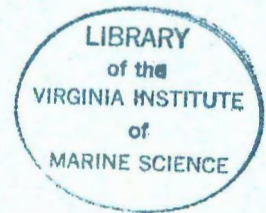


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Chesapeake Research Consortium, Incorporated

ANNUAL TECHNICAL REPORT
NSF/RANN GRANT G.I. 38973
1973-1974



Submitted to the
NATIONAL SCIENCE FOUNDATION

VOLUME XIII

Waste Water:

COMPARATIVE SEGMENTATION STUDIES ON THE
RHODE AND SOUTH RIVERS



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The Johns Hopkins University Smithsonian Institution
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COMPARATIVE SEGMENTATION STUDIES ON THE
RHODE AND SOUTH RIVERS

Integrated Progress Report on the Rhode River-South River Comparison Study
Subprogram. (Response of the estuarine biota to nutrient loading in a series
of segments)

Principal Investigators:

David L. Correll - Smithsonian
Maria A. Faust - Smithsonian
Jack W. Pierce - Smithsonian
Howard Seliger - Hopkin's University
Eugene Small - University of Maryland
Ronald Weiner - University of Maryland

ABSTRACT

The responses of plankton (bacteria, phytoplankton, and zooplankton) in a series of estuarine segments, characterized by various rates of flushing, to nutrient loading are being studied. At least two segments with each range of flushing rate are being studied presently. Earlier studies in which three segments were studied intensively but not frequently were completed. Such active parameters as species composition, primary production, and phosphorus uptake rates were measured. The present study is utilizing a numerical box model for mixing rates between the studied segments.

Introduction

The presently operational comparison study is the result of a developmental sequence of events. Originally in the CRC Proposal to NSF-RANN (Vol. IV, Rhode River Research Program, Feb. 1973), it was proposed that intensive plankton and water chemistry studies be carried out for each season of the year at (1) a location off the Londontown sewage treatment plant (in segment 5 of South River), at (2) Cadle Creek, an arm of Rhode River with extensive housing and marinas, and at (3) Rhode River proper in segment 3, an area of relatively undisturbed water. This study was carried out in a coordinated program by Dr. Eugene Small (zooplankton), Zoology Department, University of Maryland; Dr. Maria Faust (phytoplankton and bacteria), Smithsonian Institution; and Dr. David Correll (nutrients and phosphorus cycling), Smithsonian Institution.

It became apparent that this comparative study could never answer many important questions, such as the effects of estuarine exchange with adjacent water masses upon the biotic and nutrient parameters under study. The frequency of study was also insufficient and the sampling procedures did not account for patchiness in the plankton populations. This first comparison study did accomplish some important objectives. It led to some important conclusions with regards to the composition of the plankton and the major pathways of nutrient cycling. The study also established that, although the South River station was at the Londontown treatment plant outfall, it always had the lowest nutrient and plankton levels of the three study sites.

This initial comparison study led to the design and initiation of a second study which was initiated August 6, 1974 and is planned to be continued until the end of July, 1975. A number of refinements were introduced. Sampling is done from the same boat at the same time from the same water samples. Thirty two parameters are measured at stations which were chosen because they corresponded with both known loading realities and the water exchange models constructed previously [Gregory Han, Ph.D. Thesis, Johns Hopkins University (1974)]. These stations are shown in the two accompanying maps. The stations include transects within each segment of each river for integrated euphotic zone sampling and stations for vertical profiles at segment boundaries. Temperature and salinity data are also taken for 'State of the Bay' input data in the models (WR 0 and WRR 1 for Rhode River; SR 0 and SR 1 for South River). Data is collected on two cruises on adjacent days every two weeks.

Methods

In general the analytical techniques are discussed in the individual progress reports and will not be repeated here. Samples are collected from the stations shown on maps 1 and 2 every two weeks. Data is accumulated and processed at the Chesapeake Bay Center (Smithsonian Institution). At this time it is being tabulated and assembled for later transfer to computer cards. In the renewal proposal provision was made for funds to punch the data onto cards, a key punch and processing equipment are available at the center. Tables of the parameters, stations descriptions, and a tentative computer card format follow (Tables 1, 2, and 3).

