THE QUALITATIVE AND QUANTITATIVE ANALYSIS OF THE BENTHIC FLORA AND FAUNA OF BARNEGAT BAY BEFORE AND AFTER THE ONSET OF THERMAL ADDITION

Fourth Progress Report

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INTRODUCTION

During the period since the last progress report, at least 12 collecting cruises have been made to the study area. The general intensity of sampling has increased, especially for biomass studies (invertebrates), thermal tolerance (algae), seasonal variation (plankton) and primary productivity. A considerable amount of effort has been made in the direction of compiling a bibliography on thermal studies of organisms. Our collection of references now exceeds several thousand, uncollated at the moment, but many are on unisort cards.

The field conditions have not changed significantly in comparison with findings of previous years. One species of algae, Codium, now appears to be the dominant plant in certain portions of the bay (viz., the mouth of Forked River). Eight new records of invertebrates have been found for the study area. We have learned recently that during the period covered in this report the electric generating facility was pumping water in order to conduct preliminary tests of their pumps. After a visit to the reactor site at Lacey Township, the authors of this paper gained more insight into the engineering aspects of the study. However, it is felt that improved communications between the operations of the plant and the biological surveys being conducted would allow us to formulate our program better. For example, during the recent pump test, we would have liked to obtain samples to determine if silting occurred and also to test the effect of "cold" circulation on planktonic organisms.

One logistical problem has arisen due to the resignation of J. E. Taylor from the program as of 1 September. That is, Mr. Mountford, who is primarily a plankton expert, will now assume the responsibility of collecting and identifying macroscopic algae on a limited basis. Perforce, the intensity of algae sampling will be curtailed starting this fall, since there is no competent algae taxonomist available to replace Mr. Taylor. Further, since Mr. Taylor will take his truck, arrangements will have to be made with the director of Physical Plant at Rutgers for rental of a University truck to move the boat from its present location at the N. J. Game Farm to Forked River for each cruise.

It is becoming apparent that the initial phase of thermal addition will not take place until this fall (1968). Since the terms of the present contract expire May 1969, we are presently considering a formal request and application for continuance of this contract for at least one year.

A statement on the budget, the results of our investigations over the past six months, and a list of professional activities and publications follows.

BUDGET STATEMENT

With one year remaining in this investigation, our budget will still cover the anticipated operating expenses. We have hired Mr. Mountford to replace Mr. Taylor as a half-time research assistant as of 1 September 1968. Mr. Phillips will continue as a research assistant until the end of the present contract. Mr. Mountford is currently supported, in part, by this contract but receives no salary for his services. A brief statement of account is given below.

Items	Amount Alloted	Actually Spent	Balance
Salary	21,363.36	19,094.94	2,268.42
Research Vessel	2,888.00	2,648.51	239.49
Equipment	2,196.00	1,257.36	1,118.64
Operating Expenses	2,376.00	1,546.67	649.33
Scientific Supplies	1,076.64	1,376.88	- 300.24
Publication	100.00	23.16	76.84
	30,000.00	25,947.52	4,052.48

PUBLICATIONS AND PROFESSIONAL ACTIVITIES

R.E. Loveland has sent to press two manuscripts reporting research that was supported in part by this contract. They are "Oxygen consumption and water movement in *Mercenaria mercenaria*" (sent to *Physiological Zoology*) and "New records of nudibranchs from New Jersey" (sent to *Veliger*).

Between October, 1967, and February, 1968, a 25-minute color sound film (Super 8 mm Format) was produced and edited at no cost to the Project or the University by Mr. George Chase, a Bernardsville, N.J. artist, and Mr. Kent Mountford. It deals primarily with the plankton survey but discusses other phases of estuarine ecology and is oriented toward the interested layman. It was first shown before the Symposium on the Ecology of Barnegat Bay at the 14th Annual Meeting of the New Jersey Academy of Science, discussed elsewhere in this report. Requests for the film have been made by Bernardsville High School Department of Biology, the Piscataway Township School System, and the Boy Scouts of America. It will be shown July 3, 1968, to summer students in Marine Biology at the Monmouth County Regional High School.

Two papers dealing with aspects in the physical and plankton ecology of Barnegat Bay are in preparation but, with the bulk of sampling analysis still remaining, they are not likely to be in press this year.

A paper titled "New records and rare species of benthic marine algae from the coast of New Jersey" by J.E. Taylor, E.T. Moul and R.E. Loveland was submitted for publication. This manuscript is now being revised and will be resubmitted for publication in Torrey Bulletin.

A symposium entitled "The Ecology of Barnegat Bay" was organized by J.E. Taylor for delivery at the Annual Meetings of the N.J. Academy of Science. A series of four papers were delivered, as follows: "Tentative comments on the plankton of Barnegat Bay" by K. Mountford; "Distribution and periodicity of benthic algae in Barnegat Bay" by J.E. Taylor; "Organization and distribution of the benthic invertebrates of Barnegat Bay" by F.X. Phillips; and "Along-shore fish populations of Barnegat Bay" by K. Marcellus. R.E. Loveland acted as moderator. Abstracts of these papers were published in the Spring edition of The Bulletin of N.J. Academy of Sciences

PLANKTON SURVEY

The plankton through a complete annual cycle has been sampled in accordance with methods outlined in a previous report. Live analyses have been performed and permanent quantitative collections of fixed plankton and appropriate hydrographic data have been assembled.

While sampling continues at approximately bi-weekly intervals, a major drive at analysis and counting of the collected material is underway. This is necessary if meaningful sampling activity is to be pursued in the post-operational phase of the survey. It is believed that the relatively diverse approach taken during the last year will permit considerable flexibility in analysis.

Sampling was designed not only to provide data on the seasonality and occurrence of species within the estuary (see Table VI, Progress Report No. 3), but also to obtain estimates of variability in composition and density between samples. What, in essence, constitutes a significant change in populations? What constitutes significant variability among stations? When may we declare a significant stratification to exist between surface and bottom? Are such differences, in fact, discernable from the collected material?

Two sources of variability must be estimated in answering these questions. First variability within a stratum at a given station and second, variability in density per unit volume extrapolated from replicate counts on separate aliquots from the same sample.

The first source represents random variability which we can expect between samples drawn from what we assume to be the same populations. Whether or not organisms are, in fact, randomly dispersed is not pertinent since the techniques employed cannot assess microdistribution. The assumption is relative homogeneity exists within a stratum.

The second source represents estimates of differences in counts one can expect between randomly drawn and examined aliquots of the same sample and assists in placing confidence intervals around what we declare to be real differences among samples drawn from various locations in the bay.

On 28 April 1968 replicate samplings were made on a single station in the bay. The resulting material was treated in the usual manner, condensed and analysed for occurrence of species and density of organisms. This data is being subjected to statistical treatment designed to quantify the sources of variability discussed.

Concurrently, analyses are being run on each of the two hundred fifty-odd samples assembled thus far in the survey. Significant differences among various parts of the bay and significant stratifications on station will be declared when appropriate.

An annual curve of dissolved oxygen values, expressed as absolute content and percent saturation at the ambient temperature from April, 1967 through publication is being assembled for the next report. In general the dissolved oxygen technique, used through the plankton aspects of the survey, has been subjected to analysis for estimates of variability that permit, within prescribed confidence intervals, the declaration of true differences among titration means.

Daily pyrheliometric records (see Section IV, Hydrography, Progress Report No. 3) are being used to prepare a curve of weekly integral insolation values beginning in late November, 1967. These data should be useful in assessing natural temperature changes in the water column and, to some extent in evaluating estimates of primary productivity.

In April, 1968 tentative efforts were begun to secure periodic field estimates of primary productivity in the water column at stations randomly selected from the research area. A light-dark bottle method modified from Gaarder and Gran (1927) is employed on every cruise taken since April.

BENTHIC ALGAE

Summary of activities, January to June, 1968

1. Surveilance of algae flora.

Routine collections of benthic algae and concurrent environmental parameters have been carried out on a regular basis. The location and date of collection for these stations are summarized in Tables Ia and Ib.

No new species of algae have been recorded for the collections for the period covering the above months. The general seasonal flora is shown in Table II.

It is worth noting that Codium has increased in abundance in the bay. During the June-December 1967 period, the plant was found throughout the bay, but usually as small fragments. In the last period (January-June 1968) Codium has again been found throughout the bay but as large, well developed plants. This is particularly so for the last two collection dates. Every dredge haul brought aboard contained Codium even at stations that had not previously shown Codium. As judged from the dredge hauls, the areas of greatest abundance for this plant are the mouth of Forked River, off Waretown, and Light "1" south (shown in Fig 2.). These areas also have large amounts of Pecten and Mercenaria shells which might explain the high abundance of the plant since shell may act as substrate for the plant. It is in these areas also that all three of the major stages in the life cycle of the plant (Moeller, personal communication) are found concurrently. The three major stages are (1) attached, well-developed plants, (2) free, regenerating fragments, and (3) sporlings on shell. It is safe to conclude that Codium has become well established in the bay. However, its known distribution in New Jersey is still restricted to Barnegat Bay.

All determinations for the algal samples are complete to the date of this report. These data and any emendations to the previously reported lists will be included in the forthcoming winter, 1968, progress report, as will the physical data for the previous six months.

2. Culture experiments.

Long-term culture experiments were carried on this spring. Temperatures of 5, 18, and 23°C were investigated with six species of algae. These algae were Polysiphonia nigrescens, Ulva lactuca, Enteromorpha linza, Porphyra leucosticta, Punctaria latifolia, and Gracilaria foliifera.

The plants were collected 30 January 1968 from Barnegat Bay and placed in the culture tanks which contained filtered bay water of 28 o/oo salinity. Both the plants and water were collected from Buoy "F". The culture tanks were 4 litre battery jars with plate glass covers. The tanks were supplied with compressed air and contained 5 cm of washed beach sand.

Light was provided by two 40 watt cool-white flourescent tubes 36 cm from the surface of the water. The lights were on a 12 hour light-dark cycle. Previous studies with an oxygen electrode showed that this light intensity was more than sufficient for net photosynthesis. Temperature control at 5°C was provided by a walk-in cold room, and at 18°C by an air-conditioned culture room. The 23°C temperature was that of the laboratory. The cultures were started 31 March and ran until 26 May when the central power plant was shut down.

Porphyra was the most sensitive to the increased temperature. Two days after starting the cultures the plant showed signs of shedding spores and after one week it began to disintegrate. In the 18°C culture disintegration didn't occur until the third week, and in the 5°C cultures the plants did not show damage for six weeks. Enteromorpha also shed after transplantation into the 23°C culture. At the end of the experiment, the Enteromorpha was still intact in the 5°C tank, slightly damaged in the 18°C tank, and completely gone from the 23°C tank. Gracilaria showed damage such as pigment loss after the third week in the 23°C culture, and no damage for the entire course of the experiment in either of the cooler tanks. This was also the case with Punctaria and Polysiphonia. Ulva was the most resistant to the change in temperature. The plant showed slight damage only one week before the experiment was terminated in the 23°C tank, and not at all in the other two.

These results correlate with the observed changes in the seasonal flora of the bay. During the annual cycle, Porphyra is present as either large, free-floating individuals or small epiphytes only during February and March. Enteromorpha linza is characteristic of late winter and early spring and is gone by June. The two species of Punctaria, P. latifolia and P. plantagenia, first appear in late December and persist until the end of June. Polysiphonia nigrescens reaches a maximum development in the period from February to April, but is present in some form throughout the year. This year we collected large tetrasporic plants as late as 21 June. Normally it is present in the flora at this time of year as small (less than 4 cm high) pinnate plants on Pecten shells. Ulva lactuca and the two species of Gracilaria are also present year-round. These two species show periods of heavy growth in the spring and fall.

Table Ia. Date and location of stations collected in the test area during the last six months. A = complete algae sample; a = partial algae sample; P = physical data.

	CRUISE										
	68-1	68-2	68-3	68-4	68-5	68-6	KM	68-7	68-8	68-9	68-10
	DATE										
QUADRATE	1/28	3/30	4/7	4/18	5/11	5/23	5/31	6/4	6/11	6/13	6/21
8 C	A P	A P				A P	A P		a P		
9 B											A P
11				A P		A P			A P		
13 B		A P						A P			
14 B										A P	
16 B	A P		P		A P				A P		
17 A						A P			a P	A P	
17 C		A P		A P				A P			
21 D			P		A P					A P	
22 B		P						A P			
22 D		P		A P		A P			a P		a P
23 A	A P	P						A P		A P	P
23 D								P			A P
24 A				A P		P				A P	
O.C. Canal Rte. 9 Bridge	P										

Table Ib. Date and location of shore stations and stations outside test area collected during the last six months. Key is the same as in Table Ia.

	CRUISE				
	C-1	68-3	K M	68-5	68-10
	DATE				
STATION	3/3	4/7	5/3	5/11	6/21
1BSP*	A P			A P, P	
ER*	A P				
SP*	A P				
BL*	A				
CC*		P			
9AD					A P
Lavellette				P	
Light "31"				A P	
Swan Point			A P	A P	
Buoy N "74"		P			
Harvey Cedars		A P			
Brant Beach		A P			

* Shore stations; refer to winter, 1967 report for locations

Table II. General analysis of the seasonal flora of Barnegat Bay. Rare or occasionally encountered species are not included.

1. Perennial Flora (present year round)

Chlorophyta

Chaetomorpha linum
Cladophora spp.
Codium fragile ssp. tomentosoides
Enteromorpha spp.
Ulva lactuca
Ulvella

Phaeophyta

Punctaria plantaginea (The winter dominant, but can be collected through out the year)
Fucus spp. (Only on the rocks of Barnegat Light.)

Rhodophyta

Acrochaetium spp.
Agardhiella tenera
Callithamnion spp.
Ceramium fastigatium
Champia parvula (much reduced in the winter, but present)
Gracilaria verrucosa
G. foliifera
Polysiphonia nigrescens (as a small form on shells in the summer, maximum development in winter)

2. Winter Flora (Includes species that only appear in the winter quarter, as well as plants that appear fall-winter, winter-spring, and fall through spring.

Chlorophyta

Bryopsis hypnoides
B. plumosa
Enteromorpha linza
Ulothrix flacca
U. implexa

Phaeophyta

All species but Stilophora rhizodes, Fucus SP, Myrionema strangulans, Myriotrichia claveformis, Sphacelaria cirrosa, and Ralfsia verrucosa.

Rhodophyta

Bangia fuscopurpurea (particularly on rocks at Barnegat Light)
Erythrotrichia carnea
Goniotrichum alsidii
Polysiphonia nigra
Porphyra spp.
Rhodophysema georegii

3. Summer Flora (Includes spring-summer-fall, spring-summer, summer-fall, and summer species)

Chlorophyta

Entocladia viridis
Enteromorpha intestinalis
E. plumosa

Phaeophyta

Myrionema strangulans
Myriotrichia claveformis
Sphacelaria cirrosa
Stilophora rhizodes
Ralfsia verrucosa

Rhodophyta

Chondria spp.
Gelidium crinale
Griffithsia tenuis
Hildenbrandia prototypus
Lomentaria spp.
Polysiphonia spp. (Except P. nigra and P. nigrescens, all species of Polysiphonia are late summer-fall)
Spyridia filamentosa

BENTHIC INVERTEBRATES

This progress report includes all data taken from the previous report (#3) which ended X-25-67 up to the present. The results of cruise 68-9, taken V-21-68, have not yet been worked up so the benthic invertebrates are described as of V-13-68.

Field collections have been maintained as in the past. Qualitative samples are obtained from a timed bottom haul of a Caribbean dredge (Turtox). Quantitative sampling was by means of the Ponar grab dredge.

A collecting schedule tentatively planned at a frequency of one trip every nine days has been established for the period 1 June through the middle of September. To date, through June, we have maintained this schedule. The final week of July is to be devoted to the determination of the sediment size analyses of 18 stations located within the area of primary interest (along the Intracoastal Waterway and westward). All of the data concerning the sediment size distribution of the substrate will be presented in the next progress report.

Organisms which have appeared for the first time in Barnegat Bay since the study began are listed below:

Amathia sp.
Cerebratulus lacteus
Edotea triloba
Golfingia gouldi
Lumbrineris tenuis
Nassarius trivitattus
Neomysis americana
Pista cristata

The three common amphipods which have appeared in the bay have been under investigation. To date two have been keyed out; these identifications, however, are tentative. Confirmation is being sought. The two tentative identifications are Grubia compta and Ampelisca macrocephala.

With the addition of new species and identification of others the modifications to the key (p. 18, progress report of January, 1968) for the animal distribution are as follows.

Number	Species
1	Ampelisca macrocephala
2	Grubia compta
81	Amathia sp.
82	Golfingia gouldi
83	Cerebratulus lacteus
84	Edotea triloba
85	Lumbrineris tenuis
86	Nassarius trivitattus
87	Neomysis americana
88	Pista cristata
89	Sthenelais picta

Date: 12-6-67

Area 21 D ✓

species no.	no./M^2
23	42
33	6
43	1
45	3
46	71
52	105
65	176
69	7
89	22

Area 8 C - species found

7	33	40	51	69
9	35	41	52	79
18	37	45	54	90
20	39	50	57	

Area 15 B - species found

2	24	47	87
5	35	56	
18	37	63	

Area 23 A ✓

species no.	no./M^2
2	X
5	X (19)
7	X
12	X
18	X
19	X
29	(3)
35	X
37	X
40	X
47	XX
48	(1)
50	X (12)
51	X
52	X (187)
56	X (7)
63	X (3)
65	(20)
69	(10)
76	(9)
87	X

Date: 12-20-67

Area 1 ✓

species no.	no./M^2
2	X
5	X
7	X
9	X
17	(3)
18	X
31	(20)
32	X
34	X
37	X
39	X
40	X (16)
43	(3)
50	(8)
51	X (9)
54	X (16)
87	(1)
91	X

Area 17 A ✓

species no.	no./M^2
2	X
18	X
23	(24)
27	X
28	(3)
33	(15)
35	X
37	X (9)
45	(6)
48	(7)
50	X
52	(40)
56	X
63	X
65	(18)
69	(21)
74	(1)
76	(80)
87	X

Area 17 C ✓

species no.	no./M^2
1	(60)
23	(12)
33	(4)
60	(2)
65	(84)
72	(3)
73	(12)
76	(96)
88	(1)

Date; 1-28-68

Area 8 C - species found

7	23	41	54	72
9	31	45	62	85
12	37	50	63	87
18	40	51	65	

Area 24 A - species found

7	31	50
18	37	87

Date: 3-3-68

Barnegat Light-rocks, intertidal collection - species found

15, 21, 39, 42, 92, Littorina Saxatilis

Island Beach State Park-shore collection, Area "A 7" - species found

7, 40, 54, 81

Date: 3-30-68

Area 8 C - species found

5	31	51	63
9	40	54	73
18	42	56	92

Area 13 C - species found

10	35	40	51	56	73
18	39	42	54	63	92

Area 23 D - species found

18	30	35	50	56	63
29	31	40	52	62	70

Area 17 C - species found

7	22	38	53	63
9	24	40	56	70
18	31	51	62	87

Date: 4-18-68

Area 17 C

species no.	no./M^2
1	(5)
10	X
18	X (5)
20	X
29	(2)
30	(1)
31	X
40	X (5)
47	X
50	X (5)
52	(3)
53	X
56	(1)
62	X
65	(30)
76	(312)
77	(4)
84	X

Area 11

species no.	no./M^2
18	(8)
23	(24)
25	(3)
28	(2)
30	(5)
39	+
41	(4)
45	(9)
48	(3)
50	(14)
56	(5)
65	(17)
72	(31)
73	(12)
74	(5)
76	(62)
87	(12)

Date: 4-18-68 (cont.)

Area 22 A

species no.	no./M^2
18	X
23	X (52)
33	(6)
35	X
39	X
40	X
43	(1)
46	(55)
47	X
50	X
51	X
52	X (46)
56	(1)
60	(5)
63	X
65	X (140)
69	X (90)
72	(9)
76	X (8)
78	X
87	X
89	(6)

Date: 5-23-68

Area 11

species no.	no./M^2
1	(25)
2	X
16	X
17	(1)
18	X (1)
25	(2)
27	X
28	X
39	X
40	(1)
45	(6)
48	(3)
49	X
50	X (46)
56	X (23)
59	X
65	(3)
69	(10)
72	(10)
73	(6)
74	(7)
76	X (129)
77	(9)

Date: 5-23-68 (cont.)

Area 17 A

species no.	no./M^2
1	(4)
2	X
5	X
9	X
18	X (2)
23	(24)
28	X (4)
30	(1)
35	X (4)
40	X (75)
42	X
47	X
50	X (80)
51	X
52	(13)
53	X
56	X (2)
59	X
65	(16)
69	(90)
73	(8)
76	(92)

Area 8 C

species no.	no./M^2
8	X
18	X
25	(1)
27	X
30	X
32	X
40	X (27)
41	(2)
42	X
43	(3)
45	X (69)
46	(1)
50	X
52	(6)
56	(1)
62	X
63	(13)
65	(6)
73	(4)
74	(19)
76	(15)

Date: 5-23-68 (cont.)

Area 22 A

species no.	no./M^2
1	X (90)
2	X
4	(1)
17	(22)
18	X
23	(25)
24	(13)
28	X
29	X
33	(15)
34	X
39	X
40	X
46	(13)
50	X
51	X
52	(7)
56	X
60	(3)
69	X (112)
72	7
76	(57)

Date: 6-4-68

Area 17 C

species no.	no./M^2
5	X
8	X
18	X
20	X
31	X
40	X
42	X
51	X
56	X
62	X
63	X
69	X
72	(3)
76	(327)
77	(65)
79	X
84	X

Date: 6-4-68 (cont.)

Area 22 B

species no.	no./M^2
15	(45)
18	X
23	(26)
27	X
29	X
35	X (7)
39	X ++
40	X
48	(8)
50	X
51	X
52	X
54	X (148)
55	(4)
59	X (21)
65	X (20)
69	X
72	(3)
79	X
82	(3)
89	(5)
92	X (17)

Area 13 C

species no.	no./M^2
10	X
14	(7)
17	(53)
18	X
23	X (16)
24	X (126)
29	X
35	X
40	X
45	X (16)
46	(182)
47	X
51	X
52	X (15)
53	X
59	X
60	(4)
65	X (32)
69	X
70	X
78	X (13)
82	(1)
83	(1)
89	X (56)

Date: 6-4-68 (cont.)

Area 23 D

species no.	no./M^2
5	X (1)
8	X
9	X
12	X
18	X (6)
23	(46)
25	(12)
27	X
28	X
31	X
35	X (2)
39	X
40	X (9)
43	(8)
45	(72)
46	(4)
47	X
50	X (21)
51	X
52	X
53	X
63	X
65	(23)
69	(4)
72	(1)
79	X
83	(1)
92	(3)

Date: 6-13-68

Area 23 D

species no.	no./M^2
1	(8)
5	X
18	X
24	X
25	(3)
29	X
35	X (18)
40	X (19)
47	X
48	(1)
50	(5)
51	X
52	X (11)
53	X (4)
66	X
74	(3)
76	(72)

Date: 6-13-68 (cont.)

Area 24 A

species no.	no./M^2
1	(31)
8	X
19	X
23	(11)
29	X
31	X
33	(4)
35	(3)
39	+
40	X
48	(1)
50	X
52	(13)
56	X
59	X
63	X
65	(70)
66	X
69	(21)
72	X
76	(76)
79	(5)

Area 14 B

species no.	no./M^2
5	X
10	X
18	X
23	(37)
24	X (32)
29	X
30	(1)
33	(20)
35	X (51)
40	X
46	(21)
47	X
59	X (6)
65	(6)
69	X
70	X (1)
73	(8)
76	(7)
78	X (19)
80	(1)
82	(6)
93	(1)

Date: 6-13-68 (cont.)

Area 17 A

species no.	no./M^2
1	(18)
5	X
8	X
9	X
18	X (2)
23	(32)
27	X
31	X
34	X
35	X
40	X (19)
47	X
50	X (19)
51	X
53	X
56	X (2)
59	X
65	(20)
66	X
69	(111)
72	(7)
76	(122)
92	X

Area 21 D

species no.	no./M^2
2	X
7	X
10	X
23	X (40)
28	X
29	X (6)
31	X
33	(8)
35	X
40	X
45	(7)
46	X (77)
47	X
48	X
50	X
51	X
52	X (29)
56	X
59	X
65	X (50)
69	X (37)
72	(11)
78	X (48)
94	X

THE QUALITATIVE AND QUANTITATIVE ANALYSIS OF THE BENTHIC FLORA AND FAUNA OF BARNEGAT BAY BEFORE AND AFTER THE ONSET OF THERMAL ADDITION

Fifth Progress Report

March 15, 1969

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Introduction

The current report differs somewhat from previous reports in style, format and intent. Previously our reports have concerned themselves primarily with the presentation of raw data, with little emphasis on interpretation or analysis of the data. In a study of the kind pursued in Barnegat Bay, interpretation of data concerning natural populations must, perforce, await accumulation of sufficient time to distinguish and recognize natural variation from year to year. This report attempts to interpret the year to year and point for point variation of the flora and fauna of Barnegat Bay, with especial emphasis on the benthic forms. In addition, certain predictions will be made regarding the qualitative aspects of benthic algae and free-floating plankton, as well as the quantitative aspects of the benthic invertebrates. Because of the effort in time necessary to accurately analyze the data of three years, this report has been delayed for several months. It must be indicated that the interpretation of the data is still going on and should occupy us for at least a month more during the summer. Meanwhile, we feel that enough is now known so that certain generalizations can be made regarding the progress of the study.

Raw data will still be presented in tabular form as in the past. All raw data from June of 1965 through December of 1968 has been compiled and thoroughly analyzed as follows;:A) Sediments and benthic invertebrates (F.X.Phillips and R.E. Loveland), B) Benthic algae (J.E. Taylor, E.T. Moul and R.E. Loveland), C) Plankton (K.Mountford). Hydrographic data is presented, but little interpretation is attempted at this point; further correlations of biotic and abiotic data will be attempted in the future. After presentation of the data, we will attempt to predict the spacial and temporal distribution of algae, invertebrates and plankton in the study area.

Finally, a research proposal is being written to request continuance of this research study.

Budget

A detailed statement of the budget will not be presented in this report. We expect to summarize the budget expenditures in the next report (June 1969). Suffice it to say that the current grant is completely expended. We anticipate the award of contingency funds to the amount of $1000.^{00}$ in order to finish the observations of Spring 1969. We have exhausted our funds sooner than anticipated because of the inflationary increases of equipment and material and, especially, salary for the research assistants. All material has been inventoried and accounted for. The research vessel Clio is in fairly good shape after extensive engine work last Fall. We have been fortunate to be able to keep the boat in the water throughout the winter at Forked River State Marina. Mr.Holmes Lane, the Supervisor, has been most co-operative and helpful in maintaining and caring for the boat in our absence.

Publications and Presentations

J. Taylor, E.T. Moul and R.E. Loveland have co-authored a paper titled "New Records and Rare Benthic Algae from New Jersey", which has been recently accepted for publication in the "Torreya".

R.E. Loveland, G. Hendler and G. Newkirk have a paper on N.J. nudibranchs ("New Records of Nudibranchs from New Jersey") in the April issue of Veliger. R.E. Loveland and D. K.S. Chu have a paper ("Oxygen Consumption and Water Movement in Mercenaria mercenaria") which will be published soon in Comparative Biochemistry and Physiology. R.E. Loveland and J.H. Welsh have published a paper titled "5-Hydroxytryptamine in the Ascidian, Ciona intestinalis" recently in Comparative Biochemistry and Physiology.

F.X. Phillips, J.Taylor and K. Mountford attended a Thermal Addition Workshop at the Institute of Marine Resources in Solomons, Maryland, last Fall. Mr. Mountford gave a paper titled "Dissolved Oxygen as an Indicator of Primary Productivity", which is to be published soon in Chesapeake Science. Mr. Taylor spoke of his work on the algae in Barnegat Bay, and on Standing Crop as a Measure of Primary Production, the results of these presentations will also be published in Chesapeake Science.

K. Mountford will conduct a symposium in Aquatic Biology at the Annual Meetings of the New Jersey Academy of Sciences, April 1969. One of the papers will be delivered by F.X. Phillips titled "Sediment Relations in Barnegat Bay".

F.X. Phillips has been invited to speak on his work on Barnegat Bay at Jacksonville University in Florida.

E.T. Moul will publish "The Flora of Monomoy Island, Massachusetts" in Rhodora.

K. Mountford participated in the F.W.P.C.A. National Estuarine Survey Public Hearing held in Seattle, Washington 23 July,1968.

Benthic Algae

It will become quite obvious to the reader that most of the data collected for benthic algae is qualitative. The only quantitative aspects that can be ascertained with accuracy are location in the bay and time of collection. It has been virtually impossible to standardize techniques for collecting benthic algae in a manner which would allow expressions such as species per squared meter, or biomass per squared meter. The reason is two-fold: A) most of the algae in Barnegat Bay appear to be unattached. Great masses of the dominant species are literally drifting along on the bottom; B) the algae do not appear to be uniformly distributed; thus, two dredge hauls in the same area yield such variation in abundance that characterization becomes difficult. We have recently begun to express relative abundance, i.e., the percent of the total sample constituted

Benthic Algae (cont'd)

by the individual species. However, qualitative data does inform us about the species composition on the bottom from point to point and from time to time. Unfortunately we have not had the time to carefully analyze point for point (spatial) variation in the benthic algae. Only a "baywide" interpretation of the benthic algae will be presented, with major emphasis on the temporal distribution and variation.

A. Raw data.

In keeping with the format of previous reports, we herewith present the raw data for benthic algae in tabular form. This information occurs from p. 4 to p. 12 .

Kent Mountford, while engaged in the plankton aspects of the survey, has taken over the sampling of benthic algal material. Since the separation of Mr. Taylor from this team, forty-eight stations were sampled on seventeen different dates. On 3 December, a particularly intense survey was carried out covering twelve stations for the examination of distribution for the dominant species.

Because of unfamiliarity with the benthic algae, it is likely that many of the rarer species have been overlooked. Some preliminary data has been collected on the Cyanophyta, previously omitted because of taxonomic complications in Mr. Taylor's original collections. It is felt that some general idea on the periodicity and distribution of this phylum would be useful.

Several occurrences observed in the collections are worth recounting.

1. The sporelings of Codium fragile were recovered epiphytic on Ceramium species at sta. 17-B (Navigational Buoy G) on 18 December 1968 with a bottom temperature of -0.5°C and a surface salinity of 23.4 o/oo. There was a 1.5 cm ice cover at the time.
2. Seirospora griffithsiana, a species previously unrecorded for Barnegat Bay, was found at station 7-D on 15 November 1968 epiphytic on Spyridia filamentosa, at 8.3° C, 20.4 o/oo and 10.51 mg O_2/l.
   The identification was verified by Dr.E.T.Moul.
3. No significant concentration of epiphytes has been observed since Mountford began benthic algal collections, with the possible exception of Fosliella lejolisii, frequently found during late autumn on decumbent blades of Zostera marina.

Benthic Algae

Quadrate 2-D and 3-D

Species	Nov. 24	Nov. [illegible]	Feb. 2
Enteromorpha intestinalis	1		
Ectocarpus confervoides	3	3	
Desmotrichium balticum	Tr.		
Polysiphonia denudata	2		
Ceramium rubrum		2	
Fosliella lejolisii		1	
Oscillatoria			1

Quadrate 7-C, D

Species	Nov.15	Oct. 1	Nov.15	Nov. 24	Feb. 16
Anabaena sp.	1				
Ceramium sp.	1				
Cladophora refracta	1				
Enteromorpha intestinalis	1				
Spyridia filamentosa		1	1	3	4
Cladophora rudolphiana		1			
Ceramium fastigatum		1			
Ceramium strictum		1			
Codium fragile			2	2	
Ulva lactuca			3		
Lyngbya sp.			4		
Seirospora griffithsiana			5		
Gracilaria verrucosa				1	
Polysiphonia denudata				Tr.	
Elachistea fucicola				Tr.	
Agardhiella tenera					2
Ceramium rubrum					3
Desmotrichia undulatum					5
Acrochaetium sp.					6
Oscillatoria sp. (sheathed)					7

Quadrate 8-C (Light 2)

Species	July 29	Sept. 7
Codium fragile	1	
Enteromorpha plumosa	1	
Enteromortha prolifera	1	
Sphacelaria cirrosa	1	
Agardhiella tenera	1	
Ceramium fastigatum	1	1
Ceramium rubrum	1	
Champia parvula	1	
Gracilaria foliifera	1	
Gracilaria verrucosa	1	1
Polysiphonia denudata	1	
Polysiphonia harveyi	1	
Ceramium sp.		1
Polysiphonia sp.		1

Quadrate 10-C (Oyster Creek Channel)

Species	Dec. 3
Ulva lactuca	1
Gracilaria verrucosa	Tr.
Ceramium rubrum	Tr.
Fosliella lejolisii	2

Quadrate 14-B (D-1)

Species	Aug. 16	Dec. 18
Codium fragile	1	5
Ulva lactuca	1	4
Acrochaetium sp.	1	
Agardhiella tenera	1	2
Callithamnion sp.	1	
Ceramium fastigium	1	
Gracilaria verrucosa	1	1
Polysiphonia denudata	1	
Polysiphonia harveyi	1	3

Quadrate 14-C (C-1)

Species	Aug. 16
Ulva lactuca	1
Agardhiella tenera	1
Gracilaria verrucosa	1
Polysiphonia denudata	1
Polysiphonia subtillissima	1

Quadtate 15-B

Species	Oct. 29	Dec. 3	Dec. 18
Gracilaria verrucosa		1	2
Gracilaria foliifera		1	
Agardhiella tenera	1	3	3
Ulva lactuca	Tr.	2	4
Polysiphonia harveyi	3	4	1
Spiridia filamentosa		5	
Codium fragile	2		
Gracilaria verrucosa	4		
Anabaena sp.	Tr.		
Oscillatoria reddish	Tr.		
Enteromorpha intestinalis		Tr.	
Fosliella lejolisii		Tr.	

Benthic Algae

Quadrate 16-A (N-66)

Species	July 29
Codium fragile	1
Ulva lactuca	1
Agardhiella tenera	1
Antithamnion criciatum	1
Ceramium fastigatum	1
Champia parvula	1
Cracilaria verrucosa	1
Polysiphonia harveyi	1
Polysiphonia denudata	1

Quadrate 17-B (G)

Species	Aug. 16	Dec. 3	Dec. 18
Chaetomorpha linum	1		
Codium fragile	1	2	1
Ulva lactuca	1	1	4
Punctaria plantaginea	1		
Sphacelaria cirrosa	1		
Ceramium fastigatum	1		
Fosliella lejolisii	1	Tr.	5
Gracilaria folifera	1	4	
Gracilaria verrucosa	1		
Polysiphonia denudata	1		
Polysiphonia harveyi	1	3	
Spyridia filamentosa	1		
Agardhiella tenera		5	3
Lyngbya sp.		Tr.	
Oscillatoria sp.		Tr.	
Ceramium rubrum			2

Quadrate 17-C (F)

Species	July 29	Dec. 3
Codium fragile	1	
Enteromorpha intestinalis	1	Tr.
Enteromorpha plumosa	1	
Enteromorpha prolifera	1	
Ulva lactuca	1	3
Agardhiella tenera	1	2
Ceramium diaphanum	1	
Ceramium fastigatum	1	
Ceramium rubrum	1	1
Champia parvula	1	
Polysiphonia harveyi	1	4
Spyridia filamentosa	1	
Gracilaria foliifera		1
Cladophora sp.		Tr.
Lyngbya sp.		Tr.

Quadrate 17-D (Lt. 1-S)

Species	July 29	Oct. 16
Codium fragile	1	1
Enteromorpha intestinalis	1	
Enteromorpha plumosa		
Entocladia viridis	1	
Agardhiella tenera	1	3
Gracilaria verrucosa	1	
Polysiphonia denudata	1	
Polysiphonia harveyi	1	5
Spyridia filamentosa	1	
Hyella		Tr.
Ulva lactuca		2
Ceramium fastigatum		4
Oscillatoria (phormidium)		Tr.
Spirulina		Tr.
Fosliella lejolisii		Tr.
Calothrix		Tr.

Quadrate 18-D

Species	Dec. 3
Gracilaria verrucosa	1
Ceramium rubrum	2
Oscillatoria sp.	3

Quadrate 19-D

Species	Dec. 3
Ulva lactuca	Tr.
Codium fragile	1
Agardhiella tenera	3
Polysiphonia harveyi	2

Quadrate 21-D

Species	Dec. 3	Feb. 16
Gracilaria verrucosa	1	1
Agardhiella tenera	2	4
Ulva lactuca	3	2
Codium fragile	4	5
Polysiphonia harveyi		3

Quadrate 22-A (Lt. 4)

Species	July 29	Sept.7	Oct. 1	Oct. 16	Feb. 16
Ulva lactuca	1		2	2	1
Agardhiella tenera	1	1	4	1	3
Gracilaria foliifera	1				
Codium fragile		1	3	3	4
Gracilaria verrucosa		1	5	1	2
Polysiphonia sp.			1		
Spermothamnion			Tr.		
Oscillatoria				Tr.	
Polysiphonia harveyi				5	5
Polysiphonia denudata				4	

Quadrate 22-B (Lt. 12 F.R.)

Species	Oct. 16	Oct. 29
Polysiphonia harveyi	Tr.	
Spiridia filamentosa	Tr.	
Calothrix	Tr.	
Ulva lactuca	Tr.	
Gracilaria verrucosa		1
Codium fragile		1
Agardhiella tenera		1
Ceramium fastigatum		1

Quadrate 23-A

Species	Dec. 18
Codium fragile	1
Agardhiella tenera	2
Gracilaria folifera	3
Ulva lactuca	5
Polysiphonia harveyi	4
Ceramium rubrum	Tr.

Quadrate 23-D (J-Buoy)

Species	June 21	Sept. 20	Oct. 8	Oct. 16	Oct. 29*		Dec. 3	Dec. 18*	
Codium fragile	X		2	2		3		1	
Ulva lactuca	X	4	3	5	3	5	3	5	Tr
Ralfsia verrucosa	X								
Gracilaria foliifera	X						2		
Gracilaria verrucosa	X	1	4	3	1	2		4	Tr
Polysiphonia nigrescens	X								
Agardhiella tenera		2		4		1		2	
Polysiphonia species		3			2				
Polysiphonia harveyi			1			6	1		X
Callithamnion sp.			Tr			Tr			
Spyridia filamentosa				1		7		Tr	
Callithamnion baileyi				Tr					
Ceramium fastigatum						4			
Enteromorpha sp.						Tr			
Callithamnion corymbosum							4		
Ceramium rubrum							Tr		
Cladophora albida							Tr		
Elachistea fucicola								Tr	Tr
Chaetomorpha aerea?									Tr

* Two collections made on same date.

Benthic Algae

Quadrate 24 A-D

Species	Aug.16	Dec. 18
Chaetomorpha linum	1	
Codium fragile	1	2
Enteromorpha intestinalis	1	
Ulva lactuca	1	1
Ralfsia verrucosa	1	
Agardhiella tenera	1	4
Ceramium fastigatum	1	
Champia parvula	1	
Gracilaria verrucosa	1	
Polysiphonia harveyi	1	3
Polysiphonia subtilissima	1	
Ceramium rubrum		Tr.

Quadrate 16-A

Species	June 21
Enteromorpha intestinalis	1
Ulva lactuca	1
Ectocarpus confervoides	1
Ceramium diaphanum	1
Ceramium fastigatum	1
Ceramium rubrum	1
Champia parvula	1
Gracilaria foliifera	1
Polysiphonia harveyi	1
Spyridia filamentosa	1

Quadrate III-7

Species	June 21
Cladophora gracilis f. tenuis	1
Codium fragile	1
Enteromorpha intestinalis	1
Ulva lactuca	1
Ceramium fastigatum	1
Ceramium rubrum	1
Gracilaria verrucosa	1
Polysiphonia harveyi	1

Quadrate Swan Point (Off Grid, Upper Bay)

Species	Sept. 29	Oct. 1	Oct. 23	Dec.22	Feb.2
Cladophora expansa	3				
Agardhiella tenera	1			4	
Enteromorpha compressa	2				
Polysiphonia denudata		1			
Ulva lactuca		Tr.	3	2	3
Spirogira sp.		1			
Oscillatoria		1			
Anabaena		1			
Ulothrix		1			
Kylinia virgatula f. luxurians		1			
Polysiphonia harveyi			1	1	
Gracilaria verrucosa			2	Tr.	1
Cladophora rudolphiana				Tr.	
Dasya pedicellata				1	
Ectocarpus siliculosus					2

B. Species composition

During a thirty-six month period (June 1965-June 1968), samples of benthic algae were collected from Barnegat Bay during at least twenty-six of those months. A total of 119 species were identified. Of these, many species were found only a few times and only a few species were found every time. Figure A-1 is a plot of the species of benthic or epiphytic algae, with the X-axis illustrating the species code number (see page 18for master species list and code numbers) and the Y-axis indicating the number of months that each species was found out of a possible twenty-six collecting months. Two striking observations can be made from the plot of Fig.A-1: I) there are only a few dominant species of algae in the bay (Ulva lactuca, Ceramium fastigiatum, Gracillaria verrucosa and Agardhiella tenera); II) the majority of the species (86.5%) of benthic algae occur less than 50 percent of the time. At least thirty-one species can be considered rare since they occur, at most, only twice during a three-year period. Over half (58%) of the species occur less than 25 percent of the time. Finally, only 16 species (= 13.5%) occur more than 50 percent of the time. Part of the reason for such a skewed distribution in time can be attributed to the difficulty of identifying all of the rare species every time one makes a collection. However, it seems reasonable to conclude that many species are very transient visitors to the bay. It is conceivable that these rare species, many of which only occur during the summer months, will be the most sensitive species to environmental change because of their tenuous existence. Any shift in dominance in the future would also be readily detected, especially if it occurs in a downward direction (viz, Ulva suddenly occurs below the 50% Time line).

Two important conclusions can be drawn from Fig. A-1. First, it is apparent that Barnegat Bay is a complex and diverse system with respect to the algae. Many species occur throughout the year, either continuously or sporadically. The species composition tends toward heterogeneity, rather than homogeneity. This seems intuitively to be true for both spacial and temporal distribution. We would expect, therefore, that Barnegat Bay will remain a relatively diverse ecosystem in the future, without the loss or sudden increase in the rarer forms. Secondly, it appears that the effort necessary to gather data on benthic algae need not be as intensive as in the past. It no longer seems necessary to collect benthis algae every ten days. We suggest that a collecting schedule of once every two months would yield all the necessary data on benthic algae. However, because of the summer transients, once a month collections seems more reasonable, during that season.

