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Bacteriological Study of the Annapolis Basin (Nova Scotia Shellfish Growing Area No. 18)

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Atlantic Region

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BACTERIOLOGICAL STUDY OF THE ANNAPOLIS BASIN

(Nova Scotia Shellfish Growing Area No. 18)

by

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ABSTRACT

A bacteriological survey of the shellfish growing waters of the Annapolis Basin was conducted from June 6 to December 3, 1973. A total of 1,547 water samples were collected from 150 stations and 10 brooks and analyzed for total and fecal coliform densities using the standard 5-tube MPN method. An additional 253 isolates were collected from EC-and BGB-positive confirmed tests for coliform typing.

Results of the study indicate that the Annapolis River was highly polluted and had deteriorated considerably since the previous studies. An extension of the present closure (PC 1970-2189, Item 18-1) is required. Sewage pollution in the Basin was confined within the immediate areas of the Digby waterfront and Clementsport-Deep Brook closures. Tourist activities at the Smith Cove Trailer Park contributed a considerable amount of pollution to the Basin at the inlet. A new closure is recommended for this inlet.

Coliform isolates studies indicate that the fecal coliform test is a more specific indicator of fecal pollution than the total coliform test. Ninety-one point six per cent (91.6%) of the coliforms isolated from the fecal coliform test were identified as *E. coli* whereas the majority of the coliforms isolated from the total coliform test were *Klebsiella* and *Enterobacter* strains. Calculations indicate that a fecal coliform MPN value of 23 is equivalent to the total coliform MPN value of 70 for the waters of the Annapolis Basin.

RESUME

Une étude bactériologique des eaux des zones de pêche de coquillages du Bassin d'Annapolis à été conduite du 6 juin au 3 décembre, 1973. Un total de 1,547 échantillons d'eau a été ramassé à 150 postes et dans 10 ruisseaux. Ceux-ci ont été analysés pour les densités de colibacilles totales et de colibacilles fécaux en utilisant la méthode étendard de NPP avec cinq éprouvettes. Deux cent-cinquante-trois isolés additionnelles ont été ramassées des épreuves positives dans le bouillon EC et BGB pour caractériser des colibacilles.

Les résultats de l'étude indique que le Bassin d'Annapolis est très pollué et qu'il a détérioré sérieusement depuis les dernières études. Une extension de la présente fermeture (PC-1970-2189 Article 18-1) est requise. La pollution par les eaux d'égout est limité à la région immédiate des quais de Digby et aux fermetures de Clementsport-Deep Brook. Les activités tousistiques du Smith Cove Trailer Park ont contribué considérablement à la pollution du Bassin à l'embouchûre. Une nouvelle fermeture est recommendée pour cet embouchûre.

Les études de colibacilles isolés indique que la méthode pour déterminer les coliformes fécaux est un indicateur plus précis de la pollution fécale que l'épreuve de coliformes totales. Quatre-vingt-onze point six pourcent (91.6%) des colibacilles isolés des éprouvettes pour les coliformes fécaux ont été identifiés comme _E. coli_ tandis que la plupart des colibacilles isolés des éprouvettes pour les coliformes totales était des races _Klebsiella_ et _Enterobacter_. Le calcul indique que la nombre de 23 coliformes fécaux NPP est équivalent à 70 coliformes totales NPP dans les eaux du Bassin d'Annapolis.

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1 INTRODUCTION

The Annapolis Basin, in southwestern Nova Scotia, is one of the most productive shellfish growing areas in Nova Scotia. The soft shell clam (*Mya arenaria*) industry of the Annapolis Basin has been reported to approximate one half million dollars (6) in value. The fishery industry is concerned about the decrease in clam stocks in recent years as indicated by the decline in landings from 519800 pounds in 1969 to 503196 pounds in 1972. The decrease in clam stocks could be attributed to the closing of several areas to shellfish harvesting which resulted in the steady exhaustion of clam stocks in the open area. The sections of the Annapolis Basin which are presently closed to shellfish harvesting due to sewage pollution are the Raquette, Joggins, Cornwallis, and the Annapolis River (P.C. 1970-2189-Item 18). According to the MacLeod and Hill report (6), these closures covered 1023 acres with a total clam population of 112846 bushels. The clam resource breakdown in each closure area is listed in Table 1.

2 OBJECTIVES OF STUDY

The objectives of this study were:

1. to re-evaluate the bacteriological water quality of the Annapolis Basin;
2. to determine if sections of the closure areas could be opened for depuration;
3. to determine the influence of the Annapolis River on the bacteriological water quality of the Annapolis Basin;
4. to determine the relationship between the coliform and fecal coliform densities in order to establish a fecal coliform standard in place of the coliform standard of 70 for the Annapolis Basin waters; and

TABLE 1. THE SOFT SHELL CLAM (MYA ARENARIA) RESOURCE IN THE CLOSURE AREAS OF THE ANNAPOLIS BASIN.

LOCATION	AREA (ACRES)	MEAN CLAM SIZE (mm)	MEAN NO. CLAMS/ACRE	TOTAL CLAMS IN BUSHELS
Raquette	91.13	40.9 ± 14.0	216427	10273
Joggins	395.20	45.4 ± 15.9	127195	36770
Cornwallis	311.43	47.5 ± 22.8	124582	35362
Annapolis River (North Shore)	90.75	51.9 ± 13.5	209970	11059
Annapolis River (South Shore)	134.47	45.1 ± 15.2	331928	19382
TOTAL	1022.98			112846

5. to provide background data for the evaluation of the effects of the installation of sewage treatment plants at Digby and CFB Cornwallis on the future water quality of the Annapolis Basin.

3 DESCRIPTION OF STUDY AREA

The Annapolis Basin is situated in southwestern Nova Scotia, Canada. The Basin is about fifteen miles long and is connected to the Bay of Fundy by a deep, narrow channel called the Digby Gut. The Basin experiences an extremely high tidal amplitude of more than twenty-five feet. The Annapolis River, which is approximately forty-five miles long, flows into the northeastern part of the Basin at Annapolis Royal. The river drains a mixed farming-grazing-orchard watershed and carries treated and untreated sewage from a number of settlements along its banks.

The Annapolis Basin is situated in a fertile valley surrounded by forested hills 100 to 600 feet high. The northern shore of the Basin is composed mainly of farm, pasture and marsh lands. There are three small communities - Victoria Beach, Port Wade, and Port Royal - on this shore. None of these villages have water or sewage systems, and they generally discharge septic tank effluents into the Basin. The southern shore is a popular tourist area, possessing motels, restaurants, trailer camps, swimming pools, golf courses, and picnic ground facilities. The towns of Digby, CFB Cornwallis, Clementsport, Annapolis Royal, and a number of settlements along the shore discharge raw sewage directly to the Basin.

Extensive sand-mud tidal flats are found throughout the Basin. Goat Island, situated in the estuary of the Annapolis River at the northeastern end of the Basin is the most productive shellfish area in the Basin. It yields more than 70 percent of the annual clam harvest.

4 MATERIALS AND METHODS

4.1 Sampling Program. A total of 150 sampling stations were established in the three sectors of the Annapolis Basin. The locations of these sampling points are shown in Figure 1. The sampling program was carried out in three phases in order to give a better evaluation of climatic, ecological and seasonal effects on the bacteriological water quality in the Annapolis Basin. Phase I was carried out in early spring (June 6 to 27, 1973) during the period of rapid phytoplankton growth and before the influx of tourists. Phase II was carried out in late summer (August 6 to 17) at the peak of tourist activities and when there was high PSP (Paralytic Shellfish Poison) toxicity in the Basin. Phase III was carried out in November. In addition, water samples were also collected from ten brooks draining into the Basin, for the purpose of determining the influence of run-off from the adjacent water shed on the water quality of the Basin. All water samples were delivered immediately to the mobile laboratory at CFB Cornwallis at Deep Brook, and were subjected to bacteriological analysis within two to four hours of collection. A drift study was conducted in December near Digby.

4.2 Laboratory Procedures. All water samples were tested for total coliform and fecal coliform densities by multiple tube dilution technique (MPN) according to the A.P.H.A. "Recommended Procedure for the Bacteriological Examination of Sea Water and Shellfish" (1). Salinity was also determined on water samples collected from representative stations by the Knudsen Method. A total of 235 coliform isolates were isolated from positive EC and BGB confirmed tubes for coliform typing. The procedure for the biochemical identification of coliform isolates is presented in Figure 2.

5 RESULTS AND DISCUSSION

A total of 1547 water samples were collected from 150 stations in the Basin, as well as ten brooks and thirty-nine

