contributing to the total and fecal coliform pollution load entering the waters of Kent Island Narrows. A special survey was made of the study area prior to the initiation of the study. Discharges from on-site waste disposal systems which might contribute to the bacterial load in the waters of Kent Island Narrows or the marina basins were identified and eliminated. Periodic spot checks were made to assure that no additional failures occured. Water quality in the marina basins or Kent Island Narrows during the study period should not reflect any effect from on-site waste disposal systems.

Marinas

The total and fecal coliform MPN values from the waters of each marina and from each of the control areas were adjusted to a common scale by $\log_{10}$ transformation. Data spanned a two-year period from April 1974 through May 1976. Results from stations within each marina were combined to obtain a representative mean for each marina. Similarly, results from stations within each control area were combined to obtain a representative mean for each control area.

A comparison between the fecal coliform level in Kent Island Narrows (control) and the level in the waters of each marina was made using Dunnett's procedure of comparing all means with a control. The difference between fecal coliform means for the control and for each of the six marinas $(\bar{x}_i - \bar{x}_j)$ along with the significant difference for each comparison d' was calculated and is shown in Table 2. The difference between the means being compared was declared significant if the difference was greater than the significant difference d' that was calculated for that particular comparison. All marina waters were found at the 5% level to have significantly higher fecal coliform levels than the waters in Kent Island Narrows.

Dunnett's procedure was also applied to the total coliform data using the same process implemented in the evaluation of the fecal coliform data. (Table 3) All marina waters were found to have significantly higher total coliform levels than the waters of the Kent Island Narrows.

Table 2 — Fecal Coliform Level in Kent Island Narrows Compared to Fecal Coliform Levels in Six Marinas

Location	$\bar{x}_i - \bar{x}_j$ *	d' **	Significant*** at the 5% level
Seward's Point Marina	.59	.22	+
Piney Narrows Marina and Yacht Sales	.60	.22	+
County Marina	45	.32	+
Cedar Point Marina	.51	.35	+
Hartge's Boat Yard	.98	.38	+
Kent Narrows Marina	.42	.32	+

* $\bar{x}_i$ = marina fecal coliform mean; $\bar{x}_j$ = Kent Island Narrows fecal coliform mean

**d' = Dunnett's significant difference

***+ = significant

To further test the hypothesis that marina waters have higher levels of fecal and total coliform than waters outside of marinas, Dunnett's procedure was used to compare the marina waters to two other control areas. Data from the Chester River immediately north of the Kent Island Narrows was used as one control area while data from Prospect Bay immediately south of the Kent Island Narrows was used as a second control area. Results from the fecal coliform level comparison of marina waters to Chester River waters and to Prospect Bay waters are shown in Table 4. In all cases, marina waters were found to have significantly higher levels of fecal coliform than the waters of the Chester River or Prospect Bay.

Table 3 — Total Coliform Level in Kent Island Narrows Compared to Total Coliform Levels in Six Marinas

Location	$\bar{x}_i - \bar{x}_j$ *	d' **	Significant*** at the 5% level
Seward's Point Marina	.41	.20	+
Piney Narrows Marina and Yacht Sales	.45	.20	+
County Marina	.50	.28	+
Cedar Point Marina	.55	.31	+
Hartge's Boat Yard	.60	.34	+
Kent Narrows Marina	.49	.28	+

*$\bar{x}_i$ = marina total coliform mean; $\bar{x}_j$ = Kent Island Narrows total coliform mean.

**d' = Dunnett's significant difference

***+ = significant

Table 4 — Fecal Coliform Levels in the Chester River and Prospect Bay Compared to Fecal Coliform Levels in Six Marinas

Location	Chester River (control)			Prospect Bay (control)		
	$\bar{x}_i - \bar{x}_j$ *	d' **	Significant*** at the 5% level	$\bar{x}_i - \bar{x}_j$ *	d' **	Significant*** at the 5% level
Seward's Point Marina	1.00	.27	+	.63	.21	+
Piney Narrows Marina and Yacht Club	1.01	.26	+	.64	.21	+
County Marina	.86	.37	+	.49	.33	+
Cedar Point Marina	.92	.37	+	.55	.33	+
Hartge's Boat Yard	1.39	.41	+	1.02	.36	+
Kent Narrows Marina	.83	.34	+	.46	.30	+

* $\bar{x}_i$ = marina fecal coliform mean;
$\bar{x}_j$ = control fecal coliform mean

** d' = Dunnett's significant difference
*** + = significant

Dunnett's procedure was also applied to the total coliform data to compare levels of total coliform in marina waters to levels in the waters of the Chester River and Prospect Bay. In all cases, total coliform levels in marina waters were significantly higher than levels in the two control areas.

The Student's one-tailed *t*-test was employed to compare the total and fecal coliform levels in the three different control areas. (Table 5) The Chester River had significantly lower total and fecal coliform levels than the Kent Narrows and Prospect Bay areas. There is no significant difference in total and fecal coliform levels in Kent Narrows and in upper Prospect Bay.