Figure A-2 is a graphical representation of the species abundance month by month over three years. The greatest number of species

Fig. A-1. Species distribution of benthic algae over a three year interval. (1965-1968)

M[illegible]	SPECIES																	TOTAL	
1	1	13	20	33	34	44	58	63	82	89	99	104	116	121	122			15	
2	8	14	18	32	54	61	65	74	97	100	101	103	117	118	126	127		16	
3	9	10	11	19	22	24	36	38	48	57	67	73	114					13	
4	4	40	46	70	86	102	106											7	58%
5	2	28	37	68	76	78	87	91	107	113	125	128						12	
6	3	16	42	50	62	75											25% Time	6	
7	47	53	55	111	115	123												6	
8	52	66	71	90	93	129												6	
9	23	29	77	85	88	108	112											7	
10	15	105																2	28.5%
11	25	30	49	69	130													5	
12	27	51	64	92	95													5	
13	17	72	80														50% Time	3	
14																		0	
15	26	96																2	
16	21	31																2	
17	7																	1	
18	81	109																2	
19																		0	
20																		0	13.5%
21	120	124																2	
22	119																	1	
23	5	98																2	
24																		0	
25	84																	1	
26	41	94	110															3	
																		119	

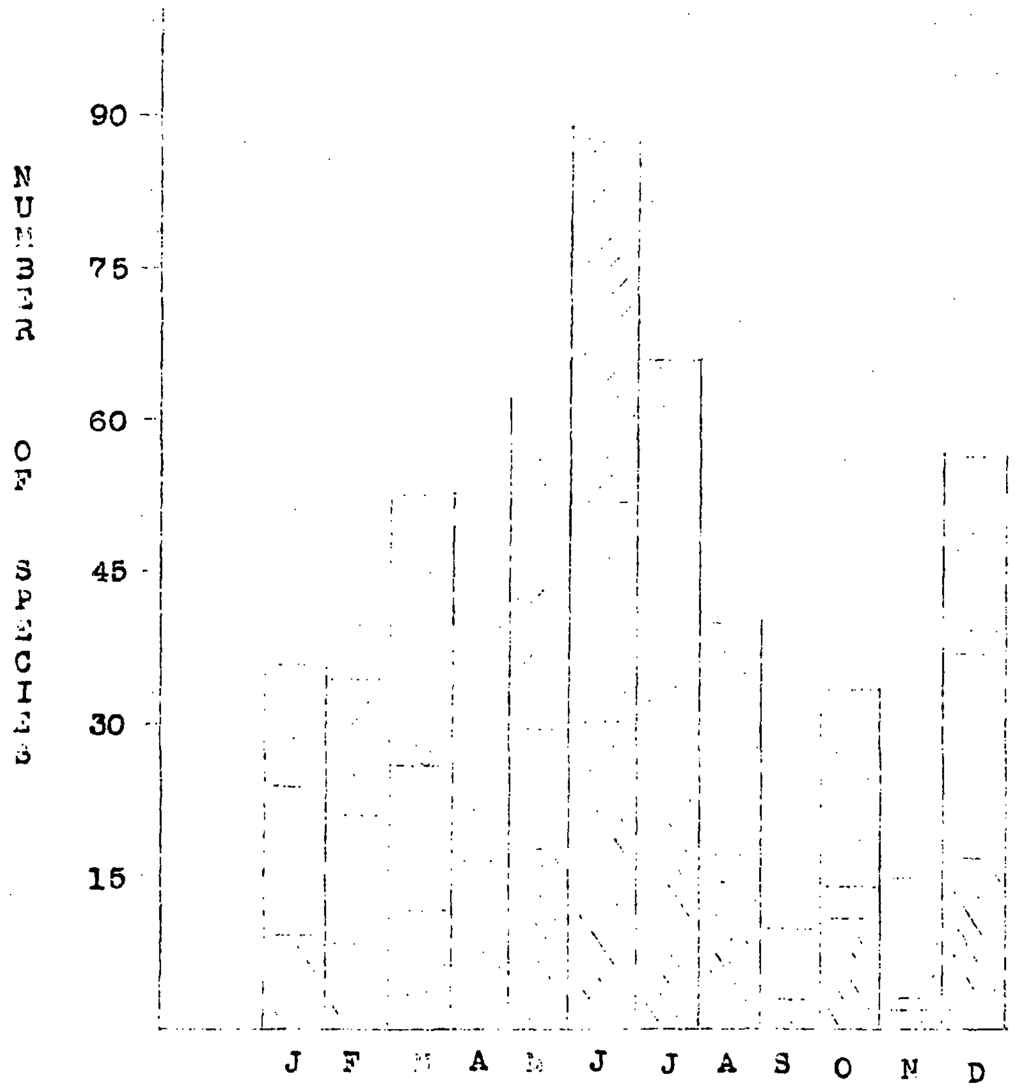

Fig. A-2. Three year average phyletic composition of benthic algae in Barnegat Bay.

Chlorophyta Phaeophyta Rhodophyta

B. Species composition (Cont'd)

occurs in June. We thought, at first, that this might indicate bias due to our sampling schedule. However, in 1968 our sampling schedule was evenly distributed throughout the year and June still proved to yield the greatest number of species. September, on the other hand, produces a paucity in diversity. Very few species occur - in fact, no brown algae have ever been detected in Barnegat Bay during September. Throughout any year, the number of species increases markedly between March and June. The Phaeophyta especially increase in percent during this period. During the warmer months, the reproductive capacity of most species appears to be stressed. This is followed by a precipitous drop in species composition, reaching a low of eleven species in September. It must be pointed out, however, that September has always been the month of least activity in the Bay, so a sampling error may be involved here. At any rate, the species composition remains low until the winter dominants appear in December.

There seems to be no change in the ratio of Chlorophyta versus Rhodophyta throughout the year; that is, their relative abundance is roughly equal during any one month. The Phaeophyta show the greatest degree of change throughout the yaar and may be much more sensitive to temperature change.

The four year totals for all phyletic groups of algae are indicated in fig. A-3.

C. Probability of occurring.

A study was made of the probability of any species of benthic algae occurring on a baywide basis. The species were ranked according to their probability of occurring 12 months out of 12, 11 out of 12, ..., 11 out of 11, 10 out of 11, ... etc. We were then able to construct a sequential checklist which would read from the most probable species (the dominants) to the least probable species (the rare forms). Those species that would occur with equal probability are listed together. We would, indicate that in some instances only the Genus was identified, species could not be ascertained due to the lack of fruiting bodies. The final list is presented on page 18 and 19. The number beside each species indicates its probable rank in any collection at any time of the year. For example, number 34 (Pilaiella littoralis) will occur with greater probability (and frequency) than number 55 (Ralfsia verrucosa).

Fig. A-4 is a plot of the frequency - probability distribution for benthic algea. It is simply a matrix which demonstrates how difficult it becomes to predict the occurrence of any species of benthic algae. In general, the fewer months a species appears, the more difficult it becomes to predict that that species will appear with the same frequency year after year. Some species are consistent in their distribution, year after year; these appear at the 1.000 probability level. On the other hand, nearly 50 percent of the species cannot be predicted with a probability of 1.000. At least

Figure A-3

FOUR-YEAR TOTALS FOR ALGAE COLLECTED IN BARNEGAT BAY, NEW JERSEY. DOES NOT INCLUDE BARNEGAT LIGHT OR SHORE STATIONS.

MONTH	NUMBER OF SPECIES					o/o COMPOSITION			
	CHLOROPHYTA	XANTHOPHYTA	PHAEOPHYTA	RHODOPHYTA	TOTAL	CHLOROPHYTA	XANTHOPHYTA	PHAETOPHYTA	RHODOPHYTA
JAN	10	0	14	13	37	27.0	0	37.8	35.1
FEB	9	0	14	12	35	25.7	0	40.0	34.2
MAR	13	0	15	22	50	26.0	0	30.0	44.0
APR	8	0	9	15	32	25.0	0	28.1	46.8
MAY	19	0	21	24	64	29.6	0	32.8	37.5
JUN	31	1	22	35	89	34.8	1.1	24.7	39.3
JUL	25	0	8	34	67	37.3	0	11.9	50.7
AUG	15	0	3	23	41	36.5	0	7.3	56.0
SEP	3	0	0	8	11	27.2	0	0	72.0
OCT	12	0	3	23	38	31.5	0	7.8	60.5
NOV	2	0	1	13	16	12.5	0	6.2	81.2
DEC	17	0	21	19	57	29.8	0	36.8	33.3

Species of Benthic Algae Listed in Decreasing Frequency Through Year.

I 1. Ulva lactuca, 2. Agardhiella tenera, 3. Ceramium fastigiatum, 4. Champia parvula, 5. Gracilaria verrucosa, 6. Polysiphonia harveyi

II 7. Acrochaetium sp., 8. Polysiphonia nigrescens

III 9. Gracilaria foliifera

IV 10. Codium fragile ssp. tomentosoides, 11. Entocladia viridis 12. Polysiphonia denudata

V 13. Enteromorpha intestinalis, 14. Callithamnion sp.

VI 15. Enteromorpha linza, 16. Desmotrichium undulatum

VII 17. Halothrix lumbricalis, 18. Rhodophysema georgii

VIII 19. Ceramium rubrum

IX 20. Cladophora sp.

X 21. Punctaria latifolia

XI 22. Chaetomorpha linum, 23. Punctaria plantaginea, 24. Stilophora rhizodes, 25. Callithamnion roseum

XII 26. Cladophora gracilis f. expansa, 27. Sphacelaria cirrosa, 28. Erythrotrichia carnea, 29. Spyridia filamentosa

XIII 30. Asperococcus echinatus

XIV 31. Enteromorpha prolifera, 32. Ectocarpus confervoides, 33. Ectocarpus confervoides v. heimalis, 34. Pylaiella littoralis, 35. Goniotrichium alsisii, 36. Hildenbrandia prototypus

XV 37. Myrionema strangulans

XVI 38. Ceramium rubriforme

XVII 39. Enteromorpha marginata, 40. Enteromorpha plumosa, 41. Ralfsia clavata, 42. Polysiphonia nigra

XVIII 43. Bryopsis hypnoides, 44. Bryopsis plumosa

XIX 45. Ectocarpus siliculosus, 46. Giffordia granulosa

XX 47. Enteromorpha biflagellata, 48. Ulvella lens, 49. Antithamnion cruciatum

XXI 50. Cladophora glaucescens, 51. Enteromorpha clathrata, 52. Rhizoclonium sp., 53. Ectocarpus sp., 54. Myriotrichia clavaeformis, 55. Ralfsia verrucosa, 56. Scytosiphon lomentaria, 57. Fosliella lejolisii, 58. Polysiphonia subtilissima

XXII 59. Cladophora gracilis, 60. Elachistea fucicola, 61. Ceramium diaphanum,
62. Porphyra umbilicalis

XXIII 63. Ascophyllum nodosum v. scorpiodes, 64. Hypnea musciformis

XXIV 65. Chaetomorpha aerea

XXV 66. Cladophora refracta, 67. Enteromorpha compressa,
68. Rhizoclonium riparium, 69. Farlowiella onusta,
70. Chondria tenuissima, 71. Griffithsoa tenuis, 72. Lomentaria baileyana

XXVI 73. Codiolum gregarium, 74. Ulothrix implexa, 75. Desmarestia viridis,
76. Myriotrichia filiformis, 77. Bangia ciliaris, 78. Gelidium crinale

XXVII 79. Cladophora crystallina, 80. Callithamnion byssoides,
81. Callithamnion corymbosum

XXVIII 82. Cladophora albida, 83. Cladophora albida v. refracta,
84. Cladophora expansa, 85. Cladophora flexousa, 86. Gomontia polyrhiza,
87. Protoderma marinum, 88. Ectocarpus tomentosus, 89. Giffordia sp.,
90. Leathesia difformis, 91. Bangia fuscoprupurea, 92. Chondria baileyana,
93. Chondria sedifolia, 94. Lomentaria baileyana v. valida,
95. Porphyra leucosticta

XXIX 96. Cladophora gracilis f. tenuis, 97. Kylinia sp., 98. Polysiphonia sp.,
99. Polysiphonia urceolata

XXX 100. Blidingia minima, 101. Cladophora flavescens,
102. Cladophora rudolphiana, 103. Monostroma oxyspermum,
104. Percursaria percursa, 105. Vaucharia sp., 106. Fucus sp.,
107. Giffordia mitchellae, 108. Petalonia fascia,
109. Punctaria latifolia f. crispata, 110. Acrochaetium flexosum,
111. Callithamnion baileyi, 112. Chondria sp., 113. Chondria strictum,
114. Cruoriopsis ensis, 115. Dasya pedicellata,
116. Lomentaria baileyana v. filiformis,
117. Polysiphonia harveyi v. arietina, 118. Polysiphonia harveyi v. olueyi

Rare forms

XXXI 119. Spirogyra sp., 120. Seirospora griffithsiana, 121. Spermothamnion sp.
122. Desmotrichium balticum, 123. Anabaena sp., 124. Calothrix sp.,
125. Hyella sp., 126. Lygbya sp., 127. Oscillotoria sp., 128. Spirulina sp.
129. Striatella unipunctata 130. Schizonema grevelli (diatom)
131. Ruppia maritima 132 Zostera marina
133 Endophyton sp. 134. Agmenellum quadrupicatum
135. Biddulphia pulchella 136. Ulothrix fucca

just started to get data

Fig.A-4. Frequency-probability distribution for benthic algae. Example, there are four species of algae which have a 0.777 probability of occurring nine months of the year.

PROBABILITY LEVEL	1	2	3	4	5	6	7	8	9	10	11	12
1.000	19	18	7	9	4	1	1	2		1		6
.917												2
.888									2			
.875								4				
.857							6					
.833						2						3
.800					4					1		
.777									4			
.750				6				1				2
.714							2					
.666			4			2			1			1
.625								3				
.600					3							
.571							4					

Occurrence (# months)

C. Probability of occurring (Cont'd)

30 percent of the species can only be predicted with an accuracy or probability of less than 0.800. One must, therefore, be cautious in predicting the occurrence of an algae species in Barnegat Bay.

D. Prediction tables.

Careful qualitative analysis of the benthic algae for three continuous years of data allow one to make predictions regarding the temporal distribution of each species throughout any year. These distributions can be best presented in bar diagrams, where each species is listed along with its probable distribution throughout a year. Such a depiction is presented in Fig. A-5. These two pages indicate the most probable occurrence of all species collected in Barnegat Bay. (Errata - Cladophora albida and Cladophora albida v. refracta were inadvertently omitted from this list; both of these species are limited to the months of May and June). An arrangement of species as in Fig. A-5 allows one to visually perceieve two things: I) The individual occurrence of any species of algae - for example, the dominant species listed on the probability checklist appear as a block assemblage or algae which are found throughout the year. II) By reading down the columns, one can detect assemblages of algae which are found during certain months of the year. Unfortunately, such a presentation tells us nothing about the abundance of each species, nor anything about its spacial distribution. We may, however, use such prediction tables to actually test the distribution of species in Barnegat Bay. For this purpose, we have constructed a probable-distribution table for the top 66% of the species of the checklist; this data is present in Fig. A-6. It is apparent from this figure that June still represents the month with the greatest number of species. Each species is listed by code number and rank. The actual species can be determined by referring to Fig. A-5; the rank number indicates its relative probability of occurring. Again, assemblages of algae can be seen. A more detailed analysis of assemblages will have to await analysis of this data by standard association techniques. We have essentially repeated Fig. A-6 for each year in Figs. A-7 - A-10. If one compares the actual occurrence of each species with the predicted occurrence of Fig. A 6, one finds that out of 825 independent observations of individual species of algae, only 23 observations (or 2.78%) were predicted wrong. That is, only 23 observations of algae occurred outside of the months in which it was predicted to occur. Thus, Fig. A-6 provides a good estimate of which species one is likely to find in Barnegat Bay during any month. If the species does, in fact, not occur during its predicted month, we would not be as disturbed as when it occurs during a month when it was not predicted. The reason for this statement is clear: it is more likely that we will miss a species during a month, because of sampling error, than it is for a warm water species, say, to occur during the winter.

Fig. A-5 Predicted Annual Species Distribution of Benthic Algae in Barnegat Bay

CODE	TYPE	RANK	SPECIES	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
40	G	74	Uloth. implexa			X	X	X	X						
128	R	62	Porphy. umbilic.			X	X	X	X	X					
2	G	43	Bryops. hypnoides			X	X	X	X	X	X				
80	B	24	Stiloph. rhizodes			X	X	X	X	X	X	X	X		
77	B	56	Scytosi. loment.		X	X	X	X							
47	B	30	Aspercocc. echinatus		X	X	X	X	X	X					
62	B	46	Giff. granulosa		X	X	X	X	X	X	X				
53	B	45	Ectocarp. siliculo.		X	X	X	X	X	X	X				
51	B	32	Ectocarp. conferv.		X	X	X	X	X	X	X				
52	B	33	Ectocarp. conf. heim.		X	X	X	X	X	X	X				
73	B	34	Pylaiella littor.		X	X	X	X	X	X	X				
108	R	35	Goniotric. alsidii		X	X	X	X	X	X	X				
70	B	21	Punctar. latifol.		X	X	X	X	X	X	X				
27	G	15	Enterom. linza		X	X	X	X	X	X	X	X			
66	B	37	Myrionema strang.		X	X	X	X	X	X	X	X			
72	B	23	Punctar. plantag.		X	X	X	X	X	X	X	X			
23	G	47	Enterom. biflag.		X	X	X	X	X	X	X	X			
17	G	26	Clado. grac. expans.		X	X	X	X	X	X	X	X			
78	B	27	Sphacel. cirrosa		X	X	X	X	X	X	X	X	X		
64	B	17	Halothr. lumbr.		X	X	X	X	X	X	X	X	X		
129	R	18	Rhodophy. georgii		X	X	X	X	X	X	X	X	X		
105	R	28	Erythro. carnea	X	X	X	X	X	X	X	X	X			
49	B	16	Desmotric. undulat.	X	X	X	X	X	X	X	X	X			
98	R	4	Champia parvula	X	X	X	X	X	X	X	X	X	X	X	X
120	R	6	Polysiph. harveyi	X	X	X	X	X	X	X	X	X	X	X	X
94	R	3	Ceramium fastig.	X	X	X	X	X	X	X	X	X	X	X	X
110	R	5	Gracilaria verru.	X	X	X	X	X	X	X	X	X	X	X	X
41	G	1	Ulva lactuca	X	X	X	X	X	X	X	X	X	X	X	X
84	R	2	Agard. tenera	X	X	X	X	X	X	X	X	X	X	X	X
81	R	7	Acrochae. sp.	X	X	X	X	X	X	X	X	X	X	X	X
124	R	8	Polysiph. nigres.	X	X	X	X	X	X	X	X	X	X	X	X
21	G	10	Codium fragile	X	X	X	X	X	X	X	X	X	X	X	X
31	G	11	Entocladia viri.	X	X	X	X	X	X	X	X	X	X	X	X
119	R	12	Polysiph. denud.	X	X	X	X	X	X	X	X	X	X	X	X
88	R	14	Callitham. sp.	X	X	X	X	X	X	X	X	X	X	X	X
26	G	13	Enterom. intest.	X	X	X	X	X	X	X	X	X	X	X	X
7	G	20	Cladoph. sp.	X	X	X	X	X	X	X	X	X	X	X	X
96	R	19	Ceram. rubrum	X	X			X	X	X	X	X	X	X	X
109	R	9	Gracilaria f[illegible]li.	X	X			X	X	X	X	X	X	X	X
95	R	38	Ceramium rubr[illegible]	X				X	X	X	X	X	X	X	X
42	G	48	Ulvella lens	X						X	X	X	X	X	X
5	G	22	Chaetomor. linum	X						X	X	X	X	X	X
85	R	49	Antitham. crucia.	X						X	X	X	X	X	X
4	G	65	Chaetom. aerea.	X							X	X	X	X	X
130	R	29	Spyridia filament.	X	X	X				X	X	X	X	X	X
92	R	25	Callitham. roseum	X	X	X					X	X	X	X	X
76	B	65	Ralfsia verru.		X						X				X
71	B	109	Punctar. lat. fol.		X										
57	B	69	Farlow. onusta		X					X	X	X	X	X	X
68	B	76	Myriotrich. filifor.		X			X	X	X					
67	B	54	Myriotrich. clavae.		X					X	X	X			
25	G	51	Enterom. clath.		X					X	X	X			
29	G	40	Enterom. plumosa		X					X	X	X	X		
46	B	63	Ascophy. nodos. scor.	X	X					X	X	X			X
38	G	68	Rhizo. riparium		X						X	X			
125	R	58	Polysiph. subtil.		X						X	X	X		
28	G	39	Enterom. margin.		X			X			X	X	X		
106	R	57	Fosliella lejo.		X			X	X			X			
37	G	52	Rhizo. sp.		X		X				X	X			
50	B	53	Ectocarp. sp.		X		X			X	X				
24	G	67	Enterom. compres.		X		X				X				
54	B	88	Ectocarp. tomento.		X	X									
19	G	66	Clado. refracta			X					X	X			
75	B	41	Ralfsia clavata			X				X	X	X			X
30	G	31	Enterom. prolif.			X	X				X	X	X	X	X

Fig. A-5 Predicted Annual Species Distribution of Benthic Algae in Barnegat Bay (Cont'd)

CODE	TYPE	RANK	SPECIES	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
127	R	95	Porphy. leuco.				XXXX	XXXX							
48	B	75	Desmar. viridis				XXXX	XXXX	XXXX	XXXX					
3	G	44	Bryopsis plumosa				XXXX	XXXX	XXXX	XXXX	XXXX				
55	B	60	Elachist. fucic.				XXXX	XXXX	XXXX	XXXX	XXXX				
1	G	100	Blidingia mini.					XXXX							
97	R	113	Chondria strictum					XXXX							
114	R	97	Kylinia sp.					XXXX	XXXX	XXXX					
87	R	77	Bangia ciliaris					XXXX	XXXX	XXXX	XXXX				
123	R	42	Polysiph. nigra					XXXX	XXXX	XXXX	XXXX				
10	G	79	Clado. crystal.					XXXX	XXXX	XXXX	XXXX	XXXX			
18	G	96	Clado. gracilis						XXXX	XXXX	XXXX				
113	R	64	Hypnea musci.						XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	
112	R	36	Hildenbr. proto.						XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
69	B	108	Petanonia fascia							XXXX					
14	G	85	Clado. flexousa							XXXX	XXXX				
61	B	89	Giffordia sp.							XXXX	XXXX				
86	R	91	Bangia fusco.							XXXX	XXXX				
65	B	90	Leathesia diffo.							XXXX	XXXX				
118	R	98	Polysiph. sp.							XXXX	XXXX	XXXX			
22	G	73	Codiolum greg.							XXXX	XXXX	XXXX	XXXX		
15	G	50	Clado. glauc.							XXXX	XXXX	XXXX	XXXX		
44	Y	105	Vaucheria sp.								XXXX				
13	G	101	Clado. flaves.								XXXX				
104	R	115	Dasya pedicel.								XXXX				
20	G	102	Clado. flaves.								XXXX				
82	R	110	Acrochaet. flex.								XXXX				
58	B	106	Fucus sp.								XXXX				
122	R	118	Polysiph. harv. olue.								XXXX				
63	B	107	Giffordia mitch.								XXXX				
101	R	93	Chondria sedif.								XXXX	XXXX			
100	R	92	Chondria bailey.								XXXX	XXXX			
32	G	86	Gomontia poly.								XXXX	XXXX			
11	G	84	Clado. expansa								XXXX	XXXX			
115	R	72	Loment. bailey.								XXXX	XXXX	XXXX		
111	R	71	Griff. tenuis.								XXXX	XXXX	XXXX		
102	R	70	Chondria tenuis.								XXXX	XXXX	XXXX		
107	R	78	Gelidium crinale								XXXX	XXXX	XXXX	XXXX	
16	G	59	Clado. gracilis								XXXX	XXXX	XXXX	XXXX	XXXX
93	R	61	Ceramium diaph.								XXXX	XXXX	XXXX	XXXX	XXXX
90	R	80	Callitham. bysso.								XXXX	XXXX	XXXX	XXXX	XXXX
91	R	81	Callitham. corym.								XXXX	XXXX	XXXX	XXXX	XXXX
36	G	87	Protoder. marinum									XXXX			XXXX
103	R	114	Cruorio. ensis									XXXX			
116	R	116	Loment. bail. fili.									XXXX			
99	R	112	Chondria sp.									XXXX			
34	G	104	Percur. percur.									XXXX			
117	R	94	Loment. bail. vali.									XXXX	XXXX		
33	G	103	Monost. oxysperm.										XXXX		
126	R	99	Polysiph. urceol.										XXXX	XXXX	XXXX
89	R	111	Callitham. baileyi												XXXX
121	R	117	Polysiph. harv. ariet												XXXX

Fig. A-6 Most Probable Species Distribution Predicted for [illegible] Period (1965-1968) in Barnegat Bay

Code	Rank	Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct
40	74	
128	62	
2	43	
80	24	
77	56	
47	30	
62	46	
53	45	
51	32	
52	33	
73	34	
108	35	
70	21	
27	15	
66	37	
72	23	
23	47	
17	26	
78	27	
64	17	
129	18	
105	28	
49	16	
98	4	
120	6	
94	3	
110	5	
41	1	
84	2	
81	7	
124	8	
21	10	
31	11	
119	12	
88	14	
26	13	
7	20	
96	19	
109	9	
95	38	
42	48	
5	22	
85	49	
4	65	
130	29	
92	25	
76	55	
57	69	
67	54	
25	51	
29	40	
46	63	
38	68	
125	58	
28	39	
106	57	
37	52	
50	53	
24	67	
19	66	
75	41	
30	31	
3	44	
55	60	
123	42	
113	64	
[illegible]2	36	
22	73	
15	50	
115	72	
111	71	
[illegible]02	70	

Fig.A-7. Distribution of Benthic Algae in Barnegat Bay
1965

Code	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
40												
128												
2												
80								XXXX	XXXX	XXXX		
77												
47												
62												
53												
51												
52												
73												
108												
70								XXXX				
27									XXXX			
66									XXXX			
72								XXXX				
23									XXXX			
17								XXXX	XXXX	XXXX		
78								XXXX	XXXX			
64												
129												
105									XXXX			
49												
98		XXXX						XXXX	XXXX			XXXX
120								XXXX	XXXX	XXXX		
94		XXXX						XXXX	XXXX	XXXX		XXXX
110		XXXX						XXXX	XXXX	XXXX		XXXX
41		XXXX						XXXX	XXXX	XXXX		XXXX
84								XXXX	XXXX	XXXX		XXXX
81								XXXX	XXXX	XXXX		
124		XXXX						XXXX	XXXX	XXXX		XXXX
21		XXXX										
31									XXXX	XXXX		
119									XXXX	XXXX		XXXX
88		XXXX								XXXX		
26								XXXX	XXXX	XXXX		
7								XXXX	XXXX	XXXX		
96								XXXX				
109								XXXX				
95		XXXX						XXXX	XXXX			
42										XXXX		
5								XXXX	XXXX	XXXX		XXXX
85									XXXX			
4												XXXX
130									XXXX	XXXX		
92		XXXX								XXXX		XXXX
76												
57												
67												
25								XXXX	XXXX			
29									XXXX			
46												
38								XXXX	XXXX			
125									XXXX			
28									XXXX			
106									XXXX			
37									XXXX			
50												
24												
19												
75									XXXX			
30								XXXX	XXXX			
3												XXXX
55												
123								XXXX				
113									XXXX			
112									XXXX	XXXX		
22									XXXX			
15									XXXX			
115								XXXX	XXXX	XXXX		
111									XXXX			
102								XXXX	XXXX	XXXX		
16									XXXX			XXXX
93									XXXX			

Fig. A-8. Distribution of Benthic Algae in Barnegat Bay

1966

CODE	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
40												
128												
2												
80							XXXX		XXXX			
77		XXXX										
47							XXXX					
62		XXXX										
53		XXXX					XXXX	XXXX				
51		XXXX					XXXX	XXXX				
52								XXXX				
73		XXXX					XXXX	XXXX				
108								XXXX				
70		XXXX			XXXX			XXXX				
27							XXXX	XXXX				
66							XXXX					
72		XXXX					XXXX	XXXX	XXXX			
23								XXXX	XXXX			
17							XXXX	XXXX	XXXX			
78							XXXX	XXXX	XXXX			
64		XXXX					XXXX	XXXX		XXXX		
129												
105	XXXX	XXXX						XXXX				
49	XXXX	XXXX						XXXX				
98	XXXX	XXXX					XXXX	XXXX	XXXX	XXXX	XXXX	
120		XXXX							XXXX	XXXX	XXXX	XXXX
94	XXXX	XXXX					XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
110	XXXX	XXXX					XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
41	XXXX	XXXX					XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
84	XXXX	XXXX					XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
81	XXXX	XXXX					XXXX	XXXX				XXXX
124							XXXX	XXXX	XXXX			XXXX
21		XXXX					XXXX	XXXX	XXXX			
31							XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
119	XXXX	XXXX					XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
88								XXXX				XXXX
26									XXXX			
7		XXXX					XXXX	XXXX	XXXX			
96		XXXX					XXXX	XXXX	XXXX	XXXX		
109	XXXX						XXXX	XXXX			XXXX	XXXX
95							XXXX	XXXX	XXXX			XXXX
42							XXXX	XXXX				
5							XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
85		XXXX					XXXX	XXXX	XXXX			XXXX
4								XXXX	XXXX			
130							XXXX	XXXX	XXXX			
92		XXXX						XXXX	XXXX	XXXX		XXXX
76								XXXX	XXXX			XXXX
57							XXXX	XXXX				
67												
25		XXXX					XXXX	XXXX	XXXX			
29							XXXX	XXXX	XXXX	XXXX		
46		XXXX						XXXX				XXXX
38		XXXX										
125												
28												
106												
37		XXXX						XXXX				
50							XXXX	XXXX				
24												
19												
75							XXXX	XXXX				XXXX
30								XXXX	XXXX			
3							XXXX	XXXX				
55							XXXX	XXXX				
123								XXXX				
113								XXXX		XXXX	XXXX	
112							XXXX	XXXX	XXXX	XXXX		
22							XXXX			XXXX		
15							XXXX	XXXX	XXXX	XXXX		
115												

Fig. A-9 Distribution of Benthic Algae in Barnegat Bay
1967

Code	Nov	Dec.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
40					XXXX							
128				XXXX			XXXX					
2				XXXX	XXXX		XXXX	XXXX				
80					XXXX		XXXX	XXXX				
77		XXXX						XXXX	XXXX	XXXX		
47		XXXX		XXXX	XXXX							
62		XXXX		XXXX	XXXX			XXXX				
53		XXXX		XXXX	XXXX			XXXX				
51		XXXX		XXXX	XXXX		XXXX	XXXX				
52		XXXX		XXXX	XXXX			XXXX				
73												
108		XXXX		XXXX	XXXX			XXXX				
70		XXXX										
27		XXXX		XXXX	XXXX		XXXX	XXXX				
66								XXXX		XXXX		
72				XXXX	XXXX		XXXX	XXXX				
23				XXXX				XXXX				
17		XXXX			XXXX			XXXX	XXXX	XXXX		
78												
64		XXXX		XXXX	XXXX		XXXX	XXXX				
129		XXXX		XXXX			XXXX	XXXX		XXXX		
105		XXXX		XXXX	XXXX			XXXX	XXXX			
49		XXXX		XXXX	XXXX		XXXX	XXXX				
98		XXXX		XXXX			XXXX	XXXX	XXXX	XXXX		XXXX
120		XXXX		XXXX			XXXX	XXXX	XXXX	XXXX		XXXX
94		XXXX		XXXX	XXXX		XXXX	XXXX	XXXX	XXXX		XXXX
110		XXXX		XXXX	XXXX		XXXX	XXXX	XXXX	XXXX		XXXX
41		XXXX		XXXX	XXXX		XXXX	XXXX	XXXX	XXXX		XXXX
84		XXXX		XXXX	XXXX		XXXX	XXXX	XXXX	XXXX		XXXX
81		XXXX		XXXX	XXXX			XXXX	XXXX			
124		XXXX		XXXX	XXXX		XXXX	XXXX	XXXX			XXXX
21		XXXX		XXXX	XXXX			XXXX	XXXX	XXXX		XXXX
31		XXXX								XXXX		XXXX
119		XXXX			XXXX		XXXX	XXXX	XXXX	XXXX		XXXX
88		XXXX		XXXX			XXXX		XXXX			
26		XXXX					XXXX	XXXX	XXXX	XXXX		XXXX
7		XXXX		XXXX			XXXX	XXXX	XXXX	XXXX		XXXX
96		XXXX					XXXX	XXXX	XXXX			XXXX
109		XXXX			XXXX		XXXX	XXXX	XXXX	XXXX		XXXX
95					XXXX		XXXX		XXXX			
42		XXXX										XXXX
5		XXXX		XXXX	XXXX		XXXX	XXXX	XXXX	XXXX		XXXX
85							XXXX		XXXX			
4		XXXX										
130		XXXX						XXXX	XXXX	XXXX		XXXX
92		XXXX								XXXX		
76				XXXX	XXXX							
57		XXXX										
67		XXXX						XXXX	XXXX			
25		XXXX					XXXX	XXXX				
29		XXXX					XXXX	XXXX				
46							XXXX					
38												
125		XXXX							XXXX	XXXX		
28		XXXX			XXXX			XXXX		XXXX		
106		XXXX			XXXX							
37		XXXX		XXXX								
50		XXXX		XXXX			XXXX	XXXX				
24		XXXX			XXXX			XXXX				
19									XXXX			
75		XXXX										
30				XXXX				XXXX	XXXX	XXXX		XXXX
3				XXXX	XXXX							XXXX
55				XXXX			XXXX	XXXX				
123					XXXX		XXXX	XXXX				XXXX
113										XXXX		
112									XXXX	XXXX		
22												
15							XXXX	XXXX	XXXX	XXXX		
115									XXXX			
111								XXXX	XXXX	XXXX		
102										XXXX		
16										XXXX		XXXX
23												

Fig.A-10. Distribution of Benthic Algae in Barnegat Bay - 1968

Code	Nov	Dec.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
40			XXXX		XXXX	XXXX						XXXX
128			XXXX		XXXX	XXXX						
2			XXXX									
80			XXXX		XXXX	XXXX	XXXX	XXXX				
77			XXXX			XXXX	XXXX	XXXX				
47			XXXX		XXXX	XXXX						
62			XXXX									
53												
51	XXXX		XXXX		XXXX		XXXX	XXXX				
52			XXXX		XXXX	XXXX						
73												
108			XXXX		XXXX		XXXX	XXXX				
70												
27			XXXX		XXXX	XXXX	XXXX					
66					XXXX	XXXX	XXXX					
72			XXXX		XXXX			XXXX		XXXX		
23						XXXX		XXXX				
17			XXXX					XXXX				
78								XXXX	XXXX			
64			XXXX		XXXX	XXXX						
129			XXXX		XXXX	XXXX						
105							XXXX					
49			XXXX		XXXX	XXXX						
98			XXXX		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
120		XXXX	XXXX		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		XXXX
94			XXXX		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
110	XXXX	XXXX	XXXX		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
41	XXXX	XXXX	XXXX		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
84		XXXX	XXXX		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
81			XX		XXXX	XXXX	XXXX	XXXX		XXXX		
124			XX		XXXX	XXXX	XXXX	XXXX				
21	XXXX	XXXX			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
31			XXXX		XXXX	XXXX	XXXX	XXXX	XXXX			
119	XXXX		XXXX		XXXX		XXXX	XXXX	XXXX	XXXX		XXXX
88					XXXX							
26	XXXX	XXXX	XXXX		XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
7		XXXX				XXXX	XXXX	XXXX				
96	XXXX	XXXX			XXXX	XXXX	XXXX	XXXX	XXXX			
109		XXXX			XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		XXXX
95							XXXX	XXXX				
42						XXXX						
5			XXXX			XXXX	XXXX	XXXX		XXXX		
85								XXXX	XXXX			
4		XXXX										
130	XXXX	XXXX	XXXX					XXXX	XXXX	XXXX		XXXX
92			XXXX					XXXX				
76			XXXX							XXXX		
57												
67												
25							XXXX	XXXX				
29							XXXX		XXXX			
46												
38												
125								XXXX		XXXX		
28												
106	XXXX	XXXX				XXXX				XXXX		XXXX
37												
50												
24											XXXX	
19			XXXX					XXXX			XXXX	
75								XXXX				
30			XXXX					XXXX	XXXX			
3								XXXX				
55	XXXX	XXXX			XXXX		XXXX					
123						XXXX						
113												
112						XXXX						
22												
15							XXXX	XXXX				
115								XXXX				
111								XXXX				
102												
16								XXXX				
93								XXXX				

D. Prediction tables (cont'd)

In Fig. A-11, we have arranged those species which will occur only once, twice, thrice, etc. in any given year. Fig. A-11-A and Fig. A-11-B differ primarily in the probability level of occurring, with Fig. A-11-A being more accurate. Again, this type of plot says nothing about spacial relations or quantity (abundance) of each species. However, on a baywide basis it compares favorably with the actual data of Fig. A-1.

Fig. A-12 predicts the relative abundance of each phyletic group of algae. Again, you will notice that the Chlorophyta and Rhodophyta are relatively equal throughout the year, whereas the Phaeophyta diminish toward September and occur in greatest abundance in the winter.

E. General conclusions on benthic algae.

Although extreme variability may occur in natural populations due to environmental factors which may be subtle or blantantly obvious, variability often is a function of the quantitative aspects of species composition. In Barnegat Bay, the benthic algae do vary in their abundance throughout the year. This is illustrated in the quantitative study of biomass summerized in Fig. A-13. However, the qualitative aspects of benthic algae in Barnegat Bay seem to be more stable, year to year. This is especially true for the season in which certain species can be expected to appear. Only one dominant has appeared during the study which was not a dominant prior to 1965 - this was *Codium fragile*. No dominants have disappeared and no rare forms have become common. The diversity of algae in Barnegat Bay has remained high throughout the study, which suggests that a rather stable community persists. We would predict, therfore, that in the absence of any stressful conditions in the bay, that the algae populations will first, adjust to the ensuing competition generated by *Codium* and then continue to exhibit a heterogeneous composition with few or no rare forms changing their status. In short, we would expect the algae populations to behave in a conservative manner. One distinct possibility which might result from the thermal addition conditions, which will occur soon, is the loss of species in the Phaeophyta during the summer months. We anticipate no change in the ratio of Chlorophyta to Rhodophyta after thermal addition.

Fig.A-11. Species distribution of benthic algae over three years. Fig. A.Species that occur at least once during indicated month, with probability level of 1.000. Fig. B. Species that occur at least once during indicated month, with probability level 1.000 and less.

Fig. A.

	Species																			Total
1	1	13	20	33	34	44	58	63	69	71	82	89	99	97	103	104	116	121	122	19
2	8	9	11	14	32	36	54	61	65	86	100	101	117	127	18	114	118	126		18
3	19	24	38	57	102	111	115	22	40	48	68	87	107							13
4	15	25	37	50	67	76	77	106	125	16	55	93	128	46	113	4				16
5	28	29	75	123	2	3	53	62	23	42	85									11
6	47	30	51	52	73	108	112	66	95											9
7	70	5	72	80	92	17	78	105	130											9
8	27	49	64	129	96	7														6
9	26	86																		2
10	21	31	119	109																4
11	81	124																		2
12	41	84	94	98	110	120														6

Occurrence, number of months per year.(=Y axis)

Fig. B.

	Species																			Total
1	1	13	20	33	34	44	58	63	69	71	82	89	99	97	103	104	116	121	122	19
2	8	9	11	14	32	36	54	61	65	86	100	101	117	127	18	114	118	126		18
3	19	24	38	57	102	111	115	18	114	118	126									11
4	15	25	37	50	67	76	77	106	125	22	40	48	68	87	107					15
5	28	29	75	123	16	55	93	128	10	90	91									11
6	47	2	3	46	113															5
7	70	30	31	51	52	73	108	112	53	62	4									11
8	27	49	5	72	80	92	66	23	42	85										10
9	64	129	17	78	105	130	95													7
10	109	96																		2
11																				0
12	41	84	94	98	110	120	81	124	21	31	119	26	86	7						14

Occurrence,number of months per year (=Y axis)

Probability decreases in this direction

Fig.A-12 EXTRAPOLATED SPECIES COUNTS

	NUMBER OF SPECIES					% COMPOSITION			
MONTH	CHLOROPHYTA	XANTHOPHYTA	PHAEOPHYTA	RHODOPHYTA	TOTAL	CHLOROPHYTA	XANTHOPHYTA	PHAEOPHYTA	RHODOPHYTA
JAN	12		16	15	43	27.9	0	37.2	34.9
FEB	13		17	14	44	29.5	0	38.7	31.8
MAR	15		17	22	54	27.8	0	31.5	40.7
APR	13		16	22	51	25.5	0	31.4	43.0
MAY	22		24	25	71	31.0	0	33.8	35.2
JUN	33	1	22	37	92	35.9	1.1	23.9	40.2
JUL	26		9	35	70	37.1	0	12.9	50.0
AUG	16		2	28	46	34.8	0	4.3	60.8
SEP	10		0	22	32	31.2	0	0	68.8
OCT	12		3	23	38	31.6	0	7.9	60.6
NOV	8		2	16	26	30.8	0	7.7	61.6
DEC	17		21	19	57	29.8	0	36.8	33.4

Fig. A-13 Results of the strip harvest studies. Values reported are in grams biomass per square meter, except the values in the two dredge loads for 10-25-67. These are dry weights for the total load.

	8-16-66 (18)			10-16-67 (15-B			10-25-67 (23-A)	Dredge	
Species	Wet	Dry	Dredge	Wet	Dry	Dredge	Diving	No.1	No.2
Bryopsis plumosa									+
Chaetomorpha linum									+
Cladophora sp.									+
Codium fragile ssp. tomontosoides	0.80	0.03	+				0.05	---	0.30
Ulva lactuca	8.10	2.10	+	---	28.7	+		640.0	577.0
Agardhiella tenera	0.30	0.02	+	1.40	0.10	+	0.13	3.70	1.80
Callithamnion sp.					+	+			
Ceramium fastigiatum	0.08	0.01	+		+	+			+
Champia parvula			+			+			+
Gracilaria foliifera						+			
G.verrucosa	63.90	8.60	+	9.10	1.20	+		4.30	19.90
Polysiphonia denudata					+	+			1.30
P. harveyi				0.10	0.001				
P. nigra									+
Spyridia filimentosa					+				

Progress Report #5: Benthic Invertebrates

The animals and their densities (expressed as number per square meter) are presented in the standard format, viz. each species' characteristic number followed by that species' density at the particular quadrate on a specific date. The number within the parentheses following the date is the number of species recorded for quantitative sampling. Where qualitative sampling was also conducted these data are presented following the quantitative material. If an animal appears in both types of samples on the same day this is denoted by an (X) following the species number in the quantitative presentation.

Following the quadrate designation are the specific station locations, these are, for the most part, self explanatory. If no definite location is listed, the station was positioned by use of a sextant and subsequently a three-point-fix. FRC and OCC refer respectively to Forked River Channel, extending from Light 12 to Light 4, and Oyster Creek Channel, from the mouth of Oyster Creek to Light 3.