Results

It seemed premature to attempt any analysis of the data from the ongoing comparison study at such an early date. The data can only be used efficiently after it has been put on cards. A systems analyst has now begun work at the center (on Smithsonian in-house funds) and he will be devoting much of his time to this problem. The parameters being measured were chosen to provide data on exchange of conservative parameters (1-3), concentration distributions of nutrients (9-16), concentration distributions of particulates (5,6) and the effect of these upon light penetration (17), phytoplankton (4), zooplankton (18-29), bacteria (30-32) and overall metabolism (8,12). The results of the preliminary first year comparison study are complete and are appended. In Tables 4 and 5 the results (Correll) on nutrient levels, phytoplankton population (chl a), primary production, and phosphorus uptake are given. In general, phosphorus levels in South River were lower than in Rhode River, while they were usually higher in Cadle Creek than in Rhode River. This was due to the relatively large volume and high exchange rates of the section of South River. The exchange rates of Cadle Creek apparently are not sufficient to prevent the establishment times of a steep gradient between the tidal creek and Rhode River.

In Tables 6 and 7 the results (Faust) from bacterial and phytoplankton work are given. In general, bacterial levels including coliforms were always high in all three locations, despite the fact that they were chosen to represent three contrasting conditions of loading.

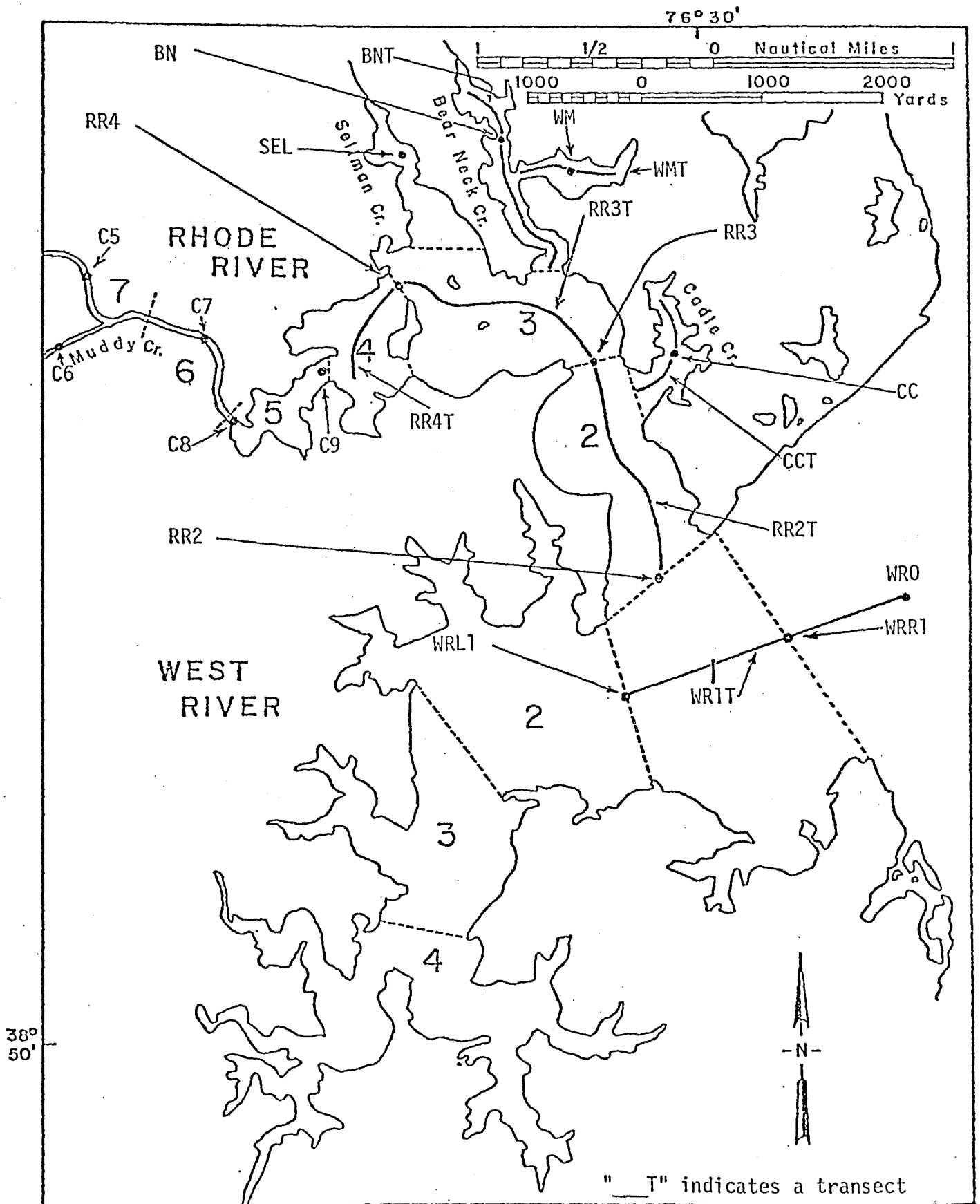
Map 1.