Table 5 — Comparison of Total and Fecal Coliform Levels in Control Areas

Areas Compared	Total Coliform Means	Significant* at the 5% level	Fecal Coliform Means	Significant* at the 5% level
Chester River vs. Kent Narrows	2.05 vs. 2.25	+	1.03 vs. 1.44	+
Chester River vs. Prospect Bay	2.05 vs. 2.24	+	1.03 vs. 1.40	+
Kent Narrows vs. Prospect Bay	2.25 vs. 2.24	-	1.44 vs. 1.40	-

* + = significant; - = not significant

The Student's one-tailed *t*-test was applied to the data to compare fecal coliform levels in the waters of a marina on a day following a weekend or holiday to the fecal coliform levels in the waters of the same marina during the week. (Table 6)

The difference between the means being compared $(\bar{x}_i - \bar{x}_j)$ where $\bar{x}_i$ is the mean for the days following weekends or holidays and $\bar{x}_j$ is the mean for days during the week is considered significant if it exceeds the *t* value for the 95% confidence level shown in Student's *t* Table.

The 3 large marinas, Seward's Point, Piney Narrows and Cedar Point, which cater primarily to pleasure craft had significantly higher levels of fecal coliform in marina waters on days following a weekend or holiday than on weekdays. Since the County Marina services only commercial fisherman who use their boats to work six days a week if weather conditions permit, it is reasonable that there is no significant difference between days following weekends or holidays and weekdays. Both Hartge Boat Yard and Kent Narrows Marina are smaller than the previous four marinas and serve a mixture of pleasure craft and workboats. The size of the marinas and the mixture of vessels may explain why no significant difference exists between the two time periods. In addition, the sample size was small for these two facilities.

Table 6 — Comparison of Fecal Coliform Levels in Marina Waters on Days Following Weekends or Holidays with Days During the Week

Location	$\bar{x}_i$ *	$\bar{x}_j$ **	$\bar{x}_i - \bar{x}_j$	Significant*** at the 5% level
Seward's Point Marina	2.36	1.93	.43	+
Piney Narrows Marina and Yacht Club	2.29	2.04	.25	+
County Marina	2.43	1.92	.51	-
Cedar Point Marina	2.23	1.73	.50	+
Hartge's Boat Yard	2.64	2.24	.40	-
Kent Narrows Marina	2.31	1.90	.41	-

* $\bar{x}_i$ = fecal coliform mean in marina on days following weekends or holidays

** $\bar{x}_j$ = fecal coliform mean in marina on days during the week

*** + = significant; - = not significant

A gradient of increasing densities of fecal coliform is evident from the mouth to the rear of Piney Narrows Marina and Seward's Point Marina. The $\log_{10}$ means of the fecal coliform MPN/100 ml for Piney Narrows and Seward's Point Marinas was higher at the stations at the rear of the two marinas than at the stations at the center or the mouth. (Table 7)

Table 7 — Log_{10} Means for Fecal Coliform Densities in Piney Narrows Marina and Seward's Point Marina

	Mouth of Marina	Middle of Marina	Rear of Marina
Piney Narrows Marina	1.74	2.19	2.30
Seward's Point Marina	1.80	2.00	2.37

The waters in the marinas and in Kent Island Narrows are classified as shellfish harvesting waters. Kent Island Narrows is extremely important to the shellfish industry as it is sheltered from winter winds and may be worked when rough waters keep harvesting boats off the open Bay.

Bacteriological water quality standards set forth by the National Shellfish Sanitation Program (NSSP) for shellfish harvesting waters were applied to all sampling stations in the marinas and the Kent Island Narrows. The fecal coliform standard for this program as applied in Maryland requires that no samples can exceed a median of 14 fecal coliform MPN/100 ml and that no more than 10% of the samples can exceed 49 fecal coliform MPN/100 ml when using the 3-tube decimal dilution test. Median values for fecal coliform MPNs were calculated for all marina and channel sampling stations over the two year period. When the National Shellfish Sanitation Program standard was applied to this data, no sampling station met the required standard for shellfish growing waters. (Table 8) This data supports the need to restrict the waters in Kent Island Narrows for shellfish harvesting.

