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BIG BEEF ESTUARY PHYTOPLANKTON AND BACTERIA STUDIES 1968–1969

By Fred Palmer, Jon Heller,
John Gatjens, and Ruth Hung

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INTRODUCTION

This report is intended primarily for investigators engaged in studies at Big Beef estuary. We have emphasized 1) estimates of phytoplankton populations, 2) bacteria of shellfish sanitation significance, 3) estimates of total food for shellfish, and 4) indicators of ecological change. The data may be useful in comparing Big Beef with other areas and as a reference line for following relatively long-term changes at Big Beef.

Figure 1 is a rough map of the estuary at Big Beef showing the locations of Stations E, 1, 3 and 9. The stream (Station S) was sampled about one mile above the laboratory. The estuary fills and empties with each tidal cycle; Station 9 is above water more of the time than it is covered; Station 3 is submerged more than Station 9 and has few shellfish; Station 1 is similar to Station 3, but has dense shellfish beds. Samples were collected near high tide and were drawn from the middle depths, when possible, to avoid the fresh water surface layer from the creek and muddy water from stirred sediments near the bottom. The 1968 samples were obtained by lowering a polyethylene bottle and allowing it to fill at the desired depth. Beginning in 1969 a submersible pump, powered by two 6-volt "Hot Shot" batteries, was used.

Phytoplankton samples were collected both in the form of unconcentrated water samples and in the form of concentrated samples by putting known volumes of water through a net, retaining particles larger than about 100μ. Net samples were preserved in iodine-potassium iodide solution and the others in 5% neutralized formalin. Organisms in the stored samples were identified and counted with the aid of an inverted microscope (loaned to us by Dr. Kelshaw Bonham) and settling chambers.

Water for bacteriological analysis was collected aseptically in sterile bottles. Dilution and inoculation of appropriate media were often performed immediately after collection of the samples. When this was impractical, samples were stored in ice for the few hours required to transport them to the University.

Coliform numbers were estimated, using Lauryl tryptose broth with confirmation on EMB agar plates (APHA 1965). Total numbers of aerobic, heterotrophic bacteria were estimated by MPN in a medium consisting of peptone, 0.1%; yeast extract, 0.05%; and starch, 0.4% in sea water. Bacteria from the positive tubes were subcultured in gelatin medium for estimation of numbers of gelatin liquifiers as representing protolytic organisms, and on starch agar plates for estimation of numbers of starch digesters.

Analyses for oxidizable carbon and Kjeldahl nitrogen were done on particulates nominally larger than 1.0μ, by procedures recommended by Strickland, Parsons (1965). Chlorophyll analyses were begun in 1969 on particles held on 0.45μ filters (UNESCO 1966).

Salinity measurements were obtained for the sample water with the use of hydrographic hydrometers. Surface water temperatures were recorded.

RESULTS AND DISCUSSION

Figures 2 - 6 show the total numbers of some of the more common genera of plankton for each station on the dates sampled. Tables 1 through 5 present similar information and data on other genera.

Algal Abundance

Naked flagellates predominate numerically in most of the samples, except possibly those from the stream. Due to their small size, the proportion of the biomass which they represent may be much smaller than their numbers would indicate. They are generally considered to be good food for shellfish.

Chlorophyll a values for 1969 are included in Figures 2 through 6 and in Table 6. The relationship of chlorophyll a to numbers of phyto-plankters is unclear in some cases, especially Stations E and 1 on August 5, 1969

It would be tempting to assign the discrepancies between chlorophyll a and numbers of organisms to error in the chlorophyll analyses for August 5, 1969. However, these pigment values continue a downward trend which began earlier.

In general, chlorophyll a should be a good index of food available to shellfish. Although as a measure of biomass it may be biased to give higher results with smaller organisms, it is these which are thought to be especially good feed for juvenile shellfish.

Total phytoplankton numbers at each station are compared in Figure 7. Stations E (Hood Canal) and S (Big Beef Creek) are often quite different in their populations, as would be expected. Samples taken at the other stations will usually be either predominantly Hood Canal or creek water, without very much mixing, depending upon the season and the depth of sampling, among other factors. This is confirmed by the salinities plotted in Figures 8 - 12. The fresh water layer is much thicker during the rainy months when the stream volume is high.

It is obvious that although the area is small, the sampling problem is complex. Patchiness in Hood Canal populations will be reflected in the estuary and modified by mixing with the stream and stratification. Averaging of values for Stations 1, 3 and 9 may be justified on the basis that the characteristics of the water and the populations in contact with the shellfish vary throughout the tidal cycle. The bottom animals are exposed to fresh water plankton when the tide is low and to sea water plankton as the water deepens.

It is believed that even such a limited sampling program is of some value in describing the conditions in the estuary and in detecting changes.

It may be worthwhile to substitute additional chlorophyll sampling for plankton enumeration and classification, which are very time-consuming.

Bacterial Abundance

The bacteriological sampling has the two aims of using bacterial numbers as indicators of changes in the estuarine ecology and of monitoring the sanitary quality of the water. Figures 8 - 11 and Table 7 plot data for total aerobic heterotrophs, starch digesters, and gelatin liquifiers. Long-term increases in any of these three categories would probably mean that substances available to bacteria as food were increasing. Cultures obtained in the sampling are tested for ability to hydrolyze starch and to liquify gelatin, to determine whether these characteristics contribute information beyond that obtained from total numbers of aerobic heterotrophs.

Significant numbers of coliforms frequently occur in Big Beef Creek, at the Hood Canal sampling Station (E) and, from both of these sources, in the estuary. The U. S. Public Health Service (1965) states that in approved shellfish-growing areas, coliform MPN may not exceed 330 per 100 ml during the most unfavorable pollution and hydrographic conditions, unless detailed studies show that the coliforms are not of fecal origin and do not indicate a public health hazard. Results of sampling in 1968 and 1969 (Figure 12) indicate that, occasionally, coliform counts exceeded the U. S. Public Health Service standards.

Chemical Estimations of Shellfish Food Abundance

Table 8 provides results of analyses of particulate material in water samples for oxidizable carbon and Kjeldahl nitrogen. It is suspected, on the basis of the low C:N ratios, that the oxidizable carbon values tend to be too low. Whether the fault is due to technique or to a method which may not be suitable for samples containing sediment is not known. The Kjeldahl nitrogen values are thought to be the more reliable of the two. These analyses could provide useful information on potential shellfish food if the reliability of the results was confirmed. However, rather than trying to prove out the methodology, we will concentrate on other techniques.

During 1970 the number of field trips was greatly reduced and the data gathered were limited to salinity, temperature, pigments and bacteria (including coliforms). Phytoplankton samples were collected, but have not been examined.

The 1971 sampling program was similar to the program described herein.