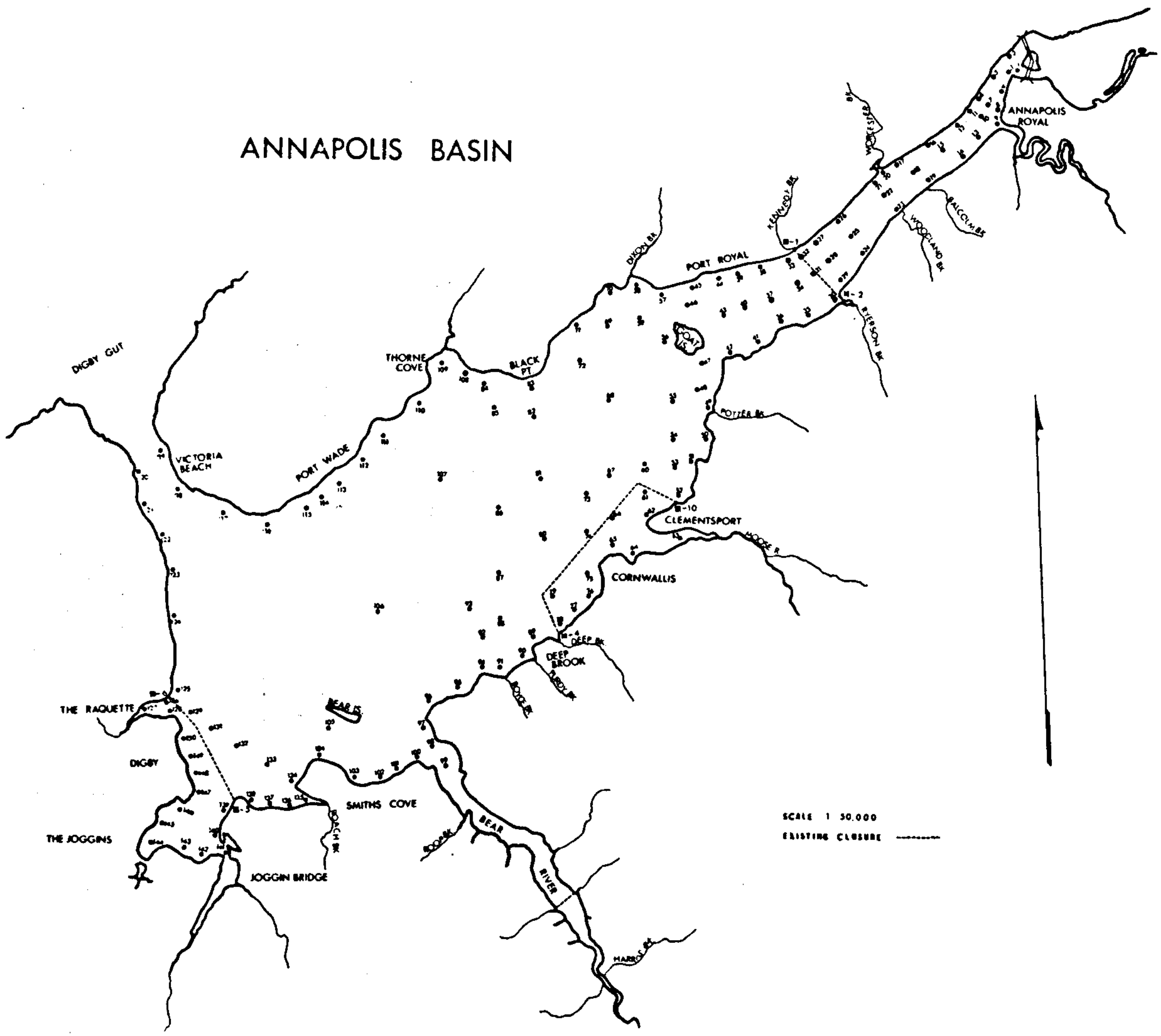


FIGURE 1 SAMPLING STATIONS IN THE ANNAPOLIS BASIN

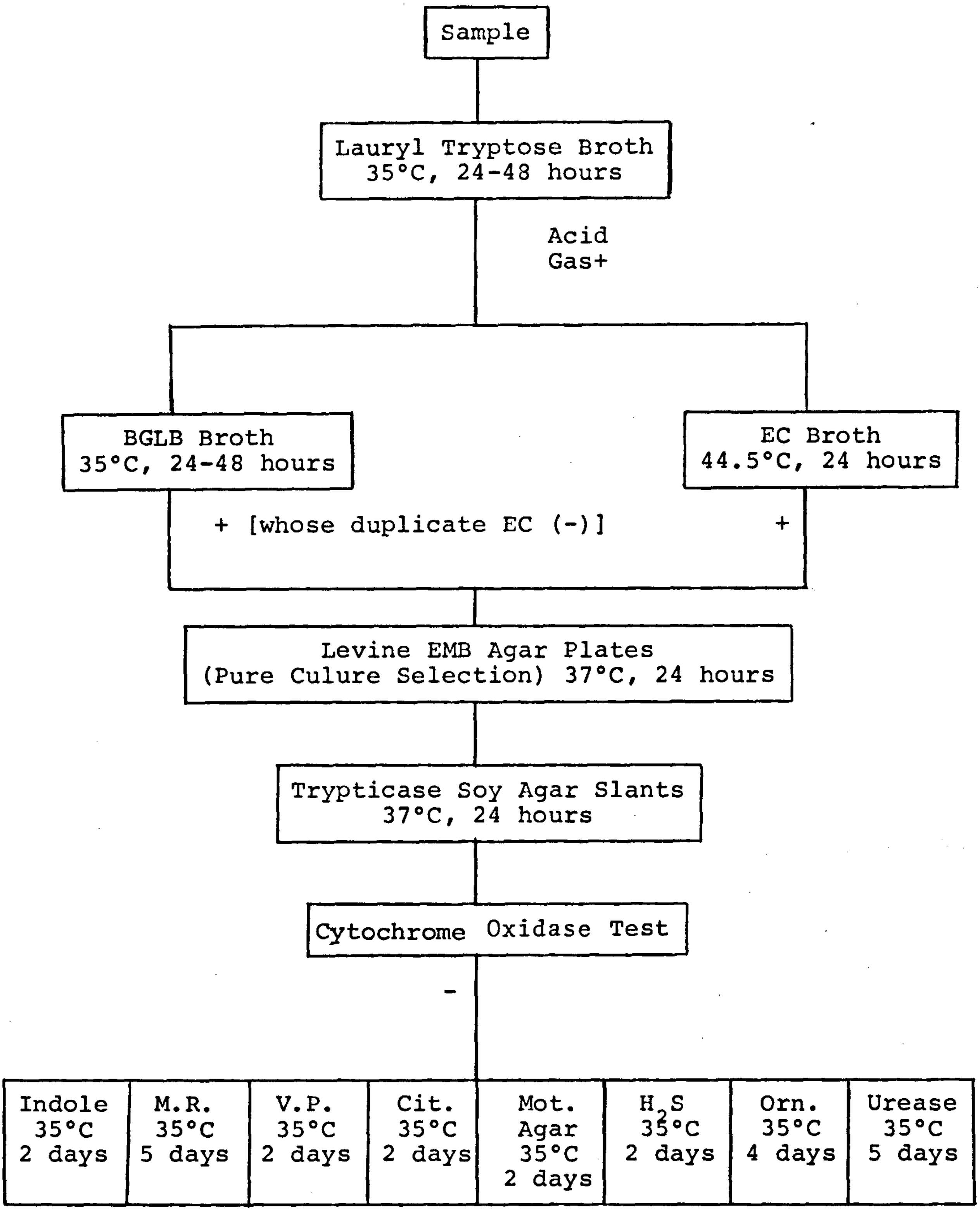
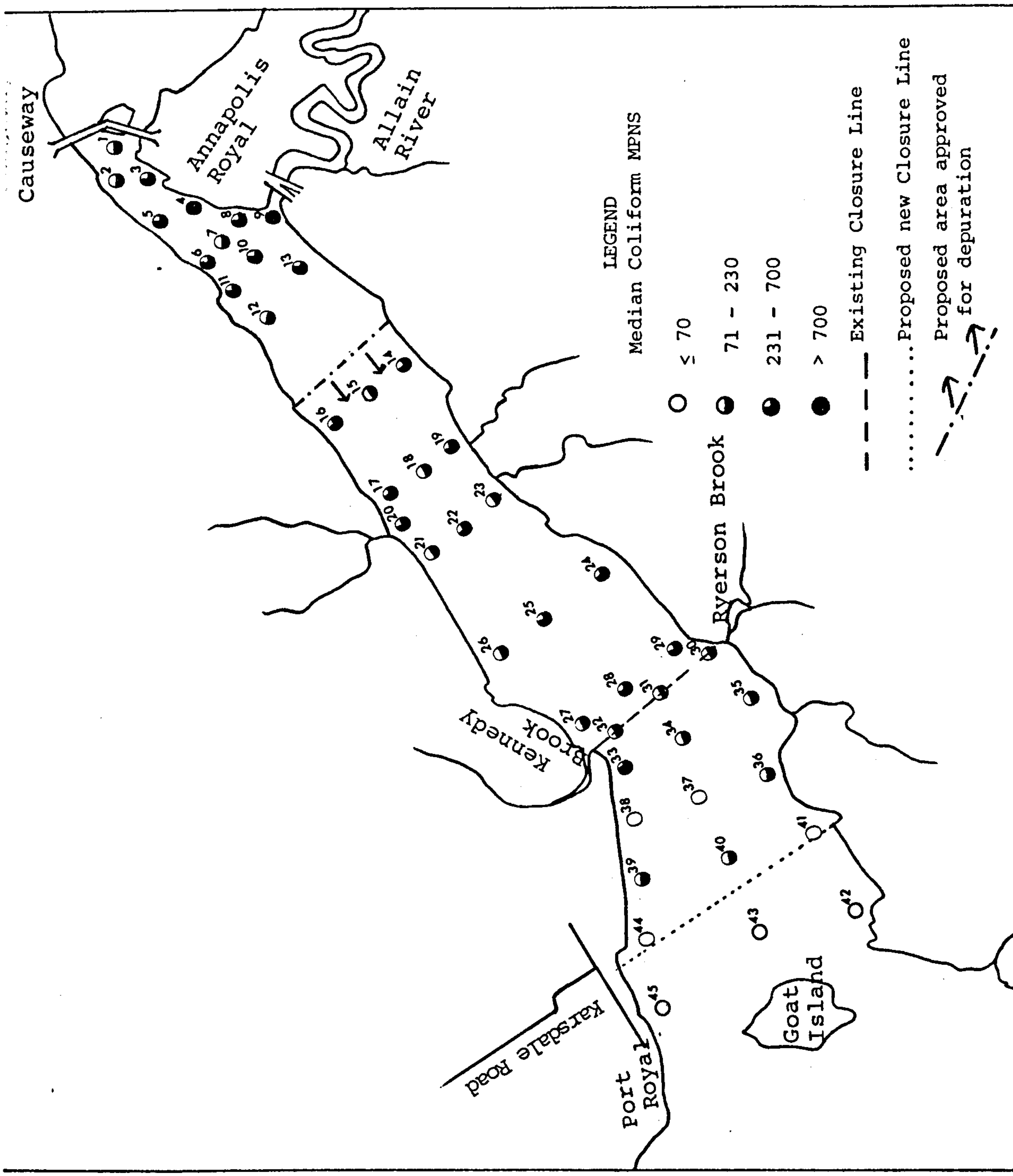
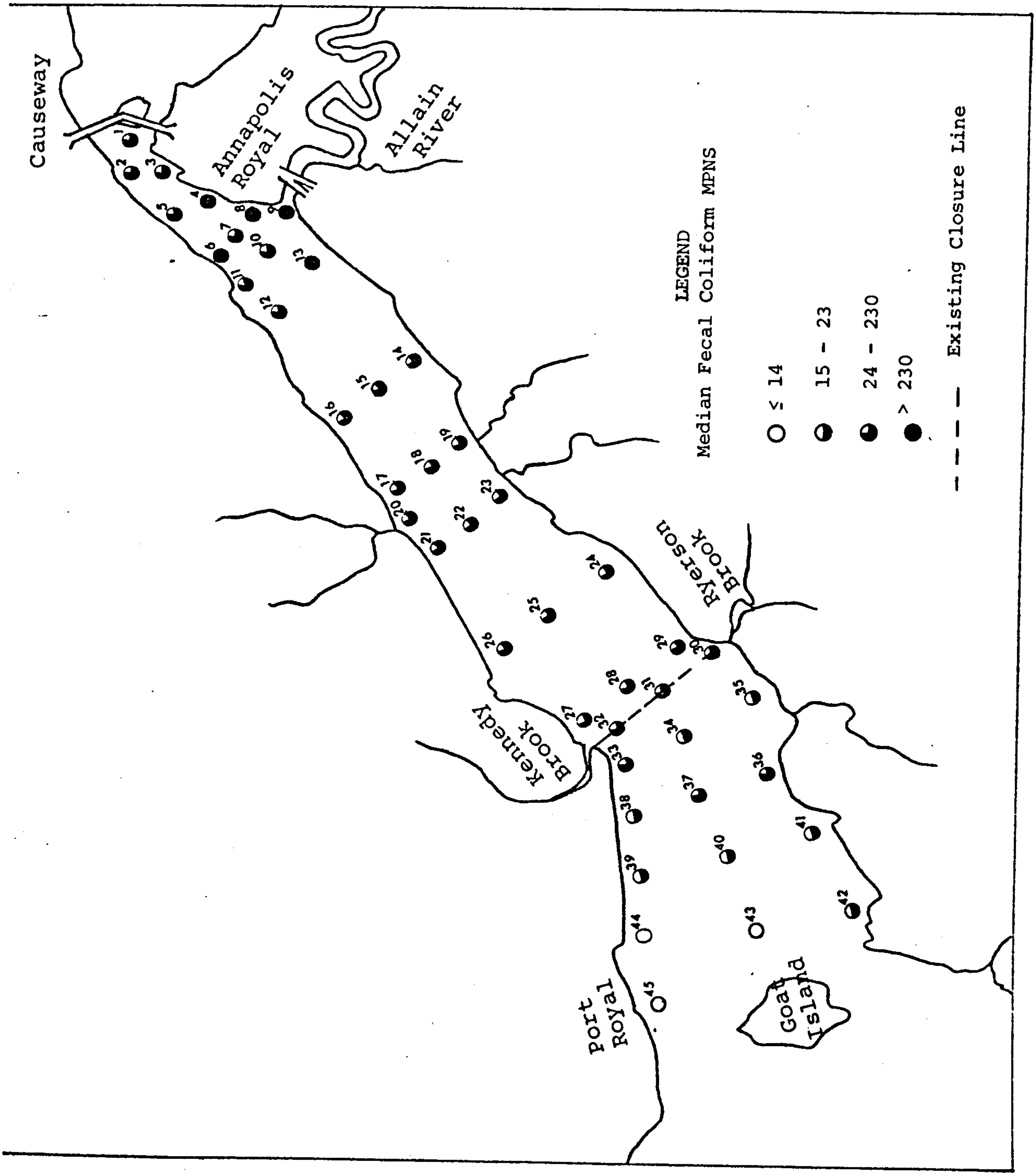


FIGURE 2 COLIFORM GROUP ISOLATION AND IDENTIFICATION PROCEDURE.

selected stations in the present CFB Cornwallis closure area and analysed for total and fecal coliform densities. A total of 235 coliforms were isolated from these sectors of the Basin and classified biochemically. Coliform and fecal coliform MPN's obtained from the Basin are tabulated in Appendix I, Tables 1, 2, and 3. Salinity data for selected stations, tidal stages at time of sampling and daily precipitation data for the towns of Digby and Annapolis Royal provided by the Atmospheric Environment Service, Environment Canada, are presented in Appendix I Tables 4, 5, and 6 respectively. For the purpose of discussion, the study area was subdivided into three sectors.

5.1 Sector 1 - Annapolis River. The Annapolis River enters the Basin at Annapolis Royal. This river carries treated and untreated sewage from the upstream communities having a total population of about 10,000. These upstream communities include Aylesford (pop. 680), Kingston (pop. 1,500), CFB Greenwood (pop. 3,000), Middleton (pop. 1,800), Lawrencetown (pop. 500), Bridgetown (pop. 1,300), and Annapolis Royal (pop. 800). The effect of these wastes on the Basin is evident in the high level of coliform and fecal coliform MPN's in the river at the Annapolis Royal Causeway west to Goat Island as shown in Figure 3A & B. Very high coliform (median-920) and fecal coliform (median - 350) densities were found at stations 4, 8, 9, 10, and 13 immediately offshore from Annapolis Royal. These high coliform counts were caused by the direct influence of raw sewage discharged from the town since much lower counts were recorded in the upstream stations 1, 2, and 3 (median coliform - 240; fecal coliform - 79). The coliform counts decreased gradually downstream from Annapolis Royal and became bacteriologically acceptable for shellfish harvesting beyond station 41. In general, the water quality of the river has deteriorated considerably since the previous surveys (4 and 5) and a relocation of the present closure line (P.C. 1970-2189, Item 18-1)


Causeway
Annapolis Royal
Allain River
LEGEND
Median Coliform MPNS
≤ 70
71 - 230
231 - 700
> 700
Existing Closure Line
Proposed new Closure Line
Proposed area approved for depuration
Ryerson Brook
Kennedy Brook
Karsdale Road
Port Royal
Goat Island



Causeway
Annapolis Royal
Allain River
LEGEND
Median Fecal Coliform MPNS
≤ 14
15 - 23
24 - 230
> 230
Existing Closure Line
Ryerson Brook
Kennedy Brook
Port Royal
Goat Island

further west of the existing line is considered necessary. The installation of a new survey monument will be required and the approximate position of the proposed closure line is shown in Figure 3A.