Estuarine Response Sampling Stations in the Rhode River Subestuary of Chesapeake Bay. Sampling transects (designated by a station number followed by T) are sampled by pumping in water from depths of 0.25 and 0.5 m while cruising along the transect. The other stations designated are sampled on station. SEL, C9, C8, C7, C6, and C5 are sampled only for surface water. Other stations are sampled as vertical profiles.

STATIONS

Rhode River and West River

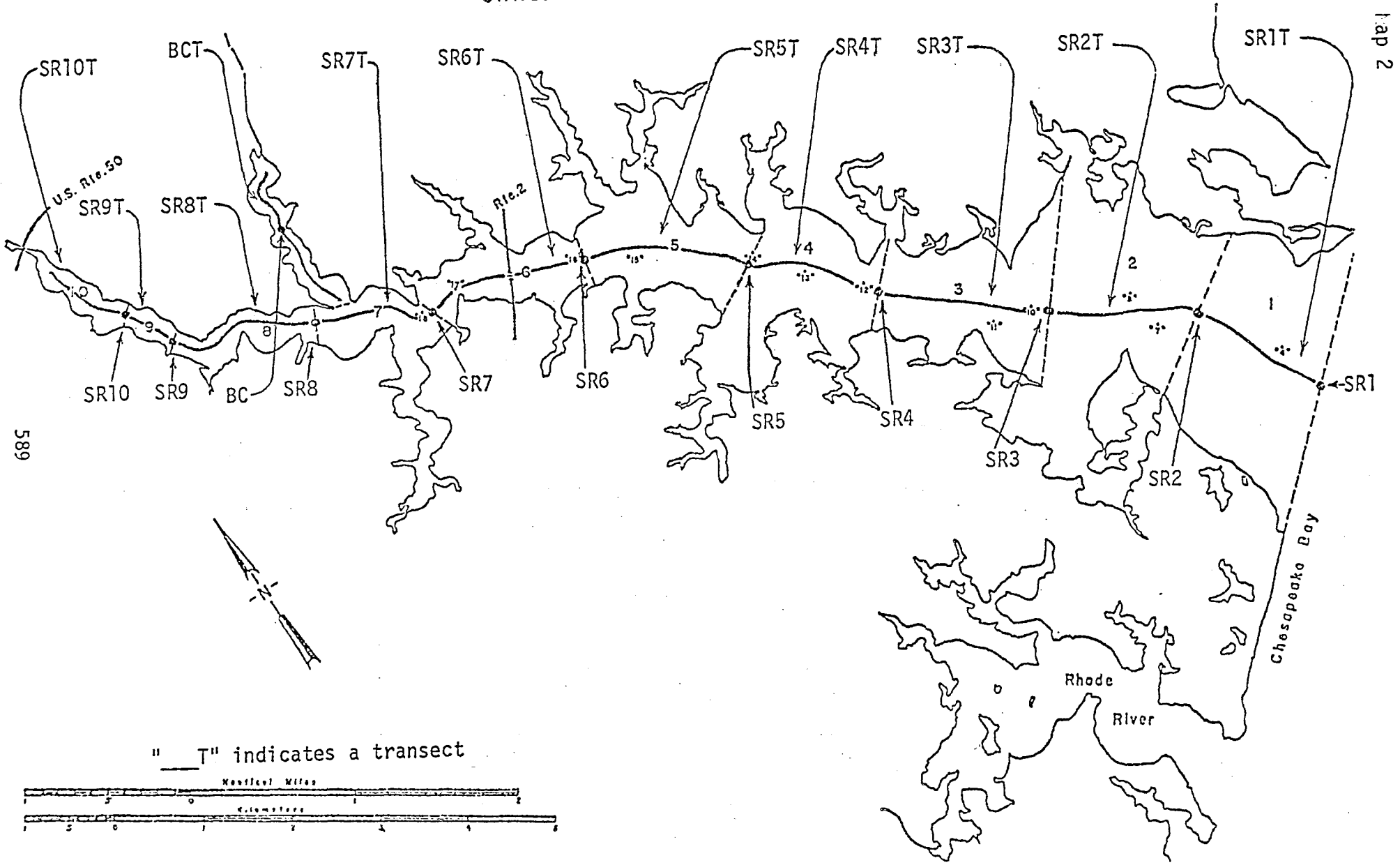
Map 1



Map 2.

Estuarine Response Sampling Stations in the South River Subestuary of Chesapeake Bay. Sampling transects (designated by a station number followed by T) are sampled by pumping in water from depths of 0.25 and 0.5 m while cruising along the transect. Other stations are sampled as vertical profiles.

STATIONS South River



Map 2

" T" indicates a transect

Nautical Miles