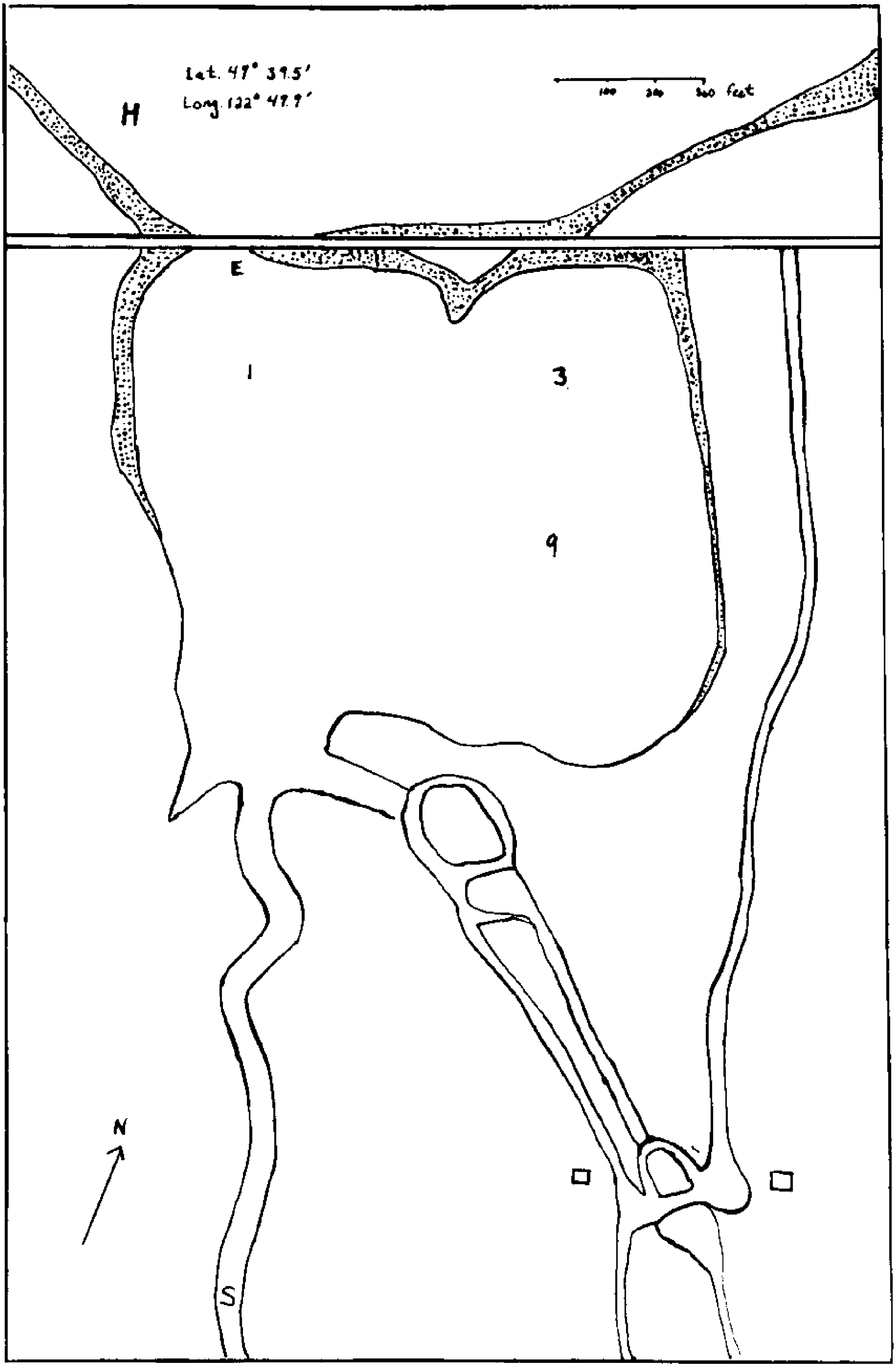
REFERENCES

American Public Health Association. 1965. Standard Methods for the Examination of Water, Sewage, and Industrial Wastes.

Strickland, J. D. H. and Parsons, T. R. 1965. A Manual of Sea Water Analysis. Fisheries Research Board of Canada Bull. 125, 2nd Ed. Ottawa.

UNESCO. 1966. Monography on Oceanographic Methodology I, Determination of Photosynthetic Pigments in Sea Water. UNESCO Publ. Center, New York. 69 p.

U. S. Public Health Service. 1965. National Shellfish Sanitation Program Manual of Operations, Part 1, Sanitation of Shellfish Growing Areas. U. S. Department of Health, Education and Welfare.



BIG BEEF ESTUARY AREA

Figure 1

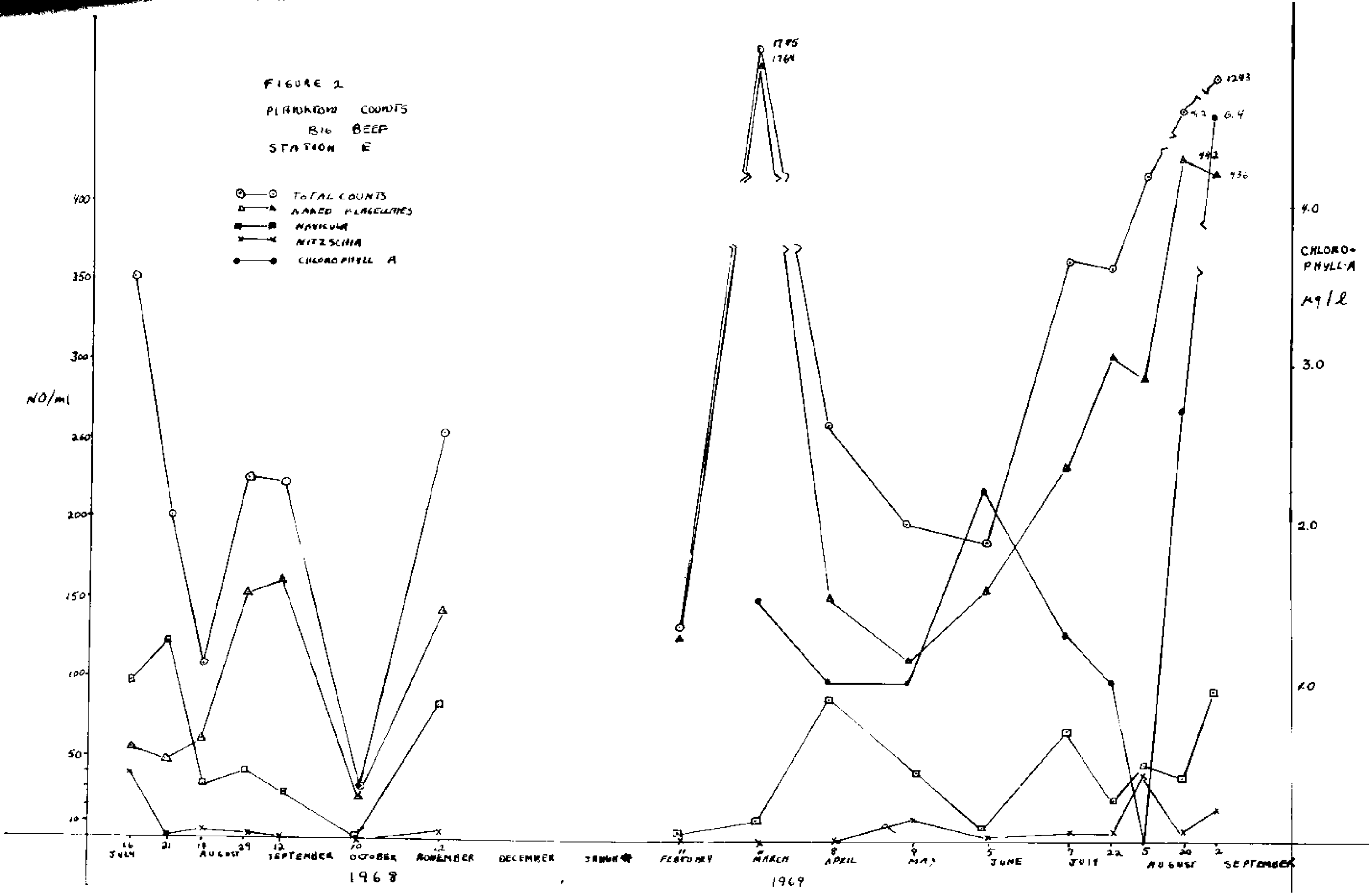
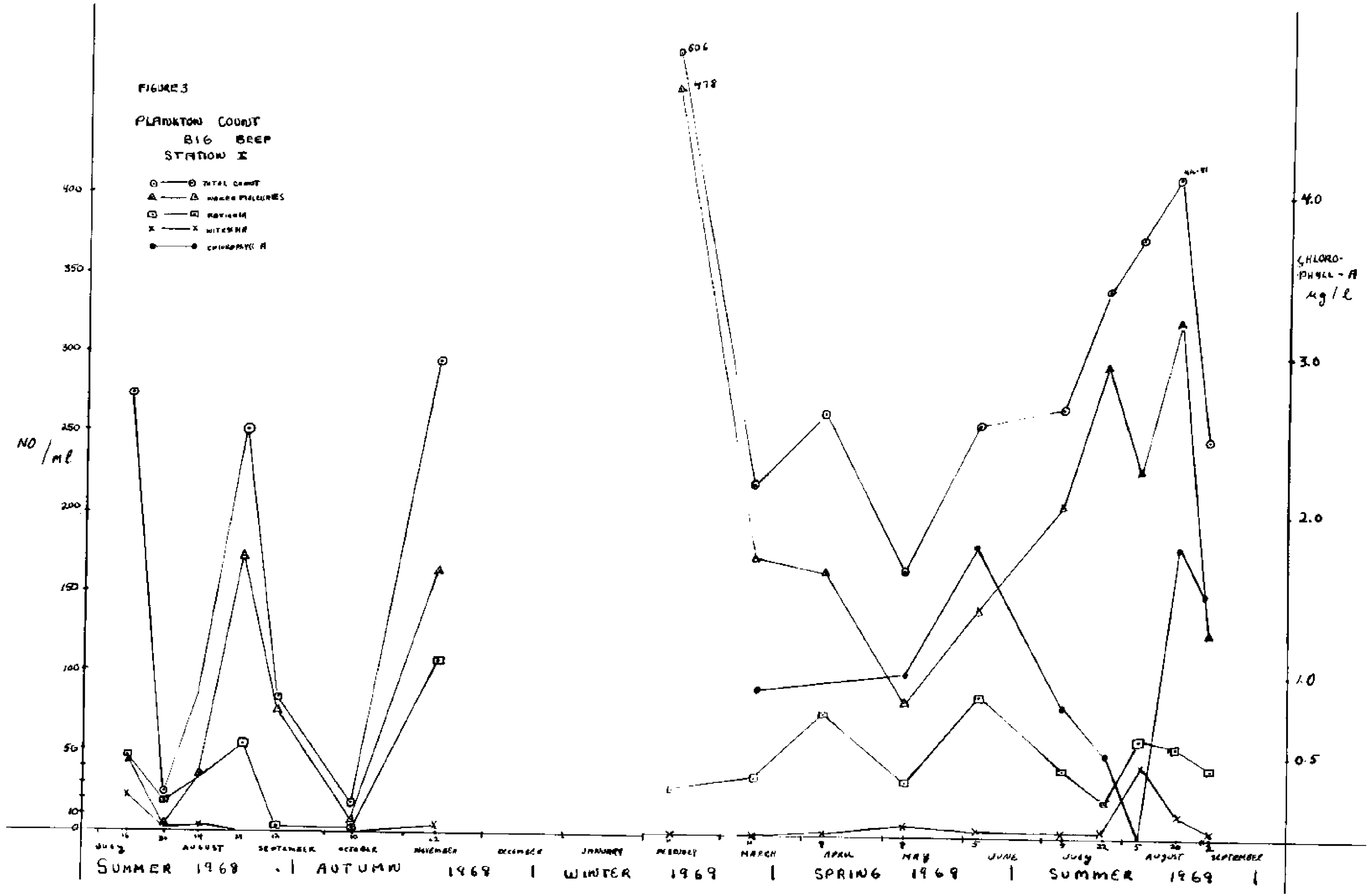