5.2 Sector 2 - Eastern Annapolis Basin (Figure 4A & B)
Water samples collected from the Goat Island area and the northern shore from Port Royal to Thorne Cove were generally of excellent bacteriological quality, with the exception of samples collected on June 26th. The high total and fecal coliform counts recorded on June 26 were the result of surface runoff induced by heavy rainfall (over 2 inches) which fell on the preceeding day. In the southern section of the Basin from Clementsport to Deep Brook, the water was contaminated by sewage discharged from the town of Clementsport, CFB Cornwallis , and some homes along the shoreline from CFB Cornwallis to Deep Brook. The sewage wastes from CFB Cornwallis pass through two septic tanks before discharging to the Basin. In order to estimate the extent to which sewage discharged from CFB Cornwallis polluted the Basin, water samples were collected at 39 selected stations, 200 yards apart, in the area of the sewage outfalls during different tidal phases (Figure 5). Bacteriological results (Table 2) indicate that the sewage discharged from CFB Cornwallis contaminated an area of over 1,000 yards radius from the outfalls on low falling and high rising tides. On a high falling and low rising tide, however, the pollution was confined primarily within the immediate area of the outfalls. It would appear that effective secondary treatment with chlorination of the sewage effluent from CFB Cornwallis would significantly reduce the influence of a major source of pollution in this portion of the Basin.

5.3 Sector 3 - Western Annapolis Basin (Figure 6A & B) Bacteriological water quality in the north and northwestern shore of this sector from Thorne Cove to the Pine Motel (Stations 108)

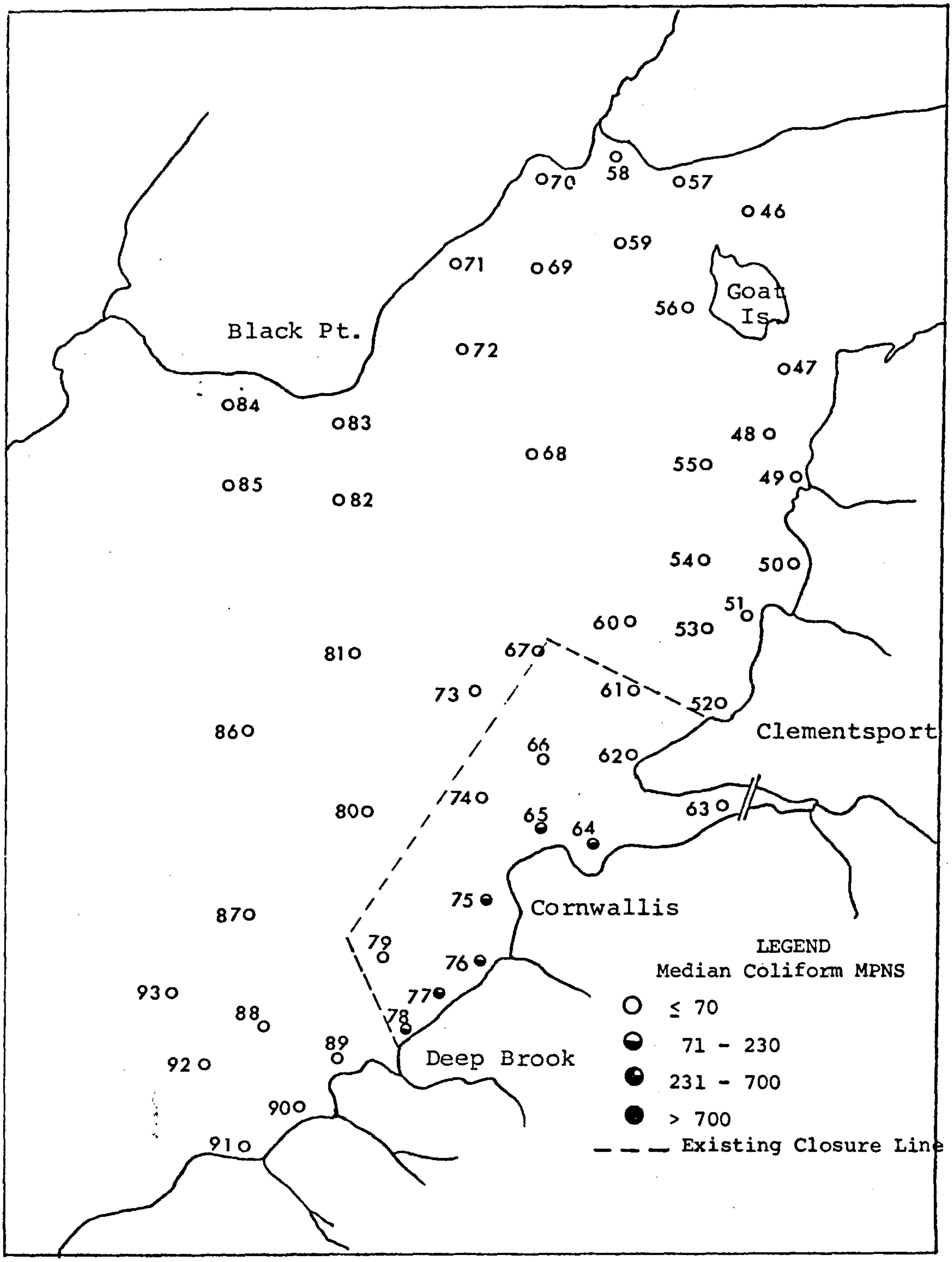


FIGURE 4A SUMMARY OF COLIFORM DATA IN EASTERN ANNAPOLIS BASIN.

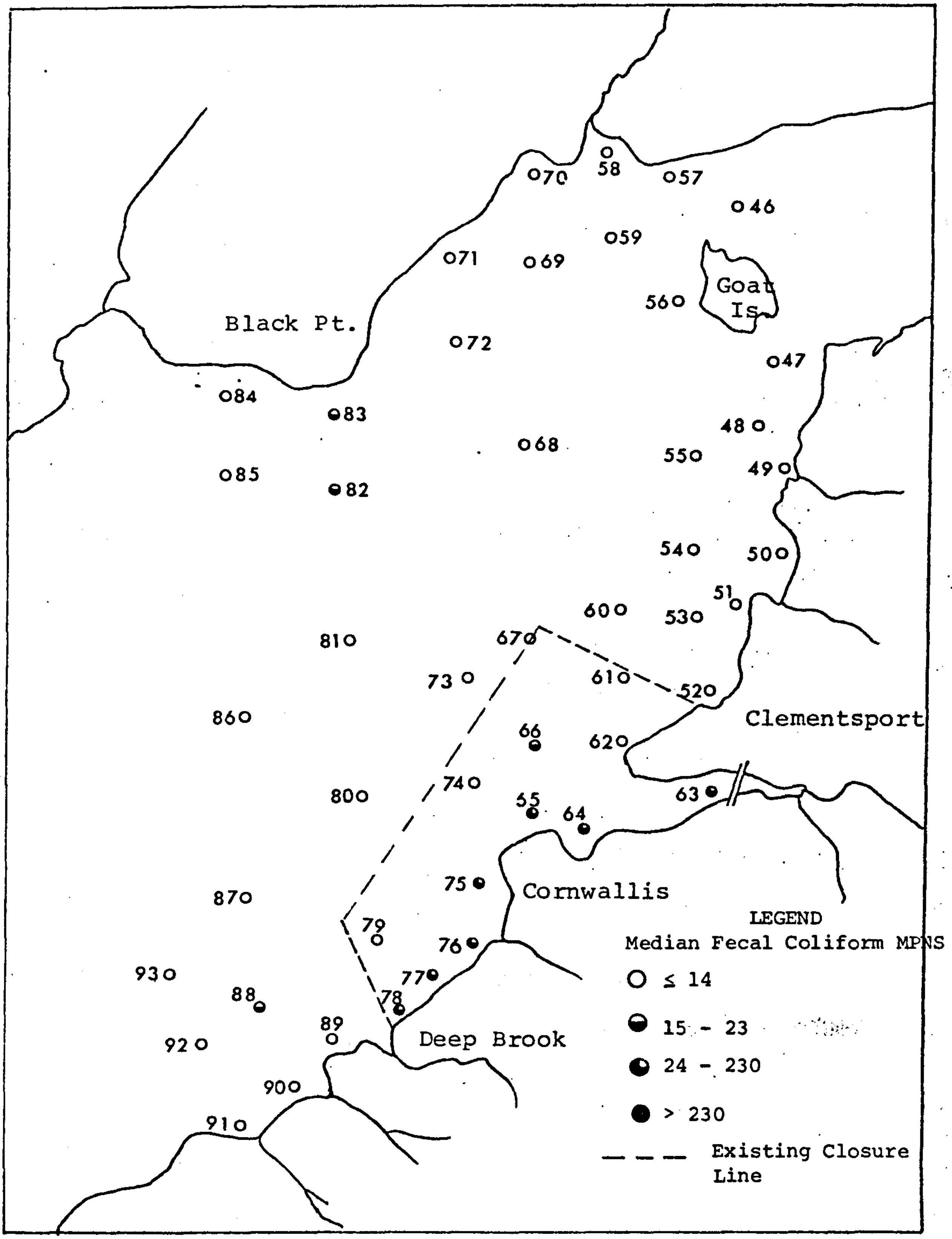


FIGURE 4B SUMMARY OF FECAL COLIFORM DATA IN EASTERN ANNAPOLIS BASIN.

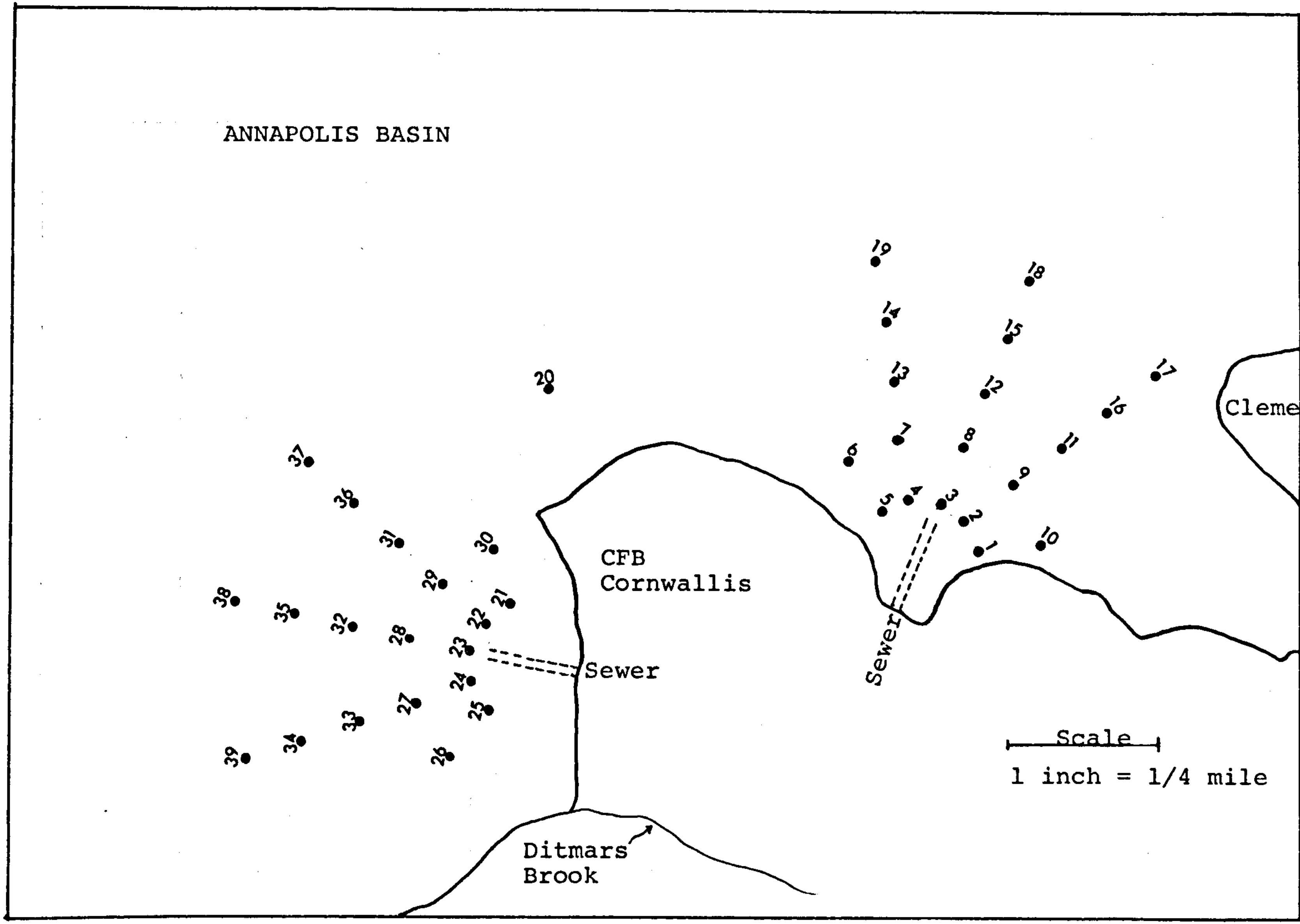


FIGURE 5 SAMPLING STATIONS AT CFB CORNWALLIS.