Kilometers

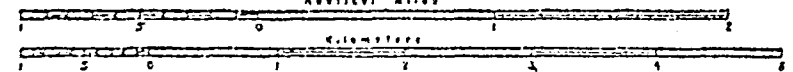


Table 1. Data Collected on Currently Ongoing Comparison Cruises in Rhode, West, and South Rivers.

#	Parameter	Units	Principal Investigator
1	Temperature (water)	degrees C	Seliger
2	Conductivity	mmhos	Seliger
3	Salinity (from 1 and 2)	0/00	Seliger
4	Chlorophyll a	mg/m ³ (T) or mg/m ²	Seliger
5*	Total Suspended particulates	g/m ³	Pierce
6*	Mineral Suspended particulates	g/m ³	Pierce
7	Dissolved Oxygen	g/m ³	Seliger
8	pH	none	Correll
9	NO ₃ +NO ₂	(mg N/m ³)	Correll
10	NH ₄ +Amino Acids	(mg N/m ³)	Correll
11	Organic N	(mg N/m ³)	Correll
12	Dissolved Inorganic Phosphorus	(mg P/m ³)	Correll
13	Dissolved Total Phosphorus	(mg P/m ³)	Correll
14	Inorganic Phosphorus	(mg P/m ³)	Correll
15	Total Phosphorus	(mg P/m ³)	Correll
16	Organic Carbon	(g C/m ³)	Correll

*These parameters were dropped after Sept. and replaced by turbidity (Correll).