FIGURE 1
PLANKTON COUNTS
BIG BEEF
STATION E

FIGURE 3

PLANKTON COUNT
BIG BEEF
STATION I



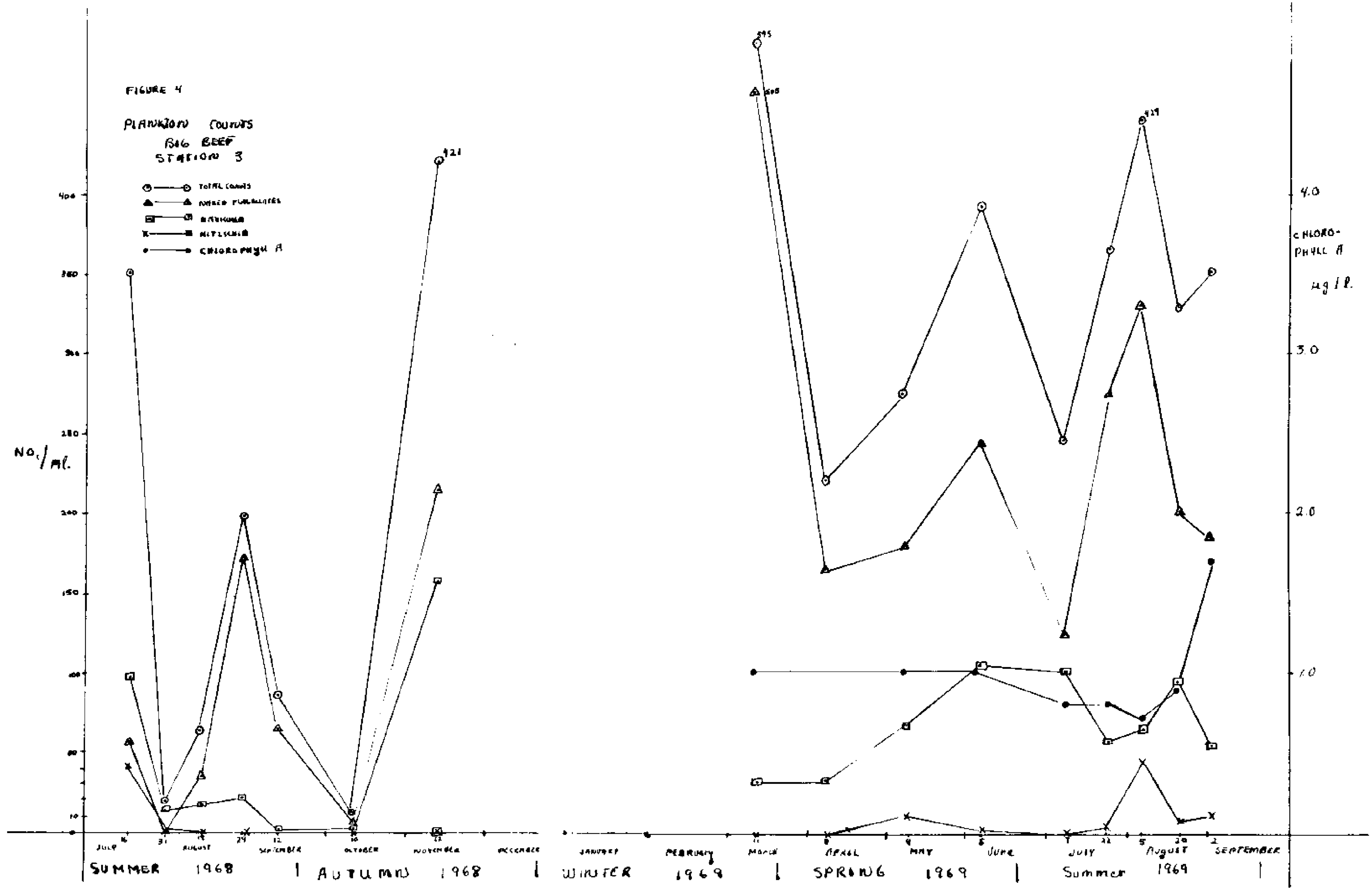


FIGURE 4
PLANKTON COUNTS
BIG BEEF
STATION 3
TOTAL COUNTS
CHLOROPHYLL A
NO./ML.
CHLORO-
PHYLL A
µg/l.
4.0
3.0
2.0
1.0
400
200
150
100
10
0
421
595
429
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
SUMMER 1968
AUTUMN 1968
WINTER 1969
SPRING 1969
Summer 1969

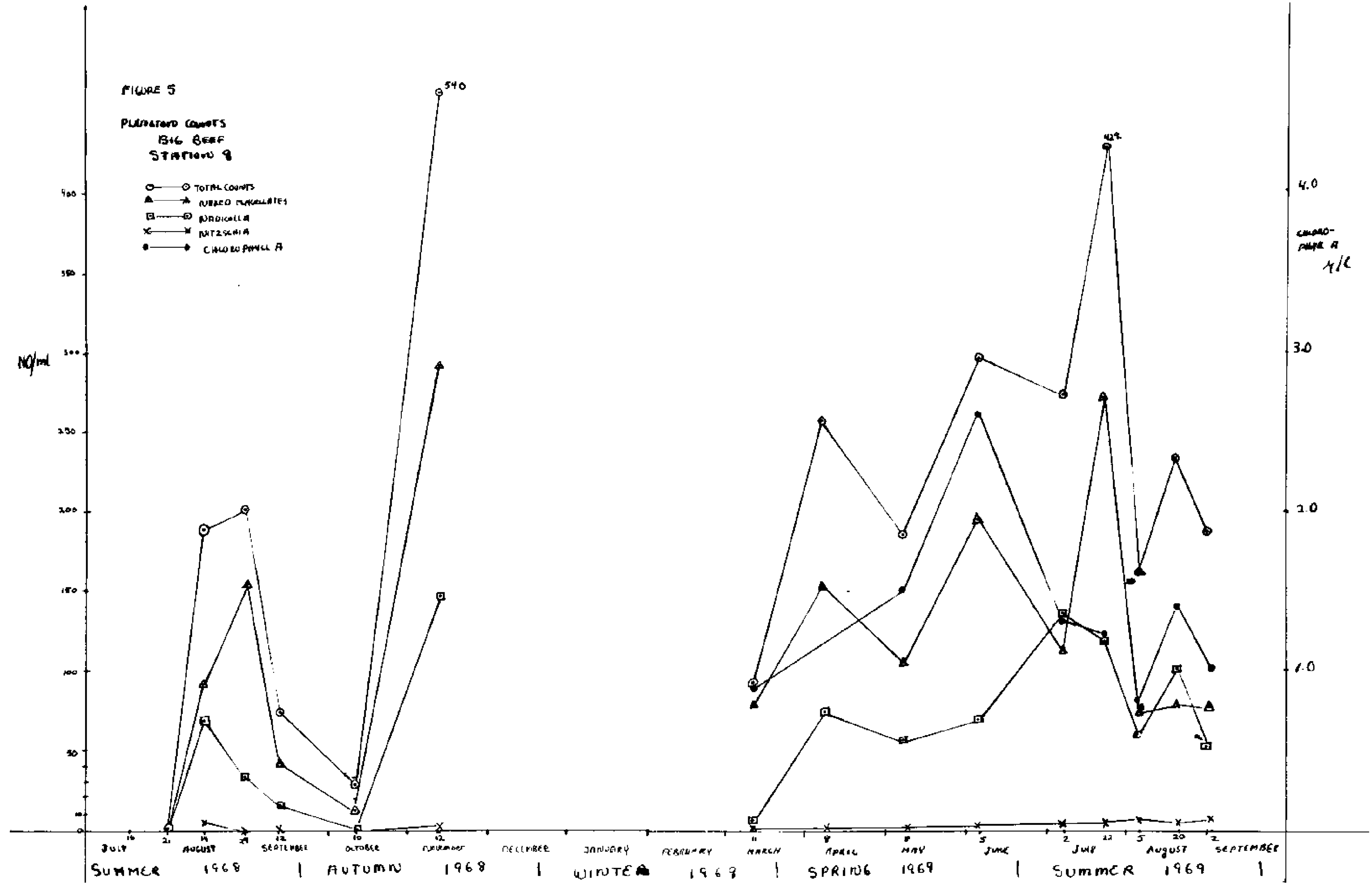


FIGURE 5
PLANKTON COUNTS
BIG BEEF
STATION 8
TOTAL COUNTS
NAKED FLAGELLATES
NAVICULA
NITZSCHIA
CHLOROPHYLL A
NO/ml
CHLORO-PHYLL A
4.0
3.0
2.0
1.0
540
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
SUMMER 1968
AUTUMN 1968
WINTER 1968
SPRING 1969
SUMMER 1969