Table 8 — Station Compliance with National Shellfish Sanitation Program Standards for Fecal Coliform

Station	Number of Samples	Median (MPN/100ml)	Percentage Over 49	Geometric Mean	
22A	29	93	52	63	Seward's Point Marina
22B	22	93	59	100	
22C	22	240	77	234	
23A	28	84	54	55	Piney Narrows Marina and Yacht Club
23B	22	240	77	155	
23C	22	240	77	200	
25A	29	93	62	79	County Marina
25B	29	43	48	72	Kent Narrows Marina
14C	22	460	73	263	Hartge's Boat Yard
13C	23	93	61	89	Cedar Point Marina
22	49	23	25	22	Kent Island Narrows
23	49	23	29	26	
24	47	43	38	39	
25	48	20	31	25	

Bacteriological water standards set forth by the Water Resources Administration for water contact recreation were applied to all sampling stations in Kent Island Narrows and the Marinas. This standard requires that fecal coliform densities in recreational waters be less than a log mean of 200 MPN/100 ml. If the bacterial water quality exceeds a log mean of 200 MPN/100 ml, water quality will be considered acceptable only if a detailed sanitary survey and evaluation discloses no significant public health risk in the use of the waters. When this standard was applied to the log means of fecal coliform MPNs at all stations in Kent Island Narrows, the water quality was satisfactory for recreational use.

Two stations located within marinas, however, exceeded the water contact recreation standards. The geometric mean for fecal coliform at Station 22C in the rear of Seward's Point Marina was 234 and the geometric mean for Station 14C in Hartge Boat Yard was 264. Both of these sampling locations are recessed from the Kent Island Narrows and are probably subject to poor flushing. Station 23C located in the rear of Piney Narrows Marina had a fecal coliform geometric mean of 200 which is the maximum permitted level.

DISCUSSION

Total coliform and fecal coliform are indicator organisms used to assess the bacteriological quality of water. Presence of the coliform group, particularly fecal coliform, is an indicator of the possible contamination of water with sewage since these organisms may be found in the enteric tract of warmblooded animals including man. Since many boats are equipped with toilet facilities which discharge raw or partially treated wastes to boating waters, it is reasonable to assume that where large concentrations of boats are found elevated levels of total and fecal coliform will be present in the waters.

Ten sampling stations were established in six marinas to study the effect boating activity may have on total and fecal coliform levels in marina waters. Data from these stations was compared to data generated at sampling stations located outside the marinas in Kent Island Narrows, the Chester River and Prospect Bay. The study spanned a two-year period.

Statistical analysis of the data has shown a significantly higher level of total and fecal coliform in marina waters than in the Kent Island Narrows channel, the Chester River or Prospect Bay. Investigation has eliminated seafood processing houses or on-shore waste disposal systems as sources of total or fecal coliform in the marina basins. The higher levels of indicator organisms in marina waters are apparently the result of human wastes discharged from the boats.

This finding of elevated coliform densities in the marinas is consistent with the findings of other investigators. The marina study by the Virginia Military Institute Research Laboratory for the Virginia Department of Health (1973), stated that the total coliform and fecal coliform MPN in boat mooring areas were significantly higher than that obtained from bacteriological tests on surrounding water. This was attributed to the lack of adequate flushing action because of the recessed location of many harbor areas.[8]

Lear, Marks, and Schmincke (1966) in their evaluation of coliform contribution from pleasure boats in estuarine waters found that the data indicated a slight increase and persistence of coliform with the congregation of pleasure yachts.[9]

Seward's Point Marina and Piney Narrows Marina and Yacht Club are located in dredged basins off the main channel of the Narrows. There is a marked increase in bacteriological loading from the mouth to the rear of these marinas. This may be related to the configuration of the marina basin and the lack of good tidal flushing.

Weekends and holidays are usually periods of high activity at marinas populated with pleasure boats. Many people never leave their boat slips and often spend the entire weekend or holiday in one location. As a result of this practice, wastewater may be discharged overboard creating an excessive bacteriological loading on surface waters. The effect of weekend boating activity on marina waters was examined by comparing fecal coliform levels in the waters of a marina on a day following a weekend or holiday to levels in marina waters on weekdays.

Seward's Point Marina, Piney Narrows Marina and Yacht Club, and Cedar Point Marina are large marinas which cater to pleasure craft. All 3 marinas had significantly higher fecal coliform values in their marina waters on days following holidays or weekends. The higher level of coliform in Cedar Point Marina is especially significant since this marina lies off from Marshy Creek, where there is little commercial or residential development.

The County Marina which services only commercial fishermen's work boats showed no significant difference between weekends and weekdays. This is consistent with the six day work week of commercial fishermen. The two smaller marinas, Hartge Boat Yard and Kent Narrows Marina, serve a mixture of pleasure craft and commercial workboats. The lack of a statistically significant difference between fecal coliform levels in their waters on weekdays and days following weekends or holidays may be a function of the mixture of vessels served, the small size of the marinas or the small sample size.

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8. Department of Health, Commonwealth of Virginia, *Marina Regulations* (House Document No. 8), Richmond, Virginia, 1973.
9. Lear, Marks, and Schmincke, *Evaluation of Coliform Contribution by Pleasure Boats*, CB-SRBP, Technical Paper No. 10, Middle Atlantic Region, FWPCA, 1966.