Table 1. (continued)

#	Parameter	Units	Principal Investigator
17	Vertical Light attenuation coefficient per meter	none	Seliger
18	adult Copepods	$\#/m^3$	Small
19	Biomass (Copepods)	mg dry wt/ m^3	Small
20	Nauplii	$\#/m^3$	Small
21	Biomass (Nauplii)	mg dry wt/ m^3	Small
22	Rotifers	$\#/m^3$	Small
23	Biomass (Rotifers)	mg dry wt/ m^3	Small
24	Other zooplankton ($\geq 80\mu m$)	$\#/m^3$	Small
25	Biomass of zooplankton ($\geq 80\mu m$)	mg dry wt/ m^3	Small
26	Tintinnids	$\#/m^3$	Small
27	Biomass (Tintinnids)	mg dry wt/ m^3	Small
28	Other zooplankton ($\geq 20 \leq 80\mu m$)	$\#/m^3$	Small
29	Biomass zooplankton ($\geq 20 \leq 80\mu m$)	mg dry wt/ m^3	Small
30	Total Coliforms	MPN/100ml	Weiner
31	Fecal Coliforms	MPN/100ml	Weiner
32	Total viable	$\#/ml$	Faust

Table 2. Sampling Station Code for Segmentation Data Collected on Currently Ongoing Comparison Cruises in Rhode, West and South Rivers.

Code#	Map Designation	Location
21	WR 0	WR 2 Channel Marker
22	WRR 1	Center of mouth of West River (line from Dutchman's Point to Curtis point)
23	WRL 1	In West River off Cheston Point
24*	WRR 4	East of Chalk Point
25*	WRR 4	West of Chalk Point
26	WR 1 T	Transect from WRR 1 to WRL 1.
27*	WR 4 T	Transect from WRR 4 to WRL 4.
28	RR 2	Center of mouth of Rhode River (line from Dutchman's Point to Cheston Point).
29	RR 3	Channel near RR 7 channel marker.
30	RR 4	In channel NW of northern end of Big Island.
31	C 9	Between Fox Point and northern end of Corn Island.
32	C 8	Downstream end of Muddy Creek Channel.
33	C 7	Halfway between C 8 and the first fork of Muddy Creek
34	C 6	Main branch of Muddy Creek above fork.
35	C 5	North fork of Muddy Creek
36	SEL	Sellman Creek (Km 1.1)

*These stations were dropped at the end of September, 1974.

Table 2. (continued)

Code#	Map Designation	Location
37	BN	Bearneck Creek (Km. 1.3)
38	WM	Whitemarsh Creek (Km. 0.5)
39	CC	Cadle Creek (Km. 0.4)
40	RR 2 T	Transect from RR 2 to RR 3
41	RR 3 T	Transect from RR 3 to RR 4
42	RR 4 T	Transect from RR 4 to north east of Corn Island.
43	BNT	Transect from BN Km 0 to BN Km. 1.8.
44	WMT	Transect from WM Km 0 to WM Km 0.8
45	CCT	Transect from CC Km 0 to CC Km 0.8
46	SR 0	1 mile east from South River-West River Intersect Marker.
47	SR 1	Center of mouth of South River (line from Saunders Point to Marshy Point).
48	SR 2	Off inlet to Ramsey Lake (0.4 Km below SR 7 channel marker)
49	SR 3	0.3 Km downstream from SR 10 channel marker.
50	SR 4	Off entrance to Harness Creek (0.2 Km downstream from SR 12 channel marker).
51	SR 5	0.2 Km upstream from SR 14 channel marker.