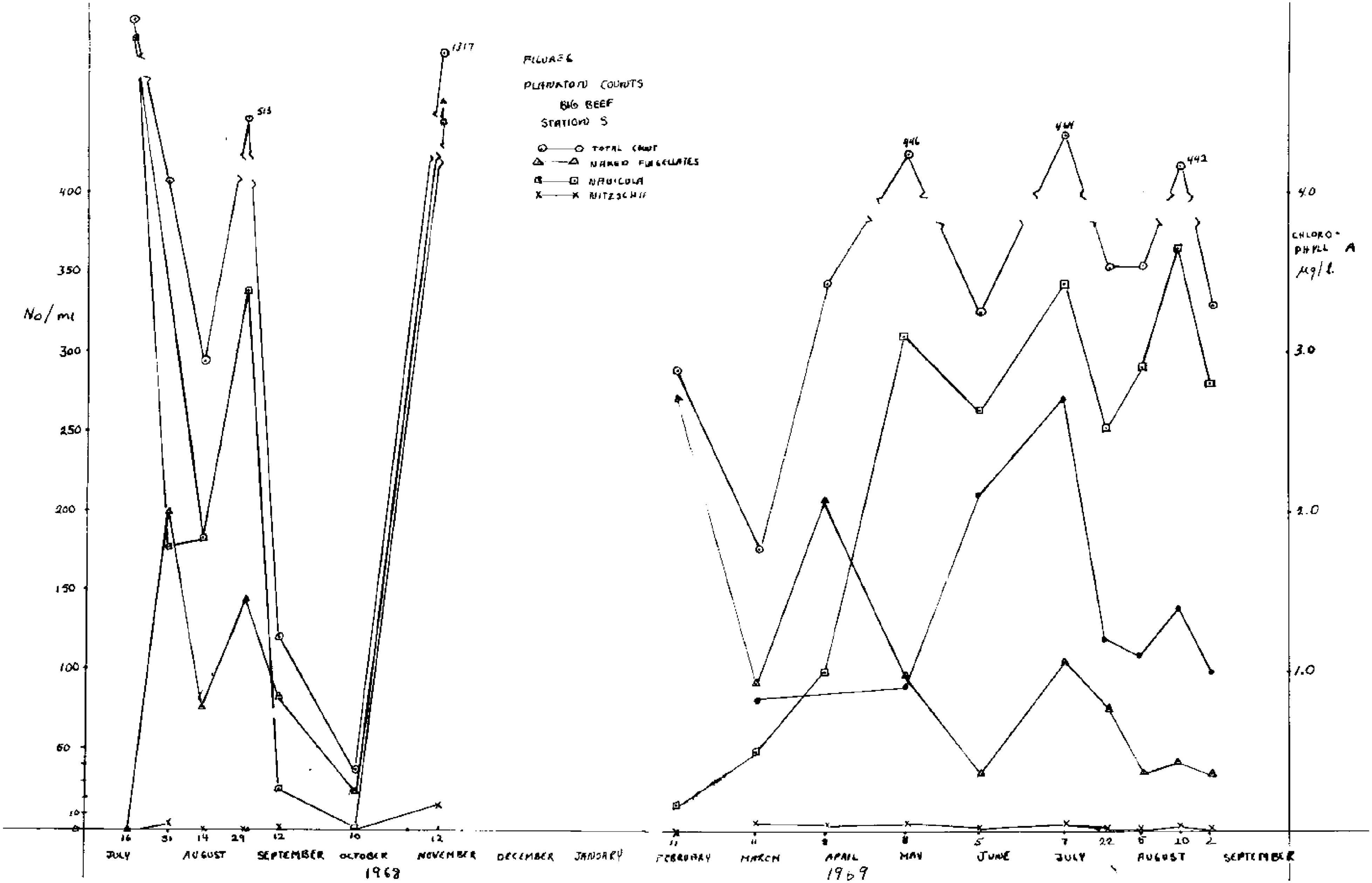


FIGURE 6
PLANKTON COUNTS
BIG BEEF
STATION 5
TOTAL COUNT
NAKED FLAGELLATES
NAVICULA
NITZSCHIA
No/ml
CHLORO-PHYLL A μg/l
1317
515
446
444
442
400
350
300
250
200
150
100
60
10
0
4.0
3.0
2.0
1.0
16
31
14
29
12
10
12
11
11
8
8
5
7
22
5
10
2
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
1968
1969