The finding of elevated fecal coliform levels in marina waters following weekends or holidays is consistent with the findings of Wagenet and Lawrence. Their eight month study to determine if recreational use had a marked effect upon the quality of impounded water showed that as recreational attendance increased on Friday and Saturday and peaked on Sunday so did fecal coliform MPN levels.[10]

The Maryland State Department of Natural Resources, Water Resources Administration, published a report in 1965 concerning the bacteriological levels at a major Chesapeake Bay boating-bathing site during the Independence Day holiday. An increase in coliform levels over the holiday weekend followed by a decrease on the subsequent weekdays was a major finding of the report.[11]

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10. R. J. Wagenet and C. H. Lawrence, *Recreational Effects on Bacteriological Quality of an Impounded Water Supply*, Journal of Environmental Health, Volume 37, No. 1, 1974.
11. A. E. Sanderson, Jr., and Thomas C. Hopkins, Jr., *Coliform and E. Coli Bacteria Counts at a Major Chesapeake Bay Boating-Bathing Site During the Independence Day Holiday Period*, Annapolis, Maryland, 1965.

CONCLUSION

Bacteriological data generated from a two-year study has shown a significantly higher total coliform and fecal coliform loading at sampling stations located in the marinas in Kent Island Narrows. Total coliform and fecal coliform levels at sampling stations in the Kent Island Narrows and at stations in the Chester River and Prospect Bay were significantly lower than those associated with marinas.

A gradient of increasing densities of fecal coliform is evident from the mouth to the rear of Piney Narrows Marina and Seward's Point Marina. Marinas located in dredged basins off the main channel may not experience good tidal flushing therefore coliform organisms may accumulate and persist in the extremities of these marinas.

A significant relationship exists between the time of the week and the fecal coliform levels in the waters of the 3 large marinas. These marinas serve primarily pleasure craft. Fecal coliform densities on days following weekends and holidays were significantly higher than fecal coliform densities on weekdays in Seward's Point Marina, Piney Narrows Marina and Cedar Point Marina. Greater weekend activity associated with pleasure craft appears to be responsible for higher weekend and holiday fecal coliform densities.

The waters in Kent Island Narrows and the surrounding marinas did not meet the National Shellfish Sanitation Program standard for shellfish harvesting waters. Results from all stations monitored in the two year period exceeded the standard. The waters of Kent Island Narrows were not acceptable for shellfish harvesting.

Bacteriological standards for Class I Recreational Waters were applied to the fecal coliform results from all sampling stations in the study. In Seward's Point Marina, water quality in the backwaters of the marina exceeded bacteriological standards for recreational vehicles. Water quality in Hartge Boat Yard also exceeded the standard. In Piney Narrows Marina, the fecal coliform level in the backwaters of the marina reached the maximum allowable limit for recreational waters. The recessed location of these three marinas apparently hinders adequate flushing action resulting in elevated fecal coliform levels.

Based on the data in this report, marinas in the Kent Island Narrows are significant contributors toward bacterial loading in surface waters.

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R. J. Wagenet and C. H. Lawrence, *Recreational Effects on Bacteriological Quality of an Impounded Water Supply*, Journal of Environmental Health, Volume 37, No. 1, 1974.

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APPENDIX

SEWARD'S POINT MARINA

Date of Sample Collection	Tide	Station 22A Coliform	Station 22A Fecal Coliform	Station 22B Coliform	Station 22B Fecal Coliform	Station 22C Coliform	Station 22C Fecal Coliform
4/16/74		---	---	---	---	---	---
4/23/74	Ebb	---	---	---	---	---	---
4/24/74	Ebb	---	---	---	---	---	---
4/29/74	Flood	---	---	---	---	---	---
5/9/74	Ebb	93	23	43	43	240	15
5/21/74	Ebb	---	---	---	---	---	---
5/29/74	Flood	460	43	1100	9.1	460	150
6/4/74	Ebb	---	---	---	---	---	---
6/17/74	Ebb	240	43	460	460	460	460
7/8/84	Ebb	---	---	---	---	---	---
7/22/74	Ebb	1100	150	240	93	240	240
7/29/74	Flood	1100	93	240	240	2400+	2400+
8/13/74	Flood	240	93	240	93	1100	460
8/21/74	Ebb	93	43	93	23	460	23
9/16/74	Ebb	460	39	93	23	240	43
10/21/74	Ebb	240	240	2400+	2400+	240	240
10/22/74	Ebb	---	---	---	---	---	---
11/12/74	Flood	460	93	240	93	240	93
12/4/74	Ebb	2400+	1100	2400+	1100	2400+	460
1/6/75	Flood	---	---	---	---	---	---
1/13/75	Ebb	460	240	1100	1100	---	460
2/5/75	Flood	460	460	1100	1100	460	460
4/7/75	Flood	93	93	93	43	460	93
4/14/75	Ebb	---	---	---	---	---	---
4/16/75	Ebb	240	9.1	43	9.1	150	39
5/7/75	Ebb	460	43	240	15	1100	1100
5/13/75	Ebb	---	---	---	---	---	---
5/26/75	Ebb	2400+	460	2400+	120	2400+	2400+
6/4/75	Flood	240	9.1	460	93	460	93
6/17/75	Flood	---	---	---	---	---	---
7/21/75	Ebb	---	---	---	---	---	---
7/30/75	Flood	460	240	460	43	2400+	1100
8/4/75		240	93	240	240	460	240
9/2/75	Flood	2400+	1100	2400+	75	2400+	2400+
9/16/75	Flood	---	---	---	---	---	---
10/8/75	Ebb	---	---	---	---	---	---
10/16/75	Ebb	1100	93	2400+	43	460	43
10/28/75	Ebb	---	---	---	---	---	---
11/17/75	Flood	---	---	---	---	---	---
1/21/76	Ebb	---	---	---	---	---	---
1/26/76	Flood	23	3.6	---	---	---	---
1/29/76	Flood	210	93	---	---	---	---
2/3/76	Ebb	2400+	43	---	---	---	---
2/4/76	Ebb	1100	23	---	---	---	---
2/11/76	Flood	1100	3.6	---	---	---	---
2/18/76	Ebb	240	43	---	---	---	---
3/2/76	Ebb	---	---	---	---	---	----
3/15/76	Flood	240	<3	---	---	---	---
4/20/76	Ebb	---	---	---	---	---	---
5/17/76	Ebb	---	---	---	---	---	---