Animals added to the checklist since the last report are:

90 Carcinus maenas
91 Callipallene brevirostris
92 Nereis succinea
93 Pista cristata
94 Busycon canaliculatum
95 Macoma balthica
96 Amphitrite ornata
97 Yoldia limatula
98 Sthenelais leidyi (picta)
99 Cancer irroratus
100 Haloclava producta
101 Nereis virens
102 Laminoea solitaria
103 Oxyurostylis smithi
104 Sabellaria vulgaris
105 Podarke obscura
106 Pista palmata
107 Metridium senile
108 Drilonereis longa
109 Marphysa sanguinea
110 Tubularia crocea

Quadrate 22A Light [illegible]
June 21 (18)

Species No.	Density
17	183
23	29
25	2
33	7
35	34
42	6
46	101
52	11
55	8
60	[illegible]
6[illegible]	40
[illegible]	36
76	30
78	31
82	11
[illegible]	4
[illegible]	[illegible]

Biomass 10.02 gm/m^2

Quadrate 9AD
June 21 (9)

Species	Density
12	7
18	2
33	6
40	16
48	11
55	1
76	173
77	31
92	23

Biomass 8.27 gm/m^2

Quadrate 23D Mouth Oyster Creek
June 21 (5)

Species No.	Density
48	3
52	190
54	740
72	7
92	9

Quadrate 23[illegible] [illegible] Buoy
June 21 (12)

Species No.	Density
1	43
23	4
29	1
40	2
48	13
[illegible]	4
[illegible]	[illegible]
56	1
59	[illegible]
65	10
72	3
76	82

Biomass 4.81 gm/m^2
Qualitative (10):
16, 18, 24, 29, 39, 48,
56, 59, 63, 65

Benthic Invertebrates

Quadrate 23A Light 3
July 1 (15)

Species No.	Density
1	9
18	2
23	7
24	40
29	1
33	4
35	7
40	4
46	8
60	3
65	36
72	1
73	4
76	35
89	2

Biomass 15.47 gm/m^2

==============================

Quadrate 22A FRC
July 1 (7)

Species No.	Density
17	7
33	16
35	3
46	15
52	14
65	190
72	5

Biomass 3.08 gm/m^2

==============================

Quadrate 22A Light 4
July 1 (9)

Species No.	Density
1	2
17	3
24	60
25	3
29	1
39	pres.
65	36
76	44
96	2

Biomass 6.54 gm/m^2

==============================

Quadrate 22A FRC
July 1 (8)

Species No.	Density
17	3
23	9
43	1
46	60
52	30
60	6
72	7
85	3

Biomass 2.52 gm/m^2

==============================

Benthic Invertebrates

Quadrate 8C July 1 — Light 2 (13)

Species No.	Density
1	5
23	3
25	3
39	pres.
40	9
45	16
48	2
52	5
65	1
73	15
76	16
85	2
92	4

================================

Quadrate 23A July 1 — (17)

Species No.	Density
8	3
16	pres.
17	2
24	11
25	17
35	4
39	pres.
41	1
45	13
48	3
50	9
60	1
72	3
73	20
74	1
76	27
79	2

================================

Quadrate 17C July 1 — F Buoy (10)

Species No.	Density
1	20
17	35
24	2
33	13
52	3
65	32
73	7
76	336
95	1
97	2

Biomass 4.35 gm/m^2

================================

Quadrate 23D July 1 — J Buoy (5)

Species No.	Density
1	10
25	6
48	1
65	37
76	15

Biomass 3.14 gm/m^2

================================

Benthic Invertebrates

Quadrate 14B July 8 — Buoy D (10)

Species No.	Density
17	135
23	6
33	38
45	8
46	101
60	96
65	57
69	23
78	73
89	9

Biomass 6.14 gm/m^2

==============================

Quadrate 15B July 8 — Buoy E (6)

Species No.	Density
17	290
23	9
24	20
46	105
52	49
60	23

Biomass 18.97 gm/m^2

================================

Quadrate 22A July 8 — (10)

Species No.	Density
17	1
18	4
23	4
25	5
33	6
48	4
52	16
65	52
74	9
76	35

Biomass 11.42 gm/m^2

================================

Quadrate 15C July 8 — Buoy D 1 (8)

Species No.	Density
10	pres.
17	11
29	3
33	5
35	9
74	4
76	36
96	2

Biomass 1.93 gm/m^2

==================================

Quadrate 23D July 8 — III-1 (4)

Species No.	Density
52	45
54	40
65	410
95	1

Biomass 4.17 gm/m^2

==================================

Quadrate 25A July 8 — Light 19 (2)

Series No.	Density
54	180
95	3

==================================

Benthic Invertebrates

Quadrate 24A — July 19 — Waretown (7)

Species No.	Density
24	3
33	16
46	8
52	20
60	24
76	55
93	1

Quadrate 16B — July 19 — (5)

Species No.	Density
24	20
45	4
52	100
72	3
76	76

Biomass 2.47 gm/m^2

Quadrate 16B — July 19 — "N 66" (8)

Species No.	Density
1	30
24	13
25	5
33	6
48	6
67	4
73	22
76	154

Quadrate 23D — July 19 — OCC (6)

Species No.	Density
17	8
29	4
54	24
65	80
72	2
92	1

Biomass 3.11 gm/m^2

Quadrate 23D — July 19 — OCC (12)

Species No.	Density
23	20
29	24
33	5
35	7
40	24
48	4
54	5
55	8
65	48
73	4
74	1
76	4

Biomass 8.73 gm/m^2

Quadrate 22B — July 19 — Light 12 (8)

Species No.	Density
9	pres.
15	55
23	40
39	pres.
51	20
54	350
82	3
92	20

Biomass 6.59 gm/m^2

Benthic Invertebrates

Quadrate 17C — Buoy F
July 19 — (8)

Species No.	Density
1	11
17	1
23	7
60	13
67	3
72	3
76	180
97	2

==============================

Quadrate 22A — Light 4
July 29 — (4)

Species No.	Density
40 (X)	71
48	318
65	218
76	50

Biomass 4.97 gm/m^2

Qualitatively found (7)
2, 18, 40, 47, 50, 51, 56

==============================

Quadrate 17C — Buoy F
July 29 — (11)

Species No.	Density
1	10
18 (X)	1
28 (X)	13
48	1
52 (X)	21
63	1
65	3
69	29
73	4
76 (X)	224
97	1

Biomass 3.22 gm/m^2

Qualitative (13)
2, 8, 18, 20, 22, 24, 28, 29,
38, 52, 62, 76, 99

==============================

Quadrate 17A — Buoy G
July 19 — (12)

Species No.	Density
1	21
17	3
23	13
24	31
48	6
52	15
60	12
69	7
72	3
73	12
76	41
98	1

==============================

Quadrate 16B — N66
July 29 — (10)

Species No.	Density
1	23
17	78
23 (X)	6
52	31
60	10
65	24
72	15
73	16
76 (X)	163
93	13

Biomass 5.11 gm/m^2

Qualitative (10)
5,18,23,34,35,40,51,53,59,76

==============================

Benthic Invertebrates

Quadrate 8C, July 29 — Light 2 (10)

Species No.	Density
8 (X)	15
31	7
40 (X)	6
50 (X)	15
52 (X)	40
65 (X)	14
69	7
72	4
76	20
85	3

Qualitative (12)
3,8,18, 20, 28, 39, 40, 42, 50
52, 59, 65

==============================

Quadrate 11, July 29 — Light 1 South (11)

Species No.	Density
8 (X)	7
17	21
18 (X)	9
32	22
40 (X)	4
41	5
72	1
73	16
76 (X)	100
98	1
100	1

Qualitative (14)
5, 8, 18, 29, 34, 37, 38, 40,
50, 52, 56, 62, 63, 76

==============================

Quadrate 15C, Aug.16 — Buoy D 1 (11)

Species No.	Density
17	3
24	7
33 (X)	23
35 (X)	5
45	1
51 (X)	11
52 (X)	12
60	3
73	15
74	3
76 (X)	60

Biomass 1.94 gm/m^2

Qualitative (15)
1, 5, 18, 29, 33, 35, 47, 51
52, 59, 65, 67, 76, 101, 102

==============================

Quadrate 17A, Aug. 16 — Buoy G (15)

Species No.	Density
1	7
17	16
22	2
23	11
28 (X)	5
33	4
45 (X)	66
48	5
51 (X)	3
52 (X)	160
56 (X)	9
60	8
65	12
72	21
76 (X)	67

Biomass 7.61 gm/m^2

Qualitative (12)
2, 18, 21, 28, 34, 45, 50, 51
52, 56, 63, 76

==============================

Quadrate 24A Aug. 16 — Waretown (20)

Species No.	Density
12	1
17	5
18 (X)	8
23	2
25	2
28 (X)	6
33	7
34 (X)	pres.
40 (X)	12
41 (X)	1
48	4
50 (X)	26
52	3
63	1
65	7
69	3
76	68
85	4
93	1
103	1

Qualitative (12)
8, 18, 20, 27, 28, 29, 34, 40, 41, 50, 51, 79

==============================

Quadrate 13A Aug. 16 — Bioy C 1 (8)

Species No.	Density
23	40
24	7
46	93
52	170
59	14
60	10
65	20
89	14

==============================

Quadrate 23D Sept.20 — Light 3 (12)

Species No.	Density
1	9
17	4
29	11
41	3
45 (X)	19
50 (X)	6
51	31
52	56
63 (X)	2
65 (X)	144
76	43
104	many

Biomass 11.21 gm/m^2

Qualitative (15)
2, 5, 20, 21, 22, 34, 37, 39, 40, 45, 49, 50, 63, 65, 101

==============================

Benthic Invertebrates

Quadrate 22A Sept.27 — Light 4 (10)

Species No.	Density
18	4
24	11
29	9
41	26
52	16
65	103
76	27
89	9
93	2
105	1

Biomass 3.01 gm/m^2

================================

Quadrate 23D Sept.27 — Buoy J (13)

Species No.	Density
18	3
23	16
25	9
29	23
41	11
45	15
50	9
52	47
65	200
76	78
92	1
105	1

Biomass 6.83 gm/m^2

================================

Quadrate 22A Sept.27 — FRC (6)

24	18
33	21
46	156
60	3
65	184
83	1

Biomass 16.77 gm/m^2

================================

Quadrate 22A Sept.27 — (11)

Species No.	Density
1	50
23	11
29	4
34	pres.
41	5
45	33
48	11
52	15
65	31
76	145
85	3

================================

Quadrate 15B Sept.27	E Buoy (13)
Species No.	Density
17	210
23	36
24	9
25	7
33	15
39	pres.
60	24
65	14
71	9
72	7
76	29
105	2
106	3

================================

Quadrate 15B Sept.27	1/2 Buoys D1-E (10)
Species No.	Density
17	177
23	50
24	38
33	29
46	32
60	20
65	53
69	41
73	8
78	18

================================

Quadrate 15C Sept. 27	D 1 Buoy (12)
Series No.	Density
23	16
24	20
26	1
29	3
33	17
41	3
45	9
60	16
65	255
76	57
106	35
107	2

================================

Benthic Invertebrates

Quadrate 16B N66
Oct. 8 (9)

Species No.	Density
2	1
5	1
23	6
28	3
35	21
65	8
76	178
106	15

Amphitrite sp.

================================

Quadrate 17C Buoy F
Oct. 8 (10)

Species No.	Density
1	4
18	7
29	3
36	15
41	4
52	41
65	41
69	2
76	161
77	3

================================

Quadrate 23D Light 3
Oct. 8 (7)

Species No.	Density
17	24
23	6
24	17
33	8
60	8
65	700
76	23

Biomass 10.74 gm/m^2

==================================

Quadrate 23A III-1
Oct. 8 (3)

Species No.	Density
54	64
72	1
89	1

==================================

Quadrate 22A FRC
Oct. 8 (15)

Species No.	Density
1	5
17	13
18	8
23	17
24	4
33	12
43	1
46	9
52	23
65	1200
76	18
82	2
85	1
89	43
102	3

Biomass 27.84 gm/m^2

Benthic Invertebrates

Quadrate 22A
Oct. 8 (16)

Series No.	Density
1	21
18	3
23	9
25	2
27	4
28	7
43	1
48	8
52	140
59	3
65	235
76	306
85	4
101	5
106	11
108	1

Biomass 19.07 gm/m^2

==============================

Quadrate 25A Light 19
Oct. 8 (1)

Species No.	Density
54	320

==============================

Quadrate 22A Light 4
Oct.16 (14)

Species No.	Density
11	1
18 (X)	2
23	1
26	1
33	5
34 (X)	pres.
36	4
41 (X)	4
52 (X)	16
65	160
72	1
73	8
76	41
106	8

Qualitative (15)
2, 5, 18, 28, 29, 39, 41, 49, 50
52, 59, 63, 92, 107, 109

==============================

Benthic Invertebrates

Quadrate 23D Oct. 16	Light 3 (8)
Species No.	Density
1	18
2	7
65 (X)	396
72	[illegible]
76 (X)	15
101	4
105	5
106	23

Qualitative (17)
5, 18, 26, 28, [illegible], 40, 41, 48
50, 51, 52, 56, 59, 63, 65,
76, 104

Quadrate 22B Oct. 16	Light 12 (16)
Species No.	Density
9 (X)	pres.
15	51
18	6
23	20
27 (X)	1
29 (X)	14
[illegible]	17
48	9
54 (X)	110
55	19
65	10
70 (X)	1
79 (X)	4
89	10
92	20
106	53

Qualitative (11)
2, 9, 21, 27, 29, 49, 51, 54.
63, 70, 79

Quadrate 22A Oct. 29	FRC (6)
Species No.	Density
23	22
52	623
54	7
65	241
76	62
95	38

Quadrate 23D — [illegible]OC
Oct.29 — (15)

Species No.	Density
1	4
2	23
17	1
18	1
23	16
28	10
40	4
50	7
59	2
60	21
65	167
72	3
73	9
76	17
85	4

==============================

Quadrate 23D — Light 3
Dec. 9 — (3)

Species No.	Density
17	21
18 (X)	3
65	49

Qualitative (5)
18, 27, 35, 40, 63

==============================

Quadrate 22B — Light 12
Dec. 9 — (6)

Species No.	Density
9	pres.
11	1
15	9
18	43
54	168
70	2

==============================

Quadrate 15C — Buoy D 1
Oct.29 — (9)

Species No.	Density
23	21
33	9
60	3
65	217
69	5
71	1
76	52
101	2
106	4

==============================

Quadrate 23D — J Buoy
Oct. 29 — (11)

Species No.	Density
1	5
23	4 (X)
29	1
34	+
45	2
51	7
52	24
63	3
65	26 (X)
72	1
76	43

Qualitative (7)

2, 5, 18, 34, 50, 63, 65

==============================

Quadrate 23D — Mouth O.C.
Dec. 9 — (6)

Species No.	Density
23	33
41	1
48	3
54	84
65	351
106	1

==============================

Benthic Invertebrates

Quadrate 23D
Dec. 9

III-1
(3)

Species No.	Density
23	4
33	3
54	19

==================================

Quadrate 25A
Dec. 9

Light 19
(1)

Species No.	Density
54	152

==================================

Quadrate 22A
Dec. 18

FRC
(10)

Species No.	Density
17	28
23	4
[illegible]	11
33	21
43	1
45	17
46	71
65	86
72	16
92	10

==============================

Quadrate 17A
Dec. 18

Buoy G
(6)

Species No.	Density
8	2
13	7
35	3
40	16
50	17
76	73

==============================

Quadrate 24A
Dec. 18

(4)

Species No.	Density
40	1
63 (X)	20
69	13
76	48

Qualitative (3)
18, 35, 63

================================

Quadrate 21D
Dec. 18

Light 1 North
(10)

Species No.	Density
18	21
24	11
29	2
34	pres.
46	21
48	12
54	16
63	7
65	49
73	3

==================================

Quadrate 23A
Dec. 18

(11)

Species No.	Density
1	3
25	1
29	4
45	3
48	11
50	13
51	+
52	16
65	57
72	1
76	39

Qualitative (5)
9, 11, 18, 29, 63

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Benthic Invertebrates

To construct some predictive pattern for the section of Barnegat Bay studied, certain areas have been emphasized. These regions are within and around the two creeks, and farther removed stations (control areas"). The quadrates selected to represent these regions are 22A, 22B and 23D as the experimental areas and as "controls" 11, 17C and 21D.

In comparing stations within the same quadrate, it has become obvious that among the stations in the experimental areas there is considerable variability in the community compositions. For this reason, the experimental quadrates have been subdivided into smaller areas of similar bottom conditions (chiefly sedimentary) and animal distributions. The "control" quadrates show much more homogeneity within themselves concerning bottom type and associated animals.

The section of the prediction concerned with what animal (s) may reasonably be expected to be found is more easily generated than the portion dealing with projected densities. For this reason, the predicted densities have been presented as a range of values. Predictions have been based on both quantitative and qualitative sampling.

Quadrate 11 Light #1 South 52 spp. found

Number of sample dates used for prediction - 7. (5 quantative; 5 qualitative)
Time of year of sampling: April - August

Total Sampling (quan. + qual.)

% samples appearance	Species number
100	18, 56
85.7	76
71.4	72, 73, 40, 50
51.7	28, 49, 59

Quantative sampling:

% appearance (density* range)	100%	80%	60%
SPECIES NUMBER:	18 (1-9)	56 (4-23)	17 (1-34)
	72 (1-30)		25 (2-3)
	73 (9-18)		40 (1-6)
	76 (55-144)		74 (4-7)

Quantitative sampling only= 21 spp. found (spp. nos. 17, 23, 24, 25, 26, 32, 33, 41, 45, 48, 60, 65, 67, 69, 72, 73, 74, 77, 87, 98, 100)

Qualitative sampling only= 18 spp. found (spp. nos. 2, 5, 10, 11, 16, 27, 29, 31, 34, 38, 42, 49, 52, 58, 62, 63, 66, 70)

Common to both types of sampling= 13 spp. (spp. nos. 1, 8, 18, 28, 30, 36, 37, 39, 40, 50, 56, 59, 76)

* Number of individuals/square meter

Benthic Invertebrates

Quadrate 17-C F Buoy 63 species total

Number of sampling dates used for prediction - 13. (10 quantitative + 7 qualitative). Time of sampling - April - December

Total sampling (quan. + qual.)

% times appeared	100%	69.3	61.5	53.8
SPECIES NUMBER:	76	1	18	33
			52	40
				56
				62
				65

Quantitative sampling - 39 spp.

% times appeared	100%	80	70	60	50
SPECIES NUMBER:	76 (83-66)				
		1 (4-60)			
			52 (2-41)		
				65(3-84)	
				73(2-33)	
					17(1-35)
					33(1-15)

Species found by qualitative sampling only (22 spp.):
2, 5, 8, 10, 20. 21, 22, 27, 31, 38, 39, 42, 47, 51, 59, 62, 66, 70, 78, 79, 84, 99

Species found by quantitative sampling only (19 spp.):
17, 23, 24, 25, 41, 43, 46, 48, 54, 60, 61, 68, 72, 73, 74, 77, 88, 95, 97

Species found by both types of sampling (22 spp.):
1, 18, 24, 28, 29, 30, 33, 35, 36, 40, 45, 50, 52, 53, 56, 60, 63, 65, 67, 69, 73, 76

Benthic Invertebrates

Quadrate 21-D Light 1 - Stouts Creek 28 Species

Number of sampling dates - 5 (4 quantitative + 1 qualitative).
Time of sampling: June - December

Total sampling (quan. + qual.)

%sample appearance	100%	80	60
SPECIES NUMBER:	---	52(2-105)	29 (2-[illegible]) 33 (6-12) 46 (21-77) 65 (49-176)

A presentation of quantitative sampling is not presented since it is identical with the total sampling results. Since only one qualitative haul was made at this station all of those animals, except species number 52 (Mulinia lateralis), were found only once.

Qualitatively found: 8, 35, 40, 47, 50, 56

Quantitatively found: 15, 18, 23, 24, 25, 29, 33, 34, 43, 45, 46, 52, 54. 55, 63, 65, 69, 72, 73, 78, 89

Commonly found: 52

Quadrate 22-A Light 4*

Number of sampling dates - 15. (13 quantitative + 8 qualitative)
Time of sampling: March - October 64 species

Total sampling (quan. + qual.)

% sample appearance	86.6	73.3	66.7	60.0	53.3
SPECIES	76	18	52	23 65	50

Quantitative sampling

% sample appearance	100	76.9	69.3
SPECIES	76(8-306)	52(2-140)	23(1-52) 65(4-235)

Species found in quantitative only (23): 11, 15, 17, 25, 26, 27, 33, 36, 43, 45, 46, 54, 60, 72, 73, 74, 85, 89, 93, 101, 105, 106, 108

Species found in qualitative only (18): 2, 16, 30, 32, 35, 37, 38, 47, 49, 50, 51, 53, 62, 66, 70, 78, 107, 109

Species found in both types of sampling (23): 1, 4, 5, 10, 18, 23, 28, 29, 34, 35, 39, 40, 41, 48, 52, 56, 59, 63, 65, 69, 76, 87, 92

*These data represent the area immediately around the Light 4 area. Another data sheet will follow which is from the area around the mouth of Forked River.

Benthic Invertebrates

Quadrate 22-A Forked River Channel*
Sampling dates - 6: all quantitative
Time of sampling: June - December 26 species

% times appearance	100	83.3	66.7	50.0
SPECIES NUMBER:	46 (9-156)			
		17 (3-183)	23 (4-29)	24 (4-18)
		33 (7-21)	52 (11-30)	43 (1)
		65 (40-1200)		60 (3-62)
				72 (5-16)

Species encountered: 1, 17, 18, 23, 24, 25, 33, 35, 42, 43, 45, 46, 52, 55, 60, 65, 69, 72, 76, 78, 82, 83, 85, 89, 92, 102

*This region is from the mouth of Forked River eastward toward Light 4. The bottom deposits are high in the finer materials (silt-clay) composition as compared with the sandier environment of the immediate Light 4 area.

Benthic Invertebrates

Quadrate 23-D Light 3
Number of Sampling dates: 16 (15 quantitative + 11 qualitative)
Time of sampling: May - December

Total sampling (qual. + quan.)

% times appearance	81.2	75.0	68.7	56.2	50.0
SPECIES NUMBER	18	50	29 52 65 76	5	40 56

Quantitative sampling

% times appearance	73.3	60.0	53.3
	65(2-700) 76(9-93)	52 (1-192)	18 (2-12) 50 (2-150)

Species found quantitatively only (22): 1, 17, 23, 25, 33, 42, 43, 46, 57, 60, 67, 69, 71, 72, 73, 76, 83, 89, 92, 104, 105, 106

Species found qualitatively only (16): 9, 12, 16, 19, 20, 21, 22, 26, 27, 28, 34, 37, 39, 49, 62, 66

Species found with both types of samples (29): 2, 5, 7, 8, 10, 11, 18, 24, 29, 30, 31, 35, 40, 41, 45, 47, 48, 50, 51, 52, 53, 56, 59, 63, 65, 70, 74, 79, 101

Benthic Invertebrates - Summary

As may be seen from the foregoing tables there are relatively few species which occur regularly throughout the areas concentrated upon in the predictive portion of this report. As a generality the infauna serve as a more reliable index than the epifauna due primarily to their life habits. Among those animals encountered within the substrate there are three species which are most commonly encountered, these are Tellina agilis (#76), Pectinaria gouldii (#65), and Mulinia lateralis (#52). The first two species are more characteristic of "sandy" areas while Mulinia tends toward less sandy areas although it appears with some regularity at stations dominated by the first two. In areas where there is good current movement but still large amounts of finer sediment materials (silt-clay fraction) the polychaete Maldanopsis elongata becomes dominant, such an area is seen in Quadrate 22A, the Forked River Channel area.

It would be practically impossible to predict precise densities of animals due to natural variability within the system, for this reason the densities were presented as ranges. It should be expected that in the coming sampling season the animals and their densities will not be appreciably different from the material presented here.

Temperature Profiles of the Intake and Effluent Channels

Profiles were made along the canals in which water moves directly toward or away from the generating station. Temperature was recorded at intervals of two feet from surface to bottom. Salinity of the bottom water was taken at the same time.

The distances of the two canals examined are similar, the Forked River section is approximately 2700 yards long while Oyster Creek is about 100 yards longer. Both longitudinal transects begin at U. S. Route #9. From these points it is still a few hundred yards to the power plant, but it is physically impossible to proceed any closer by boat. The Oyster Creek channel runs immediately to Barnegat Bay, while the Forked River channel ends where the South Branch joins the main body of the river in the area of Light #[illegible]. From this point it is an additional 1500 yards to Barnegat Bay.

Station #1 on both canals is located at the respective bridges crossing Route 9. Stations 2, 3 and 4 on the Oyster Creek side are located at distances of approximately 750, 1650 and 2800 yards from station #1. On the Forked River side, the stations are located at distances of 750, 1500, 2100 and 2700 yards from station #1. Location of the stations in the field relies upon stationary points and estimated distances from these.

Precise time of the tidal stages for the channels is not known. Time corrections for Waretown, as listed in the Tide Tables of the C. & G. S., have been used for approximating the tidal stage in the channels. It requires an average of 40 minutes to sample each channel for temperature and salinity so the time range gives, at best, an approximation of the stage of tide in the channels. The actual time of sampling at each station is recorded. In the following tables the stages are rounded off to the nearest quarter-hour.

Fig. H-1. Oyster Creek Channel - Temperature Profile (Temperatures are °C.)

Station One

	Sept. 20		Oct. 8		Oct. 29		Dec. 9	
Tide:	Lo -0.45-0.15		Hi 2:15-2:45		Lo -0.30-0.15		Hi -2:45-2:15	
	Temp.	S%	Temp.	S%	Temp.	S%	Temp.	S%
0'	22.9	14.58	16.9		14.2		2.9	
2'	23.1		17.2		15.2		2.8	
4'	23.0		17.2		15.2		2.5	
6'	22.8		16.5		15.3		2.5	
8'	22.2		16.5		15.3		2.5	
10'	22.3		16.3		15.4		2.5	
12'	22.7		16.3		15.4		2.5	
14'	22.5	23.96	16.4	26.06	15.4	26.26	2.5	21.67

Fig. [illegible]. Oyster Creek Channel - Temperature Profile
(Temperatures are °C.)

Station Two

	Sept. 20		Oct. 8		Oct. 29		Dec. 9	
Tide:	[illegible]-0.15		Hi -2:15-2:45		Lo -0.30-0.15		Hi -2:45-2 15	
	Temp.	S%	Temp.	S%	Temp.	S%	Temp.	S%
0'	23.1	13.22	17.2		13.5		2.8	
2'	23.1		17.2		13.6		2.8	
4'	22.4		17.8		13.6		2.8	
6'	22.0		16.8		13.6		2.6	
8'	21.7		16.7		13.8		2.5	
10'	21.5		16.8	26.27	14.3	25.91	2.5	20.82
11'	21.7	24.52						

Station Three

0'	22.2	15.79	17.0		12.9		2.5	
2'	22.8		17.5		13.0		2.5	
4'	22.1		17.3		12.8		2.5	
6'	21.9		17.0	25.07	12.6		2.7	
8'	21.4				12.7		4.5	
10'	21.3				12.7		4.9	21.89
12'	21.3	24.88			13.2	28.17		

Station Four

0'	22.0	23.31	17.1		12.2		2.5	
2'	22.0		17.0		12.2		2.5	
4'	22.0	23.62	17.0		12.2		2.5	
6'			16.8		12.6		2.4	
8'			16.8	27.39	12.8	27.97	2.4	19.20

Fig.H-3. Forked River - South Branch Intake Canal
Temperature Profile (Temperatures are °C.)

	Oct. 8		Oct. 29		Dec. 9	
Tide:	Hi +3:00-3:45		Lo +0.00-0.15		Hi +0.30-1:00	
	Temp.	S%	Temp.	S%	Temp.	S%
Station One						
0'	18.0		13.8		2.8	
2'	18.0		14.0		2.5	
4'	17.9		14.1		2.5	
6'	17.6		14.1		2.5	
8'	17.8		14.0		2.5	
10'	17.8		14.0		2.5	
12'	17.8	21.09	14.5	24.74	2.5	22.83
Station Two						
0'	17.8		12.7		2.5	
2'	17.8		12.7		2.5	
4'	17.7		12.8		2.5	
6'	17.9		13.0		2.5	
8'	17.9	22.41	13.1	24.61	2.5	23.59
Station Three						
0'	17.3		12.2		2.8	
2'	17.3		12.2		2.8	
4'	17.7		12.2		2.8	
6'	17.8		12.9		2.8	
8'	17.7		12.9	25.07	2.8	24.72
9'	17.7	23.64				
Station Four						
0'	17.5		11.7		2.9	
2'	17.3		11.6		3.1	
4'	17.7		11.9		3.3	
6'	17.4		12.5		3.3	
8'	17.2	25.03	14.4	24.96	3.5	25.19
Station Five						
0'	17.5		11.7		2.5	
2'	17.5		11.9		2.5	
2.5'	18.1	20.19			2.5	24.45

Sediment Study

During the four year study period (summer 1965-summer 1968) 6? stations' bottom types were sampled to determine the particle size distribution of the substrate. Quantitative bottom samplers were used in obtaining the bottom materials; random aliquots of the total sample were returned to the laboratory for the determinations.

After oven drying to constant weight, the bottom materials were sorted in the diameter range of 4000 to 1μ. Coarse analysis of the sands (4000 - 62μ) was achieved by mechanical agitation of the dried sediment through nested standard sieves (ASTM #422-51 modified). Those materials finer than 62μ (silt-clay fraction) were subsequently analyzed as to particle size by the hydrometer technique of Bouy[illegible] Determination of these finer fractions was not conducted for each station, quite frequently the low percentage (less than 5% by weight) of this portion did not warrant the 24 hour hydrometry study.

In determining the physical properties of the sediments such as median grain diameter (M_2), sorting coefficient (S_o), and skewness (S_k) as described in The Oceans (Sverdrip, Johnson and Fleming), it is necessary to know only the upper cumulative 75% of the size distribution. Knowledge of this segment of the distributional curve enables one to calculate the physical parameters listed above. Thus, if 75% or [illegible] is contained in the sands fraction, it is unnecessary to undertake the longer hydrometry section to achieve description of the bottom by the physical parameters. As mentioned above, however, hydrometry was conducted when the silt-clay was [illegible] than 5% of the sample.

The cumulative curves of the particle size distribution have been prepared and are available if desired. However, it was thought that their inclusion in this report would require more space than this section warranted. Data have been presented in tabular form, both the physical parameters and the variation among the individual size classes at the same station.

Rather than tabulate all the stations sampled, many of which are no longer routinely examined, those sites which are located within or in close proximity to the main interest area (that most likely to be noticeably influenced by the power plant's operation) are presented. These include stations in or adjacent to Forked River and Oyster Creek and a few possible outside "sediment control" areas.

Where appropriate, qualifying or explanatory statements have been included with the presentation of the data. In the following tables, each size class (in microns) is described by that fraction's weight percentage. The physical characteristics are M_2= median grain diameter, Q_1 and Q_3 first and third quartile grain size, S_o= the sorting coefficient, and S_k= skewness. The first three properties are given in microns (μ), the final two properties are dimensionless.

Sediment Data

Station III - 1, quadrate 23-A, 150 yards inside mouth of Oyster Creek

Particle size	1965	1967 a.	1967 b.	1968
4000µ	--	--		--
2000	--	0.1%	0.15	--
1000	0.3%	3.4	0.10	--
500	1.1	4.7	1.60	6.3
250	2.6	5.8	9.85	12.05
125	4.5	13.4	16.35	16.25
62	13.0	33.9	33.70	32.90
-62	76.8	38.7	38.00	32.25
M_2	24µ		79µ	92µ
Q_1	19		37	30
Q_3	54		135	175
S_o	1.98		1.91	2.42
S_k	6.54		7.95	7.55

In 1965, the station was sampled closer to the creek bank than in the following years. The shift toward slightly larger composition size in the latter two years is best explained by an increase in current velocity since these station locations were situated closer to the maintained channel. Variation in the 1967 data stems from removal of shell and *Zostera* fragments in the b series prior to analysis, this probably accounts for the weight/percentage difference in the larger particle classes.

Sediment Data (cont.)

Station III - 2, Quadrate 23D. Light #3, located 300 yards east of Oyster Creek.

Particle size	1965	1966	1967 a.	1967 b.	1968
4000μ	0.5%	--	--	--	--
2000	0.7	0.45%	4.9%	1.2%	0.25%
1000	0.9	1.15	1.1	4.2	0.60
500	5.4	6.45	4.5	36.1	1.20
250	18.7	12.65	30.1	33.6	2.50
125	16.3	8.10	43.3	7.4	4.50
62	39.4	40.65	8.3	9.7	43.95
-62	17.9	30.25	8.0	7.7	47.05
M_2	109	94	215	425	67
Q_1	68	62	145	250	38
Q_3	268	180	365	690	98
S_o	1.98	1.70	1.58	1.66	1.61
S_k	12.93	10.90	15.7	20.1	7.45

The noticeable difference between 1967 and the other years is, I believe, due to dredging which was executed to allow passage of the reactor core. Dredging occurred in 1967, this disruption of the "normal" bottom could explain the difference. Series a and b were taken five weeks apart with a Petersen and a Ponar grab respectively, the differences seen here might be due to the different digging characteristics of the two grabs and/or environmental deposition or reworking of the site materials.

Sediment data (cont.)

Forked River Channel
200 yards east of Light #12 (II-2); 22-A

Oyster Creek Channel
200 Yards east of III-1; 23-D

Particle size	Forked River Channel 1968	Oyster Creek Channel 1968
2000µ	0.25%	4.45%
1000	0.40	2.50
500	1.90	4.75
250	6.95	6.65
125	8.95	25.35
62	25.90	35.60
-62	55.65	20.85
M_2	48	112
Q_1	29	70
Q_3	98	195
S_o	1.84	1.67
S_k	7.7	11.0

Light #19, II-1, quadrate 22-B

Light #12, II-2, quadrate 22-B

Particle size	Light #19 1965	Light #19 1968	Light #12 1965	Light #12 1968
2000µ	--	0.3%	4.2%	21.75%
1000	1.9	1.15	6.6	9.70
500	21.0	7.65	10.5	9.80
250	14.6	8.40	10.6	7.75
125	12.8	11.95	12.9	8.45
62	13.3	24.85	24.9	14.40
-62	36.3	45.35	30.0	28.10
M_2	130	72	108	230
Q_1	28	35	55	54
Q_3	470	160	400	[illegible]0
S_o	4.09	2.14	2.70	5.36
S_k	10.07	8.82	14.27	19.1

Light 19 - The sample for 1968 was taken from an area inside a small elbow of land, thus the area was probably more protected and allowed the finer materials to be deposited as opposed to the more open area sampled in 1965.

Light 12 - The 1968 sample included a great deal of foreign material such as Zostera fragments, molluscan (Nassarius and Crassostrea) shells, and stones which shifted the upper region of the curve. This resulted in large differences in the secondary characteristics, most notably in the third quartile value and subsequently the S_o and S_k.

Sediment Data (cont.)

Station Light #4, II-3, quadrate 22-A, 800 yards ea[illegible] of Light #12

Particle size	1965	1966	1967	1968
2000µ	0.2%	0.95%	0.20%	0.30%
1000	1.2	1.00	3.10	1.75
500	22.9	16.10	31.55	15.70
250	45.5	41.75	57.65	38.50
125	12.3	14.65	5.15	15.20
62	10.2	10.70	1.70	17.65
-62	7.6	14.70	0.65	10.85
M_2	335	340	415	280
Q_1	195	120	210	105
Q_3	500	485	610	495
S_o	1.60	2.01	1.40	2.17
S_k	17.06	13.08	21.3	13.6

Suggested "sediment control" areas. Buoy F Intracoastal Waterway Quadrate 17-C

Particle size	1966	1967	1968
2000µ	0.15%	0.30%	0.10%
1000	0.45	0.20	0.55
500	0.70	0.70	0.85
250	1.70	1.90	1.60
125	9.95	15.40	12.05
62	71.30	68.30	70.95
-62	15.60	13.40	14.00
M_2	86µ	90µ	88µ
Q_1	68	70	72
Q_3	110	118	110
S_o	1.27	1.30	1.24
S_k	9.32	9.58	9.45

The agreement among the three years' data for this station is very good. A reasonable explanation for the apparent constancy might be the location of this station in relation to the Oyster Creek Channel which links to Barnegat Inlet. Buoy F marks the Western end of the Channel. Hydrographic data indicate that oceanic influence is very marked at the b[illegible]y area, so it would seem plausible that the currents running through the channel are of sufficient velocities and duration to maintain a fairly "clean" sand bottom of overall uniformity.

Sediment data (cont.)

Suggested "sediment control" areas.

Station I-1, Light 1 "North" off Stouts Creek. Quadrate 21-D

Station , Light 1 "South"; SW X W of Clam Island. Quadrate 11

Particle size	1965	1968	1966	1968
2000μ	6.5%	0.15%	0.60%	1.20%
1000	3.8	0.30	0.45	1.30
500	4.4	6.25	0.80	1.00
250	5.0	5.90	1.60	1.45
125	7.9	7.90	26.20	30.35
62	24.1	24.85	61.65	57.05
-62	48.1	54.35	8.45	7.40
M_2	64	58	96	108
Q_1	22	28	73	84
Q_3	150	105	130	133
S_o	2.61	1.94	1.33	1.26
S_k	7.18	7.12	9.32	10.15

Light 1 "North" is immediately off Stout's Creek (N of Forked River). It is an area of sedimentary deposition due to the very low currents prevalent in this region. It would serve as a good control area since it is in close proximity to the mainland and hence will demonstrate "natural" changes (precipitation + runoff variation, etc.) which might not be picked up as rapidly as farther removed stations. The variation in materials greater than 1000μ is a reflection of inclusion of molluscan shell fragments, etc.

Light 1 "South" is similar in some respects (hydrographically and topologically) to Buoy F. This station is the terminus for a channel running behind Clam Island and joining the Oyster Creek Channel. The bottom is "clean" sand as is Buoy F, but SCUBA diving has revealed, at least apparently, more biological material at the Light (large growths of the sponges Cliona celata and Microciona prolifera). In addition, the algae Codium fragile is seen in large amounts growing attached to suitable substrata.

Fig. H-4. Hydrographic data for study area in Barnegat Bay for 1968.

DATE	TIME (EST)	STATION	DEPTH (M)	TEMP. (°C.)	SALINITY (°/oo)	SECCHI (M)
Jan. 6	1125	7-C	0	-0.4	20.5	
			.63	-0.4	-	
			ICE		7.1	
	1235	1-B	0	-1.0	34.8	
			ICE	-	[illegible].0	
Jan.13	1420	7-C	.40	-0.4	[illegible].0	Bottom
Jan.28	1230	8-C	0	0.[illegible]	[illegible].66	
			1.37	1.35	22.54	[illegible].37B
	1330	[illegible]6-B	0	1.6	[illegible].93	
			2.74	1.9	[illegible].85	[illegible].62
	1335	2[illegible]-A	0	1.9		
			1.52	1.15		1.52B
Feb. 4	1330	22-A	0	4.7	26.1	
			.40	4.5	-	Est. 1.00
Feb.18	1045	7-D	.50	0.0	[illegible].7	Bottom
			ICE	-[illegible].5	[illegible].7	
			ICE	-[illegible].7	[illegible]2.0	
			ICE	-4.5	[illegible].8	
Mar.3	1120	7-D	.30	-0.4	[illegible]7.9	-
	1145	2-D	.40	-0.8	-	-
	1430	22-B	.40	2.5	20.6	-
	1530	rear 3-D	0	-	[illegible].7	
Mar.10	1400	7-D	0	[illegible].0	[illegible].6	
	1420	6-A	0	-	[illegible].2	Est. .16
Mar.19	1745	[illegible]3-D	.30	6.3	[illegible].6	
Mar.30	0930	[illegible]3-B	0	9.5	[illegible].22	
			3.66	6.5	[illegible].28	1.22
	1045	8-AD	0	10.4	23.33	
			0.91	10.3	22.68	0.61
	1200	[illegible]7-C	0	[illegible].5	[illegible].05	
			3.05	[illegible].5	[illegible].23	1.22
	1430	[illegible]3-D		[illegible].4	[illegible].17	
			1.07	[illegible]4	[illegible].40	1.07B
	1500	22-A	0	10.0	[illegible].96	
			2.44	7.2	25.48	1.52
	1515	22-B	0	12.8	[illegible]4.51	
			2.14	10.0	[illegible]3.13	1.07
Apr.1	1510	2-D	0	11.4	2[illegible].6	
			.85	11.2	-	
Apr.7	1420	16-B	0	10.1	23.0	
			2.75	9.2	-	1.0
	1445	21-D	0	11.0	24.0	
			2.89	10.9	-	0.9
Apr.18	1025	11	0	17.3	27.00	
			2.3	11.5	27.01	2.[illegible]B
	1107	17-A	0	1[illegible].5	[illegible].49	
			2.59	1[illegible].2	26.40	2.44
	1230	17-C	0	1[illegible].0	[illegible].72	
			2.74	1[illegible].2	2[illegible].08	2.34

II.