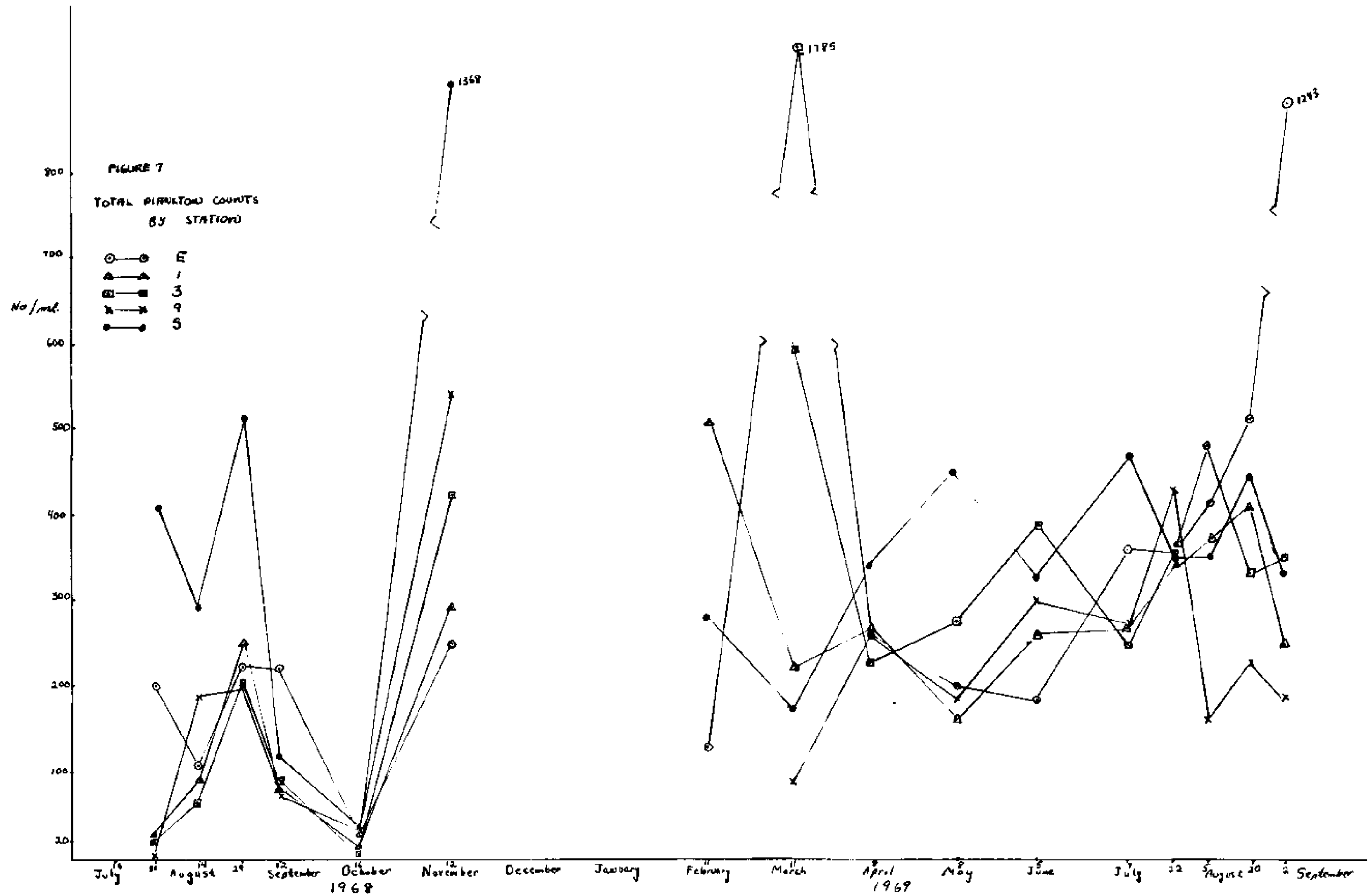
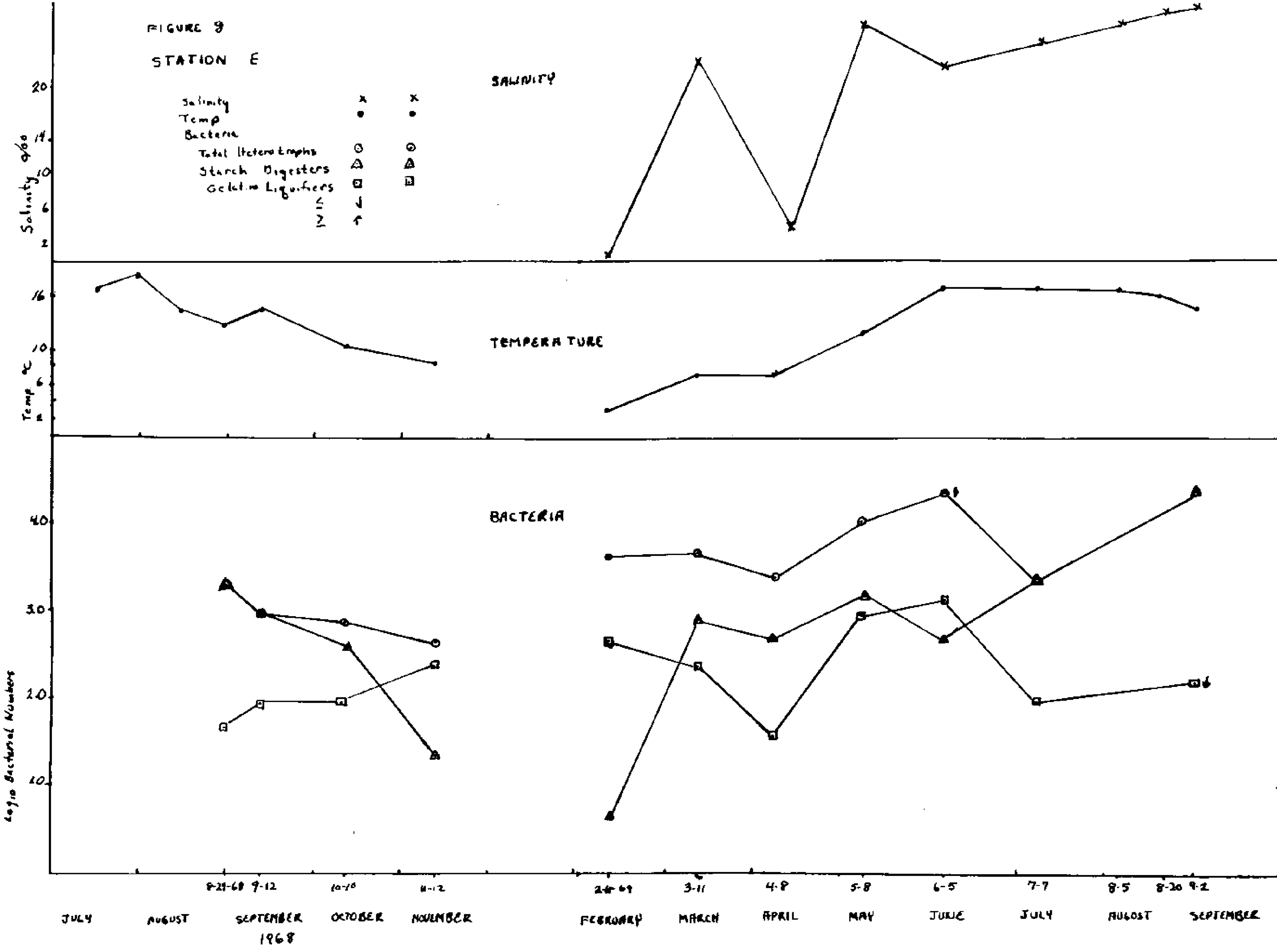
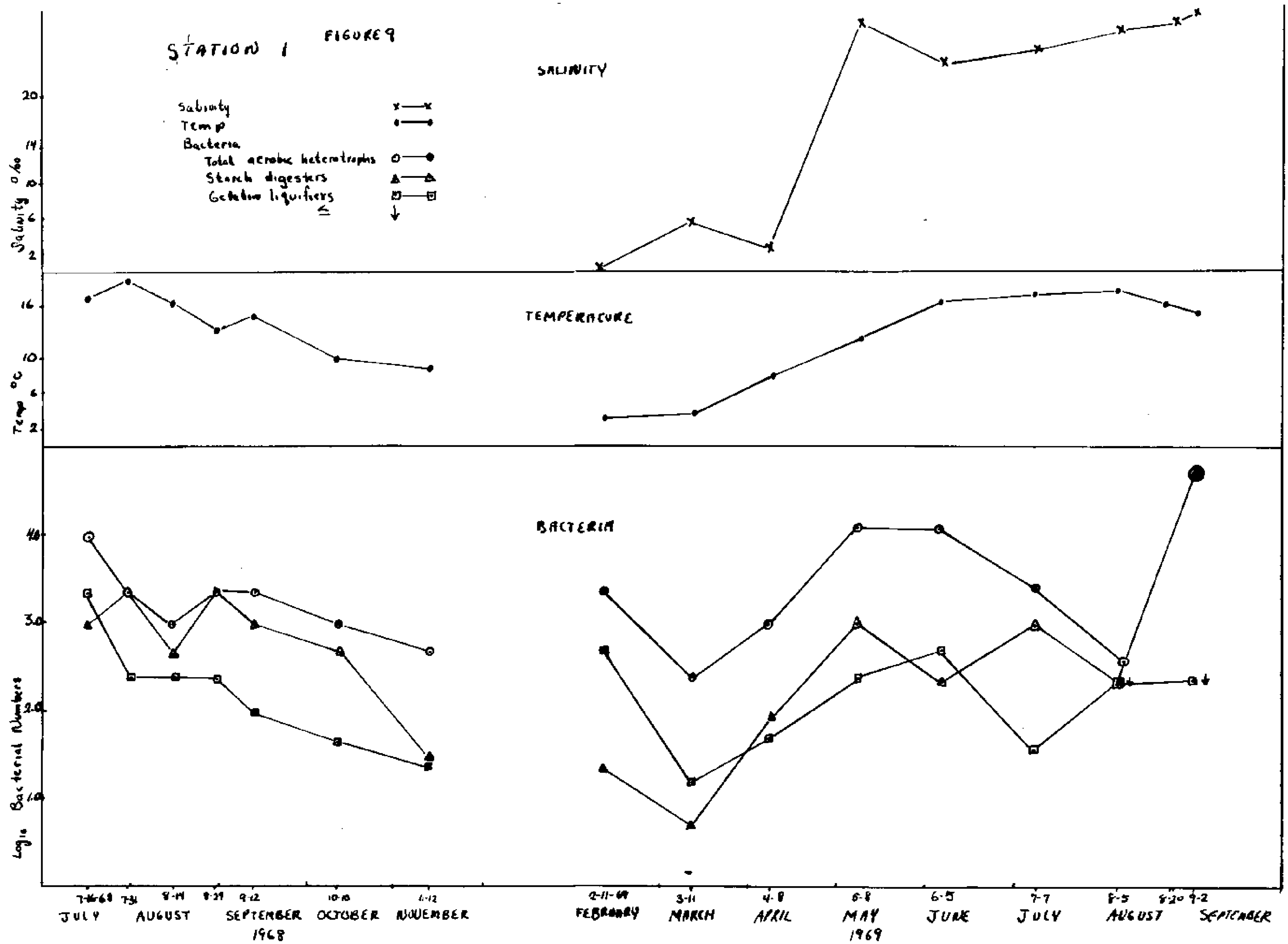


FIGURE 7
TOTAL PLANKTON COUNTS
BY STATION
E
1
3
9
5
No/ml.
800
700
600
500
400
300
200
100
20
1368
1785
1243
July
August
September
October
1968
November
December
January
February
March
April
1969
May
June
July
August
September

FIGURE 9

STATION E





STATION 1
FIGURE 9
SALINITY
TEMPERATURE
BACTERIA
Salinity
Temp
Bacteria
Total aerobic heterotrophs
Starch digesters
Gelatin liquifiers
≤
Salinity o/oo
Temp °C
Log10 Bacterial Numbers
20
14
10
6
2
16
10
6
2
4.0
3.0
2.0
1.0
7-16-68
7-31
8-14
8-29
9-12
10-10
11-12
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
1968
2-11-69
3-11
4-8
5-8
6-5
7-7
8-5
8-20
9-2
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
1969