Coliform and Fecal Coliform expressed as MPN/100 ml

PINEY NARROWS MARINA

Date of Sample Collection	Tide	Station 23A Coliform	Station 23A Fecal Coliform	Station 23B Coliform	Station 23B Fecal Coliform	Station 23C Coliform	Station 23C Fecal Coliform
4/16/74		---	---	---	---	---	---
4/23/74	Ebb	---	---	---	---	---	---
4/24/74	Ebb	---	---	---	---	---	---
4/29/74	Flood	---	---	---	---	---	---
5/9/74	Ebb	43	43	240	23	460	43
5/21/74	Ebb	---	---	---	---	---	---
5/29/74	Flood	460	93	240	43	240	240
6/4/74	Ebb	---	---	---	---	---	---
6/17/74	Ebb	460	93	2400+	460	460	240
7/8/74	Ebb	---	---	---	---	---	---
7/22/74	Ebb	1100	1100	2400+	240	460	43
7/29/74	Flood	1100	240	2400+	460	2400+	2400+
8/13/74	Flood	460	75	240	240	240	240
8/21/74	Ebb	460	93	460	75	240	93
9/16/74	Ebb	---	---	460	93	1100	93
10/21/74	Ebb	240	240	2400+	2400+	460	240
11/12/74	Flood	93	93	240	240	2400+	1100
12/4/74	Ebb	2400+	460	2400+	460	1100	240
1/6/75	Flood	---	---	---	---	---	---
1/13/75	Ebb	43	23	150	93	93	43
2/5/75	Flood	93	93	93	93	240	21
4/7/75	Flood	460	23	460	93	460	93
4/14/75	Ebb	---	---	---	---	---	---
4/16/75	Ebb	43	3.6	43	15	93	9.1
5/7/75	Ebb	240	240	1100	240	460	240
5/13/75	Ebb	---	---	---	---	---	---
5/26/75	Ebb	2400+	1100	2400+	1100	2400+	460
6/4/75	Flood	460	43	460	240	460	460
6/17/75	Flood	---	---	---	---	---	---
7/21/75	Ebb	---	---	---	---	---	---
7/30/75	Flood	1100	120	460	240	2400+	1100
8/4/75		43	23	23	9.1	1100	460
9/2/75	Flood	2400+	43	2400+	1100	2400+	2400+
9/16/75	Flood	---	---	---	---	---	---
10/8/75	Ebb	---	---	---	---	---	---
10/16/75	Ebb	2400+	150	1100	39	2400+	210
10/28/75	Ebb	---	---	---	---	---	---
11/17/75	Flood	---	---	---	---	---	---
1/21/76	Ebb	---	---	---	---	---	---
1/26/76	Flood	43	23	---	---	---	---
1/29/76	Flood	460	9.1	---	---	---	---
2/3/76	Ebb	2400+	9.1	---	---	---	---
2/4/76	Ebb	2400+	93	---	---	---	---
2/11/76	Flood	2400+	3.6	---	---	---	---
2/18/76	Ebb	1100	9.1	---	---	---	---
3/2/76	Ebb	---	---	---	---	---	---
3/15/76	Flood	150	3.6	---	---	---	---
4/20/76	Ebb	---	---	---	---	---	---
5/17/76	Ebb	---	---	---	---	---	---