DATE	TIME (EST)	STATION	DEPTH (M)	TEMP. (°C.)	SALINITY (°/oo)	SECCHI (M)
	1315	24-A	0	13.0	25.97	
			1.22	13.0	25.28	1.22B
	1325	16-B	0	12.2	25.28	
			2.74	10.5	28.33	1.98
	1335	23-D	0	12.1	25.16	
			2.28	11.0	28.28	1.98
	1445	22-A	0	12.1	25.37	
			2.44	12.1	25.70	1.98
May 11	1100	21-D	0	15.4	[illegible]	
			2.07	15.4	[illegible]	
	1200	16-B	0	15.2	24.74	
			2.74	12.6	25.75	
May 23	0810	11	0	[illegible]	26.74	
			1.98	[illegible]	27.00	2.30
	-	17-A	0	[illegible]	25.00	
			2.59	[illegible]	26.92	1.98
	1050	24-A	0	[illegible]	25.32	
			2.14	15.9	26.53	2.14B
	1230	8-C	0	16.5	24.85	
			1.67	15.8	25.05	1.67B
	1400	22-A	0	[illegible]	21.08	
			2.28	16.0	25.32	1.68
May 31	0735	21-D	0	16.0	[illegible]	
	0745		2.5	15.1	25.9	1.0
	0930	23-D	0	16.2	[illegible]	
	0945		2.6	14.9	[illegible]	
	0950	17-C	0	15.4	[illegible]	
	1000		3.1	[illegible]	25.2	1.0
	1040	7-C	0	[illegible]	23.3	
	1050		1.8	17.2	23.3	Bottom
June 4	0710	13-B	0	19.5	17.68	
			3.36	17.8	-	1.52
	0845	13-D	0	17.8	[illegible]	
			2.60	17.0	-	1.68
	0910	17-C	0	18.5	22.16	
			2.44	15.5	-	
	1325	23-D	0	[illegible]	21.17	
			1.22	19.8	-	
	1415	23-D	0	[illegible]	21.27	
			1.67	18.3	-	1.37
	1510	22-B	0	21.0	[illegible]	
			1.22	19.1	-	0.91
June 11	0910	16-B	0	[illegible]	[illegible]	
			3.0	15.4	[illegible]	
	1115	11	0	19.8	25.72	
			2.14	[illegible]	25.80	1.22
	1240	[illegible]	0	[illegible]	[illegible]	
			2.44	[illegible]	26.8	1.37

III

DATE	TIME (EST)	STATION	DEPTH (M)	TEMP. (°C.)	SALINITY (°/oo)	SECCHI (M)
June 13	0730	21-D	0	19.8	18.30	
			2.44	19.4	-	1.22
	0900	14-B	0	18.5	19.78	
			3.51	17.8	-	1.52
		17-A	0	19.8	23.68	
			3.05	17.3	-	1.22
		24-A	0	21.0	22.94	
			2.14	19.0	-	1.22
	1510	23-D	0	20.2	21.17	
			2.44	18.3	-	1.22
June 21	0800	22-A	0	20.0	19.31	
			2.13	21.8	-	1.37
	0915	23-D	0	20.2	19.54	
			1.98	21.5	-	1.37
	1045	16-A	0	20.0	20.17	
			0.91	20.9	-	0.91B
	1300	9-AD	0	22.0	19.58	
			0.61	21.2	-	0.61B
	(about)1500	23-D	0	23.1	15.07	
			2.75	21.0	-	0.91
July 1	0645	8-C	0	23.8	20.53	
			2.13	23.13	-	1.37
	0735	22-A	0	23.4	21.00	
			2.13	21.15	-	1.12
	0810	22-A	0	23.5	19.76	
			1.98	22.34	21.71	0.91
	1010	17-C	0	24.0	-	
			2.59	21.25	-	1.22
	1240	23-D	0	25.0	21.24	
			2.14	22.16	-	1.07
	1320	23-A	0	25.8	23.46	
			1.37	23.0	-	1.07
	1400	23-D	0	25.2	21.31	
			2.28	23.05	-	0.84
	1430	23-D	0	25.8	21.47	
			2.06	23.22		1.44
July 8	0940	14-B	0	23.2	20.21	
			3.04	22.43	-	1.22
	1030	15-C	0	23.2	20.39	
			3.05	21.65	-	1.06
	1135	15-B	0	23.3	21.46	
			3.35	20.0		1.17
	1235	23-D	0	25.3	24.72	
			0.91	24.3		0.61
	1250	22-A	0	24.4	23.33	
			1.83	24.12	-	1.07
	1345	22-B	0	26.8	12.99	
			0.61	26.48	-	-

DATE	TIME (EST)	STATION	DEPTH (M)	TEMP. (°C.)	SALINITY (°/oo)	SECCHI (M)
July 12	2120	15-B	0	24.2	24.3	
	2155		2.6	21.4	31.1	
	2230	21-D	0	24.4	23.9	
	2300		2.6	23.7	27.1	
July 13	0700	21-D	0	23.8	21.7	
	0720		2.6	23.1	23.4	
July 19	0810	23-D	0	27.1	24.72	
			1.67	26.92	-	1.07
	0910	23-D	0	27.5	20.79	
			1.37	27.37	-	1.07
	1005	24-A	0	27.3	25.50	
			1.98	25.93	-	-
	1100	17-A	0	27.6	25.53	
			2.44	27.12	-	1.22
	1145	17-C	0	27.3	26.00	
			2.74	25.68	-	1.22
	1300	16-B	0	27.7	-	
			2.74	27.5	-	0.91
	1400	16-B	0	28.0	26.09	
			-	27.75	-	-
	1510	22-B	0	30.1	14.96	
			1.52	28.52	-	-
July 21	0615	7-D	.35	23.2	-	Bottom
	0715		0	24.2	23.8	
			.40	24.1	23.8	
July 24	0745	13-B	0	26.7		
				25.87		
	0800	21-D	0	27.0		
				26.68		
	0820	14-B	0	26.8		
				25.30		
	0840	15-C	0	26.8		
				25.0		
	0900	15-B	0	26.9		
				19.91		
	0920	16-C	0	26.8		
				19.89		
	0945	17-C	0	26.5		
				21.62		
	1005	17-A	0	26.7		
				24.67		
	-	16-B	0	-		
				22.53		
	-	23-D	0	27.1		
				22.56		
	-	23-D	0	27.9		
				26.56		

DATE	TIME (EST)	STATION	DEPTH (M)	TEMP. (^{o}C.)	SALINITY (^{o}/oo)	SECCHI (M)
July 24	-	23-A	0	28.6		
				28.30		
	1205	23-D	0	27.3		
				27.05		
	-	22-A	0	27.5		
				26.25		
	-	22-A	0	27.9		
				27.68		
	1305	22-B	0	29.7		
				28.46		
	-	22-B	0	29.5		
				29.42		
July 29	0755	8-C	0	24.8	22.36	
			1.52	24.8	-	1.52B
	0920	16-B	0	24.1	24.14	
			3.05	22.9	-	2.14
	-	17-C	0	25.0	24.22	
			2.14	20.9	-	2.14B
	1200	11	0	26.2	25.86	
			1.98	24.6	-	0.91
	1300	22-A	0	25.8	23.80	
			2.44	25.1	-	2.13
	-	22-A	0	27.2	-	
			1.22	26.6	-	-
Aug.16	0715	17-A	0	23.8	25.61	
			2.51	23.85	25.97	2.51B
	0900	24-A	0			
	0930	17-C	0	24.5	24.25	
			2.44	23.82	26.56	2.44B
	1110	13-B	0	24.5	19.63	
			3.36	24.45	24.56	2.28
	1250	21-D	0	24.3	19.85	
			1.98	24.65	20.64	1.98B
	-	15-C	0	24.8	21.71	
			3.36	24.50	23.37	2.59
	-	23-D	0	26.5	21.49	
			1.83	25.47	23.26	1.44
	1340	23-D	0	27.2	-	
			1.67	25.30	23.03	1.07
	1335	23-D	0	25.4	23.55	
			1.83	25.09	23.59	1.83B
	1405	22-A	0	24.8	23.04	
			2.13	24.80	23.03	
	1435	22-B	0	26.1	20.88	
			1.07	25.97	21.55	0.73
	1450	22-B	0	26.3	18.50	
			1.83	25.20	23.42	0.91

VI

DATE	TIME (EST)	STATION	DEPTH (M)	TEMP. (°C.)	SALINITY (°/oo)	SECCHI (M)
Aug.27	0900	7-D	.50	20.8	25.2	Bottom
	0940	14-D	0	24.2	23.3	
			2.0	24.2	22.6	2.0
Sept. 7	0730	8-C	0	22.1	23.7	
	0745		2.10	22.2	23.7	2.0
	0830	22-A	0	22.2	23.3	
	0842		2.50	22.4	25.5	2.1
Sept.15	0930	7-D	.10	21.4	21.7	Bottom
	0935		.50	21.7	21.7	
Sept.20	1155	23-D	0	-	23.26	
			1.83	21.47	24.98	1.83B
Sept.27	0715	15-B	0	22.4	24.42	
			3.36	21.65	28.24	1.83
	0900	15-C	0	22.4	23.84	
			3.36	22.21	26.91	2.06
	1000	15-C	0	22.3	23.71	
			3.05	22.30	27.07	1.98
	1225	22-A	0	22.8	24.70	
			2.44	22.70	25.12	1.98
	1310	22-A	0	22.9	-	
			2.14	22.82	25.03	1.98
	1415	23-D	0	22.9	-	
			1.98	22.95	24.94	1.90
	1510	22-A	0	23.4	-	
			2.44	23.05	25.07	1.83
Oct. 1	0845	oyst. Rt.9	0	18.2	19.9	
	0840		3.20	21.1	19.9	1.30
	0940	22-A	0	19.8	26.5	
			.50	20.0	-	
	1450	7-D	0	24.3	24.4	
			.25	24.3	-	
Oct. 8	0750	22-A	0	15.3	--	
			1.98	16.54	26.69	1.98B
	0900	22-A	0	15.5	-	
			1.67	16.08	25.44	1.67B
	0955	17-C	0	15.8	-	
			2.44	15.57	27.65	2.44B
	1100	16-B	0	16.1	-	
			2.74	16.90	29.04	2.14
	1105	23-D	0	16.6	-	
			2.14	17.05	25.53	1.98
	1255	23-A	0	16.9	-	
			1.22	16.77	26.27	1.22B
	1500	22-B	0	17.5	-	
			0.84	17.72	20.19	0.84B

DATE	TIME (EST)	STATION	DEPTH (M)	TEMP (°C.)	SALINITY (°/oo)	SECCHI (M)
Oct.16	0850	22-A	0	18.0	23.4	
			2.14	17.70	26.89	2.14B
	1015	23-D	0	18.0	20.0	
			1.83	18.30	23.42	1.83B
	1455	22-B	0	20.5	-	
			1.22	20.35	21.94	1.22B
Oct.29	0850	23-D	0	8.1	27.1	
			1.98	12.54	25.90	1.98B
	1005	23-D	0	12.0	-	
			1.75	12.76	26.29	1.75B
	1300	14-B	0	11.8	25.1	
			2.59	11.82	24.89	2.50
	1355	22-A	0	12.0	-	
			1.83	12.2	24.29	1.83B
	1430	22-A	0	11.8	-	
			1.83	12.38	24.83	
Nov.15	1330	7-D	.20	8.3	20.4	Bottom
Nov.24	1025	7-D	.20	7.8	22.6	
	1315	2-D		10.5	27.5	
Dec. 3	1008	14-C	0	7.9	23.4	
			3.0	8.0	-	2.1
	1120	15-B	0	7.2	23.9	
			3.0	8.3	-	2.0
	1145	23-D	0	8.6	23.9	
			3.0	8.3	-	1.6
	1215	17-C	0	8.4	25.4	
			3.0	8.6		1.7
	1240	17-A	0	7.9	24.7	
			2.9	7.9		1.9
	1308	18-A	0	7.8	26.1	
			2.5	7.2		1.8
	1340	18-D	0	8.0	26.1	
			1.6	8.2		1.6
	1405	10-C	0	9.0	24.7	
			3.0	8.5		2.2
	1425	3-D	0	7.7	24.1	
			2.0	7.7		2.0
	1505	9-D	0	7.6	22.1	
			1.9	8.2		2.3 Diag.
	1520	8-C	0	-	22.0	
			-	-		
	1535	14-D	0	7.4	21.7	
			-	7.8		2.4

DATE	TIME (EST)	STATION	DEPTH (M)	TEMP (°C.)	SALINITY (°/oo)	SECCHI (M)
Dec. 9	1030	23-A	0	2.5	-	
			0.76	2.15	-	0.61
	1055	23-D	0	2.5	-	
			1.22	2.15	19.20	0.61
	1140	23-D	0	2.4	-	
			2.44	2.18	27.40	0.76
	1255	22-B	0	3.5	-	
			0.91	2.20	25.59	0.46
	1350	22-B	0	2.5	-	
			0.76	2.20	24.45	0.30
Dec.18	0950	21-D	0	-0.5	22.[illegible]	
			2.44	-1.15	23.01	1.22
	1100	22-A	0	-0.8	22.7	
			1.83	-0.52	22.65	1.22
	1135	23-A	0	-0.4	23.[illegible]	
			0.84	-0.50	24.00	0.84B
	1230	17-A	0	-0.2	25.[illegible]	
			2.44	-0.5	26.[illegible]3	1.0

PLANKTON INVESTIGATIONS CONDUCTED

IN BARNEGAT BAY, N.J.
(contract 27-4656)

SUB-TABLE OF CONTENTS FOR THE PLANKTON SECTION 1-P

SUB-TABLE OF CONTENTS FOR THE PLANKTON SECTION (Cont'd)

- - - - -

PLANKTON

FIELD SAMPLING SCHEDULE:

Sampling for the plankton program was conducted on thirty-five dates during 1968. Nine cruises were supported using a small cabin boat fitted out and maintained at no cost to the project, with only applicable operation costs reimbursed. Six visits to maintain the pyranometer (Chart changes and cleaning the cell) were also utilized for the collection of plankton, benthic algal, and photosynthesis data. The balance of twenty dates were worked in conjunction with other phases of the project, or at the personal expense of the investigator.

PLANKTON SAMPLING DURING 1968

MONTH	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
DATES	6	4	3	1	11	11	1	16	7	1	15	3
With-	13	18	10	7	23	19	12	27	15	16	24	18
in	28	-	19	18	31	-	13	-	20	29	-	22
Month	-	-	-	28	-	-	21	-	-	-	-	-
	-		-	-	-	-	29	-	-	-	-	-
STATIONS within Month	9	2	7	10	12	5	10	12	4	10	3	23

Total Stations 105
Total Dates 35

INTERNAL EVALUATION OF METHOD:

Considerable supportive material is included with this report dealing with internal evaluation of sampling techniques and the variability of the material. Considerable effort has been devoted to this aspect of the research and, while all sources of variability have not been dealt with adequately, we seek to repeatedly confront them in the hope of avoiding unwarranted conclusions.

PLANKTON

EXAMINATION OF LIVE MATERIAL

Customarily a live sample (225ml) was retained from each sampling location. These were examined individually after centrifugation. Various conditions of refrigeration and aeration were evaluated in July 1967 to determine the optimal conditions under which live samples should be held to minimize changes before examination could be carried out in the laboratory.

In examinations made 3.0, 29.8 and 44.0 hours after collection, total cell count and species composition were most stable and percent mortality was lowest when material was held near ambient environmental temperature and gently aerated by the finest possible stream of bubbles. Refrigeration for 44 hours at approx. 4°C increased mortality 40% over the ambient holding condition.

The initial species list for each date is based primarily upon examinations of live material, thus largely eliminating the loss of recognizable organisms through fixation.

PRESERVED PHYTOPLANKTON SAMPLES

Phytoplankton samples were cellected in half-liter screw-cap plastic oontainers and fixative added immediately in the field. Returned to the laboratory, they were allowed to sediment at least two days before the supernatant was siphoned off and the residue brought down to uniform volume for storage and subsequent enumeration.

Losses in this process were estimated with the 28-IV-68 material by collecting all the siphoned and centrifuged supernatants, condensing them by long-term high speed centrifugation, and enumerating the organisms observed in the residue as though they composed a separate sample. Losses approximating 5.29 cell/ml were estimated for the larger phytoplankters, an amount considered negligible. Losses in the nannoplankton approximated 52.9 cells/ml about 1.01 o/o of the estimated total number in these samples.

PLANKTON

PRESERVED PHYTOPLANKTON SAMPLES (Cont'd)

The effects of four different fixatives were evaluated in July, 1967, both from the standpoint of total cells recovered and ease of recognition for the more delicate species. The 0.2% I_2-KI reagent mentioned in previous reports was most satisfactory. A slight modification of this reagent was considered in November, 1968 and simultaneous samples were run in six replicates to evaluate its superiority. The resultant body of data also provided a convenient assessment of the accuracy of density determinations and the stability of species composition among aliquots drawn from a homogeneous source.

The modified preservative was slightly better but differences were not statistically significant. The 95% confidence interval on mean total cell number was ± 16.9 cells/ml or, for these samples, 4.2%.

REPEATABILITY OF DENSITY ESTIMATES AND SPECIES COMPOSITION IN PHYTOPLANKTON SAMPLES INDEPENDENTLY DRAWN FROM A CARBOY OF HOMOGENEOUS MATERIAL

SPECIES RECORDED	REPLICATES					
	KI-I			Plus Merthiolate		
	A	B	C	D	E	F
Number of Species:	19	18	18	18	19	18
Skeletonema costatum	164.8	164.8	123.2	187.8	138.3	134.0
Cocconeis spp.	17.6	17.6	24.0	26.2	36.4	30.6
Cryptomonas sp.	36.0	28.0	12.0	18.2	25.5	36.4
Euglenoid	1.6	1.6	0	1.5	1.5	3.6
Gyrodinium pellucidum	1.6	6.4	11.2	12.8	18.9	29.1
Bipedomonas ?	72.0	40.0	76.0	61.9	40.0	94.6
Carteria sp.	0	0	0	0	0	3.6
Unident.Micro-flagellate	40.0	28.0	36.0	40.0	40.0	51.0
Gymnodinium incoloratum	0	0	4.0	1.5	1.5	4.4
TOTAL INCL ALL OTHER SPECIES	426	402	406	404	397	438

All figuers cells per ml. $\bar{x}_{A\ B\ C}$=401.3 $\bar{x}_{D\ E\ F}$= 403.0

PLANKTON

ZOOPLANKTON COLLECTION:

Analyses of the zooplankton are based on fifty liter samples drawn together with the phytoplankton material at each station. During the initial summer a diaphragm pump was utilized to pump an equivalent sample from the bottom for both phytoplankton and zooplankton analysis.

Filtering of the sample is thru removable stainless steel A.S.T.M 230 mesh discs which, initially, were thoroughly back-flushed with a stream of water between samples and, as additional discs and a suitable filter holder became available, the entire disc was changed after each sample.

NET SAMPLE CONTAMINATION

The purpose of disc filtration was to eliminate between-sample contamination which had been suspected in the use of conventional plankton nets. To assess the importance of this factor, the following analysis was undertaken.

A plankton net (G.M.Mfg.,reverse cone mouth with removable standard bucket) was purchased in 1967 and used only for marine sampling on Barnegat Bay. It had been washed with fresh water after every use and in this analysis it was carefully re-washed using 1 liter of distilled water. The rinsings were collected and centrifuged to remove suspended matter, which was then examined microscopically. This investigator was amazed that after drying 17 days since the last use, so many cells would have been judged viable by their appearance in routine examination.

Similarly, stainless filter disc #1, which had been in use at that time for nine months and washed between samples, was dried 17 days following the last use, and vigorously scrubbed in distilled water. The washings were centrifuged for examination.

PLANKTON

NET SAMPLE CONTAMINATION (Cont'd)

RECOVERY OF ORGANISMS ADHERING TO PLANKTON NET MATERIAL BETWEEN SAMPLES

(reported as number of species observed)

	Nylon Bolting Cloth	Stainless steel mesh	% on Stainless
Phytoplankton	25	9	27.8
Zooplankton	6	2	33.3

Seven of the nine species retained on the filter were found on the netting. Of material retained on the filter, only two cells (a stalked benthic diatom Licmophora) would have been judged viable in enumeration.

It was therefore concluded that while the filter apparatus logistically limits the size of sample,(it cannot be passively towed like the net), it significantly reduces contamination between samples from station to station.

With the filters now changed after each sample and cleaned more thoroly under laboratory conditions, contamination should be negligible.

EFFECT OF NET PORE SIZE

It was desired to examine the effect of net pore size on the efficiency with which organisms are removed from the water. Random samples of both net materials were made and under the microscope, micrometer measurements were taken of pore diameter and diagonal dimensions. For woven netting where dimensional differences exist between the warp and woof, approximately half of the measurements were made on each. Twenty-five diameters and ten diagonals were measured on each sample.

PLANKTON

EFFECT OF NET PORE SIZE (Cont'd)

RANDOMLY SAMPLED PLANKTON NETTING PORE SIZE

	BOLTING CLOTH	STAINLESS 230 MESH
Mean Diameter	83.72 u	105.90 u
Range	102.72 u	60.20 u
Std.Deviation	25.08 u	16.29 u
Mean Diagonal	119.90 u	153.50 u
Std. Deviation	11.15 u	13.06 u

Pore size in the stainless material was adjudged to be more uniform, even though the sample had been in use for nine months. The bolting cloth was new and unused. Clearly, the pore size is greater for stainless filter discs. The density reported, therefore, for early naupliar stages, small tintinnids, and minute planktonic eggs is probably less than actual. Heinle (1966) found he was losing most of the early nauplii even through his bolting cloth nets (0.074 u) as well. Since such organisms are periodically of great abundance in Barnegat Bay, a way must be found to circumvent these losses.

In line with this concern, samples were drawn at four stations on the same date with both the plankton net and the filter. The volume of material retained by both systems was evaluated by calibrated centrifugation and no statistically significant differences found, although surprisingly the filter retained, on the average, a slightly higher volume. Enumeration of the samples revealed no consistent trend toward loss in any of the major zooplankton groups although variability was great enough that further investigation is warrented.

Heinle, D.R. (1966) Produ ction of a Calanoid Copepod, Acartia tonsa, in the Patuxent River Area. Ches.Sci.7: 59-74.

PLANKTON

EFFECT OF NET PORE SIZE (cont'd)

NUMBER OF SPECIES AND SAMPLE VOLUME RECOVERED IN PAIRED NET AND FILTER SAMPLES, 1-X-68

(50 liters taken within five minutes of each other on station from an anchored vessel.)

Station	Net Sample		Filter Sample	
	No.	Vol.(ml)	No.	Vol.(ml)
8-27	16	0.06	15	0.05
7-29	17	0.11	16	0.16
10-28	11	0.07	13	0.07
12-27	-	0.08	-	0.15

LOSSES IN CONCENTRATION

Estimates of losses in concentration (not filtration) of the zooplankton material showed that essentially all zooplanktons removed from the filter were retained in the final condensate. Between 1.8 and 2.3% of *Zoothamnium* , an epizooid and *Acartia spp.*, was lost in concentration. Because of its phenomenal seasonal abundance and lack of uniformity in distribution on host copepods, *Zoothamnium* has not been included in the numerical abundance data. Its occurrence however is always noted on the data sheets for purely comparative purposes.

ENUMERATION

Zooplankton samples are enumerated by depositing 1 ml. of suitably concentrated material in a Sedgewick-Rafter counting cell and counting ten random fields with the scanning lens at X 32. For large and infrequently occurring specimens the entire cell is occasionally counted.

VARIABILITY IN THE DENSITY OF PLANKTON ORGANISMS

The variability of natural plankton communities both in space and time is an accepted fact. Investigators, furthermore, have long been faced with the problem of evaluating and describing changes in the component populations. The depiction of average numbers by date produces confidence intervals so great in magnitude that often the statistical significance of date to date variations is masked.

One of the purposes of this study has been to develop a means for handling this variability, so that changes in the environment, natural or artificial, which produce measurable changes in the plankton community can be evaluated. This does not presume we will be certain to detect any changes which occur but it is believed at least that, for each point in time, we should be able to adequately characterize the existing community.

Verduin (1951) faced similar problems of variability in the distribution of a natural phytoplankton community. He despaired at gaining more than minimal insight from single station collections and suggested the possibility of altogether abandoning the station concept of sampling. Rather, he proposed, one should draw frequent successive samples at known intervals along a pre-determined course. He felt that averaging these would provide a better picture than any individual determination.

Verduin, J. (1951) A comparison of Phytoplankton data obtained by a Mobile Sampling Method with those obtained from a Single Station. Am.J.Bot. 38: 5-11

VARIABILITY IN THE DENSITY OF PLANKTON ORGANISMS (Cont'd)

It was believed in Barnegat, however, that since we were trying to determine position effects, the station concept could not be entirely abandoned. Thus, areas were chosen which might be expected to reflect differences and stations kept within these areas. (see synoptic statement at beginning of this Plankton Section)

The concept of response surfaces has proven of immense worth in evaluating experimental data. The extension of the response surface or contour mapping into natural environments has not appeared with great frequency in the literature. Hulburt (1956) presents contour maps of the phytoplankton of Great Pond, along with the associated physical parameters. Patten (1968) recently used three-dimensional surfaces to pictorially represent his factorial approach to productivity in an Atlantic Coast estuary. Isopleth maps have long been used in limnological and oceanographic work to depict depth-time changes in various environmental parameters, including nutrient and chlorophyll concentrations.

It was found that for most data collected during the initial summer, representation was sufficient in the five major areas to allow presentation of nearly continuous records. As an extension of surface methodology, organism abundance can be employed as the response and a space-time matrix as the reference plane, representing all the complex variables of temperature, insolation, salinity, and other hydrographic effects.

Patten, B.C. and Chabot, B.F. (1966) Factorial Productivity Experiments in a Shallow Estuary: Characteristics of Response Surfaces. Ches. Sci. 7:117-136.

VARIABILITY IN THE DENSITY OF PLANKTON ORGANISMS (Cont'd)

This mechanism shows definite promise for describing and evaluating the plankton and its component populations over distinct areas in the bay at successive points in time. The description of variability among stations is never sacrificed by an averaging process.

The phytoplankton for summer, 1967 is shown according to this technique in Figure 11A . Station 9-28 is the mouth of Forked River close to the Intake Canal, 10-30 represents the potential effluent area off Oyster Creek. The utility of the method for following changes in phytoplankton abundance at a particular station should be obvious.

Anomalies in the surface can almost always be explained by reference to individual sample data. The immense peak at station 10-30 in mid-August is, for example, accounted for by a concentration of the microplagellates Carteria and Bipedomonas (?) Sp

STATION 10-30 OYSTER CREEK MOUTH

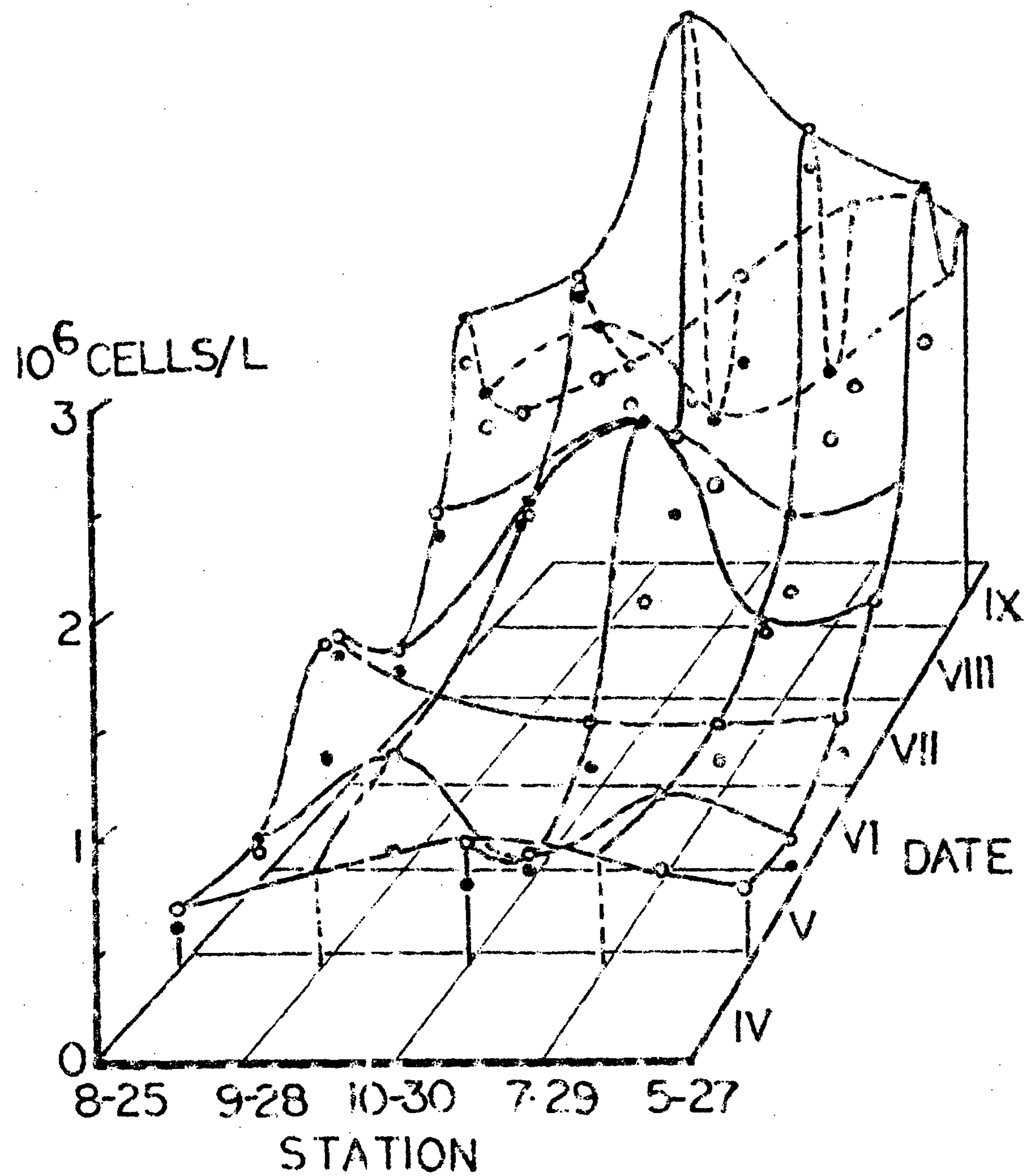
15-VIII-67

Depth	2 Species Microflag. / l.	Copepod Nauplii no./m	Temp. ^{O}C	Salinity o/oo	Oxygen mg/l
Surf.	1,786,000	14,580	22.5	22.2	6.76
2.8m	398,000	3,280	21.3	28.5	8.69

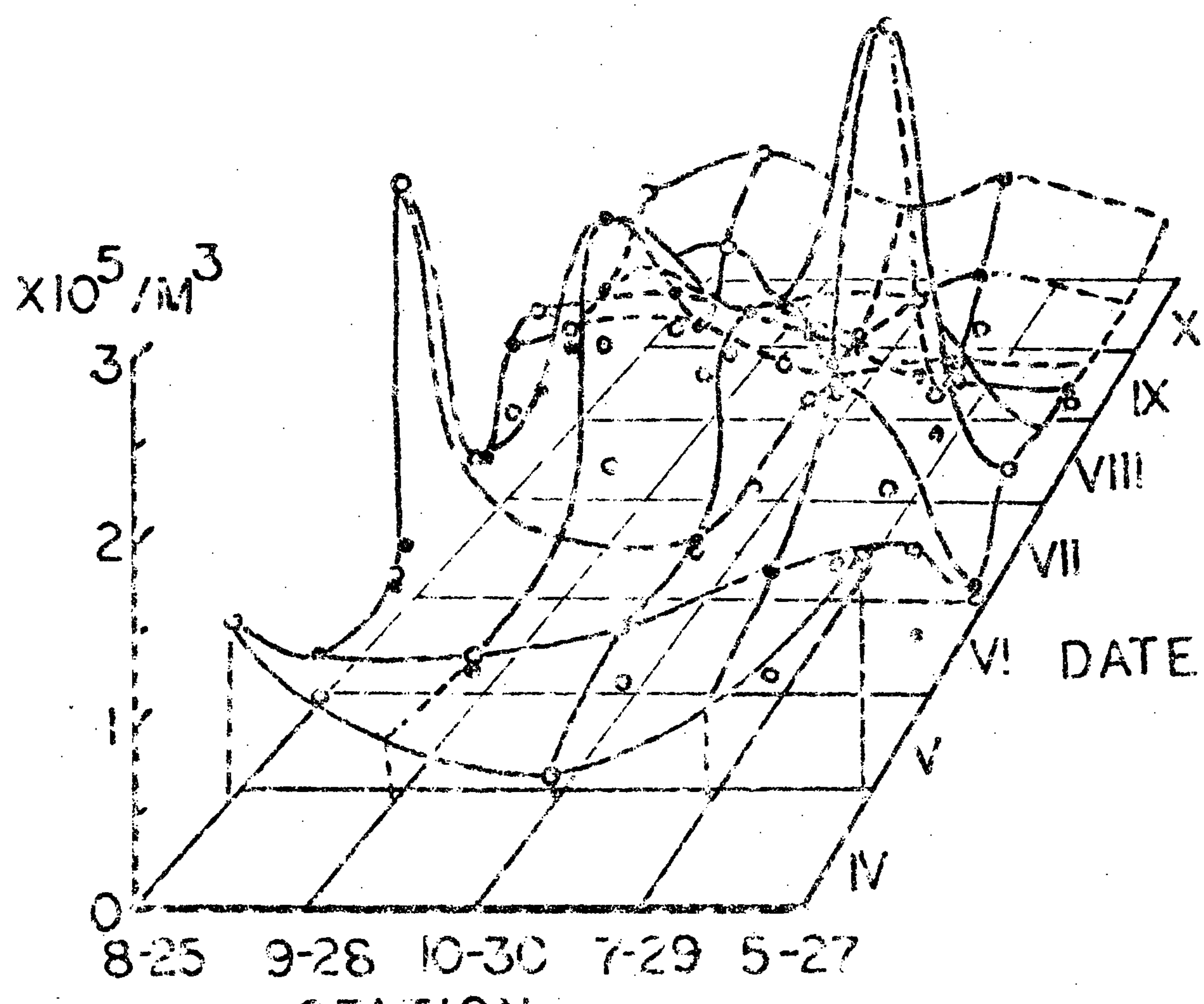
The microflagellates were of an order of magnitude that makes them acceptable food particles for the nauplii. Although no direct evidence of feeding is available from fixed material, Heinle (1969) successfully uses Carteria to rear Acartia tonsa in culture.

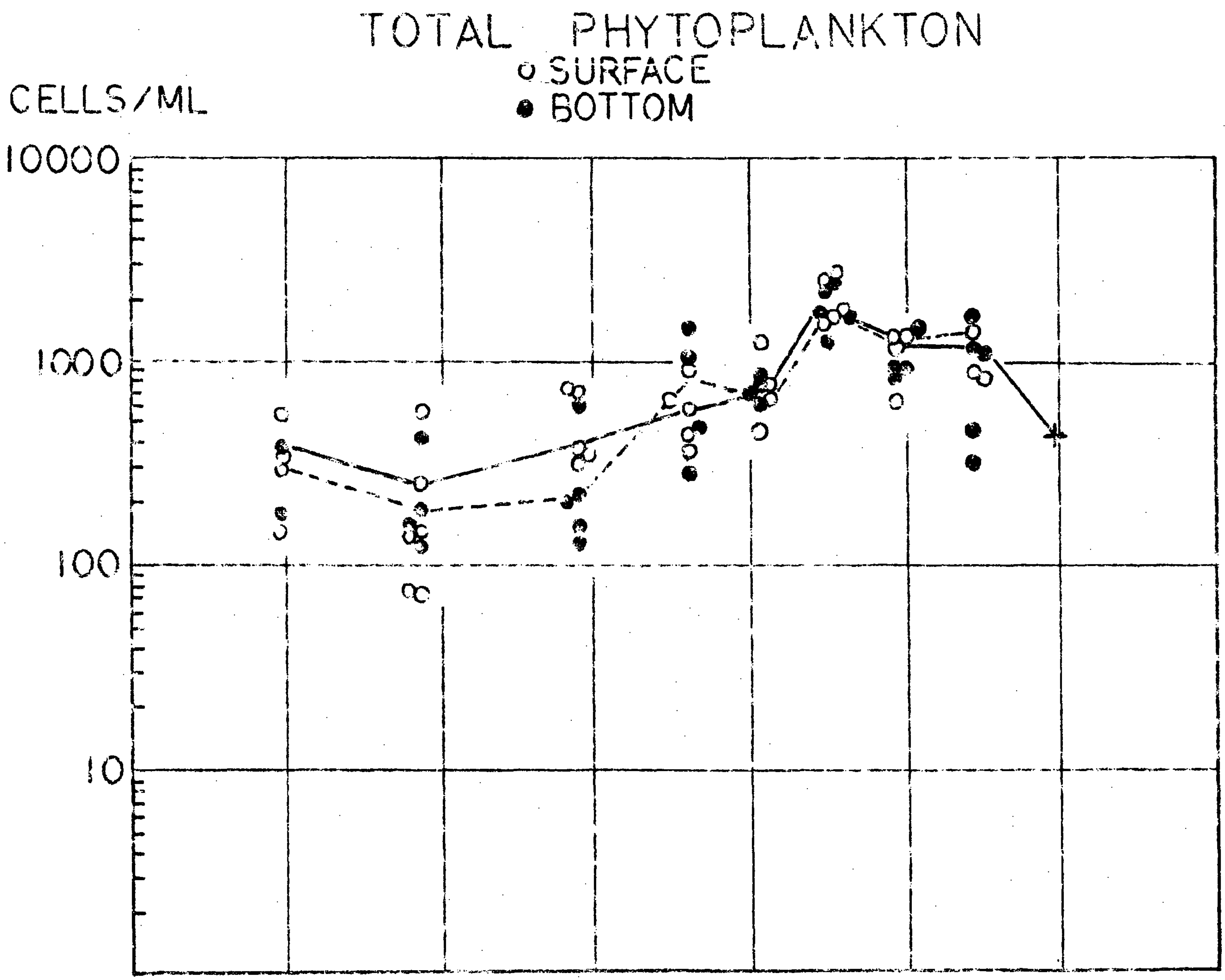
Heinle, D.R.(1969) Culture of Calanoid Copepods in Synthetic Seawater. J.Fish.Rsch.Bd.Can.26: 150-153.