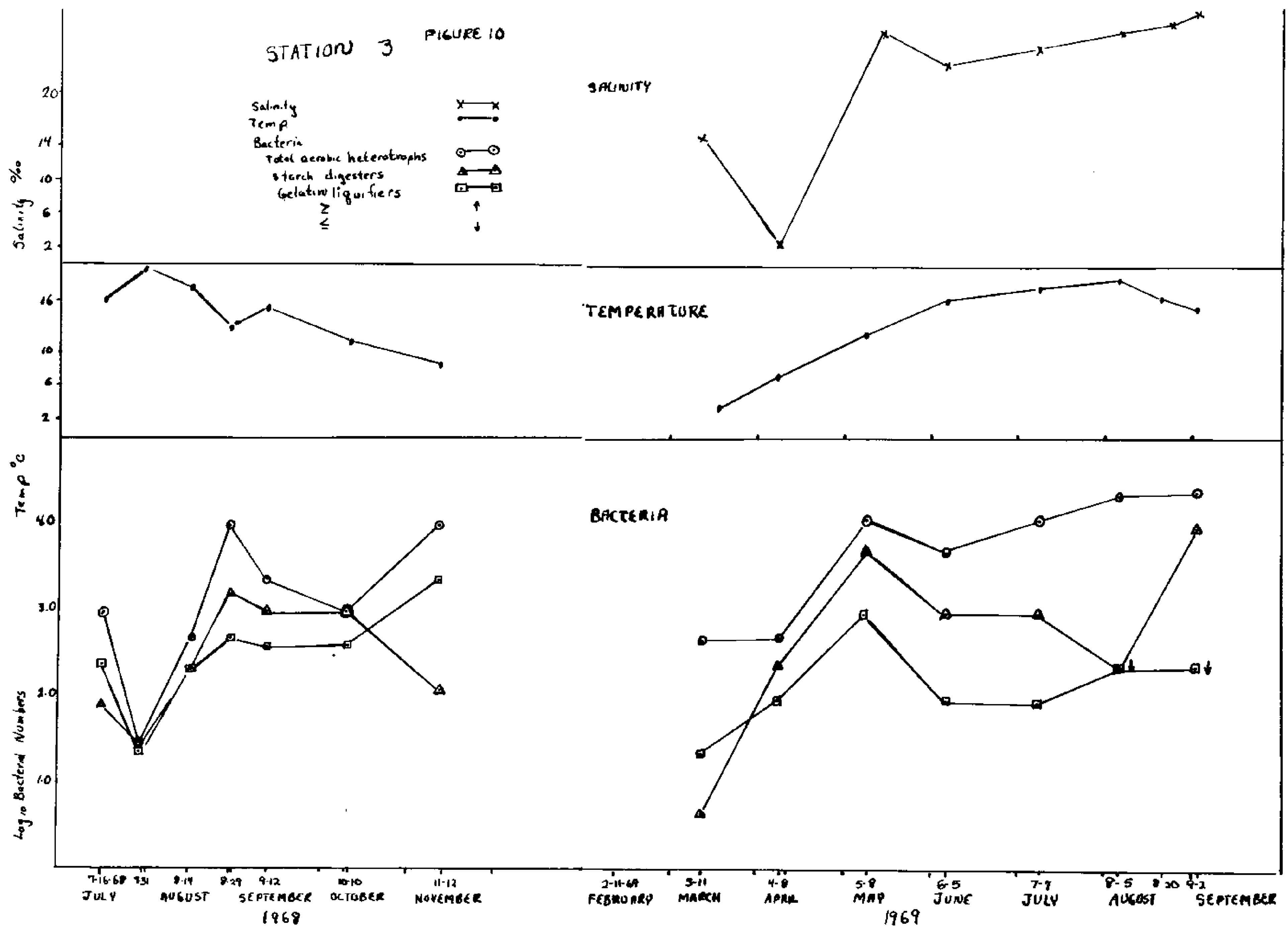
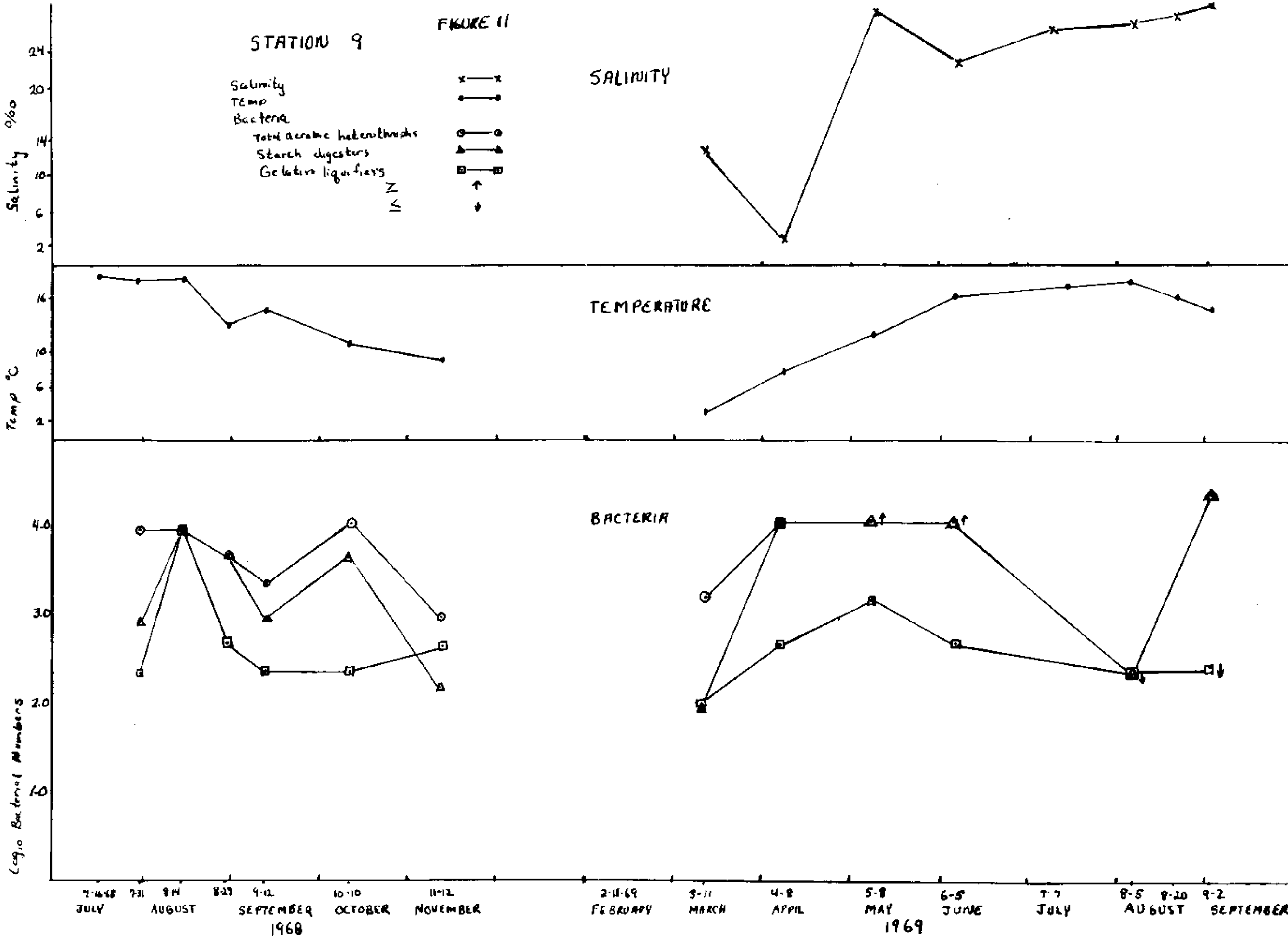

STATION 3
FIGURE 10
Salinity
Temp
Bacteria
Total aerobic heterotrophs
starch digesters
Gelatin liquifiers
≥
≤
SALINITY
TEMPERATURE
BACTERIA
Salinity ‰
Temp °C
Log10 Bacterial Numbers
20
14
10
6
2
16
10
6
2
4.0
3.0
2.0
1.0
7-16-68
7-31
8-14
8-29
9-12
10-10
11-12
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
1968
2-11-69
3-11
4-8
5-8
6-5
7-7
8-5
8-20
9-2
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
1969

FIGURE 11



STATION 9
Salinity
Temp
Bacteria
Total aerobic heterotrophs
Starch digesters
Gelatin liquifiers
≥
≤
SALINITY
TEMPERATURE
BACTERIA
Salinity ‰
Temp °C
Log10 Bacterial Numbers
24
20
14
10
6
2
16
10
6
2
4.0
3.0
2.0
1.0
7-16-68
7-31
8-14
8-29
9-12
10-10
11-12
2-11-69
3-11
4-8
5-8
6-5
7-7
8-5
8-20
9-2
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
1968
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
1969