Coliform and Fecal Coliform expressed as MPN/100 ml

HARTGES BOAT WORKS

Date of Sample Collection	Tide	Station 14C Coliform	Fecal Coliform
4/16/74	Flood	---	---
4/23/74	Ebb	---	---
4/24/74	Ebb	---	---
4/29/74	Ebb	---	---
5/9/74	Ebb	1100	460
5/21/74	Flood	---	---
5/29/74	Flood	1100	460
6/4/74	Flood	---	---
6/17/74	Flood	1100	460
7/8/74	Ebb	---	---
7/22/74	Ebb	460	43
7/29/74	Flood	460	460
8/13/74	Flood	240	43
8/21/74	Ebb	240	23
9/16/74	Ebb	2400+	240
10/21/74	Ebb	2400+	1100
10/22/74	Ebb	---	---
11/22/74	Flood	460	460
12/4/74	Ebb	2400+	240
1/6/75	Flood	---	---
1/13/75	Ebb	2400+	2400+
2/5/75	Flood	1100	1100
4/7/75	Flood	240	240
4/14/75	Ebb	---	---
4/16/75	Ebb	23	23
5/7/75	Ebb	1100	1100
5/13/75	Ebb	---	---
5/26/75	Ebb	2400+	1100
6/4/75	Flood	210	23
6/17/75	Flood	---	---
7/21/75	Ebb	---	---
7/30/75	Flood	43	23
8/4/75	Slack	2400+	1100
9/2/75	Flood	2400+	150
9/16/75	Flood	---	---
10/8/75	Ebb	---	---
10/16/75	Ebb	2400+	2400+
10/28/75	Ebb	---	---
11/17/75	Flood	---	---
1/21/76	Ebb	---	---
1/26/76	Flood	---	---
1/29/76	Flood	---	---
2/3/76	Ebb	---	---
2/4/76	Ebb	---	---
2/11/76	Flood	---	---
2/18/76	Ebb	---	---
3/2/76	Ebb	---	---
3/15/76	Flood	---	---
4/20/76	Ebb	---	---
5/17/76	Ebb	---	---

Coliform and Fecal Coliform expressed as MPN/100 ml

COUNTY MARINA

Date of Sample Collection	Tide	Station 25A Coliform	Fecal Coliform
4/16/74		---	---
4/23/74	Ebb	---	---
4/24/74	Ebb	---	---
4/29/74	Ebb	---	---
5/9/74	Ebb	240	93
5/21/74	Ebb	---	---
5/29/74	Flood	460	23
6/4/74	Ebb	---	---
6/17/74	Ebb	2400+	2400+
7/8/84	Ebb	---	---
7/22/74	Ebb	1100	460
7/29/74	Flood	2400+	150
8/13/74	Ebb	240	240
8/21/74	Ebb	1100	460
9/16/74	Ebb	460	93
10/21/74	Ebb	93	93
10/22/74	Ebb	---	---
11/12/74	Flood	43	15
12/4/74	Ebb	1100	240
1/6/75	Flood	---	---
1/13/75	Flood	460	15
2/5/75	Flood	240	240
4/7/75	Flood	150	150
4/14/75	Ebb	---	---
4/16/75	Ebb	93	<3
5/7/75	Flood	460	3.6
5/13/75	Ebb	---	---
5/26/75	Ebb	2400+	240
6/4/75	Flood	1100	460
6/17/75	Flood	---	---
7/21/75	Ebb	---	---
7/30/75	Flood	1100	460
8/4/75		2400+	1100
9/2/75	Flood	2400+	2400+
9/16/75	Flood	---	---
10/8/75	Ebb	---	---
10/16/75	Ebb	2400+	210
10/28/75	Ebb	---	---
11/17/75	Flood	---	---
1/21/76	Flood	---	---
1/26/76	Flood	23	9.1
1/29/76	Flood	150	9.1
2/3/76	Ebb	2400+	9.1
2/4/76	Ebb	2400+	39
2/11/76	Flood	2400+	<3
2/18/76	Ebb	240	93
3/2/76	Ebb	---	---
3/15/76	Flood	460	9.1
4/20/76	Ebb	---	---