Table 2 (continued)

Code#	Map Designation	Location
52	SR 6	At SR 16 channel marker.
53	SR 7	At SR 18 channel marker.
54	SR 8	Between Sylvan Shores and Porter Point.
55	SR 9	1.0 Km upstream from Beard's Point.
56	SR 10	1.5 Km upstream from Beard's Point.
57	SR 1 T	Transect from SR 1 to SR 2.
58	SR 2 T	Transect from SR 2 to SR 3.
59	SR 3 T	Transect from SR 3 to SR 4.
60	SR 4 T	Transect from SR 4 to SR 5.
61	SR 5 T	Transect from SR 5 to SR 6.
62	SR 6 T	Transect from SR 6 to SR 7.
63	SR 7 T	Transect from SR 7 to SR 8.
64	SR 8 T	Transect from SR 8 to SR 9.
65	SR 9 T	Transect from SR 9 to SR 10.
66	SR 10 T	Transect from SR 10 upstream to depth of 1 meter at MHW. (approx. 1.4 Km)
67**	BCT	Transect from mouth of Broad Creek upstream to a depth of 1 meter at MHW.
68**	BC	0.8 Km upstream from the mouth of Broad Creek.

**These stations were added in November, 1974.

Table 3. Format for Entering Segmentation Data from Comparison Cruises on Rhode, West, and South Rivers onto 80 column Hollerith Cards.

Card Column (#)	Entry	Function
1	2	Signifies Segmentation
2	1	Card #1 for data from a given sample.
3,4	numbers	Year
5,6,7	numbers	Day of year (1 to 365)
8,9,10,11	numbers	Time of day (0000 to 2400)
12,13	numbers	Codes for station
14,15	numbers or S or V	Depth of sample (m) (decimal between columns 14/15). S= Bottom Sediment V= Integrated vertical water column.
16,17,18	numbers	Parameter 1 (decimal between 17/18)
19,20,21,22	numbers	Parameter 2 (decimal between 20/21)
23,24,25,26	numbers	Parameter 3 (decimal between 24/25)
27,28,29,30	numbers	Parameter 4 (decimal between 29/30)
31,32,33	numbers	Parameter 5 (decimal between 32/33)
34,35,36	numbers	Parameter 6 (decimal between 35/36)
37,38,39	numbers	Parameter 7 (decimal between 38/39)
40,41,42	numbers	Parameter 8 (decimal between 41/42)
43,44,45	numbers	Parameter 9 (45 = exponent)
46,47,48	numbers	Parameter 10 (48 = exponent)
49,50,51	numbers	Parameter 11 (51 = exponent)
52,53,54	numbers	Parameter 12 (54 = exponent)

Table 3 (continued)

Card Column	Entry	Function
55,56,57	numbers	Parameter 13 (57 = exponent)
58,59,60	numbers	Parameter 14 (60 = exponent)
61,62,63	numbers	Parameter 15 (63 = exponent)
64,65,66	numbers	Parameter 16 (decimal between 65/66)
67,68,69	numbers	Parameter 17 (decimal between 67/68)

Card #2 Column	Entry	Function
1	2	Segmentation format
2	2	Card #2 for data from a given sample.
3 through 15	numbers S or V	As on card #1
16,17,18	numbers	Parameter 18 (18 = exponent)
19,20,21	numbers	Parameter 19 (21 = exponent)
22,23,24	numbers	Parameter 20 (24 = exponent)
25,26,27	numbers	Parameter 21 (27 = exponent)
28,29,30	numbers	Parameter 22 (30 = exponent)
31,32,33	numbers	Parameter 23 (33 = exponent)
34,35,36	numbers	Parameter 24 (36 = exponent)
37,38,39	numbers	Parameter 25 (39 = exponent)
40,41,42	numbers	Parameter 26 (42 = exponent)
43,44,45	numbers	Parameter 27 (45 = exponent)
46,47,48	numbers	Parameter 28 (48 = exponent)
49,50,51	numbers	Parameter 29 (51 = exponent)
52,53,54	numbers	Parameter 30 (54 = exponent)

Table 3 (continued)

Card Column	Entry	Function
55,56,57	numbers	Parameter 31 (57 = exponent)
58,59,60,61	numbers	Parameter 32 (61 = exponent)

Table 4

PLANKTON STUDIES - RANN
(all at depth of 1 meter)