TABLE 2 BACTERIOLOGICAL DATA, CFB CORNWALLIS

Station	July 18 High Falling Tide		July 19 High Rising Tide		July 19 Low Falling Tide		July 20 Low Rising Tide	
	Coliform	F. Coli	Coliform	F. Coli	Coliform	F. Coli	Coliform	F. Coli
1	2400+	2400+	2400+	2400+	2400+	2400+	2400+	2400+
2	110	70	2400+	2400+	2400+	2400+	540	350
3	170	79	2400+	2400+	2400+	2400+	240	130
4	110	79	920	540	2400+	2400+	2400+	2400+
5	2400+	2400+	2400+	1600	2400+	2400+	2400+	2400+
6	2400+	2400+	2400+	2400+	2400+	2400+	2400+	2400+
7	280	180	540	350	2400+	2400+	2400+	2400+
8	180	140	920	350	2400+	2400+	79	49
9	79	79	2400+	2400+	2400+	2400+	79	23
10	2400+	2400+	2400+	2400+	2400+	2400+	540	350
11	220	170	2400+	2400+	2400+	2400+	49	23
12	170	130	2400+	2400+	2400+	2400+	49	79
13	2400+	2400+	2400+	2400+	2400+	2400+	110	49

TABLE 2 BACTERIOLOGICAL DATA, CFB CORNWALLIS (CONTINUED)

Station	July 18 High Falling Tide		July 19 High Rising Tide		July 19 Low Falling Tide		July 20 Low Rising Tide	
	Coliform	F. Coli	Coliform	F. Coli	Coliform	F. Coli	Coliform	F. Coli
14	2400+	2400+	2400+	2400+	2400+	2400+	240	130
15	2400+	2400+	2400+	2400+	2400+	2400+	95	70
16	540	540	2400+	2400+	2400+	2400+	540	130
17	2400+	2400+	2400+	2400+	2400+	2400+	920	540
18	2400+	2400+	2400+	2400+	2400+	2400+	140	110
19	2400+	2400+	2400+	2400+	2400+	2400+	220	130
20	2400+	2400+	540	170	2400+	2400+	180	110
21	280	280	2400+	1600	2400+	2400+	2400+	2400+
22	110	79	350	220	2400+	2400+	130	49
23	920	540	540	540	2400+	2400+	240	79
24	170	170	2400+	2400+	2400+	2400+	2400+	2400+
25	170	130	2400+	2400+	2400+	2400+	2400+	2400+
26	130	130	2400+	2400+	2400+	2400+	2400+	2400+

TABLE 2 BACTERIOLOGICAL DATA, CFB CORNWALLIS (CONTINUED)

Station	July 18 High Falling Tide		July 19 High Rising Tide		July 19 Low Falling Tide		July 20 Low Rising Tide	
	Coliform	F. Coli	Coliform	F. Coli	Coliform	F. Coli	Coliform	F. Coli
27	240	240	2400+	2400+	2400+	2400+	2400+	2400+
28	140	140	110	79	2400+	2400+	240	240
29	130	130	14	4	2400+	2400+	140	110
30	280	220	2400+	2400+	2400+	2400+	540	110
31	350	140	170	79	2400+	2400+	130	49
32	130	130	17	8	2400+	2400+	49	49
33	110	110	920	540	540	350	49	33
34	23	23	2400+	1600	350	240	130	49
35	33	33	33	33	2400+	2400+	79	33
36	2400+	2400+	79	79	2400+	2400+	130	49
37	1600	1600	46	13	2400+	2400+	33	23
38	49	49	14	7	2400+	2400+	79	22
39	95	95	49	13	2400+	2400+	33	5

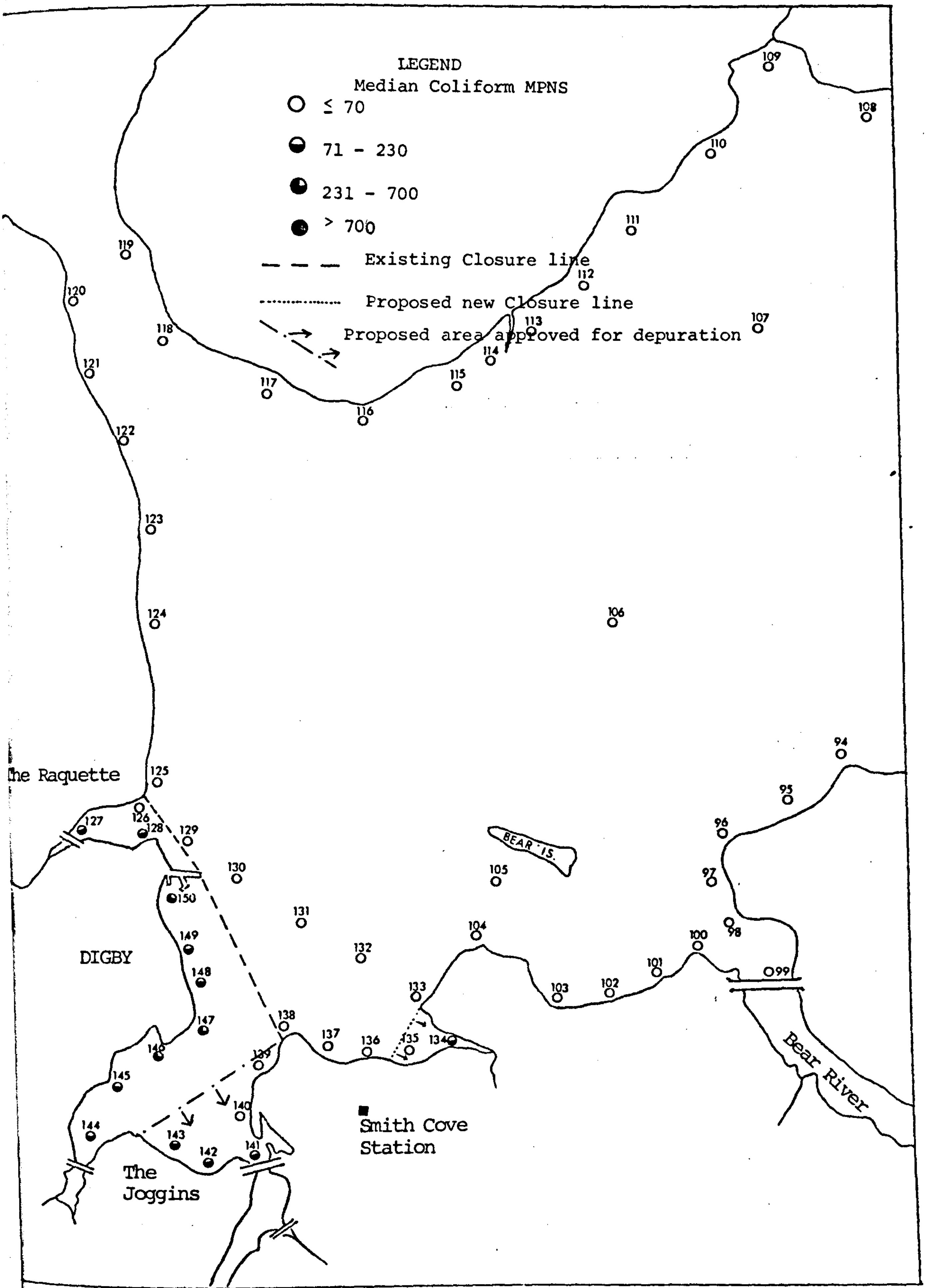


FIGURE 6A SUMMARY OF COLIFORM DATA IN WESTERN ANNAPOLIS BASIN

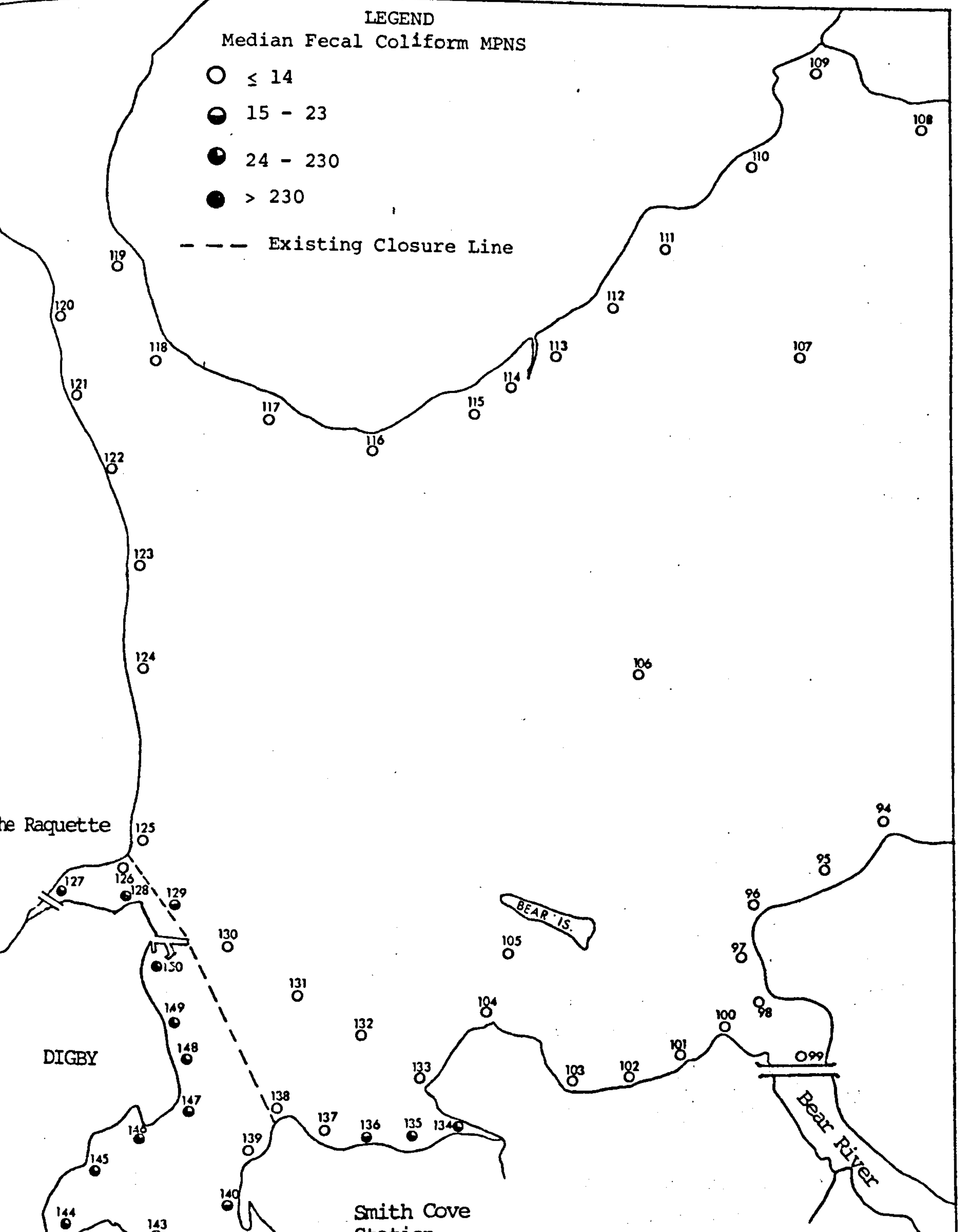


FIGURE 6B SUMMARY OF FECAL COLIFORM DATA, WESTERN ANNAPOLIS BASIN.

to 125) was excellent. The median coliform and fecal coliform MPN's were 5 and 2 respectively. The only potential source of pollution noted in this section was a small fish plant which discharges some wastes to the Basin at Victoria Beach. Because of the high tidal current at the Digby Gut, these wastes were very much diluted as indicated in the low coliform and fecal coliform MPN (median = 2) at Station 118.

Water samples collected along the southeastern shore from Bear River to Smith Cove (Stations 94 to 105) were of satisfactory bacteriological quality. High bacterial counts were found at Station 134 which was situated at the inlet adjacent to the Smith Cove Trailer Park. The median coliform and fecal coliform densities at this station were 170 and 120 respectively. The maximum coliform and fecal coliform counts found at this station were observed during August, which coincided with the peak of tourist activities; that is, when the camp site was fully occupied with trailers. It was therefore concluded that the camping activities at the trailer park were the major source of pollution at Station 134. There are probably additional sources from the Rouch Brook which passes through Imbertville before entering the Basin at the inlet. The coliform MPN's at the mouth of Rouch Brook were 540 during dry periods and 2400+ after heavy precipitation. It is therefore recommended that a new closure should be established for this inlet and the approximate position of the proposed closure line is shown in Figure 6a.