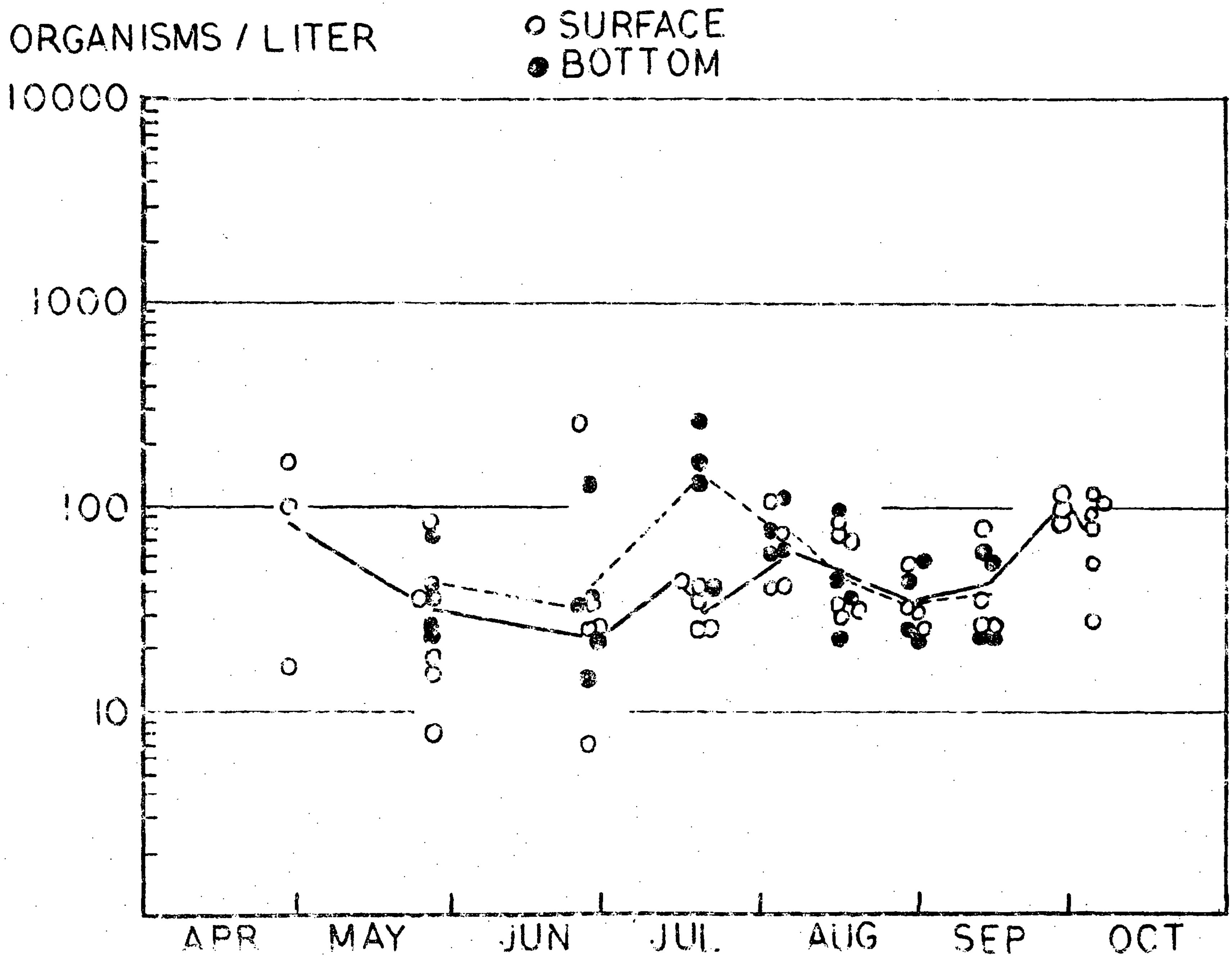
TOTAL SUMMER PHYTOPLANKTON 1967



TOTAL SUMMER ZOOPLANKTON 1967




TOTAL PHYTOPLANKTON
o SURFACE
● BOTTOM
CELLS/ML
10000
1000
100
10


ORGANISMS / LITER
o SURFACE
● BOTTOM
10000
1000
100
10
APR
MAY
JUN
JUL
AUG
SEP
OCT

G 11B

SUMMER 1967 DISTRIBUTION OF *SKELETONEMA COSTATUM*

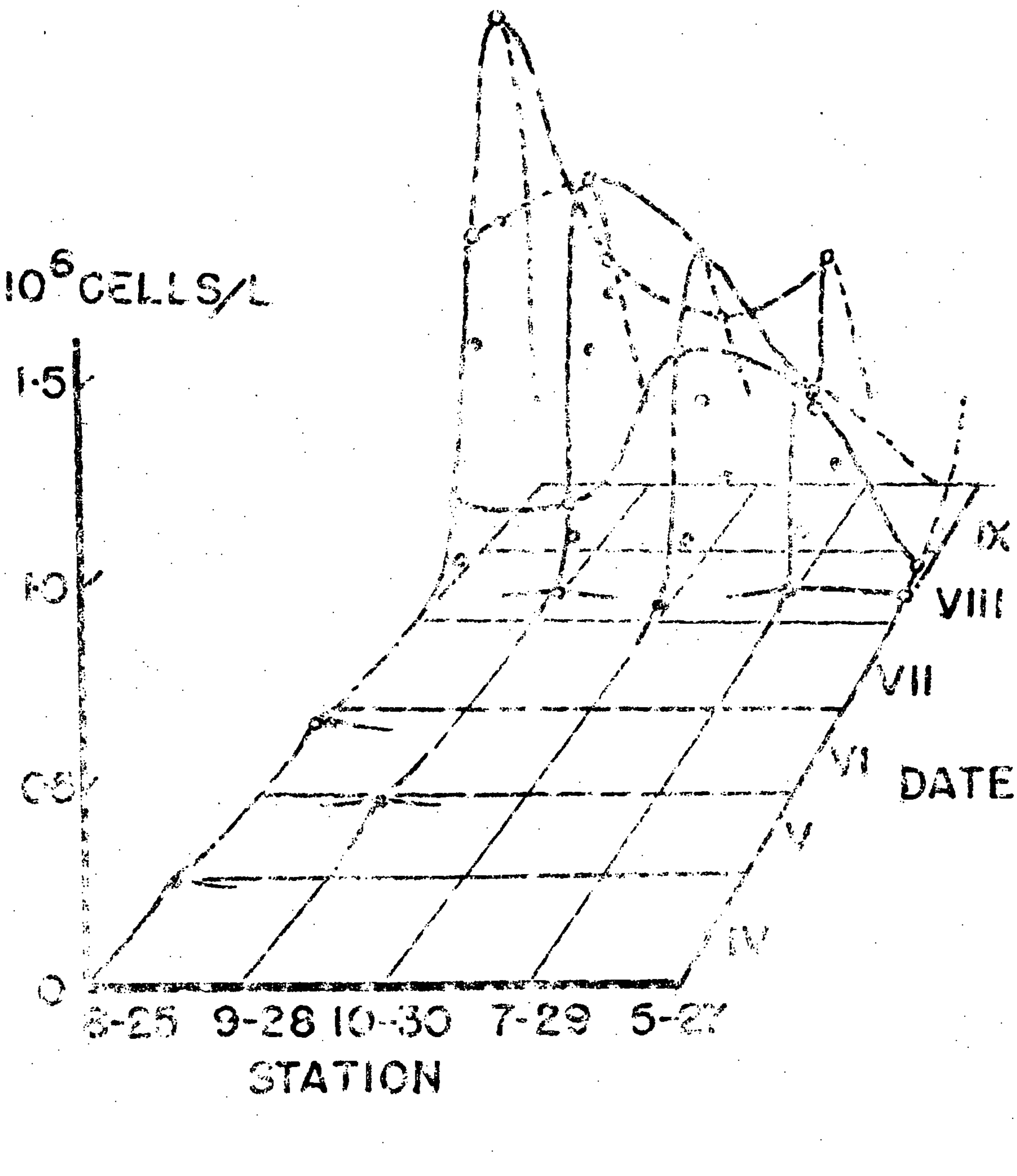
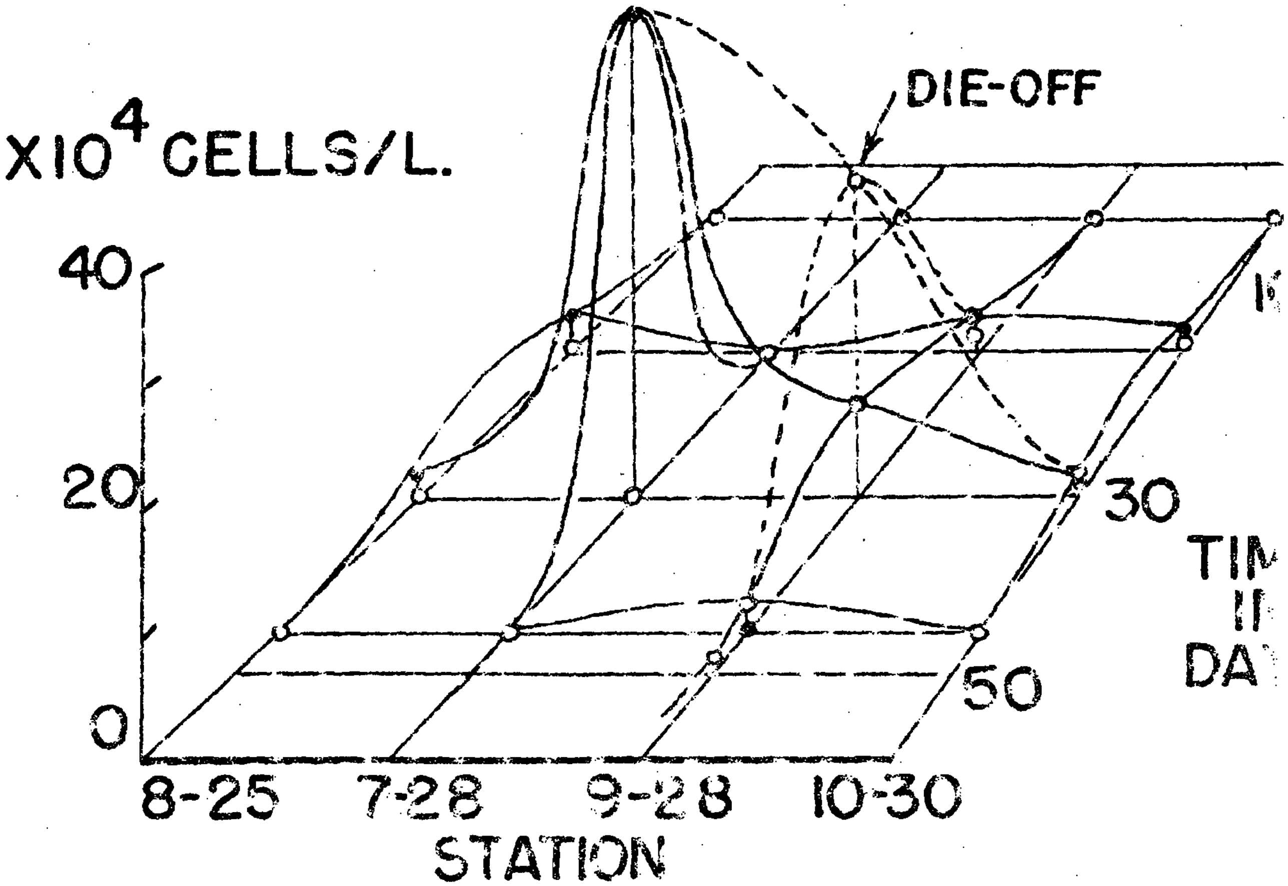
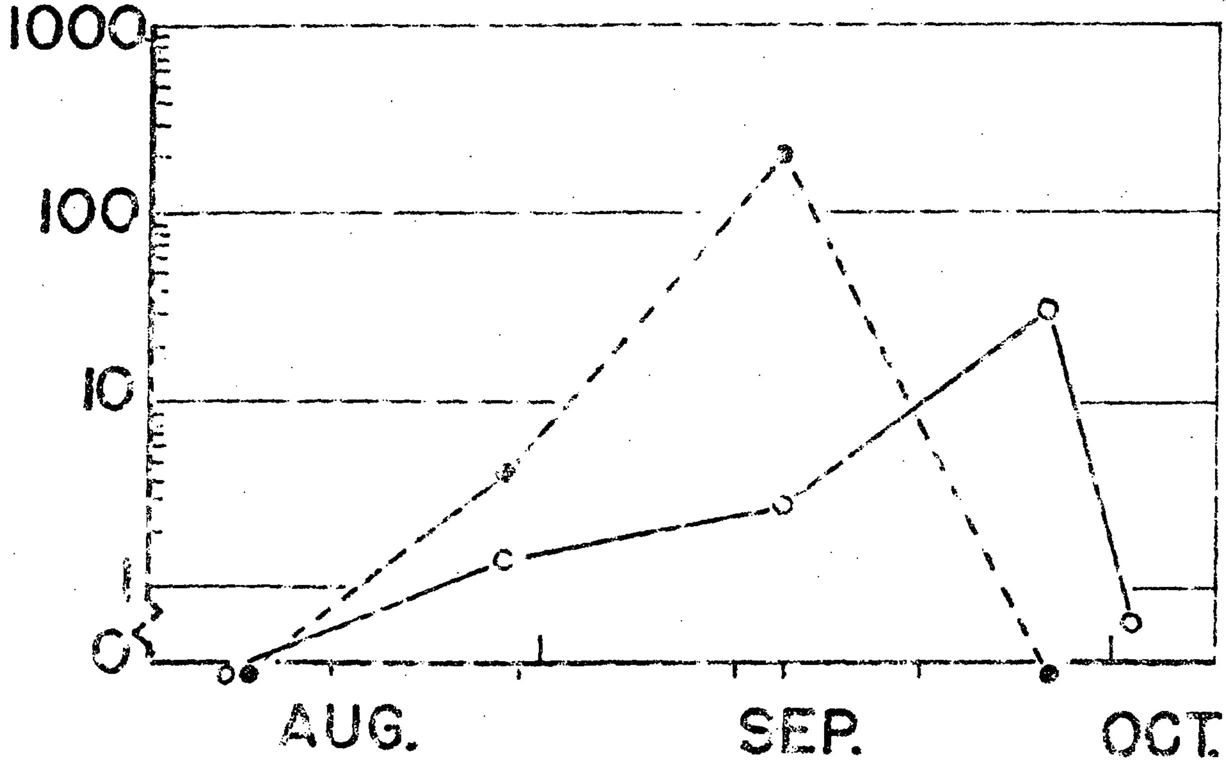


FIG. 12 A



GYMNODINIUM SPLENDE



VARIABILITY IN THE DENSITY OF PLANKTON ORGANISMS (Cont'd)

With the separate enumeration of individual species making up each sample, a practice followed throughout this investigation, the dominant organisms during a particular period (for which reasonable confidence can be obtained in estimating abundance) may be dissected from the total picture and arrayed in a similar fashion. A localized bloom of the dinoflagellate Gymnodinium splendens is shown in figure 12 A, with the conventional "mean by date" separately presented below. The latter method says nothing about maximal observed densities, or where the organism occurred. In making any inferences about effects at a particular position, both these pieces of information are essential, and both are provided by the surface. A further example is useful.

In August, Skeletonema costatum became the most abundant diatom in Barnegat Bay, a position it relinquishes only temporarily during the flowering of colder months and to occasional anomalies such as Asterionella which Edgar (personal communication) reported as a spring dominant shortly before this survey began.

One can follow the small seed stock appearing as a trace at one station or another, chiefly at the bottom in the channel off the west shore, through the summer. This continued through 2 VIII until 11 VIII, when the diatom appeared in small numbers at all but one station. Three days later, on the 15th, one encounters a veritable wall of Skeletonema rising rapidly to peak at different stations on different dates. Maximum development occurs at 8-25, the mouth of Stout's Creek, on 13 IX.

VARIABILITY IN THE DENSITY OF PLANKTON ORGANISMS (Cont'd)

Curl and McLeod (1961) determined experimentally the response of Skeletonema to several environmental parameters. They found a salinity optimum for photosynthesis at and slightly above 20.0 o/oo. Station 8-25 was 23.1 o/oo, the lowest and most nearly optimal salinity encountered on that date. The temperature, at 16.6°C was the lowest observed on that date. Skeletonema becomes light saturated at about 15 X 10^3 lux at 15-18°. A secchi reading of 0.9m, lowest of the four stations, probably served to attenuate incident surface radiation (which might have reached 100 X 10^3 lux) sufficiently to prevent inhibition.

It might be useful to note that Skeletonema seemed to become more abundant high in the water column as the bloom progressed. This trend is obvious even in the average data (Fig. 28 A). It is not clear whether this trend is accounted for by increased buoyancy, or by differential reproduction.

Application of this technique in the present report has been restricted chiefly by the availability of time, great amounts of which are demanded by the arithmetic operations involved. Future applications, it is hoped, will have the support of a computer, which quickly and inexpensively can present material in a suitable form.

Curl, H and McLeod, G.C. (1961) The Physiological Ecology of a Marine Diatom, Skeletonema costatum (Grev.) Cleve; J. Mar. Res.: 70-88.

VARIABILITY IN THE DENSITY OF PLANKTON ORGANISMS (Cont'd)

Limitations of the method are obvious. Interpolations between sampling dates and sampling locations tell us nothing about what actually occurred between points, and, while the surface represents our best estimate of what is going on at a particular point, the estimate is blurred by the width of the confidence interval surrounding each determination.

VARIABILITY WITHIN STRATUM:

If we replicate sampling of a given stratum and replicate aliquots drawn on each of those samples and then replicate counts of ten fields within each aliquot, we have a body of data permiting a rough estimate for the 95% confidence interval expected about a single determination on a single sample. The confidence interval means that for a given estimate we have 95% probability this interval contains the true mean concentration present in the source water.

Based upon such replication, this interval for the current data approximates ± 17% for a single phytoplankton determination, and ± 11% for a single zooplankton determination. Replication at any point gives a considerably better handle on our density estimate. Full replication is of course hopelessly ambitious, but in future work some continual control on sampling and counting variability will be run.

It is also considered essential to incorporate some of Verduin's ideas on mobility: to operate rather quickly, reaching an adequately large number of stations in a relatively short time, so that effects operating over a tidal cycle can be minimized.

PLANKTON

VARIABILITY WITHIN STRATUM: (Cont'd)

The Barnegat estuary, with wide tide-swept areas to the east, where water masses apparently change completely in a single tidal flux, and the deeper western portion with much slower turnover and an axis oriented essentially north-south, should be relatively well monitored by a single longitudinal transect that would cut across both intake and effluent canals and include a number of stations between and on either side. Such a situation would be ideal for the application of surface methodology, and there is no reason why photosynthesis would not also be an appropriate response.

PLANKTON

POOLING OF SAMPLES:

When some question arose with respect to continuing support for the plankton investigation, it was no longer possible to devote the time and effort necessary for uniform individual sample determinations.

Therefore, following enumeration of the initial summer's material an aliquot of each sample collected was pooled and a single determination made, resulting in an average evaluation of the plankton for each date. This operation removed any possibility of discriminating differences within date, between stations, or strata within station, but enabled a rough monitoring of seasonal patterns and abundance. It is hoped that support will be restored for more complete examinations in the future.

Dates embodying the usual degree of variability from station to station were chosen from the 1967 material, upon which numerical determinations had been made some months before. Aliquots of both the phytoplankton and zooplankton were pooled and these were then enumerated in duplicate. The pooled determinations lay within one least significant interval (L.S.I.) of the grand mean of individual enumerations and therefore would not have been declared statistically significant from the grand mean at the P=.05 level. The approximation for zooplankton was less satisfactory than for phytoplankton, as might be expected considering the relative abundance and therefore the usual number of organisms counted during a determination.

Because of the tremendous loss of pertinent information inherent in this method, however, it cannot be recommended. Portions of each sample, unpooled, are retained for the benefit of any future investigations. i

OBSERVATION OF PLANKTON STRATIFICATIONS:

During the initial summer, considerable detailed sampling was conducted to examine the existence and stability of stratification in the plankton community. The necessity of maintaining a flexible schedule of station visits made it impossible to continue

OBSERVATION OF PLANKTON STRATIFICATIONS: (Cont'd)

this detailed investigation beyond September, 1967. It was possible to gather some similar data in 1968 for the phytoplankton but the time and support required for analysis has not become available.

In examination of the summer phytoplankton twenty-five instances in which particular organisms were significantly stratified in the water column were noted (Table 20P). It is worth noting that of the eleven taxa, eight are motile species, and therefore at least in principle capable of responding to vertical gradients or stimuli in the water column.

The species involved are all, at one season or another, dominant or at least very important components in the phytoplankton community. Generally, stratification high in the water column would increase the probability of entrainment to the condensers for a given organism, and stratification near the bottom would probably preclude it.

The tendency to favor an optimum in light or salinity probably plays an important role in stratification, either thru migration or by differential reproduction and floatation. During the all-night run 12-13 July, 1968, a remarkably complete migration of luminescent dinoflagellates to the surface was noted. No luminescence could be detected in bottom samples brought to the surface from below two meters at station 9-28, the mouth of the intake canal. For an analysis of data collected on this cruise refer to overnight respiration in the Primary Productivity Section.

The tendency in zooplankton stratification is less clearcut. In five out of the eight significant ($15,000/m^3$) concentrations of polychaete setigers, the largest numbers were found near the bottom. Sanders et al (1962) reports this behavior typical of many juvenile polychaeta where exposed to a tidal stream.

Sanders, H.L., Goudsmit, Mills, Hampson (1962)
Intertidal Fauna of Barnstable Harbor, Mass.

OBSERVATION OF PLANKTON STRATIFICATIONS: (Cont'd)

Station 7-28 where this stratification was most graphically expressed, although relatively shallow (ca.2 m.), is strongly swept by the tidal currents radiating from and converging upon, the Inlet.

The mean number of pelecypod veligers by date, however was greater at the surface in all but two cases, with the greatest observed mean concentrations occurring at the surface in late August and mid September.

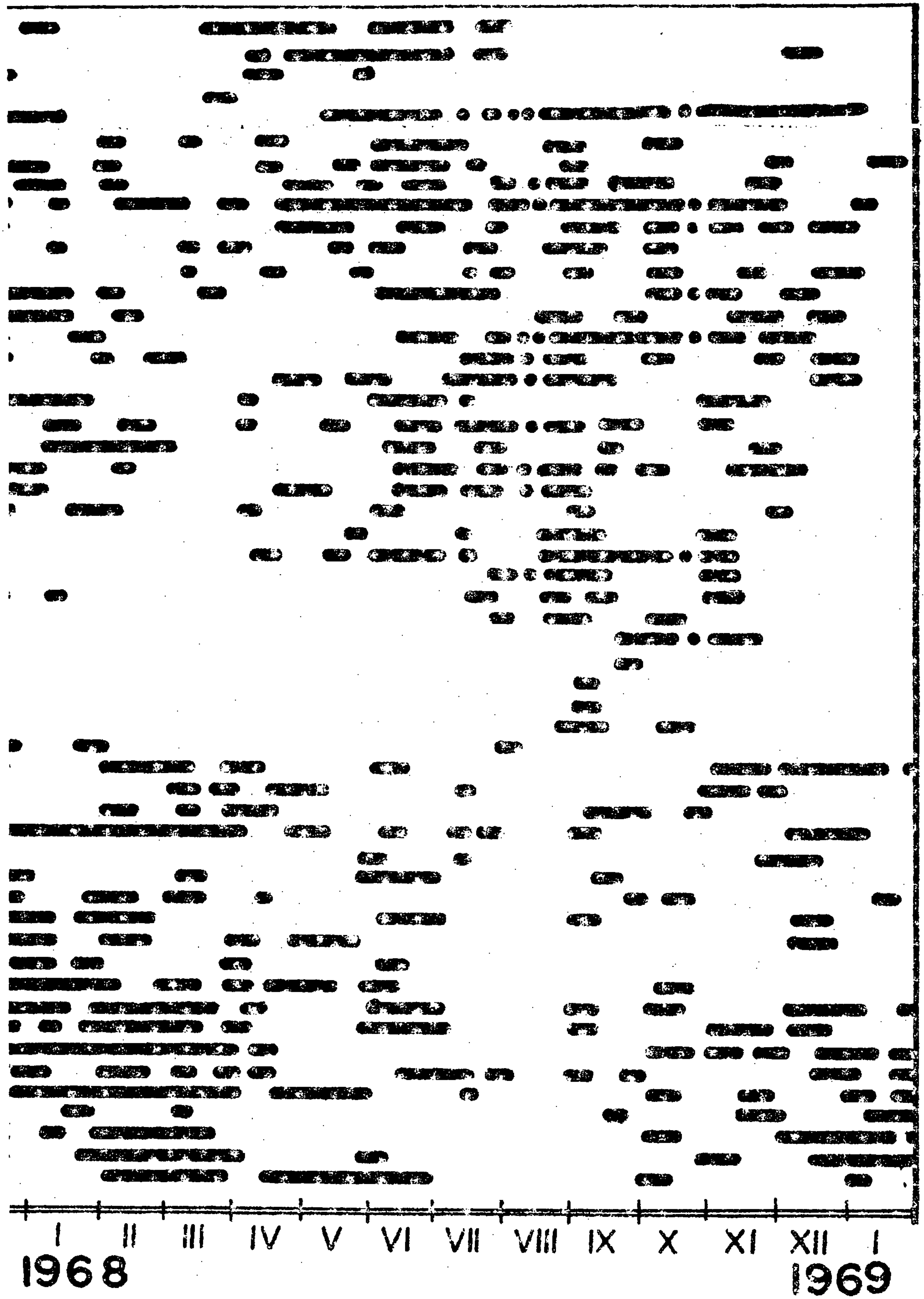
In scanning the graphic data in sections to follow it appears generally that phytoplankton density is greater near the surface between perhaps May and early September. Than for the breif period before individual determinations were suspended, the stratification breaks down or reverses. With the zooplankton, a converse pattern may be the case with concentration near the bottom until the end of August and higher in the water column afterward.

PRONOUNCED STRATIFICATIONS IN PHYTOPLANKTON

The 1967 Summer Phytoplankton of Barnegat Bay

DATE	ORGANISM	SAMPLE	STATION	COUNTS IN CELLS PER ML. SURFACE	BOTTOM
May 27	Prorocentrum Triangulatum	67-19	7-29	0	254
" "	Cyclotella	67-23	9-28	310	51
Jun 25	Gymnodinium Incoloratum	67-25	8-25	323	0
" 27	Cryptomonas	67-27	8-25	204	65
" "	Gymnodinium Incoloratum	67-31	7-29	105	60
" "	Calycomonas Gracilis	67-33	5-27	144	72
Jul.19	Gymnodinium Incoloratum	67-36	8-25	103	16
" "	Prorocentrum Triangulatum	67-36	8-25	105	0
Aug. 2	G. Incoloratum	67-45	8-25	68	247
" "	P. Triangulatum	67-47	7-29	46	117
" "	Calycomonas Gracilis	67-47	7-29	[illegible]6	182
" "	G.Incoloratum	67-50	8-25	124	45
" 15	Skeletonema Costatum	67-54	7-29	481	109
" "	P. Triangulatum	67-55	7-29	122	22
" "	Cyclotella	67-54	7-29	92	211
" "	Carteria &Bipedomonas	67-56	10-30	1786	398
" "	S.Costatum	67-57	10-30	103	581
" "	Cyclotella	67-56	10-30	201	TR
" "	S.Costatum	67-59	9-28	90	187
" "	S.Costatum	67-61	8-25	44	192
Sep.13	Gymnodinium Splendens	67-73	7-29	0	394
" "	Gonyaulax Digitale	67-73	7-29	0	394
" "	S.Costatum	67-72	7-29	676	149
" "	S.Costatum	67-74	10-30	524	128
" "	Nitzschia Closterium	67-74	10-30	43	112

ORGANISM REGISTER



I II III IV V VI VII VIII IX X XI XII I
1968
1969

A PREDICTIVE DIAGRAM

An initial objective was to examine the plankton through at least one complete annual cycle and determine to what degree the succession of species was predictable. Toward this end exhaustive live examinations have been made and checklists on individual samples have been prepared as a monitoring device. As the enumeration of fixed material progresses, additional species are added and some idea of the expected abundance develops. An alphabetical taxonomic index of the plankters recorded is presented in synoptic form, to supplement that appearing in a previous report.

The phytoplankton survey has been underway in middle and lower Barnegat for considerably less time than the Benthic survey. Nonetheless, sufficient repetition in succession has been observed to warrant development of a preliminary predictive model for the Phytoplankton.

Initial concern was with the occurrence rather than phylogenetic relations among organisms. Because of the difficulty identifying the members of some genera to species without special preparation of the cells, a number have been grouped arbitrarily (Peridinium spp.), etc. but only where members of the group appeared together or in close association. For each organism an occurrence histogram was developed and arrayed on a true time scale representing the annual cycle (arbitrarily April to April since sampling began in April 1967). The family of histograms was then ordered solely on the basis of appearance, with organisms occurring early in the cycle at the top, and successively those appearing later, and for longer periods, lower in the array. The result was a complex diagonal pattern representing the recorded seasonal succession.

Since, after all, the diagram was intended for predictive purposes, the data from an additional twelve months collecting was broken out by species, and arranged in the same order. The histograms were added, and the two patterns compared. Many organisms did not of course exhibit a clear pattern of seasonal appearance. By and large, preliminary indications suggest that the variability in abundance of many such organisms is seasonal, but the data are as yet inconclusive, so these histograms were removed from the diagrams.

A PREDICTIVE DIAGRAM (Cont'd)

The remaining two arrays, representing separate sampling and analysis of nearly two years' data bear a remarkable similarity. They are presented side-by-side in Fig. 20A.

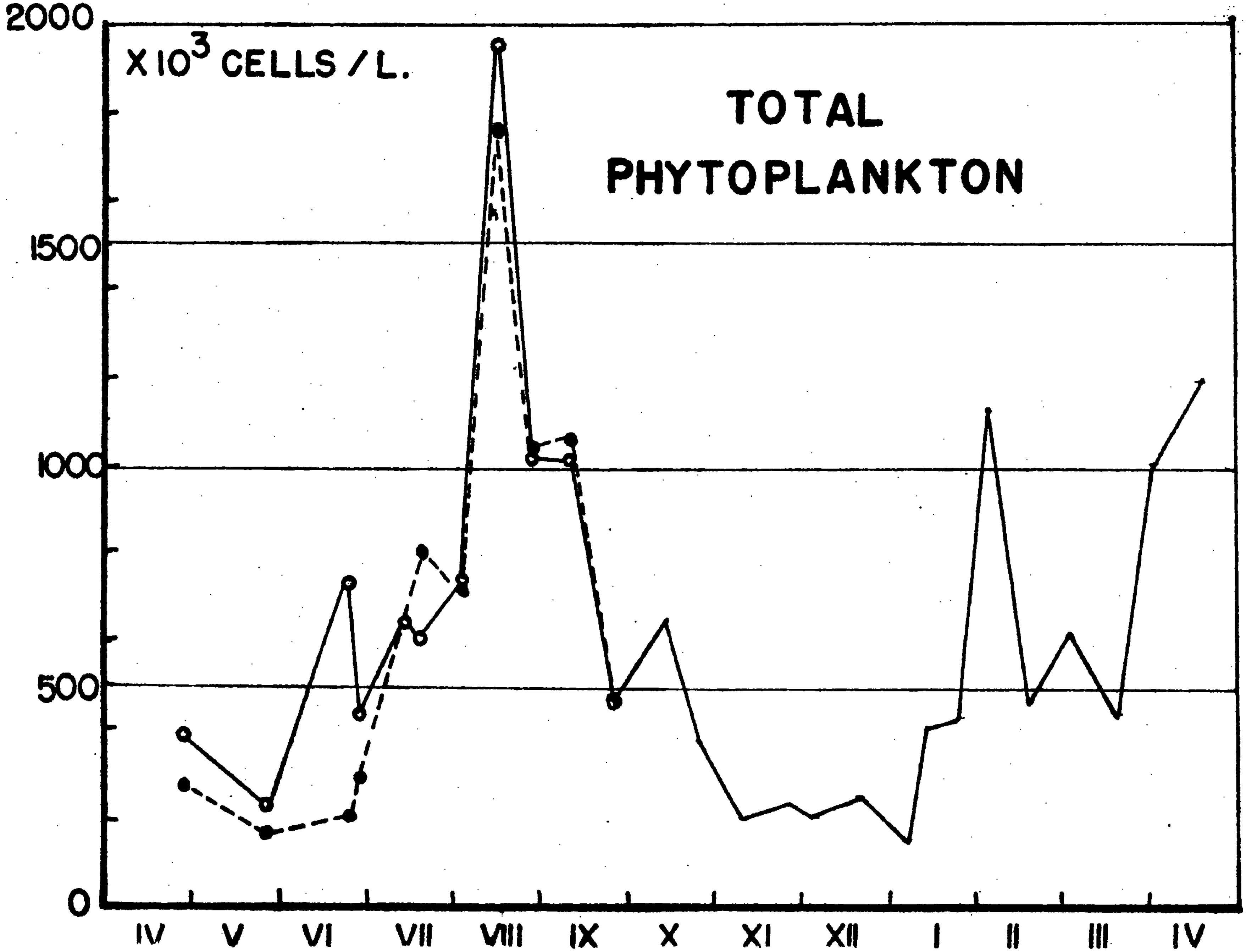
One will note an apparently reduced frequency of occurrence for many organisms in the second year. This is because nearly all the 1968 material subsequent to April has received only preliminary live examination. The 1967 and early 1968 material has been subjected to repeated analysis with collections from each date receiving an absolute minimum examination of 40 fields spread over three distinct subsamples. For this data, of course, reasonable numerical estimates are available on each important phytoplankter.

GENERALIZED SEASONAL CYCLE (PHYTOPLANKTON)

The annual cycle is perhaps most adequately represented by the diagram. Therefore only a general comment will be made.

The spring bloom seems to begin in February, starting, perhaps with an innoculum of Thalassiosira nordenskioldi and Detonula confervacea and possibly Detonula cystifera introduced through the inlet. The presence of heavy and persistent ice cover may attenuate illumination sufficiently (see Primary production estimates for 11-I-69) to prevent full development of the bloom until melting occurs. Post-ice development of Thalassiosira was phenomenal early in 1968. It appears to be augmented significantly by strong and frequent west winds typical of February and March following the passage of extra tropical cyclones. These winds produce a migration of surface water from west to east in the bay and out the inlet (3-III-69 surface salinity at Barnegat Inlet 27.7 o/oo) accompanied by an upwelling of more saline water along the West shore (3-III-69 surface salinity near Oyster Creek mouth 30.6 o/oo +2.2°C. wind NW 20 knots).

While Thalassiosira was the dominant single species during the bloom, it is significant to note that total microflagellates exceeded even this dense population (615 of every 1119 cells were microflagellates). These tiny organisms appear to be of great numerical importance in the estuary regardless of season. They are either tolerant of extremely variable conditions or capable of producing


2000
1500
1000
500
0
X 10^3 CELLS / L.
TOTAL
PHYTOPLANKTON
IV
V
VI
VII
VIII
IX
X
XI
XII
I
II
III
IV

PLANKTON

GENERALIZED SEASONAL CYCLE (PHYTOPLANKTON) (Cont'd)

almost limitless ecotypes in response to drastic environmental presures.

The Thalassiosira-Detonula complex in many estuaries is succeeded by Skeletonema costatum apparently almost completely on the basis of a higher thermal optimum greater than 2°. (Riley, 1966). Skeletonema becomes important in Delaware Bay in late winter and early spring (Haskin, personal communication). Significant zooplankton grazing, with a high standing crop of copepods, apparently prevents the intense bloom conditions from continuing. Productivity, judged by food requirements must remain very high, but a delicate dynamic equlibrium seems to exist between a succession of phytoplankters and the grazing populations.

By June, rising water temperatures beyond the optimum of cold water diatoms and the sudden decimation of the copepod stock by predacious Ctenophores brings this equilibrium to and end. Here, with warming more rapid, we see a distinct shift in the phytoplankton to a series of dinoflagellates, particularly Prorocentrum spp. Occasional "red-tide" concentrations are observed. Dinoflagellates are distinctly dominant through much of the peak-temperature season.

In general terms, one can predict that in late summer, Skeletonema costatum will become important, probably exceeding 1.0×10^6 cells per liter at most stations. Cyclotella (probably meneghiniana) is the only other diatom of condiserable importance throughout the warmer months.

This diatom is apparently encountered near the mouths of creeks and may, indeed, receive an innoculum from fresh water. A diatom closely agreeing with this species was isolated in millipore filtered Erd-Schreiber enriched Barnegat baywater at approximately 23 o/oo salinity from an exploratory culture taken in lake Farrington, a fresh-water lake, totally landlocked and separated from its outfall by a 23 foot dam. The diatom flourished for some time before the culture was lost thru a medium deficiency.

Riley, Gordon A. (1966) in Marine Biology (Proceedings) N Y. Acad. Sci. page 165.

GENERALIZED SEASONAL CYCLE (PHYTOPLANKTON) Cont'd

Microflagellates, again, are of extreme importance during the summer months, with great concentrations exceeding a million cells per liter forming from time to time (see variability section).

The chlorophyte Nannochloris was not adequately enumerated owing to its minute size and remarkable abundance. A few estimates made during summer blooms of this organism in Barnegat Bay indicate it may superimpose populations of between 1.1 and 10.3 million cells per liter on the rest of the phytoplankton community, which itself may exceed a million cells per liter at the same time.

Phytoplankton abundance decreases toward a minimum in early January, while a strong shift in species composition occurs. The dinoflagellates are again replaced, with falling temperature, by a mixed diatom population, with traces of Thalassiosira and Detonula appearing to represent seed-stock for the February spring bloom.

The synoptic list and graphic materials summarizing individual phytoplankton density determinations follow.

PLANKTON

ALPHABETICAL REGISTER OF PHYTOPLANKTON ORGANISMS RECORDED FROM BARNEGAT BAY, N.J.

* Particularly important species, seasonal dominants or ubiquitous members

Achnanthes longipes
Actinoptychus undulatus
Agmenellum sp.
Amphidinium spp.
A. carteri
A fusiforme
A. sphenoides
Amphiprora incompta
A. surirelloides
Amphora sp.
Aphanothece sp.
Asterionella japonica
Biddulphir spp.
B. arctica
B biddulphiana
v B. favus
B. granulata
B. vesiculosa
* Bipedomonas sp.?
* Calycomonas gracilis -3 forms -
Campylodiscus sp.
c. fastuosus
Carteria sp.
Cerataulina bergoni
Ceratium bucephalum ?
C. fusus
C. macroceros
C. minutum
* Ceratium tripos
Chaetoceros spp.
C. approximatus
C. boreale
C. curvisetum
C. debilis
*C. decipiens
C. dichaeta
C. didymus
C. fragile
C. secundus
C. simile
C. simplex
C. subtile
Chlamydomonas
Chroomonas sp.
* Cocconeis
Cochlodinium helicoides

PLANKTON

ALPHABETICAL REGISTER OF PHYTOPLANKTON ORGANISMS (Cont'd)

Coscinodiscus spp.

C. angstii

C. centralis

C. excentricus

C. radiatus

* Cryptomonas spp.

Cyclotella nana ?

* C. meneghiniana

Cymbella spp.

Detonula spp.

* D. confervacea

* D. cystifera

Dinophysis sp.

D. acuminata

D. acuta

D. ovum

Diploneis sp.

D. crabro

Diplopsalis lenticula

Distephanus speculum

Ditylium brightwelli

Ebria tripartita

Eucampia groenlandica

E. zodiacus

* Euglena spp.

* Eutreptia sp.

Fragillaria sp.

F. crotonensis

F. cylindrus

Glenodinium sp.

G. danicum

G. foliaceum

Gleocystis gigas

Gomphonitzschia sp.

Goniodoma sp.

Gonyaulax sp.

* G. digitale

G. polygramma

G. scrippsae

* G. spinifera

G. tricantha

Grammatophora spp.

Guinardia flaccida

Gymnodinium spp.

* G. incoloratum

G. nelsoni

G. punctatum

* G. splendens

Gyrodinium spp.

G. dominans

G. pellucidum

G. pingue

PLANKTON

ALPHABETICAL REGISTER OF PHYTOPLANKTON ORGANISMS (Cont'd)

Gyrodinium resplendens

Hemidinium sp

Lauderia glacialis

Leptocylindrus sp

L. danicus

L. minimus

Licmophora sp.

Lithodesmium undulatum

Lyngbya sp.

Massartia sp.

Melosira sp.

M. borreri

M. granulata

M. juergensii

M. nummuloides

* Nannochloris sp.

N. atomus ?

* Navicula spp.

N. crucicula

N. distans

N.(Schizonema) gravelei

N. gregaria

N. monilifera

N. nummularia

N. peregrina

Nematodium sp.

N. armatum

Nitzschia sp.

* N. closterium

N. paradoxa

N. seriata

Noctiluca miliaris

Ochromonas sp.

Oscillatoria spp.

Ostreopsis monotis

Paralia (melosira) sulcata

Pediastrum sp.

Peridinium spp.

P. brevipes

P. claudicans

P. depressus

P. excavatum

P. granii

* P. leonis

P. pallidum

P. roseum

P. triquetra

* P. trochoideum

* Peridinopsis rotunda

Phormidium sp.

Pinnularia sp.

P. ambigua

Pleurosigma (Gyrosigma) sp.

P. fasciola

ALPHABETICAL REGISTER OF PHYTOPLANKTON ORGANISMS (Cont'd)

Pleurosigma formosa

P. marinum

Polykrikos sp.

P. barnegatensis

P. hartmani

P. kofoidi

* Prorocentrum micans

* P. redfieldi

P. scutellum

* P. triangulatum

Pyramimonas sp.

P. tetrarhynchus

P. vorta

Rhabdonema adriaticum

Rhizosolenia sp.

R. alata

R. cylindrus

R. delicatula

R. fragillima

R. semispina

* R. setigera

R. stolterfothii

Scenedesmus quadricaudata

Schereff lia dubia

Schizonema (navicula) gravelei

* Skeletonema costatum

Spirodinium fissum

Spirulina sp.

Striatella unipunctata

Surirella sp.

S. smithii

Synedra sp.

S. hennedyana

Tabellaria sp.

Thalassionema sp.

T. frauenfeldii

T. nitzschiodes

Thalassiosira spp.

T. condensata

T. gravida

T. hyalina

* T. nordenskioldi

T. pacifica

T. rotula

Thallassiothrix longissima

Zygnemopsis ?

MISCELLANEOUS:

Chlorococcales

Ciliate algal swarmers

Cyanophyta misc.

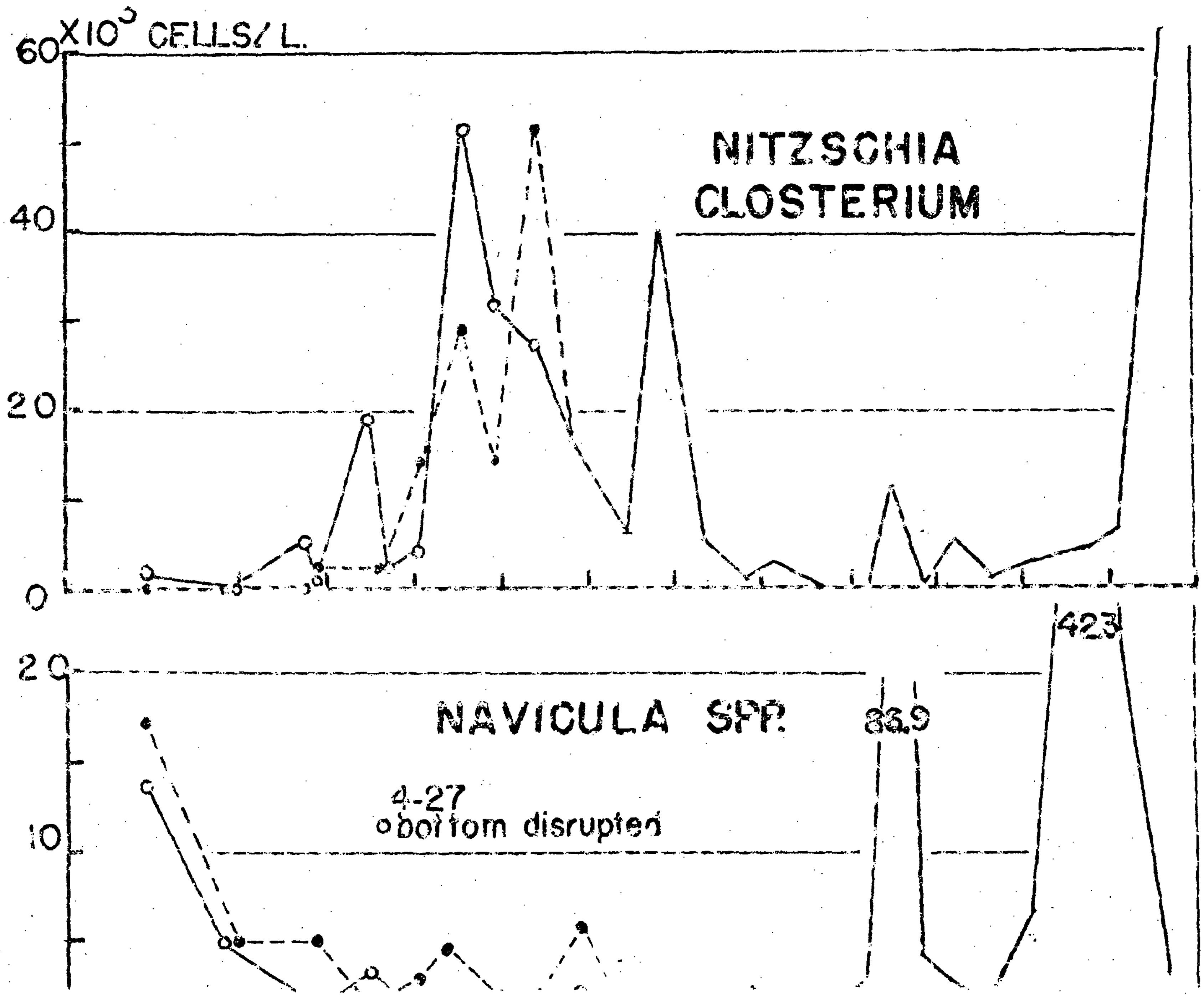
Cysts - mostly dinoflagellate

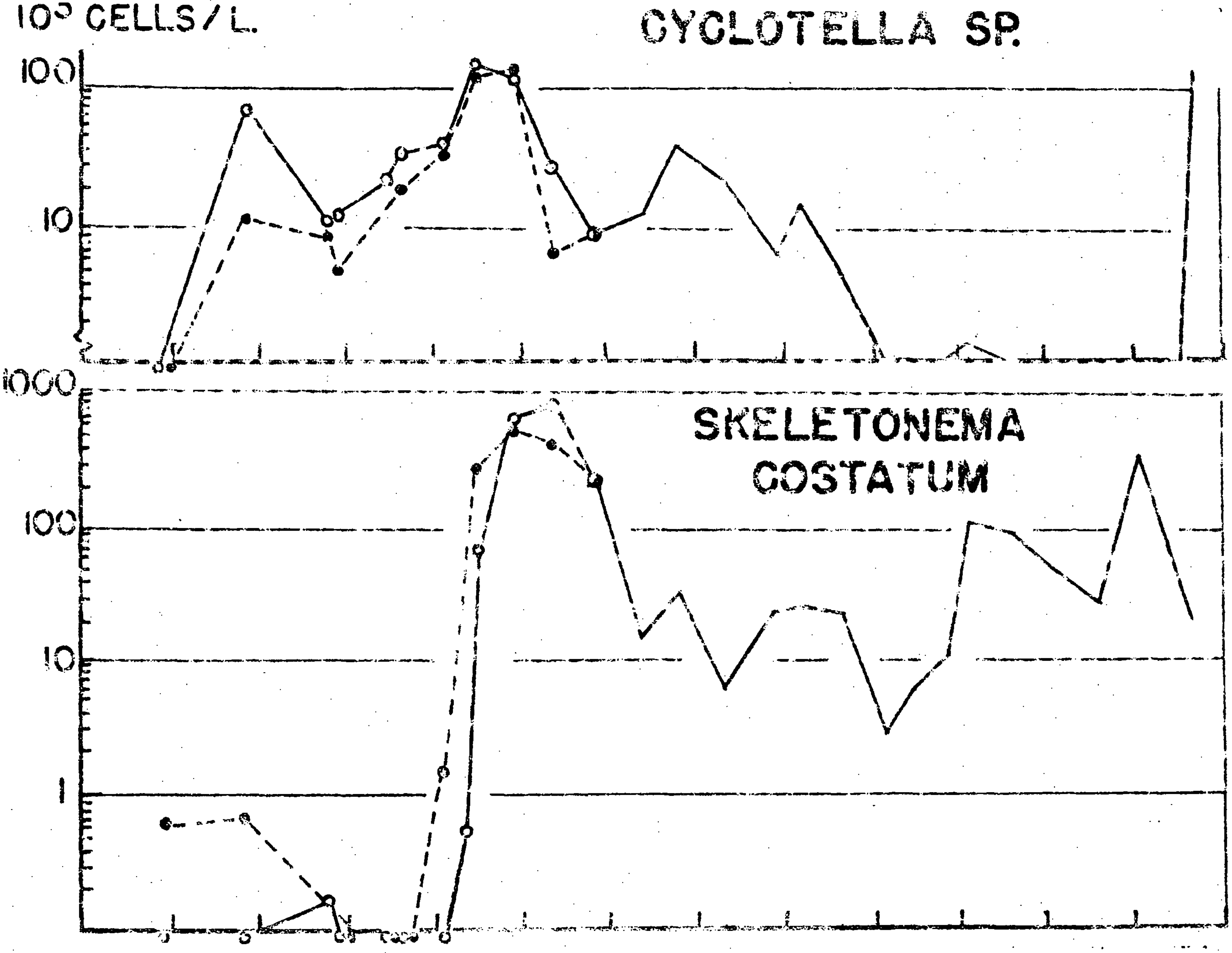
Diatoms (unidentified)

Dinoflag. (unidentified)