FIGURE 12

COLIFORM COUNTS and STREAM TEMPERATURE

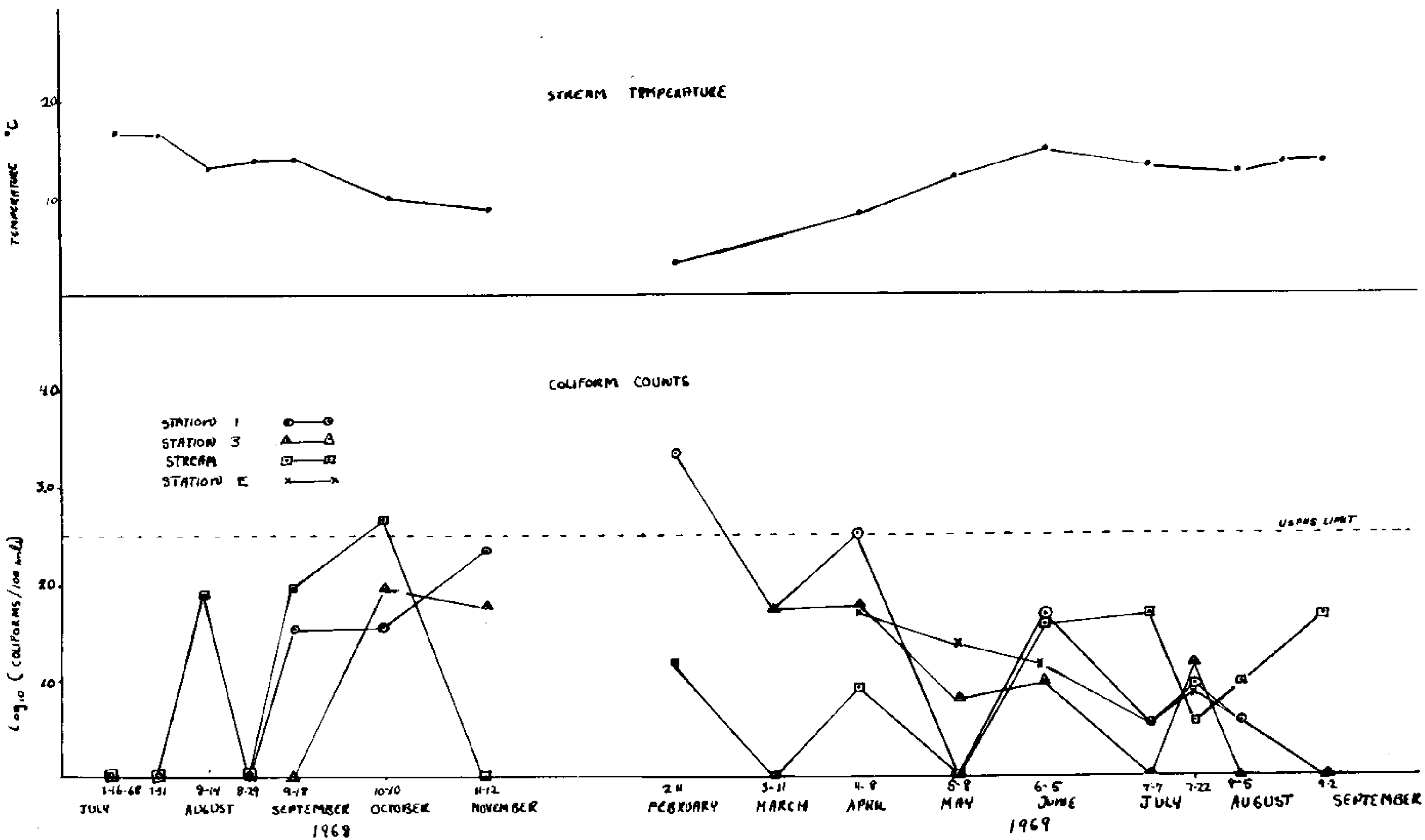


TABLE 1

PLANKTON COUNTS #/ml

STATION E

Trip and date / GENUS	2 7-31-68	3 8-14	4 8-29	5 9-12	6 10-10	7 11-12	8 2-11-69	9 3-11	10 4-8	11 5-8	12 6-5	13 7-7	14 7-22	15 8-5	16 8-20	17 9-2
Naked flagellates	44.9	62.4	156.0	160.5	20.7	141.1	126.1	1763.6	151.9	112.895	154.2	237.8	301.05	287.6	447.7	435.7
Navicula	120.8	31.2	40.8	29.3	1.4	84.3	2.8	11.4	87.2	41.54	5.8	69.0	30.71	48.1	39.7	92.4
Nitzschia		4.4	1.4			4.2				15.7	2.9	3.6	4.195	45.3	5.8	23.9
Melosira	0.1	2.9	1.4	.	0.7	1.4		0.04		0.03			0.053	0.02	0.2	
Coscinodiscus	4.2	2.2		7.2	0.7	15.7	0.2	1.40	2.765	4.3	4.4	10.2	6.975	7.1	2.9	263.0
Pleurosigma		2.9			0.04				1.4					1.3	1.5	256.0
Skeletonema					0.4				2.7	0.2			5.6	5.7	1.3	
Chaetoceros	0.01	0.01	1.4		0.2					9.9	2.9	2.2				11.4
Rhizolenia		0.01			1.4	0.4			1.36							7.0
Fragilaria									0.03				0.05	5.7		5.8
Thalassionema												7.2	1.4			2.9
Thalassiosira								4.2								53.2
Thalassiothrix			2.8	5.5								.7				
Licmophora																
Biddulphia																
Eucampia																
Achnanthes																
Asterionella																
Distephanus																
Dinophysis																
Gymnodinium				8.31							1.5	4.9	8.3			0.02
Peridinium				1.4							.11					
Miscellaneous	312	2.90	18.2	10.1	2.8	7.1	1.4	4.2	18.0	14.1	13.1	25.4	19.4	15.7	15.9	91.4
Total Plankton	201.1	108.8	223.4	220.9	28.3	254.1	130.5	1784.9	259.4	198.6	184.9	360.9	358.3	416.8	515.2	1243.3
COPEPODS	2.8	0.16			2.1	0.01		0.09	0.01			1.4	0.26		0.03	

TABLE 2

PLANKTON COUNTS #/ml

STATION 1

GENUS (trip & date)	2 7-31-68	3 8-14	4 8-29	5 9-12	6 10-10	7 11-12-68	8 2-11-69	9 3-11	10 4-8	11 5-8	12 6-5	13 7-7	14 7-22	15 8-5	16 8-20	17 9-2
Naked flagellates	2.8	36.3	171.1	74.6	8.6	164.4	478.2	171.4	163.3	82.0	142.5	207.9	295.5	228.6	320.5	127.9
Navicula	16.8	35.5	54.6	0.7	1.0	108.2	28.6	37.4	76.6	33.6	89.3	42.1	21.3	61.0	56.9	42.1
Nitzschia	1.4	2.2				2.8			0.08	5.8	1.4	1.4	1.5	45.4	14.1	4.2
Melosira	0.03	2.9			0.2	0.05			1.4			0.05	0.1	2.9	0.04	0.03
Coscinodiscus	1.4	0.7	13.6	0.2	2.9	12.6		2.7	1.4		1.3	1.4	4.3	17.0	0.04	19.7
Pleurosigma		3.6		1.5	0.14				2.8		0.03		0.03		1.5	
Skeletonema					1.0			5.4	1.4	2.9	4.0		2.9	5.7	2.9	23.9
Chaetoceros				0.08	0.04					27.8					0.04	2.8
Rhizolenia				1.0	2.1											1.4
Fragilaria		0.7						0.04	1.4		0.1			7.1	1.5	1.4
Thalassiosira																
Thalassiothrix																18.3
Licmophora																
Biddulphia																
Eucampia				0.2												
Achnanthes		0.7														
Asterionella																
Distenphanus																
Dinophysis																
Gymnodinium													1.4		1.5	
Peridinium		1.4														0.03
Miscellaneous	1.4	5.8	11.0	3.0	0.4	7.0	0.02	1.38	15.6	11.7	20.6	14.5	14.0	5.7	12.9	7.0
Total Plankton	23.9	88.8	251.7	81.1	16.2	295.1	506.8	218.3	264.1	163.9	259	267.4	340.9	373.3	411.8	248.8
Copepods	0.20	0.15			0.14											

TABLE 3

PLANKTON COUNTS #/ml

STATION 3

Trip & Date / GENUS	2 7-31-68	3 8-14	4 8-29	5 9-12	6 10-10	7 11-12-68	8 2-11-69	9 3-11	10 4-8	11 5-8	12 6-5	13 7-7	14 7-22	15 8-5	16 8-20	17 9-2
Naked Flagellates		37.8	170.2	65.8	6.9	216.2		505.9	167.5	181.4	246.3	124.4	274.8	331.0	202.6	185.2
Navicula	13.1	18.9	21.4	0.1	1.4	159.6		32.6	33.7	67.9	106.0	101.5	58.5	66.5	95.7	54.8
Nitzschia	0.3								0.03	11.1	0.03		4.2	47.1	8.4	12.6
Melosira	2.8	1.4	4.3	2.9	.05			1.4	2.8	1.4	1.4	1.4	1.4	4.2	4.2	1.4
Coscinodiscus	0.7		0.2	5.7	1.4	23.6		4.1	1.4	1.4	4.3			5.5	2.8	21.2
Pleurosigma										1.4		0.5		1.4	2.8	0.02
Skeletonema					0.3	1.4		13.6	1.4		8.4		1.4	0.03	1.4	31.0
Chaetoceros		0.7			0.04	5.6				5.5	4.3	.03				1.4
Rhizonenia			1.4	0.6	1.6											0.4
Fragilaria									1.4		0.08		1.4	2.8	0.04	7.1
Thalassionema											1.5	0.03				
Thalassiosira								1.2				0.03				25.2
Thalassiothrix																
Licmophora																
Biddulphia					0.9							1.4				
Eucampia																
Achnanthus																
Asterionella																
Distenphanus					0.004											
Dinophysis																
Gymnodinium												1.4				
Peridinium	0.7		1.4								1.4					1.4
Miscellaneous	2.1	4.2	24.3	11.4	0.2	15.3		36.7	12.8	6.9	18.7	17.2	23.7	20.8	9.9	12.6
Total plankton	19.7	63.0	199.5	86.5	12.9	421.7		595.5	221	277.0	392.3	247.4	365.4	479.2	329.3	352.5
Copepods	0.7	2.1	0.1	0.2	0.4						0.03			0.03		0.02