Bacteriological water quality in the present Digby waterfront closure (from the Raquette to the Joggins) was poor, with the median coliform densities of most stations well above the 70 MPN limit. The poor water quality was attributed to sewage contamination from a number of sewage outfalls and fish plants at Digby. The scallop fleet at the Digby wharf also contributed a considerable amount of pollution to the harbour. The Joggins itself is relatively free from any major source of sewage pollution. The only known sources of pollution in the Joggins are a sewage out-fall at the foot of King Street, a large sawmill, a gas service station, and a few houses along the western shore. There are no serious sources of pollution along the eastern shore. The few houses along the eastern shore are well back from the shoreline and do not appear to produce any serious sources of contamination. An incoming tide would sweep a good deal of sewage from Digby to the Joggins as indicated by the results of the drift study (Figure 7). It took approximately three hours for the drogues to move from Green Point at Digby to the Joggins on a rising tide. It appears that most of the sewage carried into the Joggins from the town of Digby will be confined along the western shore. This resulted in significantly higher coliform counts on the western shore (Stations 144 to 147) than on the eastern shore (Stations 138 to 141). Although the median coliform MPN's in the eastern Joggins were below 70, it is, however, recommended that it should remain closed for shellfish harvesting. Under adverse conditions, a considerable amount of pollution would enter this area by rainfall induced surface runoff and from sewage washed in from Digby or other parts of the Joggins. This is revealed in the periodically high coliform and fecal coliform counts in this area during the study.

Occasional high coliform densities were also recorded at sampling stations immediately outside the Digby waterfront closure line (Stations 129 to 133 and 137). The intrastation variation in the coliform densities were most probably due to a random distribution of pollutants or to intermittent contamination. In general the median coliform densities in these stations were within acceptable limits.

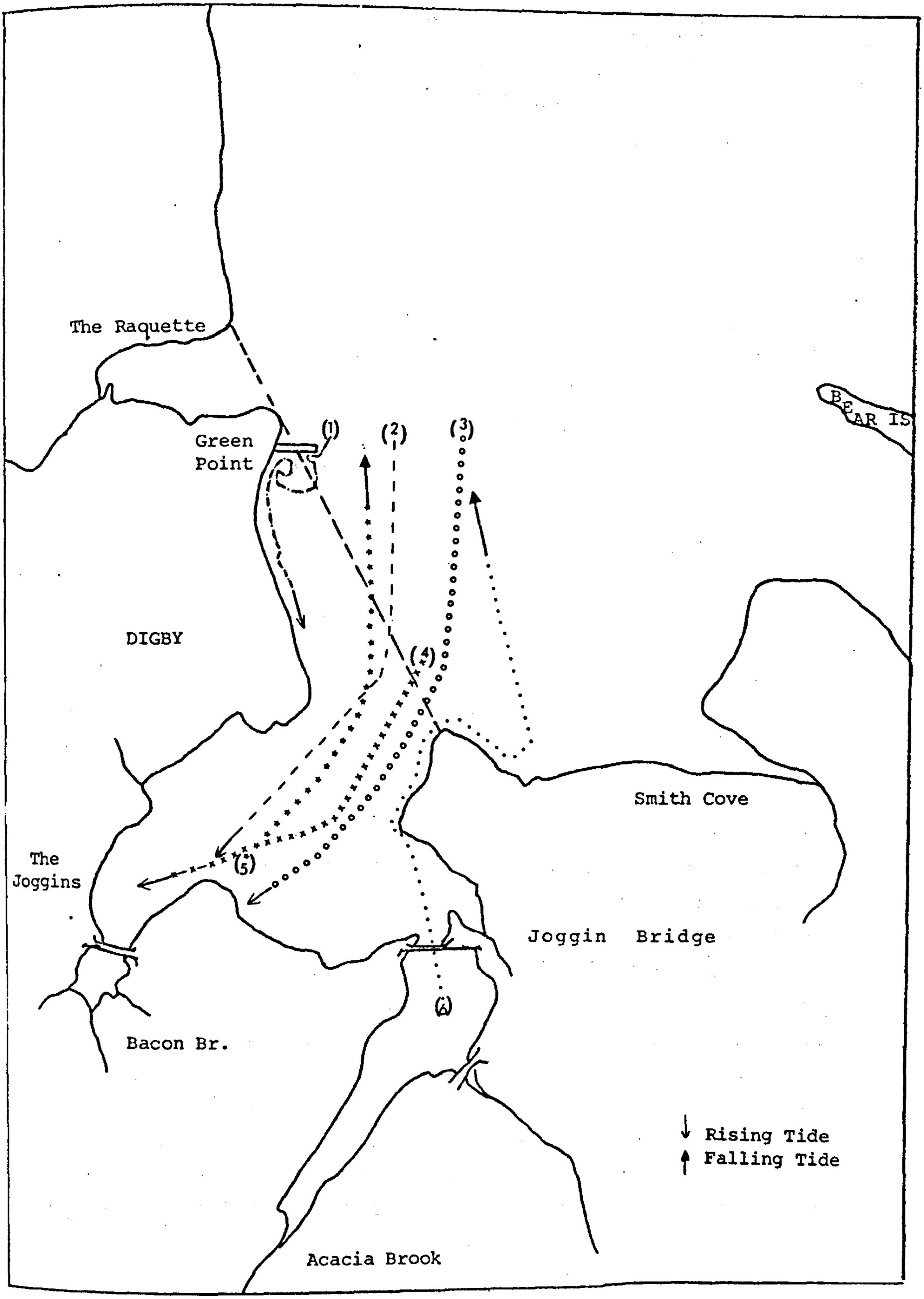


FIGURE 7 DRIFT STUDY AT DIGBY WATERFRONT.

Pollution from the town of Digby appears to be localized within the present closure area and does not produce any serious effects on the bacteriological quality of the open waters.

5.4 Environmental Factors. Because there are so many variables associated with environmental factors, it is very difficult, if not impossible, to draw any significant conclusions about their effects on the bacteriological water quality based on the limited data from this study. For a more comprehensive evaluation of the influence of environmental conditions, a time series *in situ* study on a number of shellfish growing areas for a long period of time is required. Therefore, in this report, the discussion is limited to only one environmental factor - rainfall.

Rainfall and subsequent surface runoff is one of the most important factors influencing the bacteriological quality of a water body. An increase in coliform counts generally occurs following a heavy rainfall, and this situation persists for several days thereafter. A typical example of this is demonstrated in the abrupt increase in coliform and fecal coliform counts at most stations on June 26 and August 6.

To study the effect of surface runoff on the Basin, water samples were collected from ten brooks draining into the Basin during a dry period and following a period of rainfall. Very high coliform and fecal coliform densities were found in most brook samples (Table 3). A significant increase in coliform and fecal coliform densities (2400+) was observed after a heavy rainfall indicating that surface runoff might have a potential effect on the Basin during a heavy runoff. However, under normal conditions, the low-volume flow from these brooks would not be expected to have a marked effect on the Basin. The sanitary significance of the coliforms in the runoff on the shellfish growing area depends on their origins - fecal or vegetative. If it is proven that the coli-

TABLE 3 BACTERIOLOGICAL DATA FROM BROOK SAMPLES

Source	July 10		July 12*	
	Total Coliform	Fecal Coliform	Total Coliform	Fecal Coliform
Roach Brook	540	540	2400+	2400+
Boyce Brook	920	540	2400+	2400+
Purdy Brook	2400+	240	2400+	2400+
Deed Brook	1600	240	2400+	2400+
Potter Brook	110	79	2400+	2400+
Ryerson Brook	130	33	2400+	2400+
Woodland Brook	2400+	2400+	2400+	2400+
Balcolm Brook	240	23	2400+	2400+
Worcester Brook	220	79	2400+	2400+
Kennedy Brook	540	350	2400+	2400+
Median	540	240	2400+	2400+

* 1.3 inches of rainfall fell on the preceeding day, July 11.

forms are not of direct fecal origin and do not indicate a public health hazard (3), compliance with the set coliform limits becomes subject to interpretation based on environmental observation. In this regard, it is very useful to include supplementary biochemical tests to identify some of the coliform biotypes from the study areas to assess their origin and sanitary significance.

5.5 Identification of Coliform Isolates. During the study, 188 isolates were collected from EC positive confirmed tubes and 47 isolated from corresponding BGB positive confirmed tubes that were EC negative. The rationale behind this modified procedure in collecting isolates was due to the increasing reports of the incidence of atypical coliform biotypes in the total coliform test (7, 8, 9, 10). The purpose of picking the isolates from EC confirmed tubes was to verify the fidelity of the EC test as a means of estimating *E. coli* densities. *E. coli* is considered to be the major coliform biotype in the feces of human and warm-blooded animals, comprising approximately 90 per cent of the fecal coliform density. The purpose of collecting isolates from the BGB confirmed tubes which were EC negative was to test the validity of the total coliform test in defining fecal pollution. If a large percentage of the isolates identified from either test are made up of other coliform biotypes than *E. coli*, it may be concluded that the source of coliform is from natural runoff rather than feces and the coliforms are of limited sanitary significance.

The percentage occurrence of each coliform biotype identified from the three sectors of the Annapolis Basin was calculated and summarized in Table 4. A total of twenty cultures failed to grow on subsequent transfer. *E. coli* were the predominant (91.6%) coliform biotypes isolated from the EC test and *Klebsiella* and *Enterobacter* constituted 6.8% and 1.67% of the isolates. Coliform biotypes isolated from the BGB posi-

TABLE 4 SUMMARY OF COLIFORM BIOTYPES ISOLATED FROM ANNAPOLIS BASIN.

GENUS		Source						
		ANNAPOLIS RIVER		E.ANNAPOLIS BASIN		W.ANNAPOLIS BASIN		TOTAL
		EC(+)	BGB(+)	EC(+)	BGB(+)	EC(+)	BGB(+)	EC(+)	BGB(+)
Escherichia	No	57	0	56	0	51	0	164	0
	%	89.1		93.3		92.7		91.6	
Enterobacter	No	3	4	0	4	0	0	3	8
	%	4.7	21.1		66.7			1.6	22.2
Citrobacter	No	0	1	0	2	0	1	0	4
	%		5.3		33.3		9.1		11.1
Klebsiella	No	4	14	4	0	4	10	12	24
	%	6.2	73.7	6.7		7.3	90.9	6.8	66.6
Total	No	64	19	60	6	55	11	179	36
Failed to grow on transfer		6	9	1	2	2	0	9	11

tive confirmed tubes, where duplicate EC tubes were negative, were comprised mainly of *Klebsiella* (66.6%), *Enterobacter* (22.2%) and *Citrobacter* (11.1%). No *E. coli* were isolated. The isolation of a fair number of *Klebsiella* (16.7%) from both tests is not surprising in view of the increasing reports of the ubiquitous distribution of *Klebsiella* in a wide variety of environmental sources, including plants, soils, and industrial wastes (2, 7, 8, 9, 10). The high percentage of *E. coli* (91.6%) isolated from EC positive tubes compared with the absence of *E. coli* in the BGB tubes indicates that the fecal coliform test is a much better procedure than the total coliform test for determining fecal pollution in estuarine waters that are not influenced by industrial wastes. The increasing awareness of the inadequacy of the total coliform test in defining fecal pollution has provided the impetus for many control agencies in North America to shift to a more specific fecal coliform for evaluating water quality in rivers and lakes. Because the fecal coliform test is the most accurate bacteriological test now available for detecting warm-blooded animal feces in polluted water, it would seem logical that a change should be made from a total coliform standard to a fecal coliform standard for the surveillance of shellfish growing waters. No fecal coliform standard for the shellfish growing waters has been established but an approximation of the level that is equivalent to the 70 total coliform limit may be made by determining the correlation between the two indicator groups and calculating from the regression line. A very significant correlation between fecal coliform and total coliform was obtained for all the samples (r=0.75), closed area samples (r=0.72) and open area samples (r=0.82). Calculations from the regression lines (Figure 8) indicate that the fecal coliform value of 17 is equivalent to the total coliform MPN of 70 for all the samples in the Basin. When only samples from the open and closed areas are used separately to calculate the regression line,