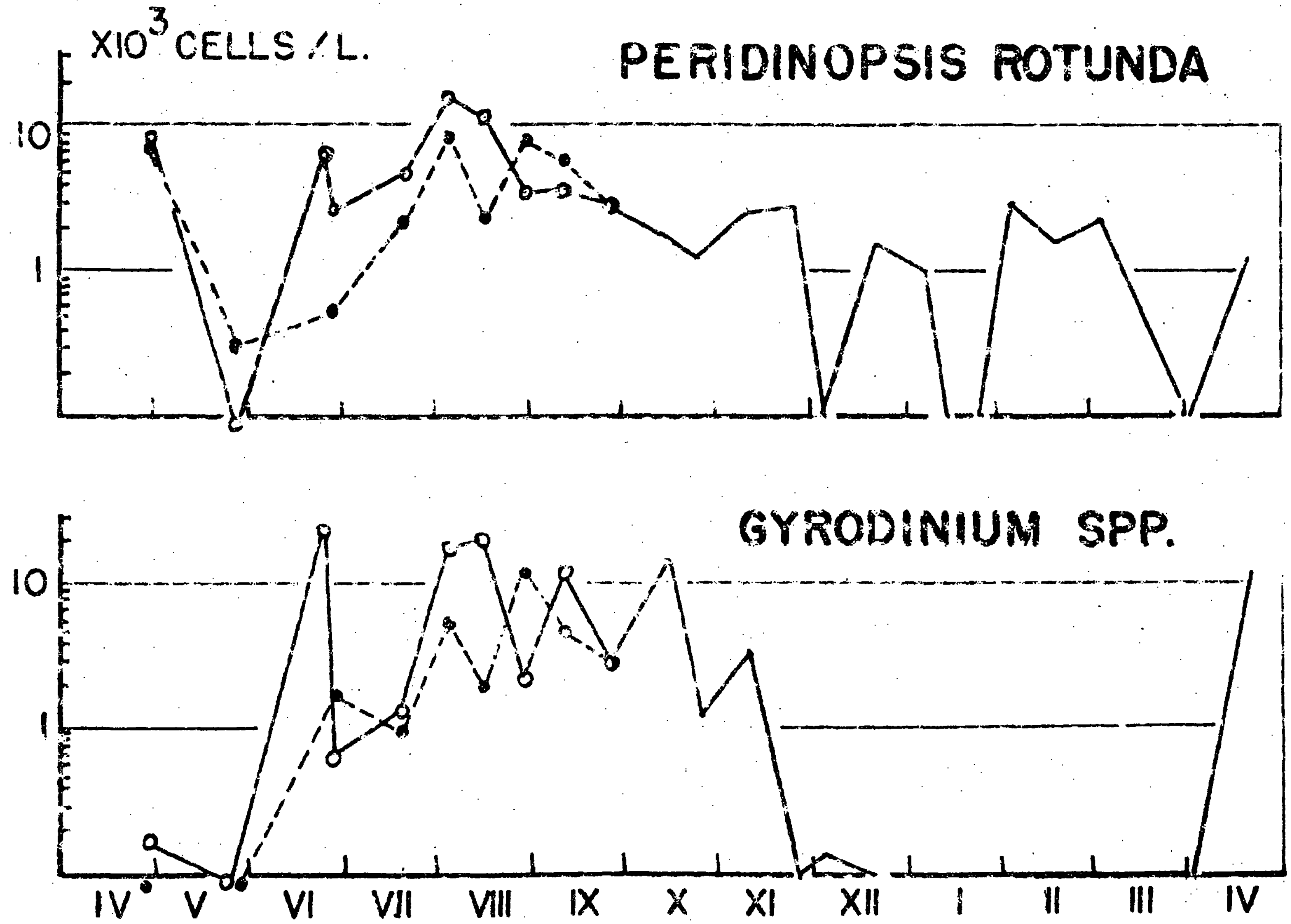
Microflagellates

Zoospores, Algal

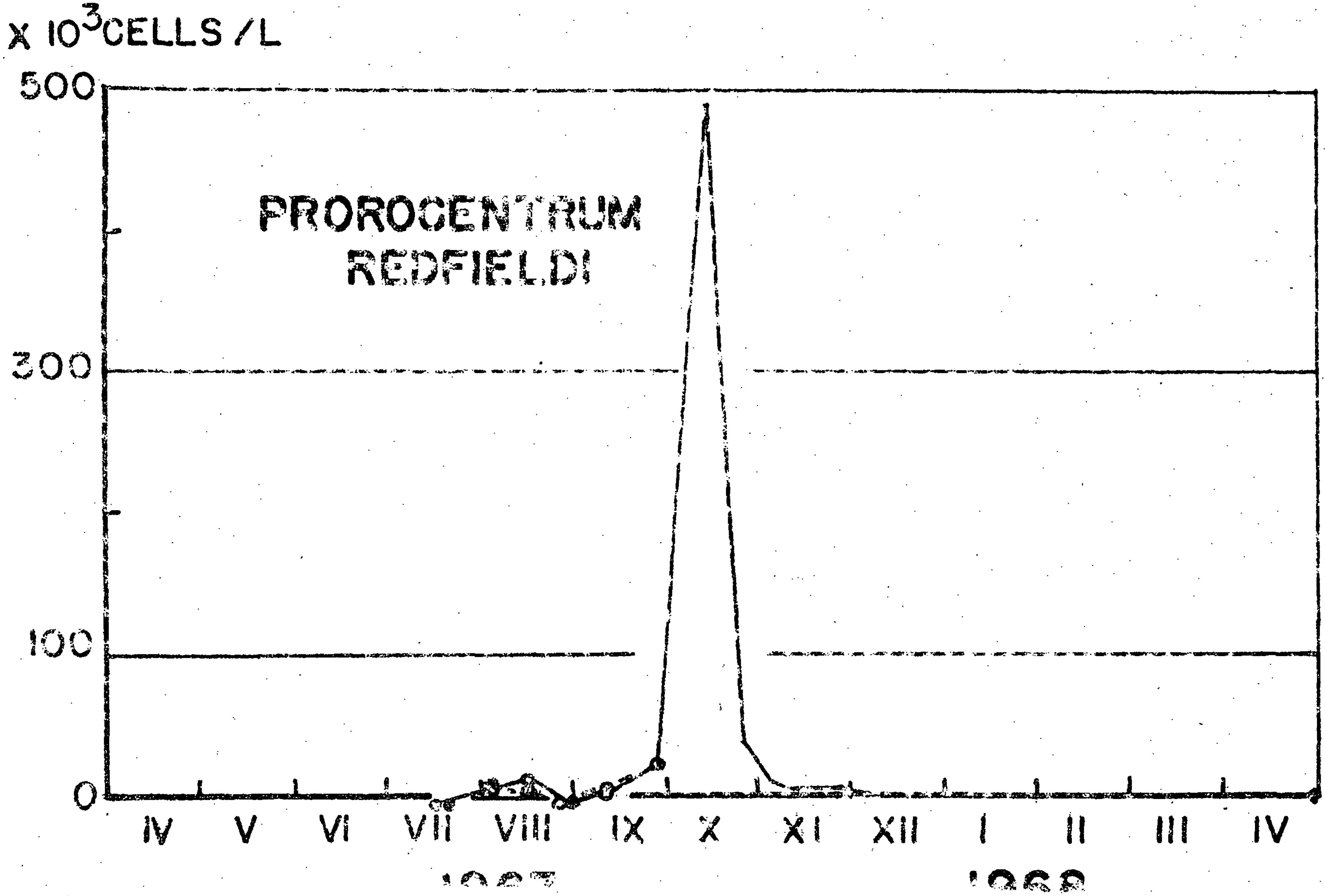

X10³ CELLS/ L.
60
40
20
0
NITZSCHIA
CLOSTERIUM
423
20
NAVICULA SPP.
83.9
4-27
o bottom disrupted
10

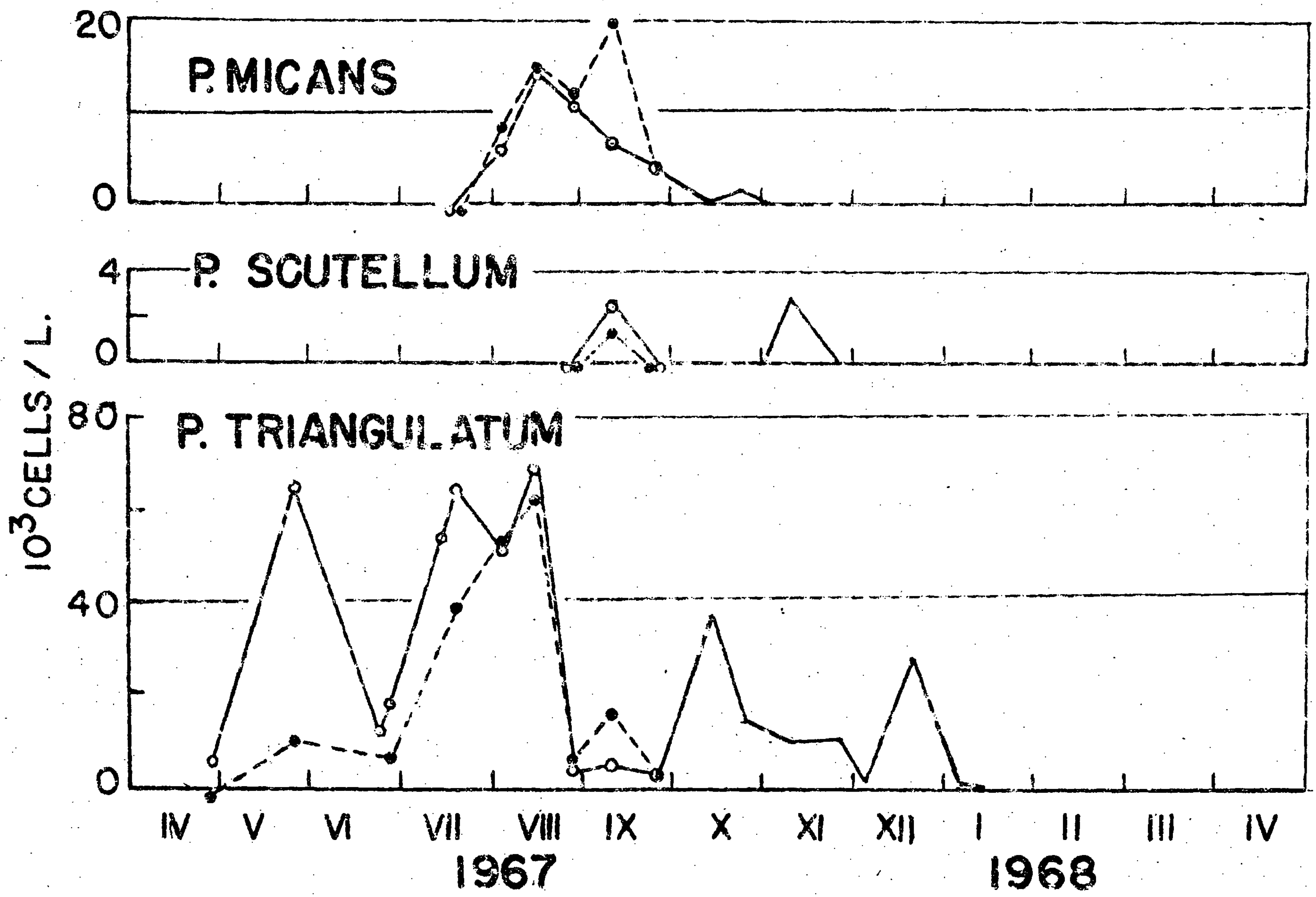


10³ CELLS/L.
CYCLOTELLA SP.
100
10
1000
SKELETONEMA COSTATUM
100
10
1

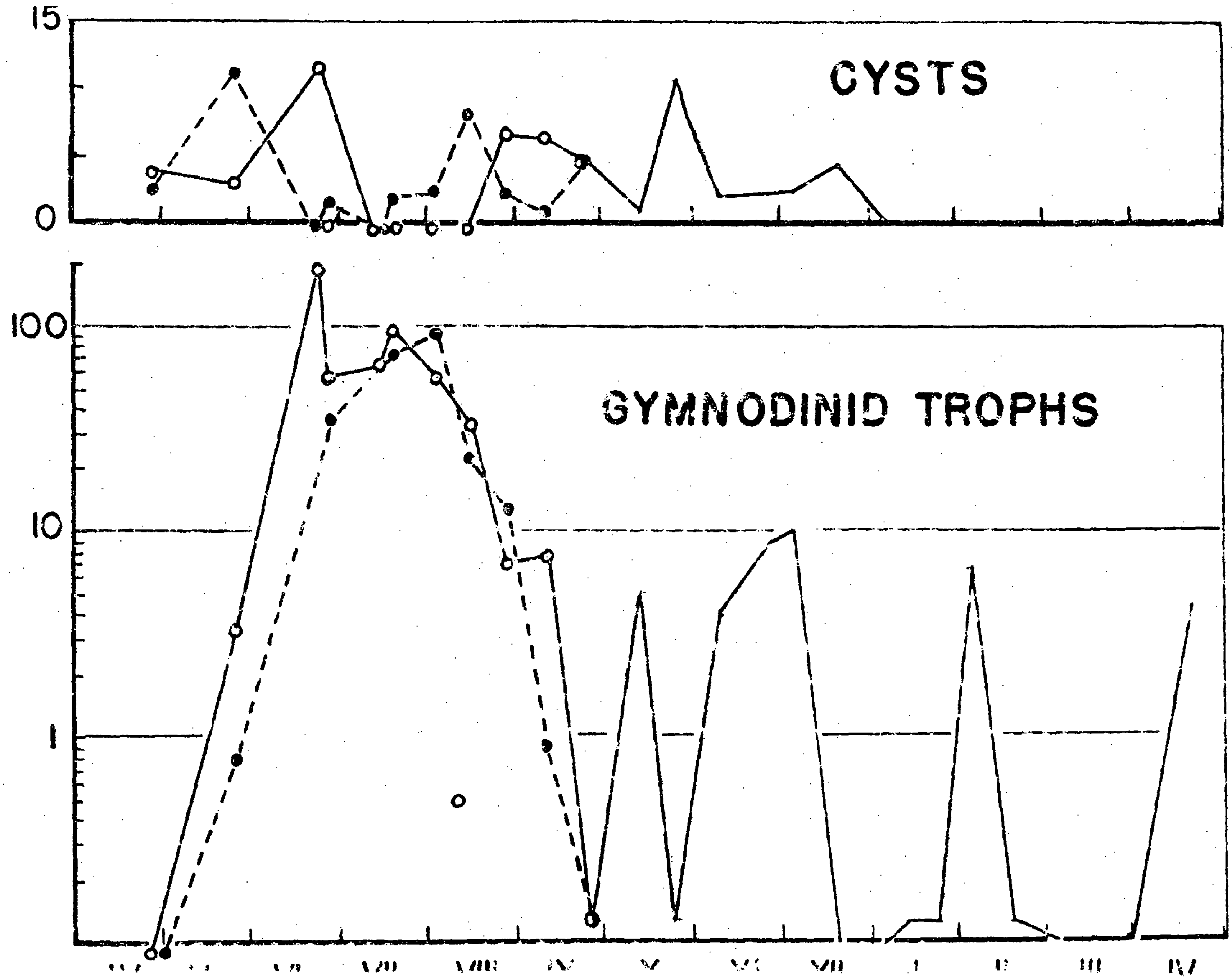

X10^3 CELLS / L.
PERIDINOPSIS ROTUNDA
10
1
GYRODINIUM SPP.
10
1
IV
V
VI
VII
VIII
IX
X
XI
XII
I
II
III
IV

27-C

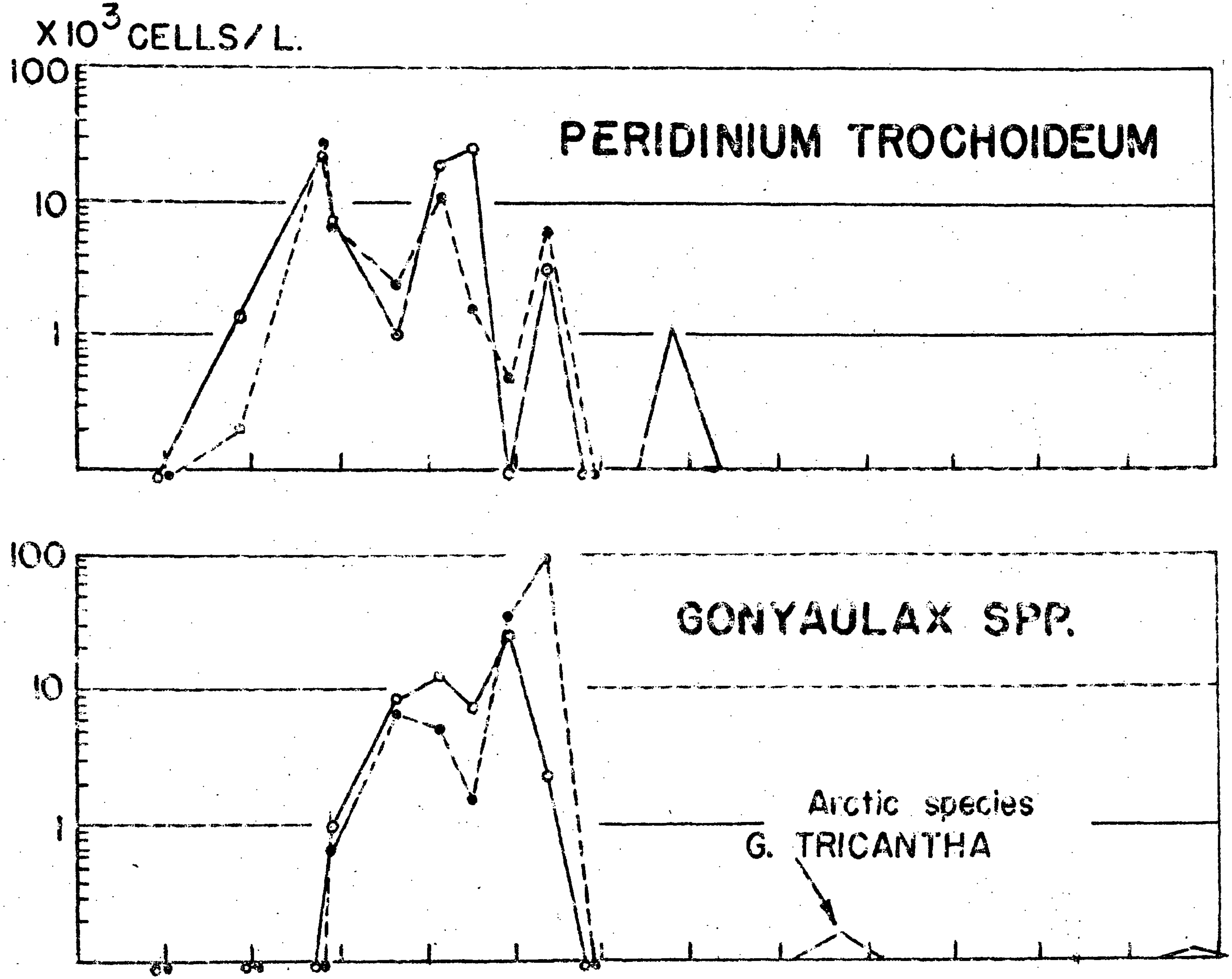

X 10³ CELLS /L
500
300
100
0
PROROCENTRUM
REDFIELDI
IV
V
VI
VII
VIII
IX
X
XI
XII
I
II
III
IV


P. MICANS
P. SCUTELLUM
P. TRIANGULATUM
10^3 CELLS / L.
20
0
4
0
80
40
0
IV
V
VI
VII
VIII
IX
X
XI
XII
I
II
III
IV
1967
1968

27-D

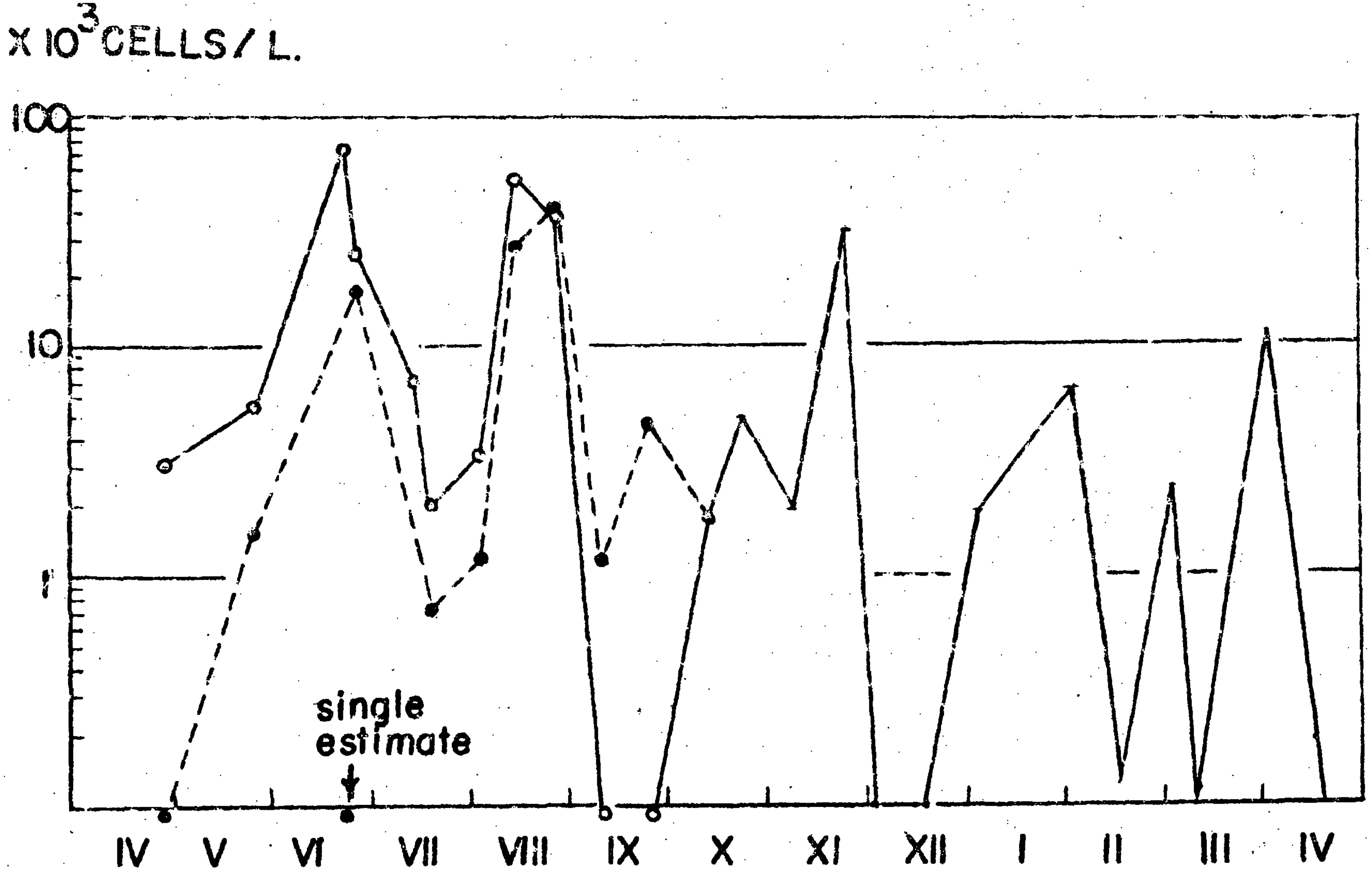


27-E

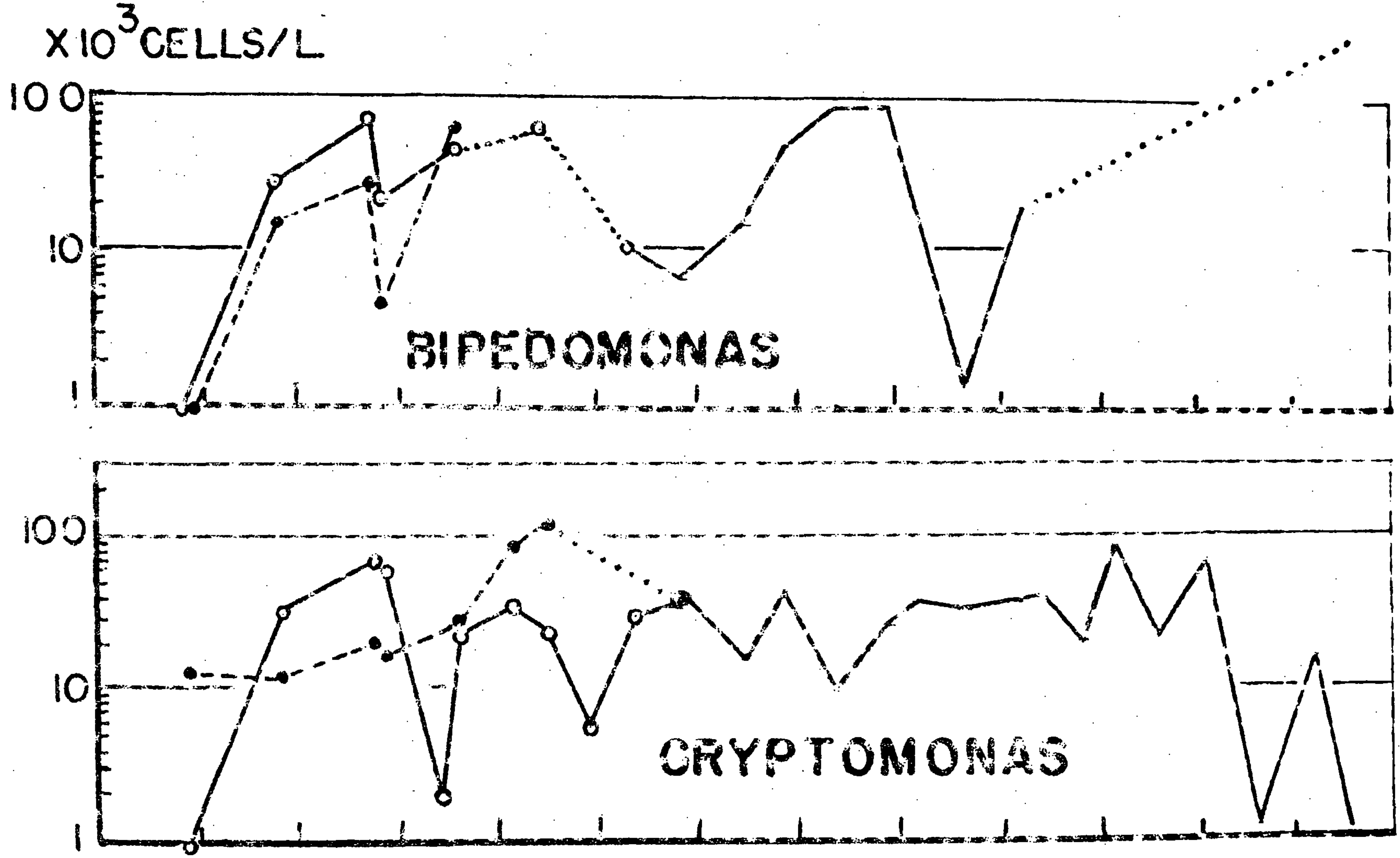


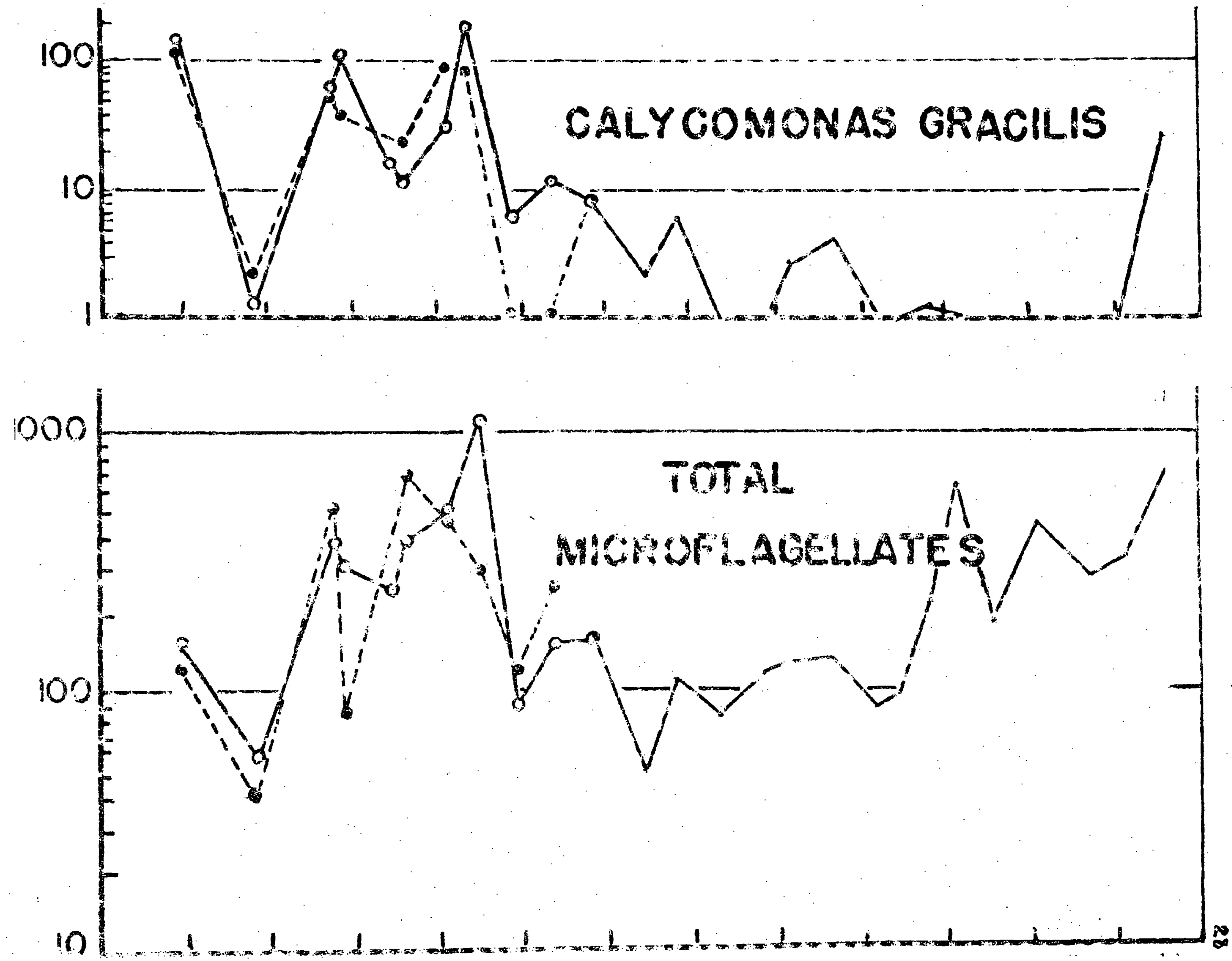
X 10³ CELLS / L.
100
10
1
PERIDINIUM TROCHOIDEUM
100
10
1
GONYAULAX SPP.
Arctic species
G. TRICANTHA

EUGLENOID FLAGELLATES



28-C





CALYCOMONAS GRACILIS
TOTAL MICROFLAGELLATES
100
10
1
1000
100
10

PLANKTON

GENERALIZED SEASONAL CYCLE (ZOOPLANKTON)

SPRING

The spring flowering provides abundant forage for a tremendous upsurge in zooplankton, dominated by calanoid copepods, chiefly Acartia spp., which in 1968 began with the first week of March, and continued quite strongly through early April. Zooplankton at this season may be so abundant as to clog the filter after only 25 l. and approximate 60 ml settled volume per cubic meter.

The occurrence of the delicate Chaetognath Sagitta is of interest. All the specimens examined were S. elegans, and this appears to be the only species thus far penetrating the bay. In previous work during 1964-1965 at the Northern end of the Bay, only an occaional Sagitta appeared during the winter, unable, it would appear to sustain populations at much lowered salinities.

SAGITTA ELEGANS IN BARNEGAT BAY
1967 - 1968

5 Min. Net-tow

Abundance	Date	Temperature	Salinity
1 individ. in 3 stations	20-XII	4.5°	27.5 o/oo
hundreds in single sample	3-III	2.2°	30.6 o/oo
many in single sample	10-III	4.7°	25.6 o/oo
2 individ. in 4 stations	7-IV	9.2°	24.0 o/oo

Sagitta is a voracious zooplankton predator, plentiful around the time of seasonal minimum temperatures and apparently (since at Mantoloking, immature specimens were observed twice in active condition between 16 and 17 o/oo) more sensitive to temperature than

GENERALIZED SEASONAL CYCLE (ZOOPLANKTON)

SPRING (cont'd)

salinity. They have never survived holding in our experience at 16-20° C for more than a few hours. Spooner (1933) reports *Sagitta* as positively phototactic and we have nearly always taken them in surface samples. This would increase the probability of their entrainment thru the condensers.

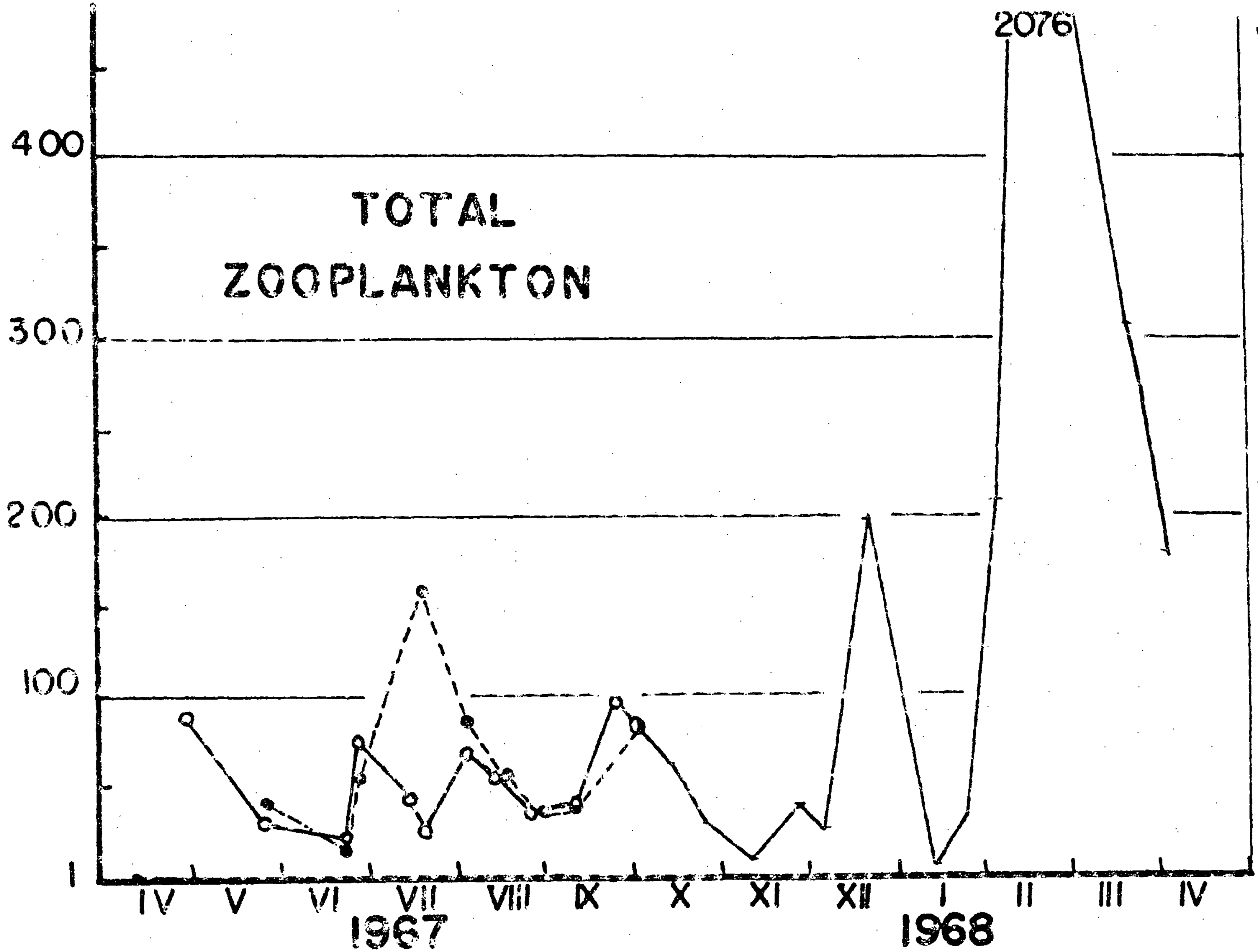
Zooplankton numbers remain fairly high through the spring, and grazing limits the development of an extremely rich phytoplankton. Through April, a number of small medusae (*Perigonemus* ?, *Aecuora*) upon which the taxonomy is incomplete are encountered. Their distribution is variable, and they appear to move about quite passively with the tide.

SMALL MEDUSAE 7-IV-68

FIVE MINUTE DRIFTS WITH 0.1m NET

STATION	10-35	10-30	8-25	7-23
	GULF PT.	OYSTER CR.	STOUTS CR.	CEDAR CR.
Temp. °C	10.0	10.1	11.0	11.6
Salinity o/oo	23.2	23.0	20.4	21.4
Mature 1cm	33	6	1	1
Immature under 1cm	26	37	17	2

Spooner, G.M. (1933) Observations on the Reaction of Marine Plankton to Light. J.M.B.A.U.K. 19: 385-438.



TOTAL
ZOOPLANKTON
400
300
200
100
1
2076
IV
V
VI
VII
VIII
IX
X
XI
XII
I
II
III
IV
1967
1968

GENERALIZED SEASONAL CYCLE (ZOOPLANKTON) (Cont'd)

SPRING (Cont'd)

When water temperatures exceed 15° the large Coelenterate Cyanea capitata becomes particularly abundant. It feeds rather heavily on small fishes and has been observed taking Menidia menedia, the metamorphosed juveniles of Anguilla americana and small sticklebacks. Cyanea disappears rather abruptly from the bay, usually in late May, when they are seen in great numbers lying scenescent in the warmer shallows along the lee shore of Island Beach. None are encountered until the following spring.

SUMMER:

The appearance of the Ctenophore Mnemiopsis leidyi late each spring in Barnegat Bay is a remarkable phenomenon. The date of appearance at Mantoloking has proven predictable ± 1 week for several years now. Temperature may be the controlling factor and it is thus not surprising that the single monitoring of this onset in lower Barnegat came somewhat later than at Mantoloking.

The densities generated in a few days are remarkable, with counts exceeding fifty organisms in 50 liters (estimated $1000/m^3$). These creatures are efficient predators on the zooplankton, feeding with particular selectivity on the calanoid copepod Acartia. Zooplankton sample volumes are immediately and drastically reduced. The initial and subsequent swarms of Mnemiopsis graze zooplankton heavily throughout the summer. Adults appear to be distributed somewhat randomly through the water column during the day but may rise to the surface at night, where extensive highly bioluminescent swarms are encountered.

Mnemiopsis appears to be the most important zooplankter for long periods in the summer. A considerable body of data is being

GENERALIZED SEASONAL CYCLE (ZOOPLANKTON) Cont'd)

SUMMER (Cont'd)

assembled on these populations and will be published at a later date.

AUTUMN

According to the experimental work of Mayer (1912) *Mnemiopsis* is more sensitive to increases in temperature than decreases. Autumn specimens, acclimated to lower temperatures, when brought into the laboratory and warmed slowly to 20° will disintegrate in a matter of hours. They may be refrigerated for several days without damage, and are found viable even in December about the lower Bay, often lying motionless on the bottom. *Mnemiopsis*, to some extent, is replaced in autumn by a second ctenophore species *Beroe ovata*. Both species apparently cease to be important predators by about mid-October.

Despite the removal of massive predation, and perhaps because of increased thermal stress from falling temperatures, zooplankton continued to dwindle into winter. It took the copepod *Acartia* until December to produce even a token adult population, so that during the fall, exclusive of naupliar stages, the rotifers *Asplanchna* and *Snychaeta* along with tintinnid protozoa became important. The large loricate tintinnid *Favella* has had rather predictable outbursts each fall in Barnegat since 1964, when collections at Mantoloking began. In 1967 a mean density of 8400 / m^3 was recorded on 14-X.