Coliform and Fecal Coliform expressed as MPN/100 ml

CEDAR POINT MARINA

Date of Sample Collection	Tide	Station 13C Coliform	Fecal Coliform
4/16/74	Flood	---	---
4/23/74	Ebb	---	---
4/24/74	Ebb	---	---
4/29/74	Ebb	---	---
5/9/74	Ebb	460	93
5/21/74	Ebb	---	---
5/29/74	Flood	1100	43
6/4/74	Flood	---	---
6/17/74	Flood	1100	93
7/8/74	Ebb	---	---
7/22/74	Ebb	460	460
7/29/74	Flood	2400+	43
8/13/74	Flood	1100	23
8/21/74	Ebb	1100	75
9/16/74	Ebb	2400+	43
10/21/74	Ebb	240	240
10/22/74	Ebb	---	---
11/12/74	Flood	240	23
12/4/74	Ebb	2400+	460
1/6/75	Flood	---	---
1/13/75	Ebb	460	240
2/5/75	Flood	43	43
4/7/75	Flood	460	93
4/14/75	Ebb	---	---
4/16/75	Ebb	23	9.1
5/7/75	Ebb	150	14
5/13/75	Ebb	---	---
5/26/75	Ebb	2400+	1100
6/4/75	Flood	460	93
6/17/75	Flood	---	---
7/21/75	Ebb	---	---
7/30/75	Flood	2400+	93
8/4/75		460	93
9/2/75	Flood	2400+	460
9/16/75	Flood	---	---
10/8/75	Ebb	---	---
10/16/75	Ebb	460	240
10/28/75	Ebb	---	---
11/17/75	Flood	---	---
1/21/76	Ebb	---	---
1/26/76	Flood	---	---
1/29/76	Flood	2400+	43
2/3/76	Ebb	---	---
2/4/76	Ebb	---	---
2/11/76	Flood	---	---
2/18/76	Ebb	---	---
3/2/76	Ebb	---	---
3/15/76	Flood	---	---
4/20/76	Ebb	---	---
5/17/76	Ebb	---	---

Coliform and Fecal Coliform expressed as MPN/100 ml

KENT NARROWS MARINA

Date of Sample Collection	Tide	Station 25B Coliform	Fecal Coliform
4/16/74		---	---
4/23/74	Ebb	---	---
4/24/74	Ebb	---	---
4/29/74	Flood	---	---
5/9/74	Ebb	75	23
5/21/74	Ebb	---	---
5/29/74	Flood	1100	150
6/4/74	Ebb	---	---
6/17/74	Ebb	460	460
7/8/74	Ebb	---	---
7/22/74	Ebb	2400+	23
7/29/74	Flood	2400+	240
8/13/74	Ebb	460	240
8/21/74	Ebb	75	23
9/16/74	Ebb	1100	43
10/21/74	Ebb	1100	1100
10/22/74	Ebb	---	---
11/12/74	Flood	240	43
12/4/74	Ebb	2400+	2400+
1/6/75	Flood	---	---
1/13/75	Flood	460	93
2/5/75	Flood	150	43
4/7/75	Flood	240	93
4/14/75	Ebb	---	---
4/16/75	Ebb	93	3.6
5/7/75	Flood	2400+	460
5/13/75	Ebb	---	---
5/26/75	Ebb	2400+	240
6/4/75	Flood	1100	150
6/17/75	Flood	---	---
7/21/75	Ebb	---	---
7/30/75	Flood	120	75
8/4/75		1100	460
9/2/75	Flood	2400+	1100
9/16/75	Flood	---	---
10/8/75	Ebb	---	---
10/16/75	Ebb	2400+	43
10/28/75	Ebb	---	---
11/17/75	Flood	---	---
1/21/76	Flood	---	---
1/26/76	Flood	23	3.6
1/29/76	Flood	210	23
2/3/76	Ebb	2400+	43
2/4/76	Ebb	2400+	9.1
2/11/76	Flood	290	9.1
2/18/76	Ebb	460	15
3/2/76	Ebb	---	---
3/15/76	Flood	240	23
4/20/76	Ebb	---	---

Coliform and Fecal Coliform expressed as MPN/100 ml

KENT NARROWS CHANNEL STATIONS

Date of Sample Collection	Tide	Station 24 Coliform	Station 24 Fecal Coliform	Station 25 Coliform	Station 25 Fecal Coliform
4/4/74	Ebb	---	---	---	---
4/16/74		43	43	9.1	<3
4/23/74	Ebb	93	15	93	7.3
4/24/74	Ebb	23	9.1	75	3.6
4/29/74	Flood	23	23	240	23
5/9/74	Ebb	43	15	93	21
5/21/74	Ebb	93	93	23	<3
5/29/74	Flood	2400+	93	460	93
6/4/74	Ebb	150	43	75	43
6/17/74	Ebb	1100	210	460	39
7/8/74	Ebb	1100	14	93	3.6
7/22/74	Ebb	43	9.1	23	3.6
7/29/74	Flood	1100	43	460	150
8/13/74	Ebb	93	93	240	240
8/21/74	Ebb	240	93	460	20
9/16/74	Ebb	240	23	93	3.6
10/21/74	Ebb	460	460	93	93
10/22/74	Ebb	460	150	23	23
11/12/74	Flood	460	240	240	240
12/4/74	Ebb	2400+	460	1100	240
1/6/75	Flood	23	<3	3.6	3.6
1/7/75	Flood	---	---	---	---
1/13/75	Ebb	460	75	460	93
2/5/75	Flood	460	460	2400+	9.1
4/7/75	Flood	150	23	2400+	2400+
4/14/75	Ebb	9.1	3.6	9.1	<3
4/16/75	Ebb	23	23	43	<3
4/22/75	Flood	---	---	---	---
5/7/75	Ebb	---	---	1100	28
5/13/75	Ebb	93	23	43	23
5/26/75	Ebb	---	---	---	---
6/4/75	Flood	240	23	1100	1100
6/17/75	Flood	1100	9.1	460	<3
6/18/75	Ebb	---	---	---	---
7/21/75	Ebb	460	240	240	9.1
7/30/75	Flood	1100	21	43	3.6
8/4/75		240	93	93	9.1
9/2/75	Flood	2400+	240	2400+	240
9/8/75	Ebb	---	---	---	---
9/16/75	Flood	240	43	150	20
9/29/75	Flood	---	---	---	---
10/7/75	Ebb	---	---	---	---
10/8/75	Ebb	43	43	23	3.6
10/16/75	Ebb	2400+	21	460	150
10/28/75	Ebb	150	150	460	460
11/3/75		---	---	---	---
11/17/75	Flood	150	75	460	240
1/21/76	Ebb	43	<3	43	9.1
1/26/76	Flood	43	7.3	23	9.1
1/29/76	Flood	460	93	1100	23
2/3/76	Ebb	1100	43	2400+	1100
2/4/76	Ebb	2400+	23	2400+	75
2/11/76	Flood	2400+	43	2400+	15
2/18/76	Ebb	43	23	460	15
3/2/76	Ebb	93	3.6	1100	3.6
3/15/76	Flood	460	9.1	150	9.1
4/20/76	Ebb	2400+	93	1100	23
5/17/76	Ebb	---	---	---	---