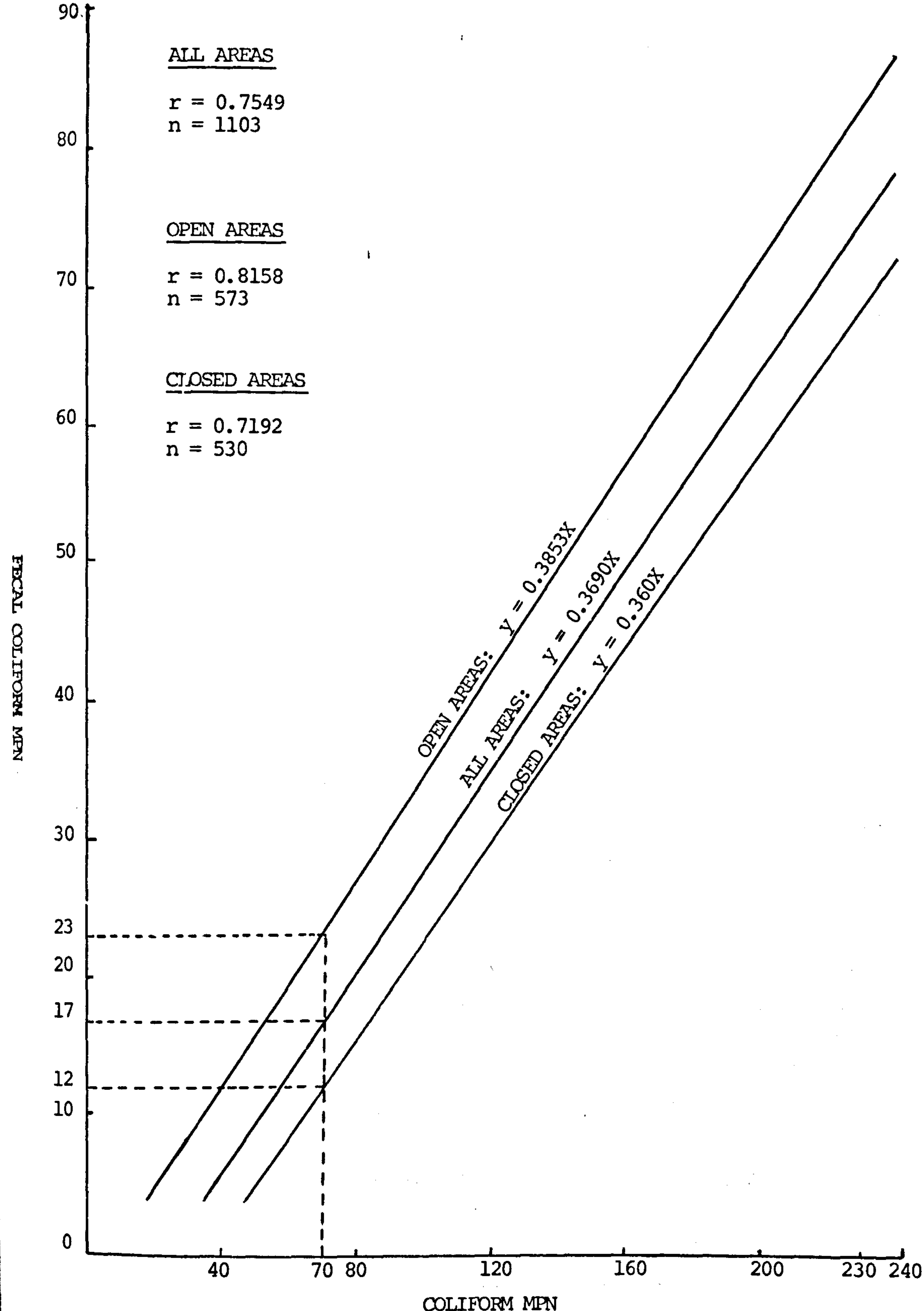


FIGURE 8 COMPARISON OF COLIFORM AND FECAL COLIFORM MPN's

the fecal coliform MPN value of 23 and 12 respectively correspond to the total coliform MPN of 70 for open and closed areas in the Basin.

6. CONCLUSIONS

A bacteriological survey of the shellfish growing waters in the Annapolis Basin indicates that the Annapolis River is highly polluted by sewage from the upstream communities and Annapolis Royal. Data indicate that the present closure (PC 1970-2189 Item 18-1) should be extended further west of the existing closure line as shown in Figure 3A.

The waters in most areas of the Annapolis Basin were of satisfactory bacteriological quality, and should remain open for the harvest of shellfish. The sewage from Digby, CFB Cornwallis and Clementsport appears to be confined within the presently closed areas (PC 1970-2189 Item 18-2, 18-4), and does not influence the open waters. Tourist activities at the Smith Cove Trailer Park appear to contribute a considerable amount of sewage pollution to the Basin inlet adjacent to the Rouch Brook. This portion of the inlet (shown in Figure 6 A) should be closed for shellfish harvesting.

Occasional high coliform and fecal coliform counts recorded on some sampling stations were probably attributable to sporadic episodes of landwash pollution or to intermittent contamination from the immediate shore area. The high coliform and fecal coliform counts found in the brook samples and concurrent with dramatic increase in bacterial counts in most stations after an episode of heavy rainfall emphasized the urgent need for administrative mechanics for temporary closure of susceptible shellfish growing areas during the period of heavy runoff pollution.

The traditional concept of using total coliforms as an index of pollution has been a subject of controversy in recent years due to its inability to distinguish coliforms of fecal origin from coliforms of nonfecal origin. Fecal coliforms are a more specific indicator of fecal pollution as indicated by the fact that 91.6% of the fecal coliforms isolated from this study were *E. coli*. It appears that a change from a coliform standard to a fecal coliform standard for use in the surveillance of shellfish growing waters is warranted. Regression analysis indicated a fecal coliform value of 23 is equivalent to the total coliform MPN of 70 for the open waters of Annapolis Basin. This fecal coliform value of 23 is much greater than the value of 14 proposed in the Eighth National Shellfish Sanitation Workshop at New Orleans, 1974, but it is precisely the same value that Tennant et. al. (11, 12) recommended for Atlantic shellfish growing areas in their 1964 and 1968 reports. However, it should be kept in mind that the ratio between total coliform and fecal coliform varied greatly in different geographical locations and under different environmental conditions. Therefore, it will be very difficult, if not impossible, to select a fecal coliform value which can be related in all shellfish growing areas to the degree of public health hazard expressed by the current coliform MPN 70 standard. It appears that before accepting any arbitrary fecal coliform value there should be a more accurate and critical evaluation of the potential health hazard of a water body containing a known level of fecal coliforms. At present, there is no epidemiological data available to show the threshold concentration of fecal coliforms beyond which the health hazard increases. Therefore, research into the development of a more meaningful indicator and standard based on epidemiological data is needed.

RECOMMENDATIONS

1. It is recommended that the present closure of the waters in the Annapolis River (P.C. 1970-2189, Item 18-1) be rescinded. A new closure line should be established by drawing a straight line across the river from Karsdale Road east of Port Royal to the unnamed point immediately southwest of station 41 at latitude 40°41'8" N and longitude 65°35'3" W. The exact position of the closure line must be defined by the installation of survey monuments. A portion of the closure area in the River downstream from the Allain River (Figure 3A) can be approved for the harvesting of shellfish for depuration.

2. The present closure of the waters along the south shore from Clementsport to Deep Brook (P.C. 1970-2189, Item 18-2) are subjected to direct fecal contamination from the town of Clementsport, CFB Cornwallis and settlements along the shore. It is thus recommended that this area remain closed for all purposes of shellfish harvesting.

3. The waters along the Digby waterfront are seriously contaminated by a number of sewage outfalls from Digby. The present closure (P.C. 1970-2189, Item 18-4) must be retained but a portion of the eastern Joggins as shown in Figure 6B be approved for the harvesting of shellfish for depuration. Because of the large resource of shellfish in this area, it is strongly recommended that the proposed treatment plant at Digby be constructed as soon as possible and the sewage outfall be diverted as far as possible from the Joggins.

4. The presence of a significant number of coliform and fecal coliform indices in the inlet of the Basin below the Smith Cove Trailer Park indicates that a closure is required for this area. The recommended closure area lies within a straight line drawn between the Smith's Cove Station and the tip of the Smith Cove Peninsula as shown in Figure 6A. The location of the closure should be defined later in terms of survey monuments. This closure can be approved for the harvesting of shellfish for depuration.

5. The remainder of the Annapolis Basin is of satisfactory bacteriological quality and should remain open for the harvesting of shellfish.

6. Bacteriological quality of the Annapolis Basin would probably improve should sewage treatment facilities be constructed at the towns of Annapolis Royal, Digby, and CFB Cornwallis.

REFERENCES

1. American Public Health Association, Recommended Procedures for the Examination of Sea Water and Shellfish, Fourth Edition, American Public Health Association, New York, (1970).

2. Duncan, D.W. and W.E. Russell, Klebsiella Biotypes among Coliforms Isolated from Forest Environments and Farm Produce, Applied Microbiology, p. 933-938, (1972).

3. Houser, L.D., Ed. The National Shellfish Sanitation Program Manual of Operation, Part 1, Sanitation of Shellfish Growing Areas, Public Health Service Publication No. 33, (1965 Revision).

4. Kindrasky, G.A., and M. Debellefeulle. Bacteriological Survey, Annapolis-Digby, N.S. 31 and 32, Department of National Health and Welfare, Public Health Engineering Division, Manuscript Report No. 67-7 (1967).

5. Legault, R. Bacteriological Survey, Annapolis Basin, N.S. 18, Department of Fisheries and Forestry, Public Health Engineering Division, Manuscript Report No. OR-70-7 (1970).

6. MacLeod, L.L., and M. Hill. A survey of soft shell clam (*Mya arenaria*) populations of the polluted areas of the Annapolis Basin. N.S. Department of Fisheries, Resource Development Division, Pictou, N.S. 19 pp. (March 1973)

7. Menon, A.S., H.R. VanOtterloo and B.J. Dutka. A preliminary investigation of a pulp and paper mill aeration lagoon. Environment Canada, Environmental Protection Service, Technical Development Report EPS4-WP-72-5. 153 pp., (1972).

8. Menon, A.S. and W.K. Bedford. A bacteriological study of the Upper Rainey River. Environment Canada, Environmental Protection Service, Surveillance Report EPS5-WP-72-4, 47 pp., (1972).

9. Menon, A.S. and W.K. Bedford. A study of the seasonal effects on the microbiology of a northern pulp and paper mill aeration lagoon. Environment Canada, Environmental Protection Service, Technical Development Report EPS4-AR-73-1, 44 pp., (1973).

10. Tennant, A.D., J.A.P. Bastien and R.M. Marion. A preliminary bacteriological evaluation of pulp and paper mill effluents, Domtar Mills, Cornwall and Trenton, Ontario. Environment Canada, Environmental Protection Service, Manuscript Report No. OR-71-11, 67 pp (1971).

11. Tennant, A.D., J.E. Reid and J.A.P. Bastien. A comparison of the coliform and fecal coliform indices of water pollution, with special reference to Canadian Atlantic Shellfish Growing Areas. Dept. National Health and Welfare, The Laboratory of Hygiene, Manuscript Report No. 64-6, 30 pp (1964).

12. Tennant, A.D., G.A. Kindrasky and J.A.P. Bastien. Coliform MPN: Fecal Coliform MPN Relationships, 1965-67, with special reference to Canadian Atlantic Shellfish Growing Areas. Department of National Health and Welfare, Public Health Engineering Division, Manuscript Report No. OR-68-12, 23 pp (1968).

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APPENDIX

TABLES

TABLE 1-A COLIFORM MPN's OF SEA WATER SAMPLES FOR ANNAPOLIS RIVER (SECTOR 1)

Sta. No.	MOST PROBABLE NUMBERS (MPNS) PER 100 ML OF WATER										
	Jun 6	Jun 12	Jun 19	Jun 26	Aug 6	Aug 9	Aug 15	Nov 1	Nov 6	Dec 3	Median
1	5	<2	130	920	280	130	---	240	79	2400+	130
2	220	<2	49	110	350	2400+	---	240	49	2400+	220
3	13	<2	350	1600	540	540	---	240	33	2400+	350
4	1600	2400+	350	2400+	1600	2400+	---	1600	540	2400+	1600
5	49	5	130	920	2400+	1600	---	2400+	130	240	240
6	49	5	130	540	2400+	2400+	---	920	110	2400+	540
7	13	9	79	540	2400+	540	---	79	40	920	79
8	350	2400+	130	920	2400+	350	---	540	540	2400+	540
9	130	920	79	540	1600	2400+	---	2400+	430	2400+	920
10	23	<2	540	540	1600	920	---	49	920	2400+	540
11	13	79	350	240	1600	540	---	540	49	110	240
12	11	110	70	920	920	540	---	350	70	49	110
13	33	<2	240	540	1600	2400+	---	1600	350	1600	540
14	49	920	130	1600	1600	240	---	130	350	540	350
15	49	17	350	23	1600	540	---	79	79	2400+	79
16	8	170	110	540	540	920	---	920	40	920	540
17	23	240	240	350	350	540	---	170	64	1600	240
18	33	130	240	170	170	540	---	130	79	2400+	170
19	70	350	130	920	540	540	---	240	130	2400+	350
20	17	240	240	920	130	540	---	130	79	2400+	240
21	23	33	110	1600	350	920	---	79	130	1600	130
22	33	540	110	350	350	240	---	350	79	1600	350
23	33	79	70	540	540	540	---	79	79	2400+	79

TABLE 1-A COLIFORM MPN's OF SEA WATER SAMPLES FOR ANNAPOLIS RIVER
SECTOR 1 (CONTINUED)