Day of 1973	Station	Particulate Phosphorus Uptake Rates (ug P/l/hr.)			Water Chemistry Data (ug P/l)			
		Light	Dark	Inhibited*	Dissolved Ortho Phosphate	Total Ortho Phosphate	Dissolved Total Phosphorus	Total Phosphorus
165 (6/14)	Rhode River (Box 3)	10	10	4.1	39	82	-	161
190 (7/9)	Rhode River (Box 3)	28	39	35**	110	138	-	236
191 (7/10)	Cadle Creek	50	77	43**	186	268	-	597
193 (7/12)	South River (Box 5)	32	32	31**	78	94	-	161
219 (8/7)	Rhode River (Box 3)	15	22	8.0	62	88	-	187
249 (9/6)	Rhode River (Box 3)	7.9	26	4.8	80	110	-	197
263 (9/20)	South River (Box 5)	17	12	2.3	19	18	18	106
276 (10/3)	Rhode River (Box 3)	5.9	5.3	3.1	6.0	20	7.5	47

*0.05 u Iodoicetic acid present

**Conc of indoicetic acid was only 0.01u

Table 4 (continued)

Day of 1973	Station	Particulate Phosphorus Uptake Rates (ug P/l/hr.)			Water Chemistry Data (ug P/l)			
		Light	Dark	Inhibited*	Dissolved Ortho Phosphate	Total Ortho-Phosphate	Dissolved Total Phosphorus	Total Phosphorus
303 (10/30)	Cadle Creek	3.3	3.4	0.05	4.5	9.0	9.5	85
304 (10/31)	Rhode River (Box 3)	2.5	2.1	0.14	3.0	9.5	5.5	56
306 (11/12)	South River (Box 5)	1.8	1.9	0.07	2.0	9.0	4.0	28
330 (11/26)	Rhode River (Box 3)	42	39	0.00	6.5	9.0	13	68
352	Rhode River	1.6	0.62	0.00	3.0	5.5	-	-
<u>Day of 1974</u>								
29 (1/29)	Rhode River	0.56	0.55	0.023	1.5	4.5	-	-
30	South River	1.07	1.67	0.06	1.5	3.5	-	-
31	Cadle Creek	1.44	1.34	0.00	2.0	3.0	-	-
59 (2/28)	Rhode River	1.16	1.99	0.08	2.0	3.5	-	28

Table 4 (continued)

Day of 1974	Station	Particulate Phosphorus Uptake Rates (ug P/l/hr.)			Water Chemistry Data (ug P/l)			Total Phosphorus
		Light	Dark	Inhibited*	Dissolved Ortho Phosphate	Total Ortho Phosphate	Dissolved Total Phosphorus	
101 (4/11)	Rhode River (Box 3)	10.7	-	-	5.0	7.0	-	-
101 (4/11)	Cadle Creek	1.88	-	-	4.5	8.0	-	-
100 (4/10)	South River	3.66	-	-	1.5	8.0	-	-
133 (5/13)	Cadle Creek	28.2	-	-	8.0	13	-	-
134 (5/14)	Rhode River (Box 3)	10.1	-	-	7.0	13	-	-
170 (6/19)	Rhode River (Box 3)	6.43	-	-	14	21	23	144
170	Cadle Creek	14.6	-	-	10	18	10	145
200 (7/19)	Rhode River (Box 3)	5.37	-	-	43	68	-	-
200	Cadle Creek	6.79	-	-	15	27	-	-
269 (9/20)	Rhode River (Box 3)	4.93	-	-	4.0	18	-	-
269	Cadle Creek	11.7	10.1	-	4.0	15	-	-

Table 5

PLANKTON STUDIES - RANN

(all at depth of 1 meter)