Coliform and Fecal Coliform expressed as MPN/100 ml

KENT NARROWS CHANNEL STATIONS

Date of Sample Collection	Tide	Station 22 Coliform	Station 22 Fecal Coliform	Station 23 Coliform	Station 23 Fecal Coliform
4/4/74	Ebb	---	---	---	---
4/16/74	Flood	75	23	240	240
4/23/74	Ebb	23	<3	93	15
4/24/74	Ebb	23	3.6	23	9.1
4/29/74	Flood	93	23	240	43
5/9/74	Ebb	150	9.1	93	15
5/21/74	Ebb	23	9.1	240	240
5/29/74	Flood	240	93	240	43
6/4/74	Ebb	43	43	93	15
6/17/74	Ebb	23	3.6	43	43
7/8/74	Ebb	240	<3	93	23
7/22/74	Ebb	23	9.1	23	3.6
7/29/74	Flood	93	43	240	93
8/13/74	Ebb	23	3.6	240	240
8/21/74	Ebb	210	93	150	43
9/16/74	Ebb	240	9.1	43	<3
10/21/74	Ebb	93	9.1	43	43
10/22/74	Ebb	9.1	9.1	93	9.1
11/12/74	Flood	43	15	23	23
12/4/74	Ebb	460	43	2400+	1100
1/6/75	Flood	43	<3	43	<3
1/7/75	Flood	---	---	---	---
1/13/75	Flood	460	23	240	9.1
2/5/75	Flood	43	7.3	93	93
4/7/75	Flood	240	23	460	23
4/14/75	Ebb	23	<3	23	<3
4/16/75	Ebb	43	<3	23	<3
4/22/75	Flood	---	---	---	---
5/7/75	Ebb	1100	93	460	93
5/13/75	Ebb	43	23	23	3.6
5/26/75	Ebb	---	---	---	---
6/4/75	Flood	240	240	240	240
6/17/75	Flood	150	15	210	9.1
6/18/75	Ebb	---	---	---	---
7/21/75	Ebb	460	23	150	9.1
7/30/75	Flood	460	93	93	9.1
8/4/75		1100	460	1100	240
9/2/75	Flood	2400+	93	2400+	93
9/8/75	Ebb	---	---	---	---
9/16/75	Flood	43	43	240	43
9/29/75	Flood	---	---	---	---
10/7/75	Ebb	---	---	---	---
10/8/75	Ebb	93	23	23	23
10/14/75	Flood	---	---	---	---
10/16/75	Ebb	2400+	43	240	15
10/28/75	Ebb	240	240	1100	1100
11/3/75		---	---	---	---
11/17/75	Flood	93	43	240	240
1/13/76	Flood	---	---	---	---
1/21/76	Ebb	23	3.6	23	3.6
1/26/76	Flood	23	9.1	23	9.1
1/29/76	Flood	460	240	460	3.6
2/3/76	Ebb	2400+	15	2400+	15
2/4/76	Ebb	2400+	290	2400+	150
2/11/76	Flood	2400+	290	2400+	150
2/18/76	Ebb	1100	9.1	150	7.3
3/2/76	Ebb	460	9.1	240	3.6
3/15/76	Flood	240	9.1	240	43
5/20/76	Ebb	150	93	43	3.6
5/10/76	Ebb	---	---	---	---
5/17/76	Ebb	43	23	93	23

Coliform and fecal coliform expressed as MPN/100 ml

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