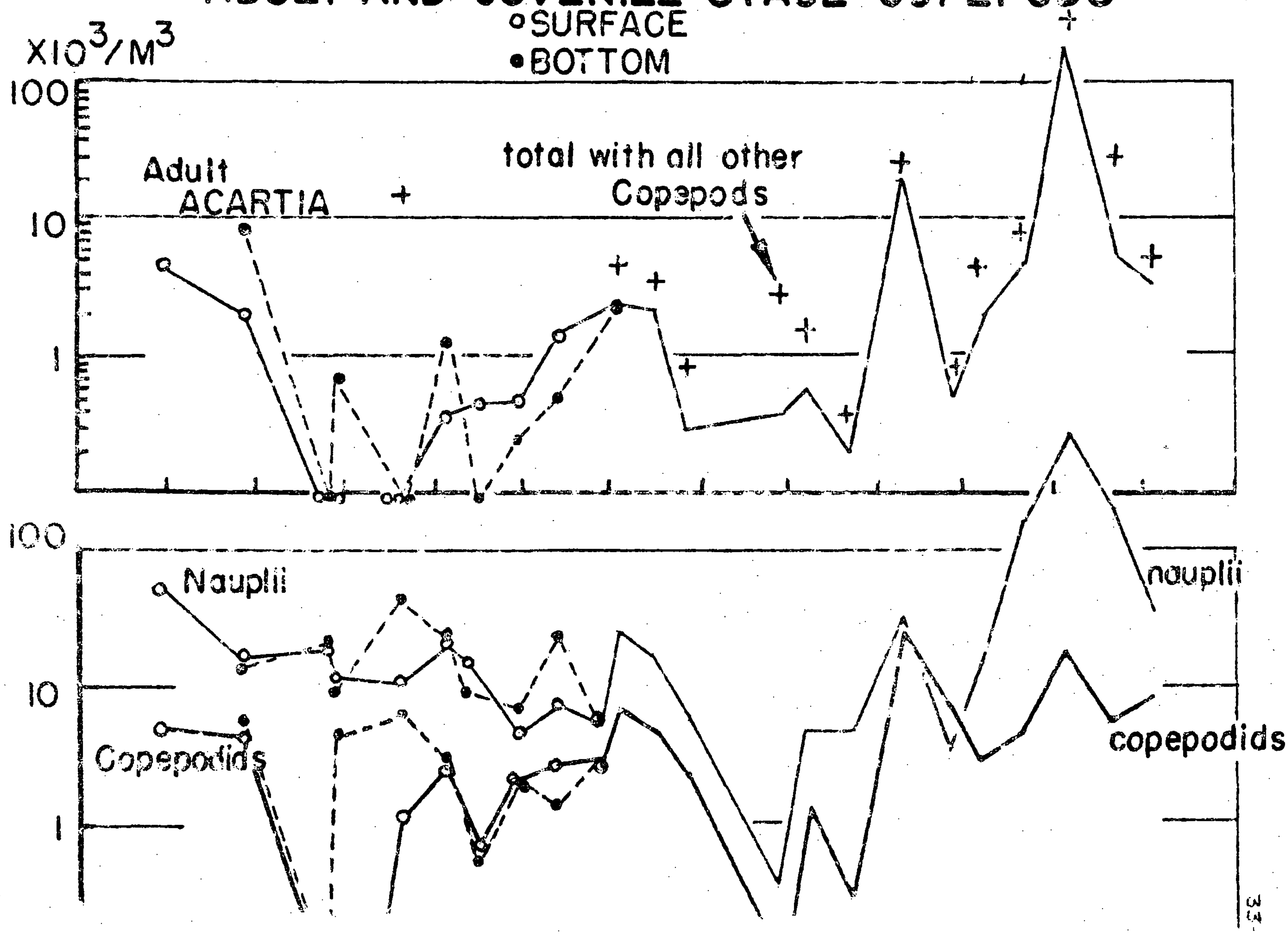
WINTER

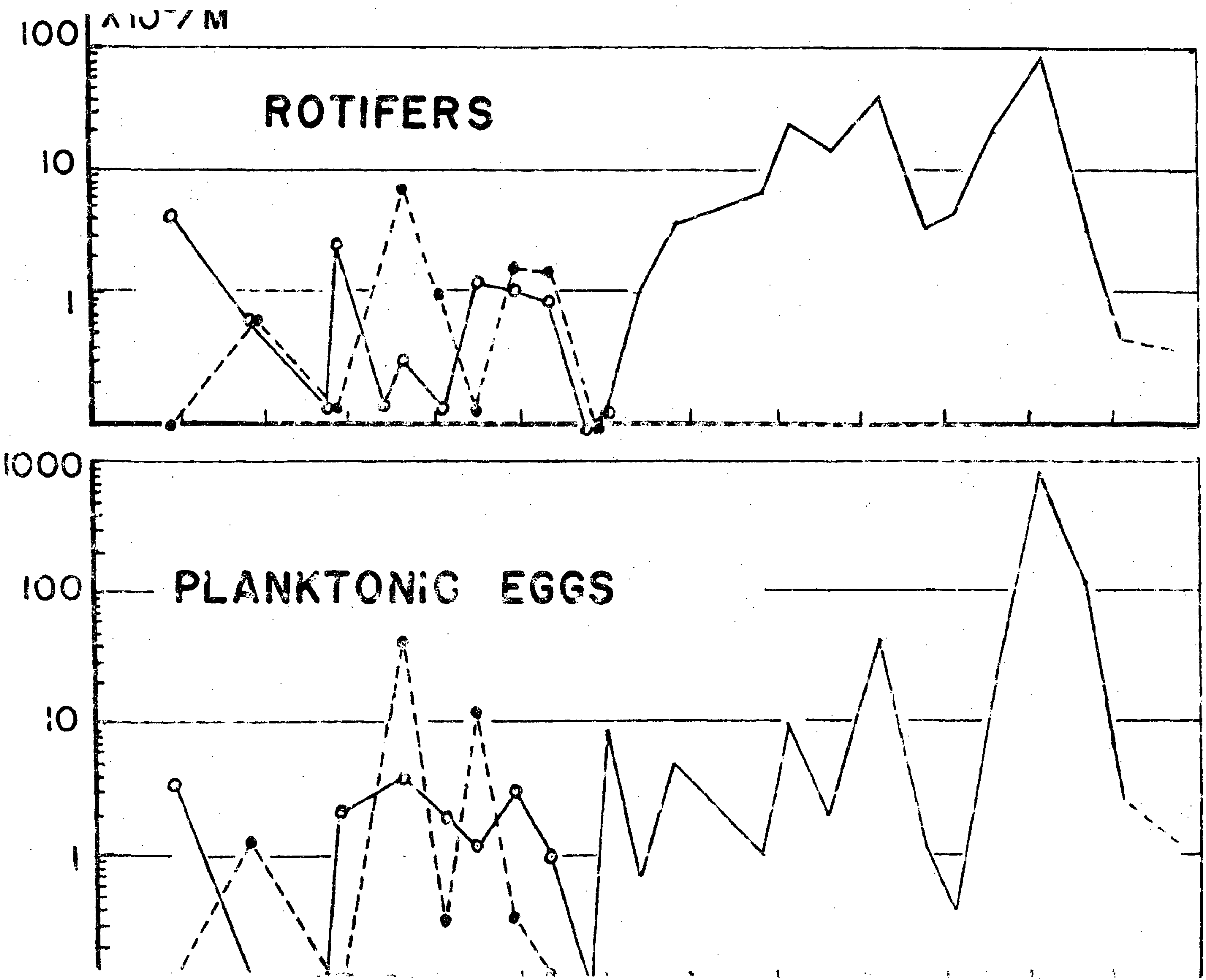
A significant accumulation of zooplankton was observed by early January 1968; then, during the period of minimum temperatures, zooplankton fell to extremely low levels or became torpid and sank from the water column. (if, indeed, we can judge from a curtailed sampling program). They remained so until the February flowering.

Zooplankton began responding, apparently to increased phytoplankton, in early February. A lag of 27 days was observed between the apparent maximum of phytoplankton and the subsequent peak of zooplankton abundance, a remarkable 2,076,100 organisms per m^3.

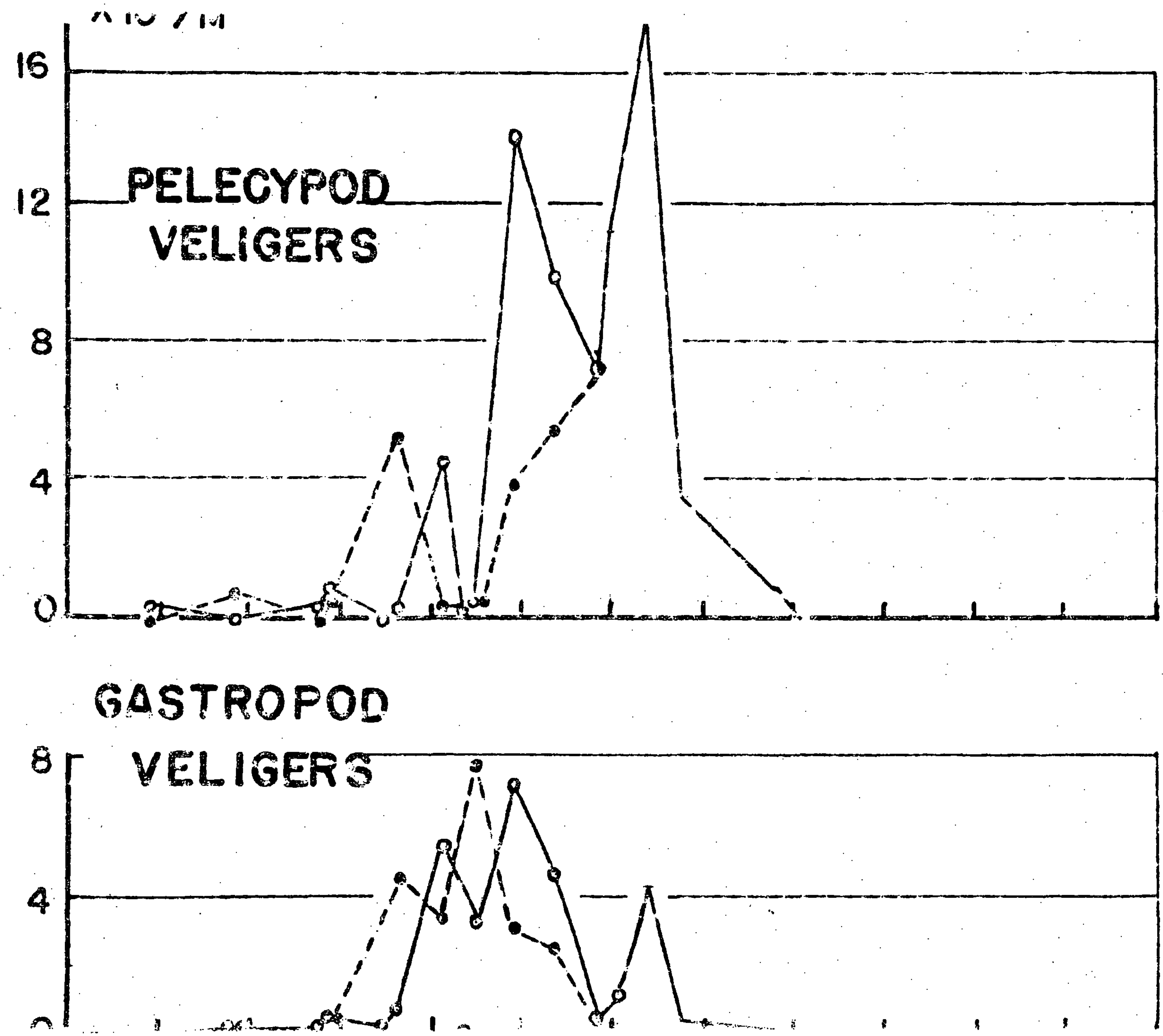
Mayer, A.G. (1912) Ctenophores of the Atlantic Coast of North America, Carnegie Institute, Wash.

ADULT AND JUVENILE STAGE COPEPODS



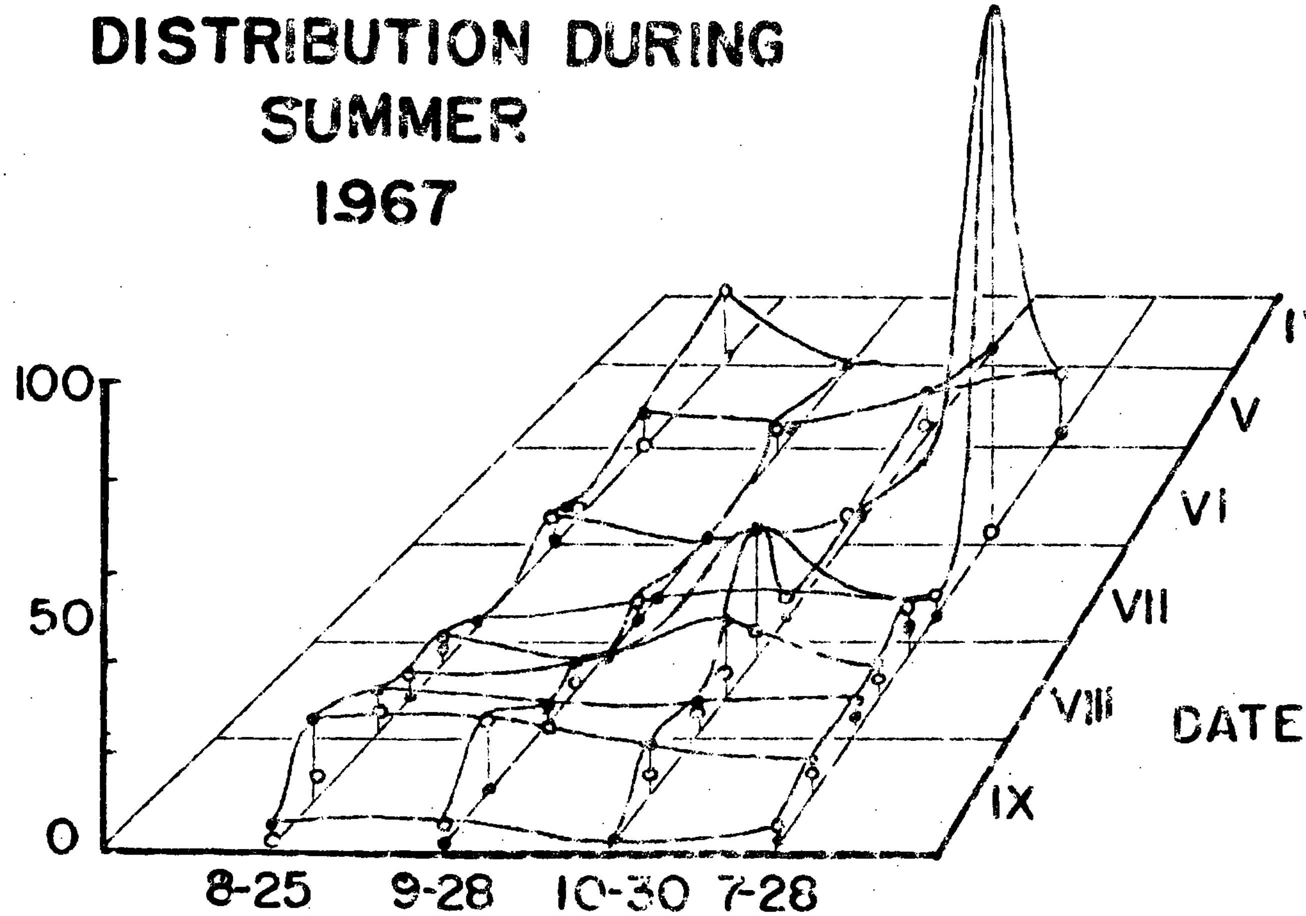


33-B

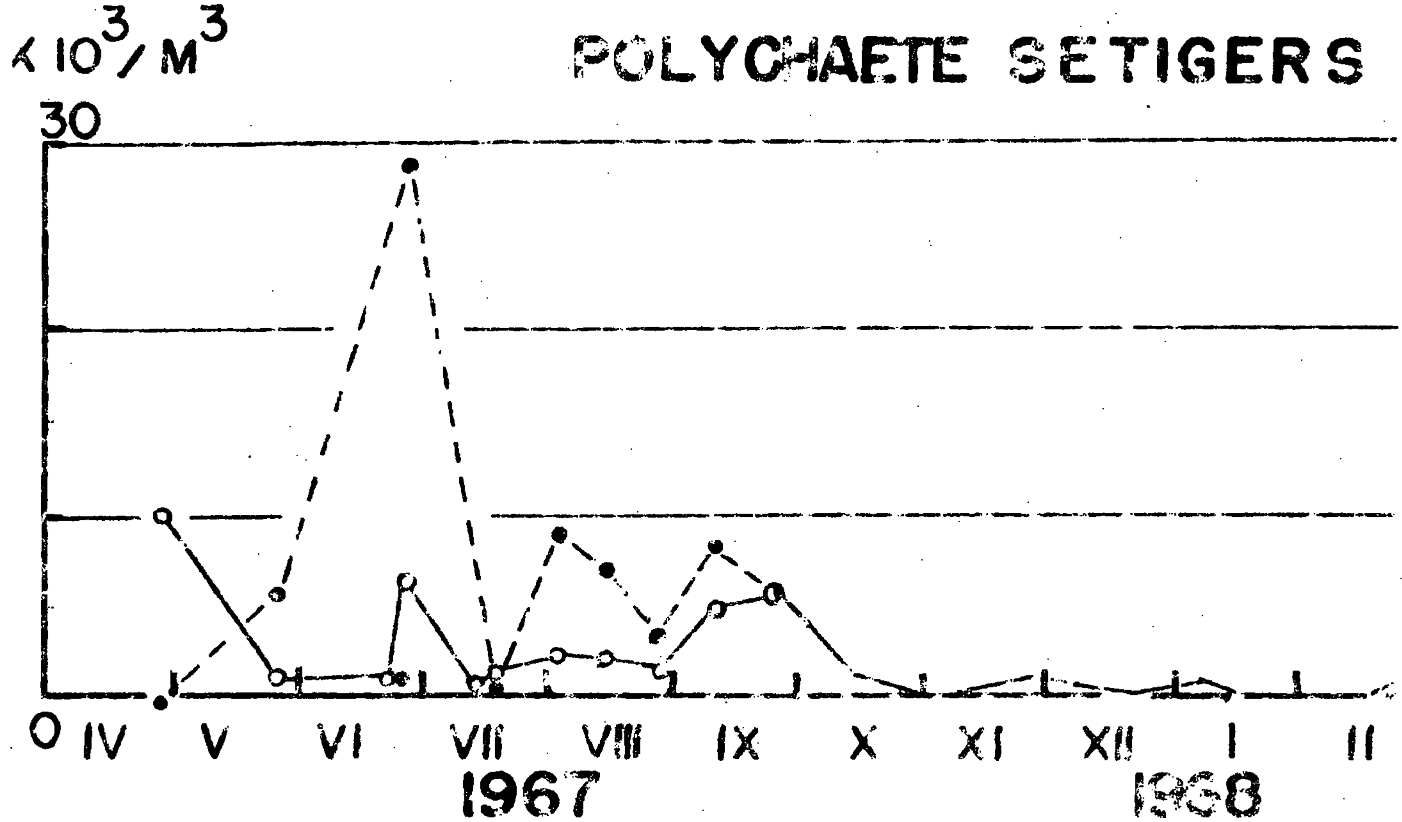


16
12
8
4
0
PELECYPOD
VELIGERS
GASTROPOD
VELIGERS
8
4

DISTRIBUTION DURING SUMMER 1967



POLYCHAETE SETIGERS



GENERALIZED SEASONAL CYCLE (ZOOPLANKTON) Cont'd)

WINTER: (Cont'd)

Graphic materials follow this section, summarizing the census data for a number of the more important zooplankton organisms. Breakdown of surface and bottom density is presented for the initial summers's data as applicable. This investigator is not prepared to commit the data to a predictive diagram as has been done with the phytoplankton. A preliminary checklist for the zooplankton organisms is, however, included.

- - - - - - - - - -

PRELIMINARY CHECKLIST OF ZOOPLANKTERS
COLLECTED IN BARNEGAT BAY

Hold and Tycho-Plankters indicated *

Protozoa
- Foraminifera
  - *Pulvinulina sp.*
- Radiolaria
  - Unident. Radiolarian
- Infusoria
  - *Amphileptus gutta*
  - *Chilodon cucullus*
  - *Condylostoma sp.* ?
  - *Dactylopusia brevicornis*
  - *Diophrys appendiculatus*
  - *Paramecium sp*
  - *Zoothamnium sp*
  - Unident. *Hypotrich protozoans*
- Tintinnoida
  - *Favella sp.*
  - *Tintinnus sp.*
  - Unident. Tintinnids

Porifera
- Unclassified Statoblasts

Coelenterata
- Cnidarian Blepharoplasts
- Cnidarian Planula
- *Aequora sp.*
- *Cyanea capitata*
- * *Obelia geniculata* ?
- *Perigonemus* ?

Ctenophora
- *Beroe ovata*
- *Mnemiopsis leidyi*

Nemathelmia
- * Unidentified Nematodes

Chaetognatha
- *Sagitta elegans*

Rotifera
- *Asplanchna sp*
- *Synchaeta sp.*
- Unidentified Rotifer
- Unident.Rotifer Egg 18-1

Polychaeta
- * Undifferentiated Trochophores
- * Undifferentiated Setigers

Arthropoda
- (Arachnida)
  - * *Hydrobates sp*
- (Crustacea)
  - Calanoid copepods,incl.:
    - *Acartia tonsa (clausii)*
    - *Centropages spp.*
    - *Eurytemora sp.*
    - *Temora longicornis*
    - *Tortanus discaudatus*

PLANKTON

PRELIMINARY CHECKLIST OF ZOOPLANKTERS COLLECTED IN BARNEGAT BAY

Hola and Tycho-Plankters indicated (*)

Arthropoda

(Crustacea)

* Harpacticoid Copepods
  Undifferentiated Nauplii
  Various Copepodid stages
  Undifferentiated Copepod eggs incl. Evrytemora
* Brachyuran Zoea
  Balanus (Eburneus ?) Nauplii
  Cladocera
* Unidentified Amphipods
* Unidentified Mysids
* Unidentified Cumacid
* Ostracods

Mollusca

* Gastropod Veligers
* Pelecypod Veligers

Polyzoa

* Bryozoan Statoblasts

Echinodermata

* Pluteus Larvae

Chordata (Tunicata)

Oikepleura Doicia

(Pisces)

Anguilla Americana (post-elver juveniles)
Undifferentiated Fish Larvae

DISSOLVED OXYGEN

It was considered useful to develop a body of dissolved oxygen data for the test area covering the pre-operational period thru at least a single annual cycle. Twenty-two months data have now been assembled.

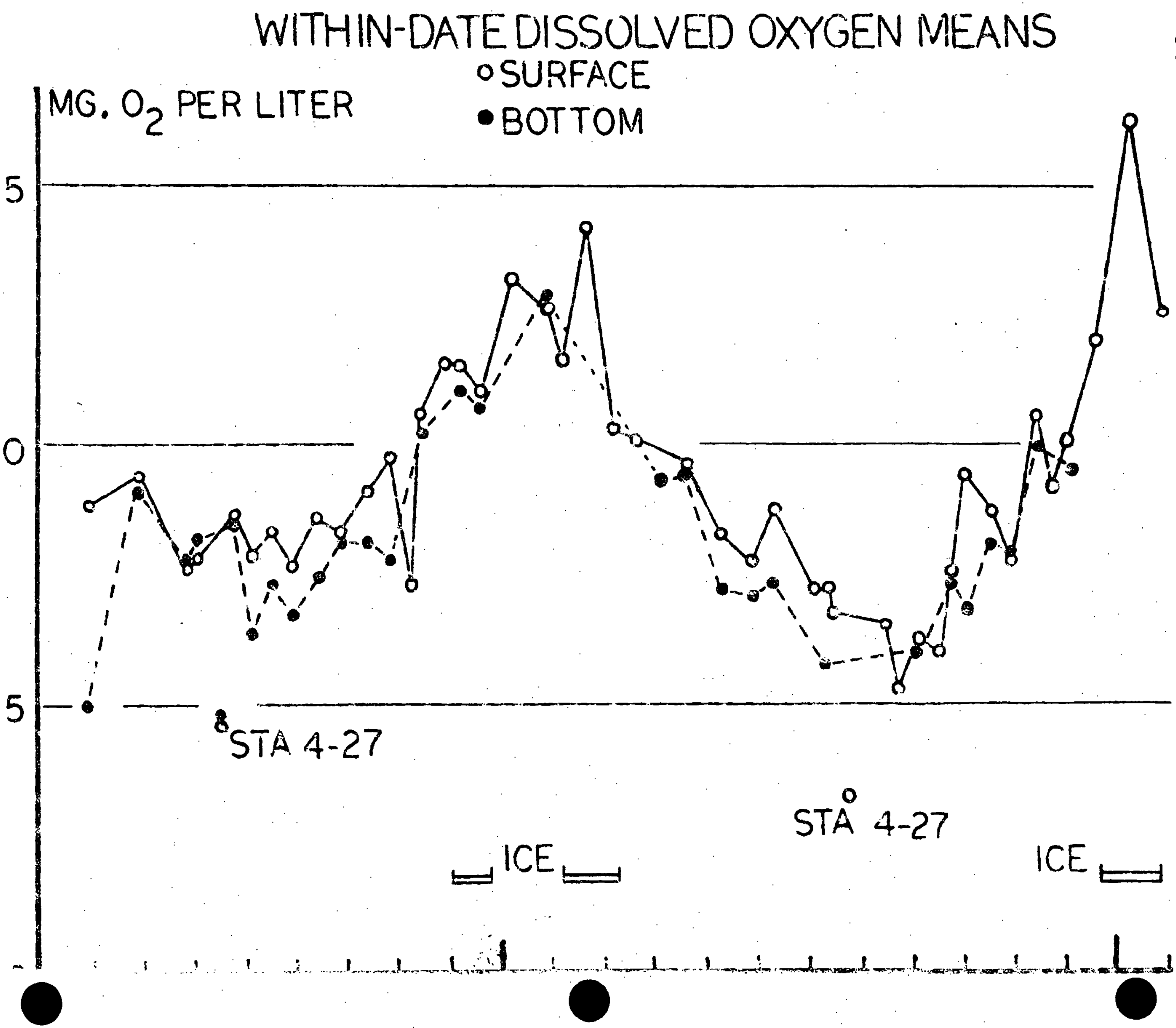
Both surface and bottom samples were drawn with a Kemmerer or Van Dorn sampler and fixed in the field including acidification. Aboard "La Boheme" and "Beroe" samples were stored in the dark, or in subdued light below deck to inhibit photooxidation and thermal expansion. This was not possible because of space limitations aboard "[illegible]". Duplicate titrations were always made on each bottle, and if these did not fall within 0.05 ml thiosulfate of each other, a triplicate titration was carried out.

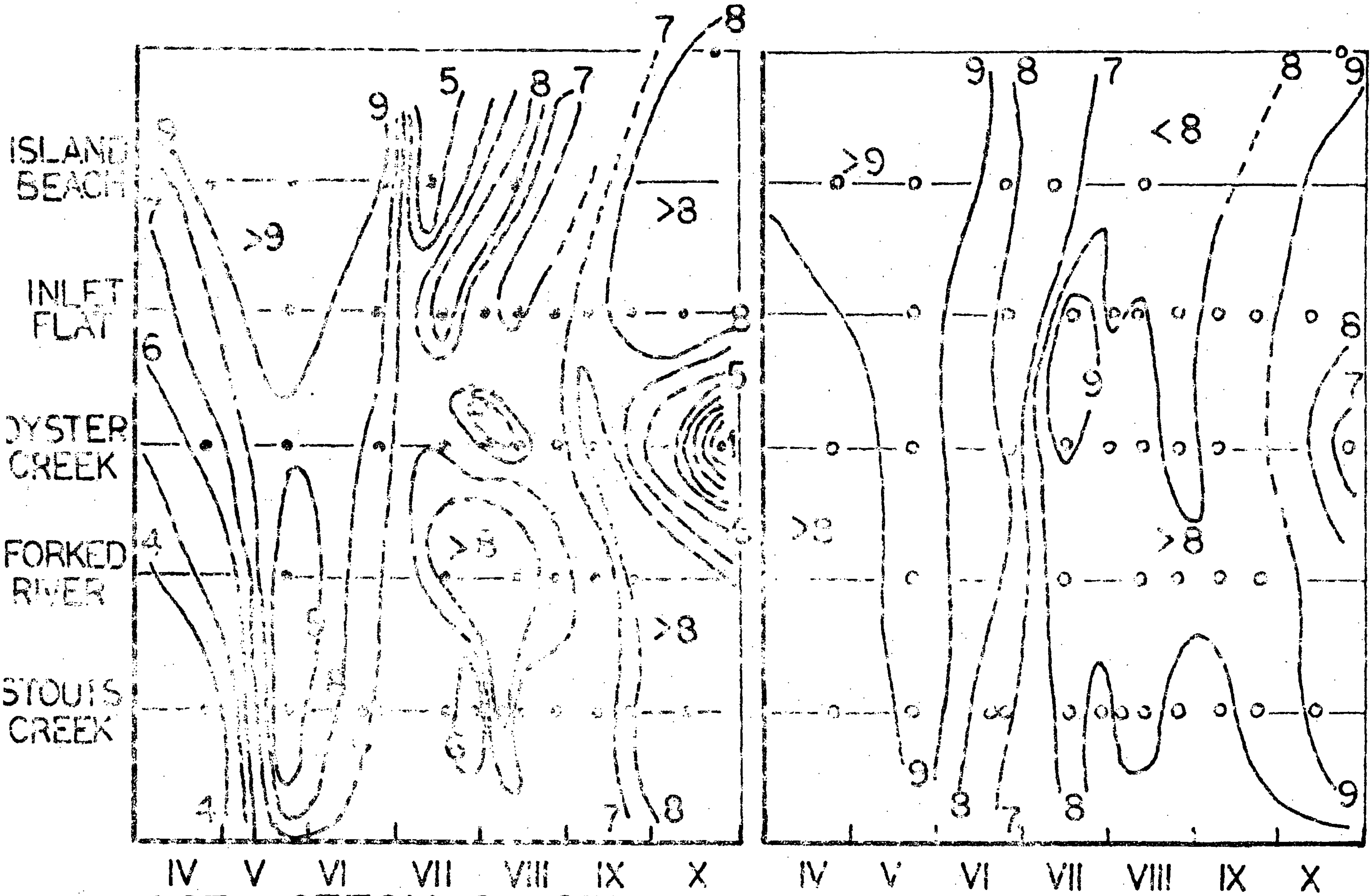
The data for this work, expressed as within-date means, (Fig. 35 A) surface and bottom, indicates a fairly consistent decrease in oxygen toward the bottom. Oxygen is highest during the winter and even in fairly shallow water does not appear to deplete beneath thick and persistent ice cover. It is not clear whether this reflects a sustained photosynthetic capacity of the phytoplankton or minimal bacterial and zooplankton respiratory demands in water that is frequently below 0° C surface to bottom in as much as three meters depth.

Two approaches have been taken in presenting the oxygen material. First, the standard two dimensional means within date, (Fig. 35-A) and second a matrix approach, (Fig. 35-B) which follows a series of stations, essentially contiguous to each other in the bay, through somewhat over six months in 1967. Contour maps have been constructed for both surface and bottom oxygen. The irregularity with which individual stations were visited leaves unavoidable gaps in this material and it is hoped that far better use of this approach might be made in later efforts. The convenience of such an array in attempting to assess the effects of plant operation are obvious.

DISSOLVED OXYGEN (Cont'd)

A number of very low dissolved oxygen readings were observed at station 4-27 (5-27 area off Island Beach). This is a shallow, easily wind-aerated region but one particularly subject to severe diurnal warming at almost any season. A differential in water temperature from 1.5 to 10.0°C was observed over a horizontal distance approximating ten meters on 15 Feb., 1967, and in summer inshore temperatures may exceed thirty degrees. This natural thermal loading may be responsible for lowering dissolved oxygen but the role of substrate materials (although the bottom is sand with patches of *Zostera marina*) cannot be ruled out at this time.


WITHIN-DATE DISSOLVED OXYGEN MEANS
○ SURFACE
● BOTTOM
MG. O_2 PER LITER
15
10
5
STA 4-27
STA 4-27
ICE
ICE



1967 BOTTOM OXYGEN 1967 SURFACE OXYGEN

PLANKTON

INVESTIGATION OF PRIMARY PRODUCTIVITY:

It was not considered reasonable to totally ignore primary production (the rate at which new organic material is generated). The light-dark bottle method of Gaarder and Gran (1929) offered, as an extension of the dissolved oxygen work in this survey, a method of estimating productivity and also of assessing the significance of respiration. Because of the peripheral nature of the work, only minimal replication was possible.

METHOD

Numbered series of 300 ml (306 ml to permit introduction of reagents) dissolved oxygen bottles, washed in distilled water and air dried before use, were suspended at one or more stations and at one or more depths within station. The dark bottles were black vinyl taped and then wrapped in aluminum foil to totally exclude light and minimize differential warming in comparison with the uncovered light bottles, a factor discussed by Patten, et al (1964).

Conversion from the measured parameter of dissolved oxygen to carbon fixed was made by applying a factor of 0.375, representing a photosnythetic quotient suggested as appropriate by Dr.F.B.Trama, Department of Zoology.

The demands of multiple station operation made it impractical to suspend productivity rigs on station for more than a few hours. Significant oxygen changes were often obtained in as little as 1.5 hours. These, of course, are virtually point-in-time measurements, but give a general idea of daily patterns.

Minimizing the time of exposure has the distinct advantage of reducing bacterial contamination of the bottles and the resulting inflation of respiration. In addition, Pratt and Berkson (1959) have shown that differential reproduction and mortality may occur within bottles during customary 24 hour experiments. Such long exposures seem warranted only in the most oligotrophic of waters.

Pratt and Berkson (1959) Two sources of variability in the Light and Dark Bottle Method. Limnol.& Oceanog.IV: 328-334.

PLANKTON

ANALYSIS OF METHOD:

The variability in weather conditions, particularly cloud cover, may have had dramatic effects, either by inhibiting light saturated populations, or enhancing those in sub-optimal illuminations.

Vandals, on several occasions destroyed or removed productivity apparatus from station while the R/V was continuing its sampling nearby. Consequently a few estimates were made on plankton samples immersed in tubs or buckets on deck, in which the water was frequently changed to minimize temperature fluctuations. The results of such estimates were reasonable when compared with simultaneous estimates of material suspended on station, although the system is not entirely practical aboard the R/V Clio.

PRELIMINARY *in situ* AND ON-DECK PRODUCTIVITY COMPARISONS

Date	7-IX-68		20-IX-68		
	Net	Gross		Net	Gross
In situ 0.1 m	13.0*	27.1	In situ 0.1 m	20.1	24.8(poss.anomaly)
			Bottom 1.9 m	22.4	58.6
On Deck	15.4	24.3	On Deck	24.8	57.5

* All values expressed as mg C/m ^{3}/hour

PLANKTON

ATTENUATION OF PLANKTON PRODUCTIVITY WITH DEPTH:

In August, September, October and January, estimates were made to assess the response of plankton photosynthesis to depth and decreasing illumination in the water column. Several experiments were attempted in other months but the apparatus were either stolen or destroyed. On the basis of this very preliminary data which, unfortunately, includes only dates upon which visibility and hence light transmission was reasonably high, there is no clearcut evidence of either a reduction with depth, or inhibition by surface intensities. To obtain a complete picture for each date, it is necessary to consider not only incident radiation (available from the Pyranometer data, when organized) but the individual sample cell counts, which, for 1968 have not been completed

INVESTIGATION OF
ATTENUATION OF PLANKTON PRIMARY
PRODUCTIVITY WITH DEPTH
1968 - 1969

	DATE - STATION										SUB-ICE EXPERIMENT	
	27-VIII		15-IX		20-IX		16-X		29-X		11-I-69	
DEPTH	(6-27)		(4-27		(11-29)		(9-28)		(10-29)		(4-27)	
	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross
SURFACE					24.8	57.5					9.4	28.7
0.1m	27.0	41.3	Neg.	27.1	20.1	24.8						
0.2m											4.1	14.0
0.3m							51.4	63.6				
0.5m			Neg.	55.8					91.8	-		
1.3m							24.8	27.0				
1.5m									72.0	-		
1.9m					22.4	58.6						
2.0m	26.0	288.0										
2.3m							35.9	73.4				
2.5m									128.0	137.0		
Secchi	Over 2m		Bottom		Over 1.9m		3.0m 0800 1.3m 1425		2.5m		Bottom	

NIGHTTIME PLANKTON RESPIRATION

In connection with the productivity work it was desired to obtain some estimate of the respiratory requirement of the plankton during the hours of darkness. During the overnight cruise 12-13 July, 1968, the following data were gathered at two stations between 2200 and 2300 hours.

PHYSICAL DATA FOR TWO NIGHT STATIONS
12-VII-68

Sta.	Location	Depth	Temp.	Salinity	mg/l. Dissolved Oxygen	Percent Saturation
9-27	Mouth Forked R.	0.2 m	24.2°	24.3 o/oo	7.96	111.6
		2.6 m	21.4°	31.1 o/oo	5.16	72.
8-25	Mouth Stouts Cr.	0.2 m	24.4°	23.9 o/oo	6.95	97.2
		2.6 m	23.7°	27.1 o/oo	6.80*	95.9

* Only a single replication was obtained on this titration, the second was so low as to be considered an anomaly.

In a 6.75 hour dark bottle experiment 2300 - 0545, respiration in the surface water at station 8-25 was estimated at 0.0222 mg O_2/l/hr and at the bottom (2.6 m) 0.0533 mg O_2/l/hr. The same station, measured between 0700 - 1030 the next morning showed dark bottle respiration increase at the surface to 0.0486 mg O_2/l/hr. Despite this rise, net photosynthesis indicated by light bottle in the morning experiment would have been sufficient to compensate for ten hour's respiration in total darkness (considerably more than actual) with only 1.8 hours of daylight.

The supersaturation at station 9-27 was associated with a fairly dense population of an apparently bioluminescent dinoflagellate, *Glenodinium* (danicum ?). *Prorocentrum triangulatum* shared dominance.

NIGHTTIME PLANKTON RESPIRATION (Cont'd)

No Glenodinium were observed in live examination of the bottom sample which was quite low in dissolved oxygen (5.16 mg/l, 72%).

The high nighttime respiratory rate at 2.6 m. on station 8-25 was associated with a dense population of Eutreptia sp., not present in such abundance at the surface.

PRODUCTIVITY ESTIMATES

Based upon eighteen dates, covering nine months, with 42 sample sets estimated by over 250 titrations, mean net primary productivity by the plankton community amounted to 20.95 mgC/m^3/hr of daylight. Mean gross primary production by the phytoplankton and associated photosynthetic bacteria was 117.1 mgC/m^3/hr of daylight.

As might be expected, gross productivity in particular showed responses to certain major phytoplankton phenomena. Gross productivity would predict decreasing cell counts from spring into summer with increases later in August, and a decrease into September. Examination of the generalized phytoplankton cell counts in (Fig11A) shows this to be the case. Correlations within station against individual cell counts would most practically be tackled by the computer.

The four dates 18-XII-1968, 11-I, 3-II and 16-II, 1969 closely follow the early spring diatom bloom, much of which occurred sub-ice in Barnegat Bay, under attenuated illumination which contributes to the less than phenomenal responses in terms of apparent production.

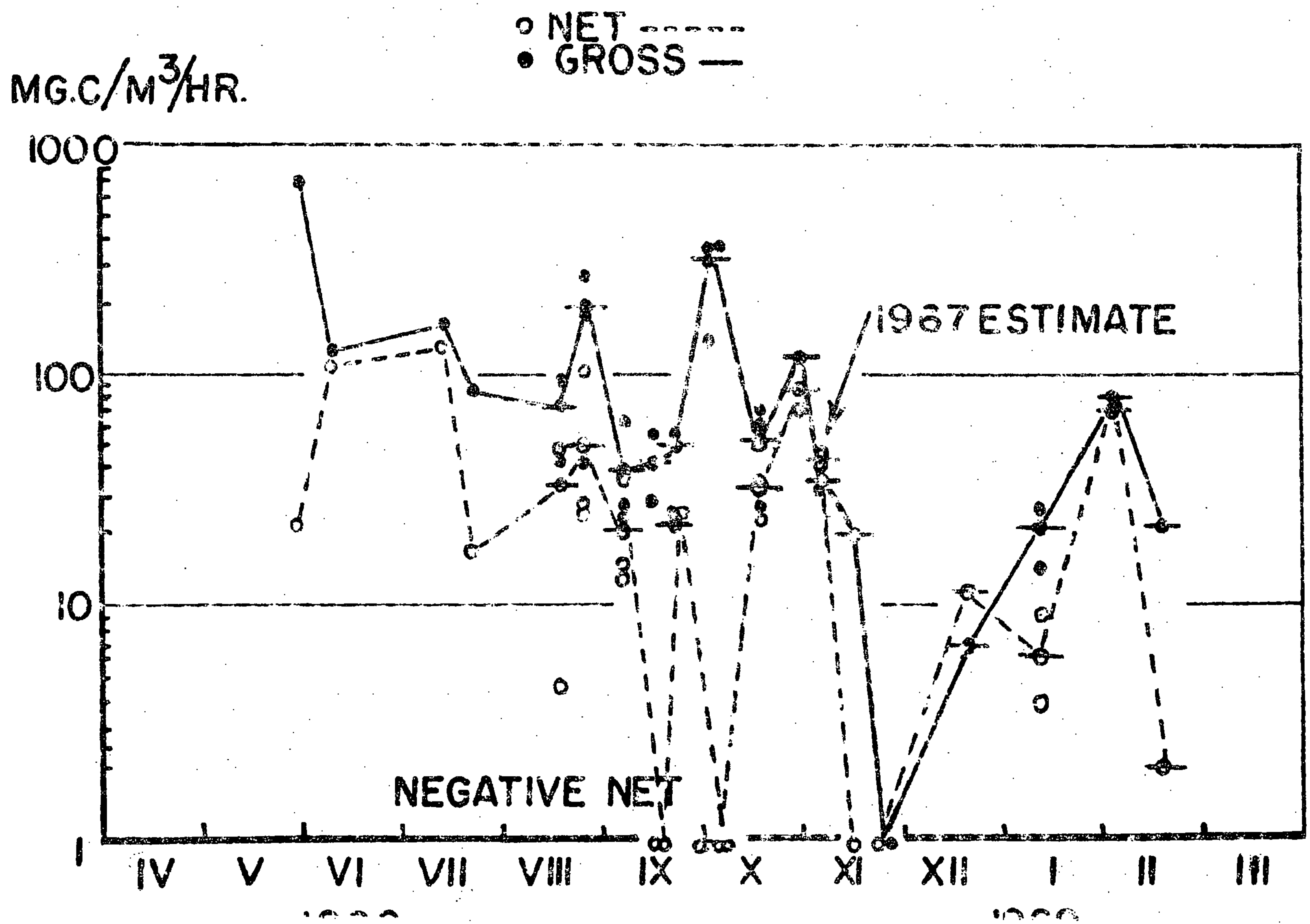
While productivities were generally higher about the summer solstice and lower near the winter solstice, it is considered hazardous to otherwise discuss seasonal differences, at this stage.

ESTIMATES OF MEAN PRIMARY PRODUCTION BY THE PLANKTON COMMUNITY ARRAYED BY DATE

Date of Experiment	Net mg. C/m ^{3}/hr	Gross mg. C/m ^{3}/hr	No. Samples in mean *
31 V	24.3	700.0	1
11 VI	110.3	117.0	1
15 VII	154.3	172.4	1
21 VII	11.9	90.1	1
16 VIII	23.6	72.9	3
27 VIII	5[illegible].3	170.3	3
7 IX	21.8	39.2	3
15 IX	-7.9	41.5	2
20 IX	22.4	53.0	3
1 X	-139.3	310.8	4
16 X	37.4	55.3	3
29 X	97.3	137	3
15 XI	-133	19.6	2
24 XI	0.0	- .001	2
18 XII	10.3	6.6	2
11 I	6.8	21.4	2
3 II	75.7	79.7	3
16 II	1.2	21.5	3

* Each sample represents a light and dark bottle together with accompanying initial dissolved oxygen determination. The estimate for each bottle is based upon duplicate titrations, usually ± 0.05 ml thiosulfate and occasionally a third titration where variability exceeded this limit.

LIGHT-DARK BOTTLE
PHYTOPLANKTON PRODUCTIVITY ESTIMATES



PRODUCTIVITY ESTIMATES (Cont'd)

It was intended that pyranometer data, collected for the last year on Island Beach, be utilized in the analysis of primary production estimates. In particular, the insolation curve can be integrated over a portion of the daily cycle during which a productivity experiment was carried out, and over some months of experimentation a scatter diagram prepared to examine the relationship between actual incident radiation at the sea surface and the estimates of in situ carbon fixation. Furthermore with frequent secchi disc readings (Fig) the degree to which illumination is attenuated in the water column can be examined in relation to productivity.

The pyranometer charts also give a moderately direct read-out on solar thermal input to the bay. The relationship of this input to changes in water temperature would be valuable to examine, particularly since fifteen months of virtually continuous pre-operational records have been obtained.

Unfortunately, the time required to integrate the graphic records exceeded that available to the survey staff, and the exhaustion of funds precluded hiring even relatively inexpensive student assistance. It is anticipated that it will be possible to utilize these records during future operations.