Day of 1973	Station	Phytoplankton Parameters			
		Biomass (ug chl a/l)	Photosynthetic Assimilation Ratio (mg c/hr mg chl a)	Primary Production (ug c/hr.)	Autotrophy Index <u>atoms inorganic carbon fixed</u> <u>atom phosphorus assimilated</u>
165 (6/14)	Rhode River (Box 3)	38	3.8	15	37
190 (7/9)	Rhode River (Box 3)	55	1.7	92	8.6
191 (7/10)	Cadle Creek	540	1.9	1000	53
193 (7/12)	South River (Box 5)	-	-	87	7.0
219 (8/7)	Rhode River (Box 3)	-	-	150	26
249 (9/6)	Rhode River (Box 3)	74	1.3	95	24
263 (9/20)	South River (Box 5)	82	0.71	58	8.7
276 (10/3)	Rhode River (Box 3)	24	120	46	1200
303	Cadle Creek	44	0.86	38	30

Table 5 (continued)

Day of 1973	Station	Biomass (ug chl a/l)	Phytoplankton Parameters		
			Photosynthetic Assimilation Ratio (mg c/hr mg chl a)	Primary Production (ug C/l/hr.)	Autotrophy Index $\frac{\text{atoms inorganic carbon fixed}}{\text{atom phosphorus assimilated}}$
304 (10/31)	Rhode River (Box 3)	22	3.3	74	76
306 (11/12)	South River (Box 5)	26	4.5	114	163
330 (11/26)	Rhode River (Box 3)	15	2.5	36	2.2
352 (12/18)	Rhode River (Box 3)	18	1.4	26	42
<u>Day of 1974</u>					
29 (1/29)	Rhode River (Box 3)	4.9	18.5	91	418
30	South River (Box 5)	19	1.3	25	60
31	Cadle Creek	7.1	7.1	51	91
59 (2/28)	Rhode River (Box 3)	7.3	2.8	20	46

Table 6 Populations of Bacteria and Algae in Surface Water Samples Collected at Cadle Creek, South River and Rhode River Stations at Four Different Seasons.

Day of Year	Station	Cells/ml ^a		Biomass (mm ³ /l) ^b		Individual species of Algae
		Bacteria	Algae	Bacteria	Algae	
191 (1973)	Cadle Creek	5.0 X 10 ⁶	20,261	9.4	60.2	28
303 (1973)	Cadle Creek	3.7 X 10 ⁶	1,505	1.4	0.6	25
31 (1974)	Cadle Creek	3.6 X 10 ⁶	2,224	3.3	0.5	18
101 (1974)	Cadle Creek	4.5 X 10 ⁶	1,659	-	2.0	22
193 (1973)	South River (Box 5)	11.3 X 10 ⁶	19,670	13.1	57.0	14
306 (1973)	South River (Box 5)	1.5 X 10 ⁶	2,737	1.7	1.3	32
30 (1974)	South River (Box 5)	3.0 X 10 ⁶	2,457	2.8	1.5	20
100 (1974)	South River (Box 5)	3.7 X 10 ⁶	2,629	1.1	0.8	22
190 (1973)	Rhode River (Box 3)	8.6 X 10 ⁶	114,670	4.3	20.2	16
304 (1973)	Rhode River (Box 3)	2.9 X 10 ⁶	3,284	1.8	0.9	36
29 (1974)	Rhode River (Box 3)	2.7 X 10 ⁶	229	2.3	0.1	16
101 (1974)	Rhode River	1.8 X 10 ⁶	2,075	-	1.8	20

^aDetermined by direct microscopy.

^bEstimated from cell count and cell size and shape data.

Table 7 Populations of Total and Fecal Coliforms in Surface Water Samples Collected at Cadle Creek and South River Stations at Four Different Seasons.

Day of Year	Station	Coliforms (MPN/100ml)	
		Total	Fecal
191 (1973)	Cadle Creek	33	33
303 (1973)	Cadle Creek	2400	170
31 (1974)	Cadle Creek	33	0
101 (1974)	Cadle Creek	130	130
193 (1973)	South River (Box 5)	79	79
306 (1973)	South River (Box 5)	540	49
30 (1974)	South River (Box 5)	79	13
100 (1974)	South River (Box 5)	240	130