Sta. No.	MOST PROBABLE NUMBERS (MPN's) PER 100 ML OF WATER										
	Jun 6	Jun 12	Jun 19	Jun 26	Aug 6	Aug 9	Aug 15	Nov 1	Nov 6	Dec 3	Median
24	49	240	79	350	920	540	----	350	79	920	350
25	17	17	79	1600	1600	540	----	350	79	2400+	350
26	5	49	49	920	920	350	----	170	49	2400+	170
27	21	79	13	350	350	240	----	130	49	2400+	130
28	23	49	33	540	350	540	----	540	240	1600	350
29	7	79	22	540	540	920	----	220	17	540	540
30	<2	70	49	920	170	350	230	79	130	1600	150
31	13	79	8	220	540	240	540	49	70	350	150
32	49	79	33	350	1600	540	110	240	220	2400+	230
33	11	130	23	920	2400+	540	350	27	17	2400+	240
34	2	49	23	920	2400+	1600	230	79	110	920	170
35	2	70	23	540	2400+	220	46	130	26	350	100
36	5	33	17	350	2400+	350	95	79	27	130	87
37	<2	17	2	240	2400+	280	49	22	110	49	49
38	<2	23	17	280	920	110	230	33	27	27	30
39	2	170	8	540	540	170	130	17	130	1600	150
40	2	33	13	240	540	110	79	70	33	540	75
41	<2	49	2	920	170	140	49	70	21	220	60
42	2	8	17	130	33	180	49	23	8	33	28
43	33	13	8	350	64	46	13	33	49	17	33
44	33	17	13	350	49	70	110	17	17	33	33
45	33	11	11	350	33	33	46	49	17	13	33

TABLE 1-B FECAL COLIFORM MPN's OF SEA WATER SAMPLES FOR ANNAPOLIS RIVER SECTOR (1)

Sta. No.	MOST PROBABLE NUMBERS (MPN's) PER 100 ML OF WATER										
	Jun 6	Jun 12	Jun 19	Jun 26	Aug 6	Aug 9	Aug 15	Nov 1	Nov 6	Dec 3	Median
1	5	<2	79	540	110	33	---	49	49	2400+	49
2	220	<2	49	70	140	540	---	49	33	2400+	70
3	8	<2	170	920	110	170	---	130	22	540	130
4	1600	2400+	110	1600	170	2400+	---	920	220	2400+	1600
5	49	5	130	240	2400+	1600	---	1600	49	79	130
6	49	5	79	340	2400+	2400+	---	920	79	920	340
7	5	9	79	220	240	540	---	33	33	70	70
8	350	2400+	79	220	1600	240	---	350	170	540	350
9	130	540	49	350	920	2400+	---	2400+	170	2400+	540
10	13	<2	220	350	140	920	---	13	350	540	220
11	8	79	240	130	920	350	---	350	11	70	130
12	4	79	49	350	540	350	---	130	33	46	79
13	17	<2	79	350	540	2400+	---	1600	39	350	350
14	49	280	49	540	920	49	---	22	170	46	49
15	7	14	79	23	540	130	---	33	33	14	33
16	5	110	70	240	130	920	---	540	34	9	110
17	13	130	130	240	49	170	---	110	8	21	110
18	17	79	27	240	130	130	---	33	8	20	33
19	70	130	130	350	79	170	---	22	27	2400+	130
20	8	240	130	350	79	350	---	33	22	11	79
21	23	17	79	540	79	920	---	33	130	21	79
22	13	350	79	240	170	240	---	33	49	110	110
23	17	49	49	350	170	240	---	49	49	540	49

TABLE 1-B FECAL COLIFORM MPN's OF SEA WATER SAMPLES FOR ANNAPOLIS RIVER (SECTOR 1) (CONTINUED)

Sta. No.	MOST PROBABLE NUMBERS (MPN's) PER 100 ML OF WATER										
	Jun 6	Jun 12	Jun 19	Jun 26	Aug 6	Aug 9	Aug 15	Nov 1	Nov 6	Dec 3	Median
24	17	130	49	110	220	130	—	79	17	11	79
25	11	11	49	350	110	350	—	49	33	540	49
26	<2	33	23	280	49	240	—	33	23	140	33
27	2	49	8	170	240	33	—	33	23	23	33
28	23	22	23	220	130	130	—	33	27	79	33
29	7	27	22	350	220	79	—	26	11	9	26
30	<2	49	33	350	49	240	33	22	27	21	33
31	5	49	5	130	110	79	170	14	21	7	35
32	49	23	17	240	170	540	79	22	130	21	64
33	5	130	17	350	920	110	79	13	13	20	50
34	2	22	23	540	920	170	230	23	12	20	23
35	2	46	23	170	1600	70	13	23	9	4	23
36	2	13	17	130	350	33	46	27	22	4	25
37	<2	49	2	130	240	49	33	<2	33	4	33
38	<2	23	17	170	280	49	130	23	8	7	23
39	2	110	8	350	110	49	27	11	13	7	20
40	2	17	8	130	33	33	33	33	13	17	20
41	<2	13	2	170	70	110	23	17	7	9	15
42	2	8	17	49	23	23	13	23	<2	13	15
43	33	7	8	240	22	17	5	13	7	2	11
44	17	13	8	130	13	23	22	8	4	4	13
45	23	8	11	240	11	13	17	23	13	2	13

TABLE 2-A COLIFORM MPN's OF SEA WATER SAMPLES FOR EASTERN ANNAPOLIS BASIN (SECTOR 2)

Sta. No.	MOST PROBABLE NUMBERS (MPN's) PER 100 ML OF WATER									
	Jun 7	Jun 12	Jun 20	Jun 26	Aug 7	Aug 13	Aug 15	Nov 21	Nov 26	Median
46	33	5	22	240	21	5	33	31	27	33
47	33	2	5	70	49	31	17	33	70	33
48	23	2	13	23	33	13	13	33	49	23
49	2	<2	23	---	49	23	8	---	23	23
50	2	<2	33	---	49	49	13	33	33	33
51	11	<2	8	130	23	5	<2	11	27	11
52	17	<2	11	---	11	5	8	13	17	11
53	7	2	2	350	33	7	13	17	22	13
54	5	<2	<2	49	17	2	23	17	14	14
55	8	<2	<2	49	26	14	39	17	70	17
56	8	<2	<2	33	11	11	11	11	32	11
57	5	<2	2	240	17	5	58	14	33	14
58	33	<2	<2	---	49	49	13	33	46	33
59	22	2	<2	79	39	70	13	33	23	23
60	5	2	<2	130	70	---	13	22	70	18
61	2	<2	<2	40	240	---	17	17	13	15
62	2	<2	<2	1600	170	5	49	110	11	11
63	40	<2	13	920	2400+	79	49	---	170	64
64	70	8	5	---	2400+	920	70	170	95	83
65	350	<2	130	350	240	2400+	23	170	17	170
66	920	<2	<2	130	49	22	49	17	10	22
67	8	<2	2	79	46	7	17	13	11	11
68	17	2	<2	79	13	8	49	13	46	13
69	7	4	<2	240	22	33	23	22	49	22

TABLE 2-A COLIFORM MPN's OF SEA WATER SAMPLES FOR EASTERN ANNAPOLIS BASIN (SECTOR 2) (CONTINUED)

Sta. No.	MOST PROBABLE NUMBERS (MPN's) PER 100 ML. OF WATER									
	Jun 7	Jun 12	Jun 20	Jun 26	Aug 7	Aug 13	Aug 15	Nov 21	Nov 26	Median
70	17	4	<2	130	---	17	49	17	4	17
71	11	<2	<2	49	11	33	130	13	8	11
72	17	2	<2	33	49	26	79	24	14	24
73	5	<2	<2	46	26	46	33	5	13	13
74	2	<2	<2	46	33	8	540	34	13	13
75	33	<2	49	170	95	130	1600	220	540	130
76	920	<2	2	110	280	2400+	110	23	170	110
77	2400+	2	<2	79	540	70	1600	540	540	540
78	13	<2	<2	79	350	79	13	170	1600	79
79	17	<2	<2	110	140	49	33	79	49	49
80	5	<2	<2	33	33	170	130	11	2	11
81	2	<2	5	46	33	23	33	49	14	23
82	17	<2	13	79	49	33	49	33	2	33
83	17	7	23	49	70	23	14	13	4	23
84	13	8	17	130	33	17	49	2	<2	17
85	8	2	13	33	17	33	13	14	<2	13
86	13	<2	8	79	49	8	33	13	13	13
87	7	<2	11	170	46	17	23	11	21	17
88	17	<2	5	140	64	17	23	9	33	17
89	8	<2	5	130	33	49	8	70	46	33
90	2	<2	4	49	27	23	11	27	11	11
91	<2	<2	--	220	46	5	17	22	11	14
92	<2	<2	<2	140	13	8	7	70	5	7
93	5	<2	2	94	17	33	13	11	11	11

TABLE 2-B FECAL COLIFORM MPN's OF SEA WATER SAMPLES FOR EASTERN ANNAPOLIS BASIN (SECTOR 2)

Sta. No.	MOST PROBABLE NUMBERS (MPN's) PER 100 ML OF WATER									
	Jun 7	Jun 12	Jun 20	Jun 26	Aug 7	Aug 13	Aug 15	Nov 21	Nov 26	Median
46	33	5	14	130	14	2	13	8	5	13
47	17	2	5	23	33	5	4	8	21	5
48	13	2	13	8	3	2	2	8	33	8
49	2	≤2	13	—	17	13	2	—	11	11
50	2	<2	13	—	14	23	5	13	13	13
51	11	<2	8	79	17	5	2	2	11	8
52	7	<2	2	—	7	2	2	5	11	4
53	7	2	<2	240	24	5	8	13	22	8
54	2	<2	<2	13	9	2	5	17	11	5
55	2	<2	<2	11	14	5	13	11	8	8
56	8	<2	<2	11	7	5	8	6	17	7
57	5	2	2	33	13	2	17	8	10	8
58	14	<2	<2	—	17	23	7	8	7	7
59	7	<2	<2	33	14	46	13	17	13	13
60	2	<2	<2	49	17	—	5	9	11	5
61	2	<2	<2	23	79	—	5	5	8	5
62	2	<2	<2	350	110	5	17	79	7	7
63	33	2	2	540	2400+	14	23	—	110	28
64	49	5	5	—	2400+	140	22	49	33	41
65	79	<2	49	240	33	920	8	46	13	46
66	920	<2	<2	33	23	17	23	7	7	17
67	2	<2	2	33	31	2	23	8	8	8
68	17	2	<2	23	7	5	9	13	11	9
69	4	2	<2	79	9	13	8	14	17	9

TABLE 2-B FECAL COLIFORM MPN's OF SEA WATER SAMPLES FOR EASTERN ANNAPOLIS BASIN (SECTOR 2) (CONTINUED)

Sta. No.	MOST PROBABLE NUMBERS (MPN's) PER 100 ML OF WATER									
	Jun 7	Jun 12	Jun 20	Jun 26	Aug 7	Aug 13	Aug 15	Nov 21	Nov 26	Median
70	17	4	<2	49	—	8	23	13	2	11
71	7	<2	<2	13	7	23	33	13	2	7
72	17	2	<2	13	23	11	49	13	7	13
73	2	<2	<2	17	13	17	23	2	2	2
74	2	<2	<2	21	23	2	230	9	2	2
75	23	<2	23	70	70	49	350	46	350	49
76	230	<2	2	46	120	1600	49	13	79	49
77	2400+	2	<2	49	220	49	540	230	350	230
78	13	<2	<2	33	280	33	2	33	920	33
79	7	<2	<2	46	110	17	8	11	4	8
80	5	<2	<2	17	23	79	49	5	2	5
81	2	<2	5	17	33	23	8	8	5	8
82	17	<2	13	79	13	13	23	7	<2	17
83	17	7	23	49	26	23	5	13	2	17
84	13	8	17	130	23	13	23	<2	<2	13
85	8	2	13	33	11	23	8	8	<2	8
86	13	<2	8	79	11	<2	11	2	8	8
87	7	<2	11	170	17	11	8	5	17	11
88	17	<2	5	140	21	5	23	8	23	17
89	8	<2	5	130	5	49	2	14	13	8
90	2	<2	4	49	13	23	<2	17	11	11
91	<2	<2	—	220	33	2	8	8	11	8
92	<2	<2	<2	140	8	5	<2	23	2	2
93	5	<2	2	94	4	13	5	11	4	5

TABLE 3 A COLIFORM MPN's OF SEAWATER SAMPLES FOR WESTERN ANNAPOLIS BASIN (SECTOR 3)