TABLE 4

PLANKTON COUNTS #/ml
STATION 9

TRIP & DATE	2	3	4	5	6	7	9	10	11	12	13	14	15	16	17
GENUS	7-31-68	8-14	8-29	9-12	10-10	11-12-68	3-11	4-8	5-8	6-5	7-7	7-22	8-5	8-20	9-2
Naked Flagellates	0.08	91.8	153.5	42.4	12.7	290.8	79.5	154.9	104.8	195.7	112.9	270.1	73.8	80.0	78.1
Navicula	0.05	69.9	33.6	15.7	0.1	147.6	6.8	74.1	55.3	69.4	138.1	117.7	59.9	101.4	53.0
Nitzschia		5.6				1.4	1.3	1.4	1.4	2.9	4.3	4.2	8.4	5.8	9.8
Melosira	0.14	8.5	0.7	0.01	3.5	5.6	0.6	2.9	1.4	1.4	2.9	6.9	4.2	8.6	2.8
Coscinodiscus		2.8	5.6	1.5	2.8	25.5		8.5	0.06		1.4	1.4	2.8	4.3	5.6
Pleurosigma	0.002	5.6			0.01	2.8		2.8	1.53	1.38	2.9	8.3	2.8	10.2	8.4
Skeletonema					0.6		0.7		0.03	5.8		1.1	2.8		2.8
Chaetoceros	0.002			0.03	0.02				1.5	1.4	0.02	0.1			
Rhizonenia			0.05	3.6	2.8										1.4
Fragilaria								0.1	3.1				0.02	5.8	1.4
Thalassionema					0.7										
Thalassiosira							0.7								5.6
Thalassiothrix			0.3												
Liomophora															
Biddulphia					0.02										
Eucampia															
Achnanthes															
Asterionella						1.4									
Distenphanus															
Dinophysis					0.7										
Gymodinium															
Peridinium			0.004		0.01										
Miscellaneous	0.02	5.6	8.5	10.3	2.8	15.5	2.6	12.7	15.0	19.4	10.2	19.4	5.6	17.1	17.5
Total plankton	0.29	190.0	201.7	73.6	27.0	540.1	92.3	257.3	184.1	297.2	272.8	429.2	160.2	233.2	186.4
Copepods	0.14	0.14	0.03	0.078	1.4		0.02				0.02				

TABLE 5

PLANKTON COUNTS #/ml

STATION S

Trip and Date	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
GENUS	7-31-68	8-14	8-29	9-12	10-10	11-12-68	2-11-69	3-11	4-8	5-8	6-5	7-7	7-22	8-5	8-20	9-2
Naked Flagellates	199.3	74.4	142.3	81.7	23.8	769.4	270.4	91.4	206.4	97.8	34.4	106.9	77.8	35.9	44.3	35.8
Navicula	174.5	183.8	336.0	24.9	1.3	481.7	15.7	49.9	99.1	309.4	261.9	341.2	251.6	289.5	362.9	278.8
Nitzschia	3.4					15.4		4.2	1.4	1.4	0.03	1.5	0.04	0.1	1.4	
Melosira	6.9	0.7	14.0	0.1	0.1	4.2							0.1	1.4	4.2	0.03
Coscinodiscus	2.1	12.8		6.9	8.3	25.1		16.6	.02			2.9 2.9	0.1	6.8	11.1	2.9
Pleurosigma		2.1							1.4							
Skeletonema																
Chaetoceros				0.03								0.02				
Rhizosenia		0.03	2.8	0.2	0.1							1.4				
Fragilaria	0.7	4.3						2.8	7.0	15.7	1.4		4.3	9.7	2.8	1.4
Thalassionema																
Thalassiosira								0.1								1.4
Thalassiothrix	16.8	0.02	1.4													
Licmophora		0.02														
Biddulphia		0.01														
Eucampia		0.7														
Achnanthes																
Asterionella																
Distenphanus																
Dinophysis										0.3						
Gymnodinium																
Miscellaneous	4.2	14.0	16.7	4.2	1.3	21.0	1.5	11.1	25.1	21.4	23.6	10.1	17.0	9.7	15.2	8.6
Total Plankton	408.0	292.9	513.2	118.0	34.9	1316.8	287.6	176.0	340.3	446.2	321.4	464.0	350.3	353.0	441.8	328.9
Copepods		.03										5.7				

TABLE 6

Plant Pigments 1969

a - Chlorophyll a
b - Chlorophyll b
car. - Carotenoids

μg/l

		E	1	3	9	
March 11, 1969	a	1.5	0.9	1.0	0.9	0.8
	b	0	0	0	0	0
	car.	1.2	0.7	1.2	0.8	0.8
May 8, 1969	a	1.0	1.0	1.0	1.5	0.9
	b	0.5	0.5	0.5	0.3	0
	car.	1.6	1.4	1.2	1.5	0.6
June 5, 1969	a	2.2	1.8	1.0	2.6	2.1
	b	0.5	0	0.5	0.5	0
	car.	1.7	1.6	1.2	1.8	1.4
July 7, 1969	a	1.3	0.8	0.8	1.3	2.7
	b	0	0	0.7	1.5	1.1
	car.	1.7	1.6	1.6	2.0	3.6
July 22, 1969	a	1.0	0.5	0.8	1.2	1.2
	b	0	1.0	1.2	0	1.7
	car.	1.4	1.2	2.0	2.4	1.0
August 5, 1969	a	0	0	0.7	0.8	1.1
	b	0	0	0	0.5	0
	car.	0.7	0.7	1.3	0.5	2.1
August 20, 1969	a	2.6	1.8	0.9	1.4	1.4
	b	1.2	1.2	0	0.5	0
	car.	2.0	1.3	1.2	1.6	1.6
September 2, 1969	a	6.4	1.5	1.7	1.0	1.0
	b	0.5	0.6	0.5	0	0
	car.	4.8	1.7	2.2	1.1	1.6

Pigment values less than 0.5 μg/l are reported as 0.

TABLE 7

BACTERIA

Trip	Date	Station	Coliforms per 100 ml	Total per ml	Starch Digesters per ml	Gelatin liquifiers per ml
1	7-17-68	1	0	9300	930	2100
		3	0	930	75	230
		Stream	0			
2	7-31-68	1	0	2300	2300	230
		3	0	43	43	23
		9		9300	750	230
		Stream	0			
3	8-14-68	1	0	930	430	230
		3	0	430	230	230
		9	73	9300	9300	9300
		Stream				
4	8-29-68	E		2100	2100	43
		1	0	2300	2300	210
		3	0	9300	1500	430
		9		4300	4300	430
		Stream				
5	9-12-68	E		930	930	93
		1	36	2300	930	93
		3	0	2300	930	230
		9		2300	930	230
		Stream	91			

TABLE 7 (continued)

Trip	Date	Station	Coliforms per 100 ml	Total per ml	Starch digesters per ml	Gelatin liquifiers per ml
6	10-10-68	E	36	750	390	93
		1	91	930	430	75
		3		930	930	230
		9	430	11,100	4300	430
		Stream				
7	11-12-68	E	230	430	23	230
		1	73	430	28	430
		3		9300	120	2300
		9	0	930	150	430
		Stream				
8	2-11-69	E	1500	4300	43	430
		1		2300	23	430
		3				
		9	15			
		Stream				
9	3-11-69	E	53	4600	750	150
		1	53	230	43	15
		3		430	43	23
		9	0	1500	75	93
		Stream				

TABLE 7 (continued)

Trip	Date	Station	Coliforms per 100 ml	Total per ml	Starch Digesters per ml	Gelatin Liquifiers per ml
10	4-8-69	E	43	2400	430	39
		1	290	930	75	43
		3	53	430	150	93
		9		11,000	11,000	430
		Stream	7.3			
11	5-8-69	E	20.4	11,000	1,500	930
		1	0	11,000	930	230
		3	6.2	11,000	4,600	930
		9		> 11,000	> 11,000	1500
		Stream	0			
12	6-5-69	E	15	> 11,000	430	1500
		1	43	11,000	210	430
		3	9.1	4,600	936	91
		9		> 11,000	> 11,000	430
		Stream	39			
13	7-7-69	E	56	2,400	2,400	91
		1	3.6	2,400	930	36
		3	0	11,000	930	91
		Stream	43			

TABLE 7 (continued)

Trip	Date	Station	Coliforms per 100 ml	Total per ml	Starch digesters per ml	Gelatin liquifiers per ml
14	7-22-69	E	7.3			
		1	9.1			
		3	15			
		Stream	3.6			
15	8-5-69	E				
		1	3.6	360	< 230	< 230
		3	0	2300	< 230	< 230
		9		< 230	< 230	< 230
		Stream	9.1			
	9-2-69	E	0	24,000	24,000	< 230
		1	0	46,000	46,000	< 230
		3	0	24,000	9,300	< 230
		9		24,000	24,000	< 230
		Stream	43			

TABLE 8

Carbon and Nitrogen in Big Beef Estuary
(Oxidizable carbon in µg/l and nitrogen in µg/l by Kjeldahl)

Trip	Date		STATION E	1	3	9	Stream
3	8-14-68	C	79	135	285	210	116
		N	50	31	79	47	29
4	8-29-68	C	218	83	174	151	144
		N	76	75	70	72	79
5	9-12-68	C	367	305	281	305	141
		N	48	31	38	36	25
6	10-10-68	C	47	136	70	89	0
		N	58	42	55	54	52
9	3-11-69	C	143	222	28	18	0
10	4-8-69	C	102	177	126	99	139
		N	77	79	116	138	118
11	5-8-69	C	166	167	165	229	158
		N	143	88	62	9.1	69
12	6-5-69	C	218	153	232	164	27
		N	32	143	140	140	119
14	7-22-69	C	330	99	123	150	-
		N	82	72	62	92	47
15	8-5-69	C	175	127	144	215	119
		N	20	21	45	57	35
16	8-20-69	C	400	400	538	648	-
		N	106	95	77	76	80
17	9-2	C	590	228	331	278	181
		N	52	42	53	52	120