Sta. No.	MOST PROBABLE NUMBERS (MPN's) PER 100 ML OF WATER										
	Jun 8	Jun 14	Jun 21	Jun 27	Aug 9	Aug 15	Aug 16	Nov 1	Nov 21	Nov 26	Median
94	<2	11	2	79	17	<2	23	--	33	13	13
95	4	23	<2	49	13	2	8	--	<2	8	8
96	5	9	<2	49	22	<2	17	--	5	7	7
97	2	22	2	170	33	13	<2	--	49	13	13
98	5	49	2	70	540	49	2	--	34	14	34
99	8	33	17	46	2400+	23	49	--	33	17	33
100	5	33	4	170	130	17	8	--	13	27	17
101	2	70	<2	33	17	5	49	--	8	<2	8
102	2	17	<2	130	13	8	<2	--	8	6	8
103	<2	14	<2	79	33	46	33	--	2	5	14
104	<2	17	<2	46	7	13	49	--	14	34	14
105	<2	8	2	49	22	23	49	--	7	5	8
106	<2	<2	<2	14	----	2	49	--	8	<2	<2
107	<2	<2	8	5	23	17	11	--	11	<2	8
108	<2	23	7	23	70	13	5	--	5	<2	7
109	<2	13	<2	17	49	13	7	--	<2	4	7
110	<2	33	2	8	31	<2	23	--	<2	2	2
111	<2	8	11	23	33	2	23	--	<2	2	8
112	<2	11	33	17	49	<2	33	--	4	2	11
113	2	5	14	23	17	2	23	--	2	2	5
114	<2	13	11	33	33	<2	23	--	11	4	11
115	<2	<2	8	46	33	<2	23	--	<2	2	2
116	<2	2	4	23	17	5	23	--	8	<2	5
117	11	5	2	22	22	5	23	--	<2	9	9
118	<2	<2	2	17	49	14	2	--	2	2	2
119	8	5	<2	8	5	7	<2	--	2	2	5
120	<2	<2	2	7	5	2	<2	--	<2	<2	<2
121	<2	<2	<2	13	5	13	<2	--	<2	5	<2
122	<2	5	<2	5	11	13	49	--	8	11	8

TABLE 3A COLIFORM MPN's OF SEA WATER SAMPLES FOR WESTERN ANNAPOLIS BASIN SECTOR 3 (CONTINUED)

Sta. No.	MOST PROBABLE NUMBERS (MPN's) PER 100 ML OF WATER										
	Jun 8	Jun 14	Jun 21	Jun 27	Aug 9	Aug 15	Aug 16	Nov 1	Nov 21	Nov 26	Median
123	<2	5	8	11	13	8	49	8	4	5	7
124	<2	4	7	5	—	49	33	17	21	23	17
125	<2	2	8	27	11	70	46	5	23	13	12
126	<2	26	5	49	23	130	920	79	240	7	35
127	2	130	—	130	79	49	540	1600	—	79	110
128	<2	2	5	79	79	2400+	350	79	350	2400+	79
129	<2	2	2	33	22	27	64	79	22	33	25
130	2	<2	<2	540	13	49	79	10	170	8	13
131	<2	8	<2	70	4	49	130	5	40	64	23
132	<2	49	<2	49	7	79	220	49	5	49	49
133	<2	130	<2	49	4	79	230	49	5	70	49
134	49	240	—	170	2400+	2400+	540	70	—	79	210
135	2	79	—	350	33	49	33	22	—	49	41
136	<2	4	2	240	33	79	46	33	11	130	33
137	<2	<2	<2	49	17	79	46	49	79	170	48
138	<2	<2	2	46	13	130	33	22	14	95	18
139	<2	<2	8	130	11	49	33	170	350	920	41
140	8	8	49	140	79	230	33	49	280	280	64
141	<2	23	17	350	280	33	79	110	—	1600	79
142	<2	2	17	140	130	350	350	49	—	1600	140
143	2	23	79	540	33	170	230	130	—	350	130
144	<2	170	—	920	130	350	49	350	—	2400+	170
145	2	46	130	110	170	920	22	240	—	2400+	130
146	130	170	49	130	2400+	350	540	350	—	2400+	350
147	2	170	33	130	350	2400+	79	350	540	540	270
148	2	<2	—	350	8	230	49	350	920	460	230
149	95	<2	33	2400+	2400+	110	110	110	920	2400+	110
150	2	14	920	2400+	79	350	2400+	350	130	240	230

TABLE 3B FECAL MPN's OF SEAWATER SAMPLES FOR WESTERN ANNAPOLIS BASIN (SECTOR 3)

Sta. No.	MOST PROBABLE NUMBERS (MPN's)PER 100 ML OF WATER										
	Jun 8	Jun 14	Jun 21	Jun 27	Aug 9	Aug 15	Aug 16	Nov 1	Nov 21	Nov 26	Median
94	<2	7	<2	49	8	<2	5	—	17	8	7
95	2	13	<2	23	13	<2	5	—	<2	5	5
96	5	7	<2	13	13	<2	7	—	5	2	5
97	2	17	2	79	23	5	<2	—	17	5	5
98	2	13	<2	49	34	33	<2	—	22	14	14
99	5	13	8	21	1600	23	8	—	23	11	13
100	2	17	4	70	33	13	5	—	5	22	13
101	2	23	<2	11	17	2	33	—	5	<2	5
102	2	5	<2	17	5	2	<2	—	5	2	2
103	<2	7	<2	49	13	23	13	—	<2	<2	7
104	<2	13	<2	17	7	5	17	—	8	27	13
105	<2	<2	2	17	14	8	33	—	4	5	5
106	<2	<2	<2	2	—	<2	23	—	8	<2	<2
107	<2	<2	8	2	8	13	2	—	8	<2	2
108	<2	8	5	8	49	8	<2	—	2	<2	5
109	<2	8	<2	8	23	13	<2	—	<2	4	4
110	<2	13	2	5	23	<2	23	—	<2	<2	2
111	<2	8	7	8	23	2	8	—	<2	2	7
112	<2	8	13	8	13	<2	8	—	4	2	8
113	2	5	14	5	7	<2	5	—	<2	2	5
114	<2	8	5	5	8	<2	13	—	5	2	5
115	<2	<2	8	8	22	<2	13	—	<2	2	2
116	<2	2	2	5	7	2	8	—	2	<2	2
117	4	<2	2	14	8	<2	13	—	<2	<2	2
118	<2	<2	2	5	14	11	<2	—	2	2	2
119	8	5	<2	5	2	5	<2	—	2	<2	2
120	<2	<2	<2	<2	2	<2	<2	—	<2	<2	<2
121	<2	<2	<2	2	<2	13	<2	—	<2	<2	<2
122	<2	<2	<2	2	11	8	13	—	8	<2	2

TABLE 3B FECAL MPN's OF SEAWATER SAMPLES FOR WESTERN ANNAPOLIS BASIN (SECTOR 3) (CONTINUED)

Sta. No.	MOST PROBABLE NUMBERS (MPN's) PER 100 ML OF WATER										
	Jun 8	Jun 14	Jun 21	Jun 27	Aug 9	Aug 15	Aug 16	Nov 1	Nov 21	Nov 26	Median
123	<2	5	5	5	5	8	17	8	<2	5	5
124	<2	4	7	2	—	13	8	17	7	13	7
125	<2	<2	5	8	2	8	11	5	5	13	5
126	<2	13	5	13	13	49	350	23	49	<2	13
127	<2	49	—	33	33	17	49	920	—	49	41
128	<2	2	5	33	17	2400+	130	23	70	540	28
129	<2	2	2	23	11	14	17	49	17	9	16
130	<2	<2	<2	240	8	23	33	5	14	8	8
131	<2	8	<2	23	<2	23	79	5	8	14	8
132	<2	33	<2	33	4	49	70	11	<2	13	12
133	<2	79	<2	17	2	79	230	5	2	21	11
134	22	130	—	110	1600	2400+	230	10	—	17	120
135	<2	49	—	240	33	33	8	33	—	14	33
136	<2	4	<2	130	33	23	33	5	8	22	15
137	<2	<2	<2	17	7	23	11	5	49	33	9
138	<2	<2	<2	33	5	49	23	10	7	70	9
139	<2	<2	2	49	5	33	17	8	34	540	7
140	8	8	23	110	23	230	13	49	49	140	23
141	<2	13	11	240	170	13	79	23	—	920	23
142	<2	2	13	46	34	79	79	26	—	540	34
143	<2	8	49	170	7	49	79	33	—	220	49
144	<2	70	—	280	33	49	17	33	—	920	41
145	2	33	79	79	33	350	8	240	—	1600	79
146	26	110	17	49	2400+	350	110	130	—	920	110
147	<2	70	<2	79	79	2400+	22	240	170	170	79
148	2	<2	—	240	5	33	8	240	350	240	33
149	49	<2	13	2400+	2400+	33	33	6	540	2400+	48
150	2	11	350	2400+	33	49	2400+	240	79	130	100

TABLE 4 SALINITY DATA FOR SELECTED STATIONS AT ANNAPOLIS BASIN, 1973

Station	Salinity in Parts Per Thousand								
	Annapolis River								
	June 6	June 12	June 19	June 26	Aug 6	Aug 9	Nov 1	Nov 6	
1	18.8	16.2	18.8	10.2	20.8	23.5	15.3	25.9	
15	18.8	29.5	24.2	16.9	22.2	10.2	15.3	27.2	
30	26.8	16.2	24.2	16.9	22.2	16.9	25.9	28.5	
43	29.5	24.2	29.5	16.9	26.1	20.8	25.9	28.5	
	Eastern Annapolis Basin								
	June 7	June 12	June 20	June 26	Aug 7	Aug 13	Aug 15	Nov 26	
54	26.8	29.5	29.5	27.4	22.2	16.9	28.5	28.5	
66	29.5	29.5	29.5	27.4	24.8	30.2	20.6	28.5	
68	29.5	29.5	29.5	30.2	30.2	30.2	28.5	31.2	
88	29.5	33.4	29.5	30.2	30.2	30.2	28.5	28.5	
	Western Annapolis Basin								
	June 8	June 14	June 21	June 27	Aug 9	Aug 15	Aug 16	Nov 1	Nov 6
98	29.5	26.8	29.5	30.2	18.2	16.9	15.3	----	28.5
106	29.5	29.5	29.5	30.2	30.2	30.2	28.5	----	28.5
108	29.5	29.5	29.5	30.2	30.2	30.2	25.9	----	28.5
119	29.5	29.5	32.1	30.2	27.4	30.2	28.5	----	31.2
135	29.5	29.5	29.5	24.8	30.2	30.2	25.9	28.5	25.9
144	29.5	29.5	29.5	30.2	27.4	22.2	28.5	31.2	28.5
149	29.5	29.5	26.8	30.2	27.4	30.2	28.5	31.2	28.5

TABLE 5 TIDAL PHASE AT TIME OF SAMPLING, ANNAPOLIS BASIN, 1973

SECTOR 1			SECTOR 2			SECTOR 3		
Date	Time	Tide	Date	Time	Tide	Date	Time	Tide
Jun 6	13.30-15.30	Low Rising	Jun 7	8.30-12.15	Low Falling	Jun 8	13.30-17.00	Low Rising
Jun 12	8.00-10.00	Low Falling	Jun 12	15.00-17.00	Low Rising	Jun 14	8.15-11.15	High Rising
Jun 19	10.30-12.00	High Rising	Jun 20	13.00-15.00	High Rising	Jun 21	10.00-13.30	Low Falling
Jun 26	14.00-15.00	Low Falling	Jun 26	15.15-17.00	Low Rising	Jun 27	8.00-11.00	High Falling
Aug 6	14.30-18.00	High Rising	Aug 7	12.00-13.30	Low Falling	Aug 9	8.30-12.00	High Falling
Aug 9	12.30-15.00	High Falling	Aug 13	10.30-13.00	High Falling	Aug 15	13.30-14.30	High Falling
Aug 15	15.00-15.30	Low Falling	Aug 15	15.30-17.30	Low Falling	Aug 16	11.00-13.30	High Rising
Nov 1	14.00-15.00	High Rising	Nov 21	11.30-13.00	Low Falling	Nov 1	13.00-14.00	High Rising
Nov 6	11.00-13.00	Low Falling	Nov 26	13.30-15.00	High Falling	Nov 21	13.00-14.30	Low Falling
Dec 3	15.30-16.30	High Rising				Nov 26	15.00-17.00	High Falling

TABLE 6 DAILY PRECIPITATION (IN INCHES) AT ANNAPOLIS ROYAL AND DIGBY, N. S.

DATE 1973	Annapolis Royal			Digby		
	JUNE	AUG.	NOV.	JUNE	AUG.	NOV.
1		1.42	.76	TR	.27	.95
2		.02	.41		.08	.38
3		.84	.04		.93	TR
4		.13			.08	
5			.01			TR
6					TR	TR
7						
8		.02	.25			.10
9		.35			TR	TR
10						
11		TR				
12	.41			.45		
13	.31		.06	1.04		.10
14	.29		.03			TR
15	.30	.14	.05		.18	.10
16	1.50		.16	1.08		.20
17	.35			.34		
18						TR
19					.09	
20						
21						
22	.57	.46		.66	.50	
23	.39		.06	.18		TR
24	.41		.08	.70		.09
25	1.20		.03	.79		TR
26	.02					
27	.24		.09	.28	.80	.15
28	.01	.69	1.63	.23		1.80
29						TR
30						TR
31						
Total	6.00	4.07	3.66	5.75	3.10	3.37

TR = Trace

V on