FIELD ESTIMATES OF PLANKTON PRIMARY PRODUCTIVITY

Date	Sta.	Treat-ment	Lite	Init.	Dark	Tot. O_2 Changes Net	Tot. O_2 Changes Gross	Expos. Time	mg C/m^3hr. Net	mg C/m^3hr. Gross
1967*										
4-XI	5-27	0.1m	7.75	7.26	7.14	0.49	0.61	5.40	34.1	42.4
4-XI	5-27	0.1m	7.81	7.26	7.22	0.55	0.59	5.40	38.2	41.0
1968										
[illegible]	5-27	0.1m	8.46	8.28	3.26	0.18	5.20	2.8	24.3	700.0
1[illegible]-VI	7-28	0.1m	9.50	8.46	8.40	1.04	1.10	3.53	110.3	117.0
1[illegible]-VII	8-25	0.1m	7.30	6.86	6.69	1.44	1.61	3.50	154.3	172.4
2[illegible]-VII	4-27	0.1m	3.23	3.13	2.72	0.10	0.51	2.1[illegible]	17.9	90.1
16-VIII	12-31	0.1m	7.48	6.81	6.46	0.67	[illegible].02	5.03	49.5	75.5
16-VIII	7-29	0.1m	7.08	7.04	6.98	0.04	1.10	4.17	3.60	99.1
1[illegible]-VIII	5-27	0.1m	6.36	5.99	--	?	0.37	3.17	--	44.0
2[illegible]-VIII	4-27	0.1m	5.02	4.15	3.52	0.83	1.50	3.08	101.	182.
2[illegible]-VIII	6-27	0.1m	6.92	6.77	6.69	0.15	0.23	2.08	27.0	41.3
2[illegible]-VIII	6-27	2.0m	7.01	6.90	6.80	0.11	1.21	1.58	26.0	288.
7-IX	7-29	0.1m	6.51	6.41	6.30	0.10	0.21	2.92	13.0	27.1
7-IX	7-29	Deck	6.49	6.37	6.30	0.12	0.19	2.92	15.4	24.3
7-IX	9-28	0.1m	6.66	6.47	6.32	0.19	0.34	1.92	36.9	66.2
15-IX	4-27	0.1m	5.97	6.04	5.90	-.07	0.14	1.92	-13.5	27.1
15-IX	4-27	0.5m	5.98	6.09	5.72	-.01	0.27	1.83	-2.18	55.8
20-IX	11-29	0.1m	7.90	7.77	7.74	.13	0.16	2.42	20.1	24.8
20-IX	11-29	Deck	7.93	7.77	7.56	.16	0.37	2.42	24.8	57.5
20-IX	11-29	1.9m	7.76	7.63	7.42	.13	0.34	2.17	22.4	58.6
1-X	2-4	0.1m	9.10	10.40	8.49	-1.30	1.91	2.38	-205.	301.
1-X	4-27	0.25m	12.76	13.16	12.70	-.40	0.46	1.18	-127.	147.
1-X	4-27	$\bar{x}$2 0.25m	13.04	13.16	11.92	-.12	1.24	1.18	-38.1	394.
1-X	4-27	$\bar{x}$2	12.90	13.16	12.31	-.59	1.26	1.18	-187.	401.
16-X	9-28	$\bar{x}$2 0.3m	9.44	8.72	8.55	0.72	0.89	5.25	51.4	63.6
16-X	9-28	1.3m	8.95	8.62	8.59	0.33	0.36	5.00	24.8	27.0
16-X	9-28	2.3m	8.25	7.79	7.30	0.46	0.95	4.83	35.9	73.4
29-X	10-29	$\bar{x}$2 0.5m	8.98	7.94	8.45	1.04	0.53	4.25	91.8	?

* A single pair of productivity estimates was made in 1967 in connection with a study of the Ctenophore population of Barnegat Bay, work which will ultimately be published under separate cover.

(Table continued next page)

FIELD ESTIMATES OF PLANKTON PRIMARY PRODUCTIVITY (Cont'd)

Date	Sta.	Treat-nent	Lite	Init.	Dark	Tot. O_2 Changes Net	Gross	Expos. Time	mg. C/m ^{3}/hr. Net	Gross
29- X	10-29	1.5m	8.88	8.11	8.50	0.77	0.38	4.00	72.0	?
29- X	10-29	2.5m	9.29	8.01	7.92	1.28	1.37	3.75	128.	137.
15-XI	4-27	$\bar{x}_2$ mean 0.1m	9.56	10.51	9.42	-0.95	0.14	2.67	-133.	19.6
24-XI	4-27	$\bar{x}$ of 2 0.2m	8.89	9.28	8.96	0.0	-0.07	3.50	0.0	- .001
18-XII	8-26	$\bar{x}$ 2 Deck Surface	12.29	12.15	12.20	0.14	0.09	5.17	10.3	6.6
9 I	5-27	$\bar{x}$ 2 Sub-Ice	16.78	16.29	16.45	0.16	0.49	6.42	9.4	28.7
[illegible]-I	5-27	$\bar{x}_2$	16.53	16.29	16.37	0.07	0.24	6.42	4.1	14.0
[illegible]-II	5-32	$\bar{x}_3$	11.17	10.16	10.11	1.01	1.06	5.0	75.7	79.7
[illegible]-II	9-28	$\bar{x}_3$	12.82	12.81	12.73	0.01	0.19	3.30	1.2	21.5

THE QUALITATIVE AND QUANTITATIVE ANALYSIS OF THE BENTHIC FLORA AND FAUNA OF BARNEGAT BAY BEFORE AND AFTER THE ONSET OF THERMAL ADDITION

Sixth Progress Report

June 1, 1970

Robert E. Loveland, Department of Zoology
Edwin T. Moul, Department of Botany

with the assistance of Kent Mountford, Phillip Sandine, Donna Busch, Edward Cohen, Nancy Kirk, Marsha Moskowitz, and Charles Messing.

Rutger's University, New Brunswick, New Jersey

Introduction

The principle purpose of the current report is to bring the reviewer up to date on the events of 1969. No elaborate presentation of raw data will be attempted as in the past, instead this data is being stored in the Department of Zoology at Rutgers University and will be made available on request. We will attempt in this report to review the general implications of our data and to outline our intentions for future work in Barnegat Bay. For the first time during this study, we have begun very critical analysis of the data utilizing the techniques of statistics and computer science. Unfortunately, analysis of data is a time consuming task and will undoubtedly persist throughout the summer. We now have a team of workers who have been able to co-ordinate their efforts in a very constructive way. While each person may be specifically interested in one small phase of the work, each is constantly communicating with the other people involved since we all share the same laboratory.

Some generalizations regarding this project can be made. In 1969 we had almost a complete turn-over of personnel; most of the assistants joined us with little or no previous experience. However, a difference in attitude also was introduced. We have become much more concerned with accuracy and interpretation of data as well as careful planning. Thus, although it may appear that we have done quantitatively less than in previous years, we are much more confident in our sampling techniques and laboratory analysis. We have focused on five regions of the bay for sampling stations: 1.) Forked River at Route 9; 2.) Forked River Mouth; 3.) Stout's Creek Mouth; 4.) Oyster Creek Mouth; and 5.) Oyster Creek at Route 9. In addition stations have been taken from other regions of the bay, as well as from within the confines of the generating plant itself. During 1969, we made 17 cruises for benthic invertebrates alone and have sampled all months except January, April and May.

Over 120 benthic samples were analyzed for invertebrates. Additional cruises and samples were made for the plankton, benthic algae and productivity studies. This study has continued uninterrupted since June of 1969, with 7 additional cruises being made through May 1970. It is our hope that this project will continue for at least one more year---to that end we are requesting supplementary funds for summer 1970 and for additional funds for one more year. Such a proposal is to be submitted to the Joint Investigatory Committee presently.

<u>Publications and Presentations:</u>

Loveland, R.E., Gordon Hendler and Gary Newkirk. 1969 New records of nudibranchs from New Jersey. The Veliger <u>11</u>(4): 418-420.

Loveland, R.E, and David S.K. Chu. 1969. Oxygen consumption and water movement in <u>Mercenaria mercenaria</u>. Comparative Biochemistry and Physiology <u>29</u>(1): 173-184.

Taylor, Jonathan E., Edwin T. Moul and R.E. Loveland. 1969. New records and rare benthic marine algae from New Jersey. Bulletin of the Torrey Botanical Club Vol. <u>96</u>(3): 372-375.

Loveland, R.E. and J.S. Wasser. 1969. Electrophysiological and histological evidence of a chemoreceptor in the antenna of <u>Oniscus sp.</u>, the common pillbug. The Bulletin (N.J. Acad. Sci.) <u>14</u>(1-2): 89.

Dr. R.E. Loveland attended the AAAS Meetings in Boston in December and recently delivered a paper at the University of Delaware. Mr. W. Cohen and Dr. Loveland gave a joint paper on <u>Codium</u> at the N.J. Academy of Sciences this Spring.

Personnel:

Mr. Phillip H. Sandine has joined our project and will be primarily concerned with the field operation. His principle interest in research is productivity in plankton populations. He has been sampling the water in and around the area of the generating station through the kind permission of Mr. B.A. Johansen of the Jersey Central Power and Light Co.

Miss Nancy Kirk, an undergraduate at Douglass, has been responsible for sorting and tabulating species identified from samples. She has been also analyzing Pectinaria and Mulinia.

Mr. Edward Cohen, an undergraduate from Rutgers College, has been studying the effects of temperature on the productivity of Codium fragile. He has recently been accepted to the Department of Oceanography at the University of Washington.

Mrs. Marsha Moskowitz, a graduate student in the Department of Zoology at Rutgers, has been conducting a critical survey of the diversity of benthic invertebrates from the principle study areas of the bay. Her principle interest is in the statistics of diversity.

Mr. Charles Messing, an undergraduate from Rutgers College, has been studying the size-frequency distribution of Mulinia throughout the bay. He has recently been appointed to an NSF Graduate Fellowship at the University of Miami.

Dr. R.E. Loveland spent three days in St. Peter's Hospital for surgery on his wrist which resulted from an injury due to an accident on the R.V. Clio last Fall.

Mr. Frank Phillips is now teaching at the University of Jacksonville in Jacksonville, Florida.

Budget:

Expenses for this project have been steadily increasing. Two reasons can account for this: 1) as with any other economic endeavour, inflationary increases at all levels constantly reduces the purchasing power of our resources; 2) we have had to rely more and more on human labor to get each of our data acquisition, tabulation and analysis completed. With regard to this last point, we have found that any one person can only become expert in their contribution to this project if he (or she) concentrates on one area of endeavour. Thus, we have had to bring in additional people to work on separate aspects of the project. Some of these people have worked for no financial reward whatsoever; others have been paid on part-time labor funds. We have found that in order to perform at the level which we now operate, we have had to add people to the staff. Therefore, we anticipate that unless we get additional contingency funds for the month of August, our funding will be exhausted sometime in July. The amount of this additional award is modest in comparison to the return on the investment. We estimate that an additional $3000.00 will cover any and all costs for the project through 31 August 1970. We are, therefore, going to submit a separate proposal to the committee for contingency funds for this period.

The following table indicates a breakdown of our expenses through 1 June 1970:

Item	Allotted	Spent	Balance
Salary	18001.22 -	13349.17	4652.05
Equipment	388.00 -	585.00	- 187.00
Supplies	900.00 -	533.49	366.51
Operating expenses	800.00 -	1072.50	- 272.50
Research vessel	850.00 -	770.06	79.94
Publications	280.00 -	236.65	43.35
	21080.22	16535.17	4594.05 *

* these figures are those of RGL since he keeps the books on this project; however, the amounts indicated to us by the Research and Contracts Office of Rutgers are often quite different, and are, in general, less than our figures. We probably have, therefore, less than this amount since it does not reflect outstanding requisitions and current salary costs.

I. Plankton:

Introduction

Much of our previous effort studying the plankton of Barnegat Bay has been directed toward finding some reasonably stable indicator of change as well as obtaining some understanding of the system as it operates. This has required a rather broad approach and has not met with favor in all quarters.

During the past year a great deal of additional effort has been invested studying chlorophyll concentrations, primary production, and respiration associated with changes in the plankton. The potential role of some component populations is emerging. Species composition was shown in the March, 1969 report to exhibit some regular patterns of change with the seasons. Several species have regularly dominated the plankton at relatively predictable intervals and appear to signal normal seasonal shifts. The appearance and disappearance of these organisms has now been associated with changes in the quantity and productivity of the plankton community.

Summary of operations

During the year March, 1969 through February, 1970 the following field operations were carried out in connection with the plankton survey.

Number of cruises	21
Number of transect stations	10[illegible]
Total stations including canals	1[illegible]0
Phytoplankton samples	153
Zooplankton samples	154
Chlorophyll determinations	2[illegible]0
R/V Beroe operational hours	115

Five regular stations are worked on each cruise. They are spaced 1700 to 2200 meters apart on a North-South transect 7.8 kilometers in length. Stations off Forked River and off Oyster Creek are replicated completely on each cruise to obtain estimates of sampling variability within station. The resulting aggregate of seventy replicate determinations for each major biological parameter (Zooplankton density, phytoplankton cell counts, chlorophyll, respiration, gross and net photosynthesis) permits a fair estimate of the confidence interval about single determinations.

The transect is run within a fraction of the tidal cycle, usually about three hours, to limit the effects of exchange, and alternately from the North or South to minimize the bias from sample incubation differences. No systematic effects have yet been detected from these sources with the possible exception that gross production may tend to be higher near ebb tide during the summer. This is consistent with our observation that the higher salinity stations, Buoy F and Buoy G, tend [illegible]
[illegible]

Productivity studies:

Primary production and plankton respiration has been estimated using the light and dark oxygen bottle method, with exposure made at ambient light intensity. Our previous experience with vandalism dictates shipboard incubation of the samples in a tank under about two decimeters of water, approximating the conditions of collection. Replicate determinations suggest a standard error for gross production approximating $\pm$ 20 mg $O_2 . m^{-3} . hr^{-1}$ and a 95% confidence interval approximating $\pm$ 30 mg $O_2 . m^{-3} . hr^{-1}$. Gross photosynthesis has been more variable off Oyster Creek ([illegible] 36.1).

Preliminary assessment of these data suggest we may be able to distinguish relatively consistent differences among stations based upon productivity. If the relationship among stations changes significantly, we should seek associations with corresponding environmental differences. The differences shown in Fig. [illegible] are with a few exceptions, not significant at the 95% level but their consistent appearance would seem to merit further study. In addition, it is questionable whether we should apply so severe a test of significance in a highly variable situation. Perhaps 80% is more realistic.

Hydrographic data taken from salinity profiles constructed on each date indicate that the southern two stations [illegible] F and G are generally quite stratified, particularly near flood tide. Mixing of the bottom water with upper layers apparently tends to elevate salinity at the surface as well, and this elevation is associated, without the implication of causality, with a decrease in gross production.

The role of *Nannochloris atomus*:

In 1969 there was a productivity peak in July associated with maximum cell numbers. The summer predominance of *Nannochloris* has now been documented for three successive summers (Fig. 2). Blooms of this Chlorophyte have been related to severe organic pollution by Ryther, 1954 and Ryther *et al*, 1958. Gross production during the summer months plots very closely with the logs of cell counts for *Nannochloris* and it is tempting to suggest that this organism may be the most important summer phytoplankton producer. A preliminary experiment was made on the closely related *Kirchneriella* Hulburt taken from Raritan Bay by O'Reilly* and given to us. Net production under constant light (ca 1500 fc) was still increasing along a temperature gradient at 35-37° C. O'Reilly also gave us quantities of a dinoflagellate *Prorocentrum micans* (Carolina Biological Supply clone) similar to one frequently seen in Barnegat.

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*John O'Reilly is working with Red-Tide dynamics at the Rutgers Shellfish Laboratory, Monmouth Beach, N.J. under Dr. H.H. Haskin and Walter Canzonier.

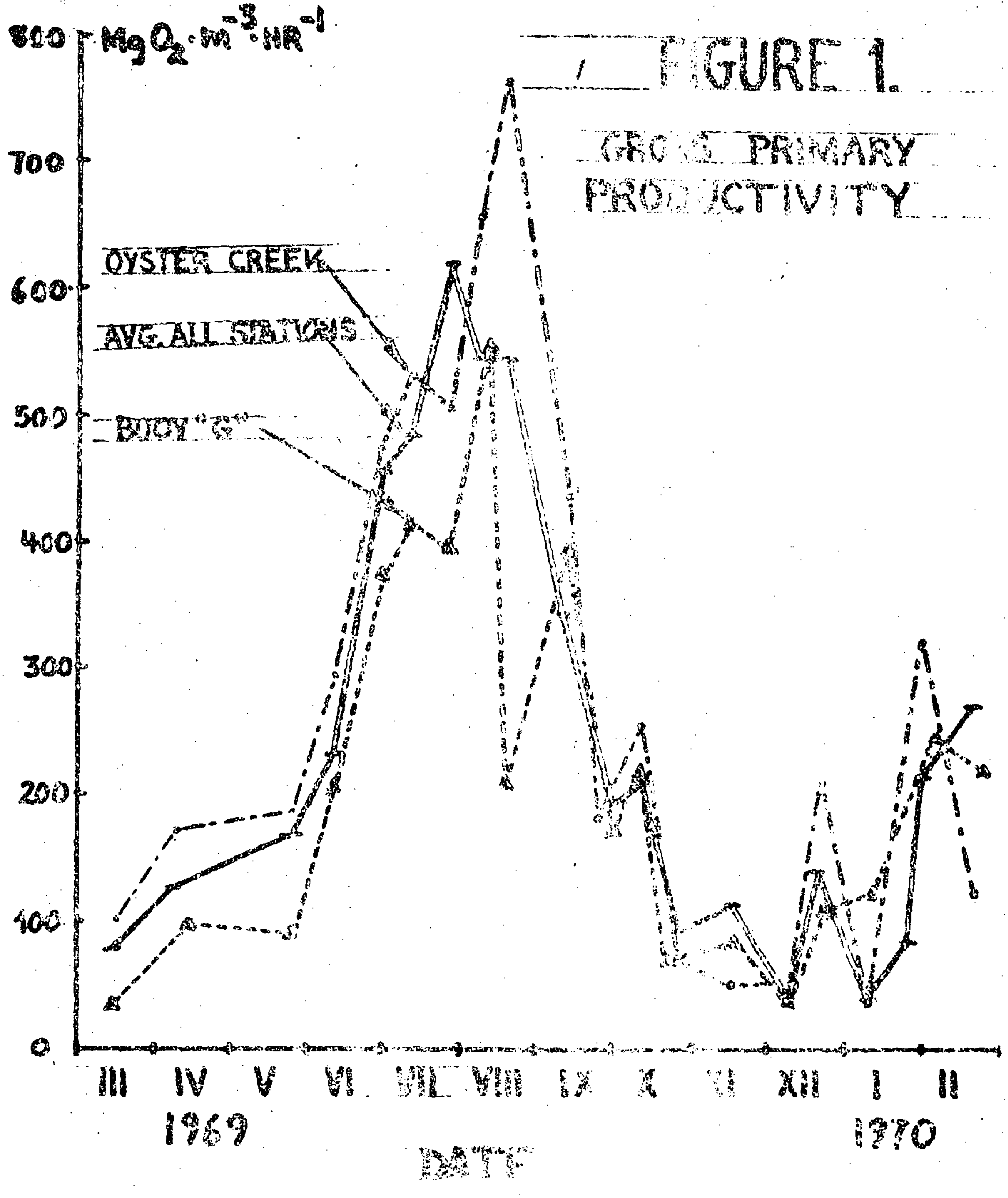
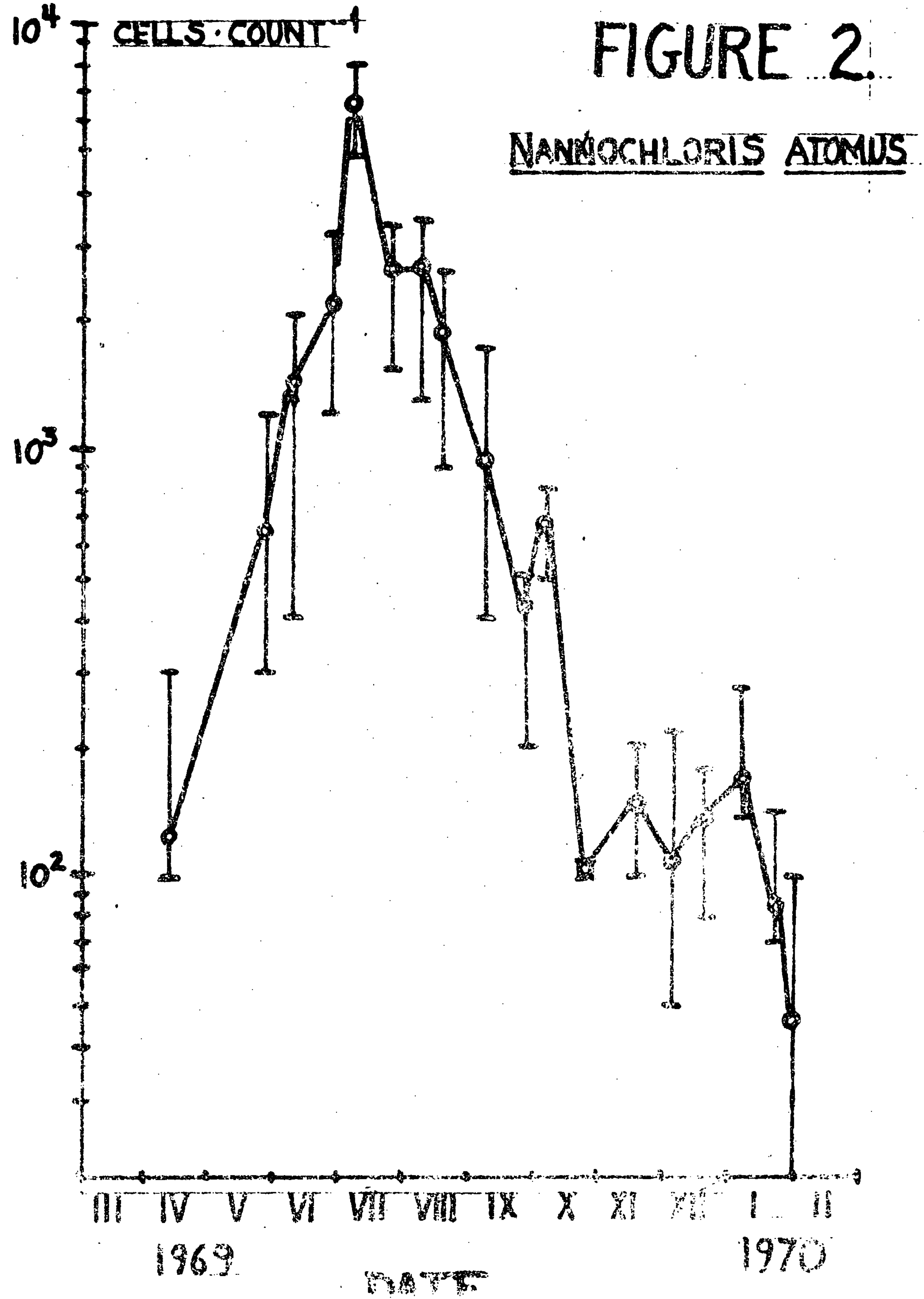


FIGURE 1.
GROSS PRIMARY PRODUCTIVITY
Mg O2 · m-3 · HR-1
800
700
600
500
400
300
200
100
0
OYSTER CREEK
AVG. ALL STATIONS
BUOY "G"
III
IV
V
VI
VII
VIII
IX
X
XI
XII
I
II
1969
1970
DATE

FIGURE 2.


NANNOCHLORIS ATOMUS
CELLS · COUNT
10^4
10^3
10^2
III IV V VI VII VIII IX X XI XII I II
1969
1970
DATE

A partial light-temperature response surface was run with this organism and indicated an optimum at or below 16° C, depression of photosynthesis at 26-28°C and negative production at 34-38° C.

Diversity:

Phytoplankton diversity was estimated using the average number of cells and average number of species recorded during enumeration on each date. The relationship;

$$S = a \log_e (1 - \frac{N}{a}) ,$$

was employed according to a graphical method published by Lewis and Taylor, 1967. Without including *Nannochloris* counts, there is a slight tendancy for phytoplankton diversity to decrease during the summer. (The effect on diversity of including *Nannochloris* is shown in Fig. 3.)

Plankton respiration:

There is a summer increase in plankton respiration measured by dark bottle-initial differences which may be associated with changes in seasonal temperature patterns. The increase in variability during winter seems quite clearly associated with strong salinity stress when virtually fresh water runoff underlies heavy ice cover. Only limited mixing occurs but plankton diatoms swept into this situation are covered with large clusters of bacteria. Samples taken from this layer had apparent respirations of from 1395 to 4136 mg $O_2 . m^{-3} . hr^{-1}$. Fig. 4 shows the observed pattern.

Chlorophyll a:

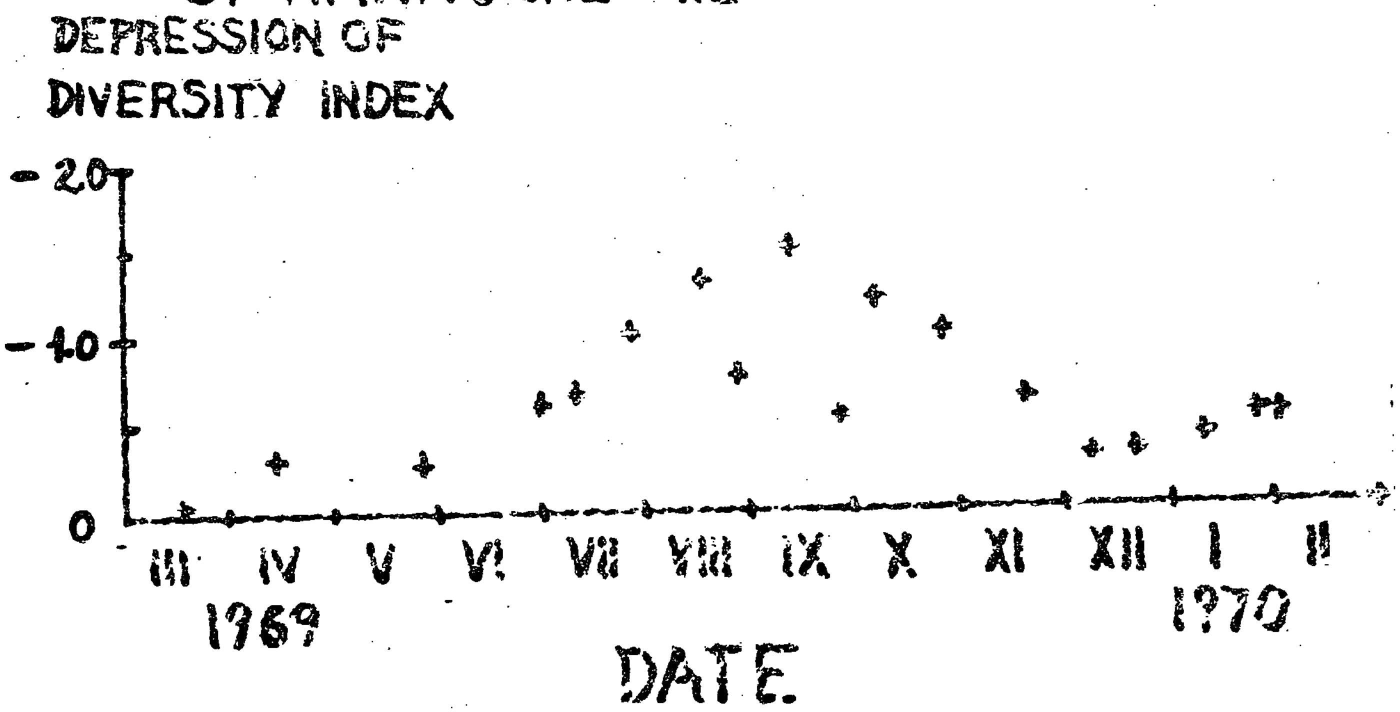
Chlorophyll determinations were replicated at almost all stations throughout the year following the recommendations of Strickland and Parsons, 1968. The agreement obtained among replicates was of the order of 0.5-1.5 $ug.1^{-1}$. The pattern of distribution is shown in Fig. 5. Maximum values were observed during the winter-spring blooms dominated by *Thalassiosira nordenskioldi* and *Detonula confervacea*. These species constitute the core of a distinctly coldwater flora. There is a secondary chlorophyll maximum in summer associated with peak cell numbers and, particularly, with the development of *Nannochloris*.

Throughout much of the year Oyster Creek apparently contributed chlorophyll to the bay. This contribution was maximal in July and coincided with the highest observed *Nannochloris* counts. This contribution may not be present during a normal winter situation when the bulk of chorophyll apparently comes from *Thalassiosira* which seems more successful in higher salinity coastal water.

It is conceivable that higher productivity and chlorophyll estimates associated with Oyster Creek could be due to organic pollution effects or simple eutrophication, rather than any thermal effects. This is especially true in light of the fact that the generating plant did not begin to release warm water until December of 1969. Additional primary productivity studies have been conducted

DIVERSITY DEPRESSION BY NANNOCHLORIS

FIGURE 3.



Computing phytoplankton diversity with and without *Nannochloris* produces two different indices. The difference between the two in "diversity units" is considered to represent a depression in diversity contributed by *Nannochloris*.

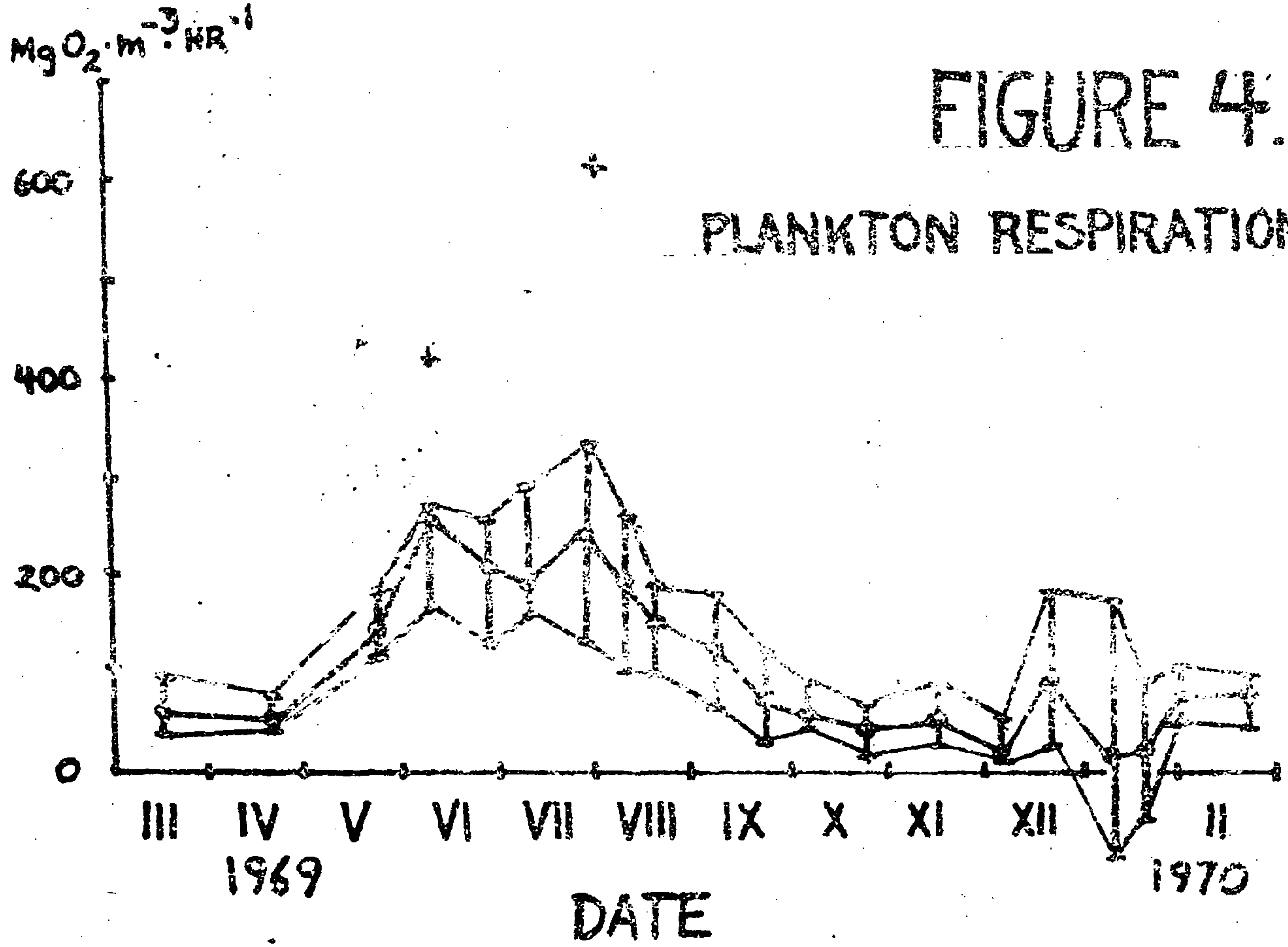
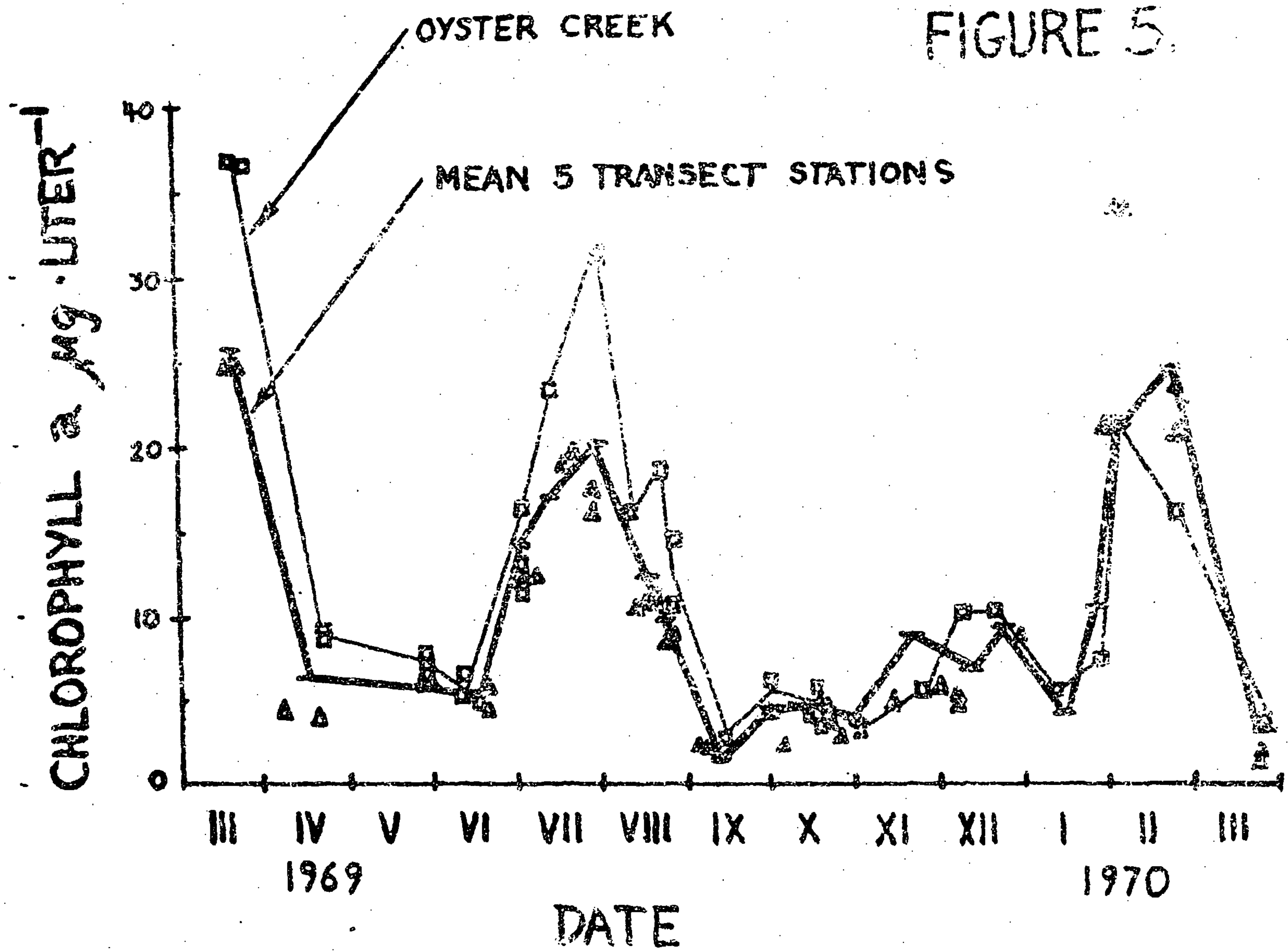


FIGURE 4.

PLANKTON RESPIRATION

FIGURE 5.

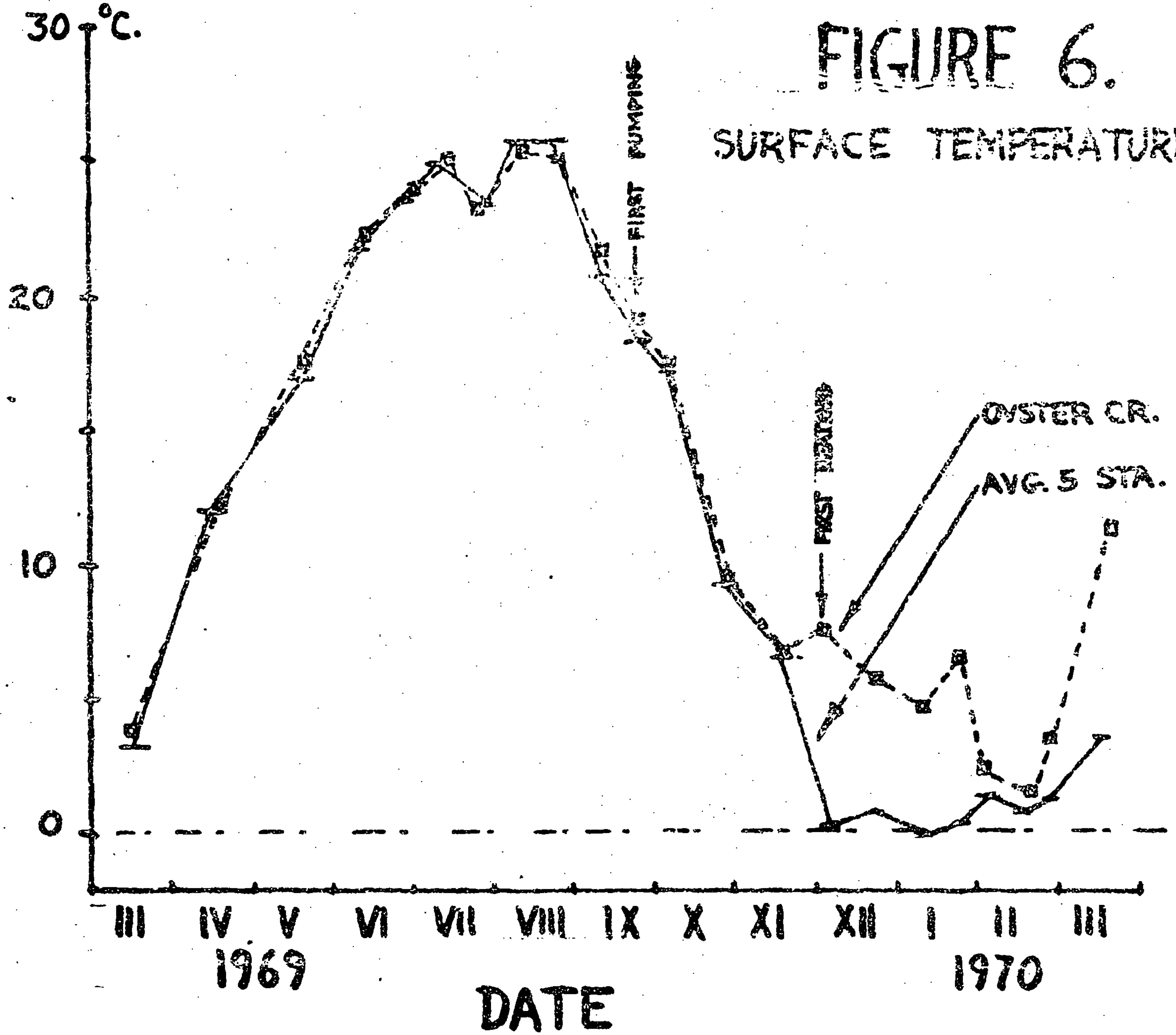


OYSTER CREEK
MEAN 5 TRANSECT STATIONS
CHLOROPHYLL a μg·LITER⁻¹
40
30
20
10
0
III
IV
V
VI
VII
VIII
IX
X
XI
XII
I
II
III
1969
1970
DATE

14.

FIGURE 6.

SURFACE TEMPERATURE



at the intake-outfall on the property of the generating plant and downstream on both Forked River and Oyster Creek. Eight experiments performed between December '69 and March '70 indicate that the net productivity of Forked River was, on an average, twice as high as net productivity in Oyster Creek (0.24 mls O_2/liter/hr. vs. 0.11 mls O_2/liter/hr., respectively). Respiration rates for both Forked River and Oyster Creek plankton was, on the average, the same.

In addition, a study of mortality of copepods was conducted on 31 March 1970. Quantitative samples of water from Forked River (5° C) and Oyster Creek (13°C), (both samples taken at Route #9 bridge) were brought to the laboratory without change in temperature. Living and dead copepods were counted. It was consistently found that the percentage dead copepods was higher for Oyster Creek than for Forked River (32.7% vs. 14.9%, respectively). It was also found that hydrozoan medusae were generally moribund after passing through the generating station.

Chlorophyll concentrations alone permit a reasonable first approximation of primary production but the confidence around such simple predictions is not high for several reasons. First it completely ignores the effect of varying solar radiation. Individual estimates for energy income to each productivity estimate have been prepared from pyranometer records. In addition, there appear to be species effects operating. It is possible at this point to segregate, by eye, subsets of points representing specific populations. We are dealing as well with experimental error in both the determination of chlorophyll and the measurement of oxygen changes. These sources have been reasonably well quantified by replication.

Temperature is certainly an important factor in mediating all of these changes but its role is always masked by complicating and interacting factors. Even detailed inspection and dissection of our data reveals only generalizations. Stepwise multiple regression techniques are being tried to begin assessing the relative roles of these parameters. This technique is far from being a panacea and, we are quite aware of the assumptions which must be made, and occasionally violated, in its application.

Distinct, if sporadic, post-operational data began with the 7 December, 1969 cruise when a mean temperature differential of 9.91° C, was observed between Forked River and Oyster Creek (Fig. 6). Frequent down time at the plant coupled with acid cleaning and chlorination on an unknown schedule has made the postulation of specific effects on the natural system a virtual guessing game. The ability to plan sampling runs during periods of consistent operation and rather specific information on chemical input schedules are required for any degree of fair evaluation.

Forked River—Oyster Creek Plankton Comparison

20 samples, each containing 10 mls, were counted. Only adults were counted. Mortality was defined as no movement or response of the copepod after being touched with a probe three times.

Raw data

	F.R. Live	F.R. Dead	O.C. Live	O.C. Dead
	94	5	15	13
	13	4	19	11
	25	7	10	4
	31	2	24	5
	15	4	26	6
	16	4	7	14
	17	2	13	11
	23	5	25	7
	18	3	18	13
	22	0	15	12
	36	6	29	3
	20	4	13	8
	17	3	16	8
	22	9	39	17
	14	3	43	4
	10	5	33	15
	38	6	31	23
	32	6	18	13
	18	4	16	13
	45	10	26	12
N	20	20	20	20
x	526	92	436	212
x^2	20,280	528	11,272	2724
x	26.30	4.60	21.80	10.60
x	18.42	2.35	9.64	5.01
^2x	339.27	5.52	93.01	25.09

Forked River

total live	526	—	85.11%
total dead	92	—	14.89%
total animals	618		

Oyster Creek

total live	436	—	67.28%
total ~~live~~ dead	212	—	32.72%
total animals	648		

Original Concentration

Forked River

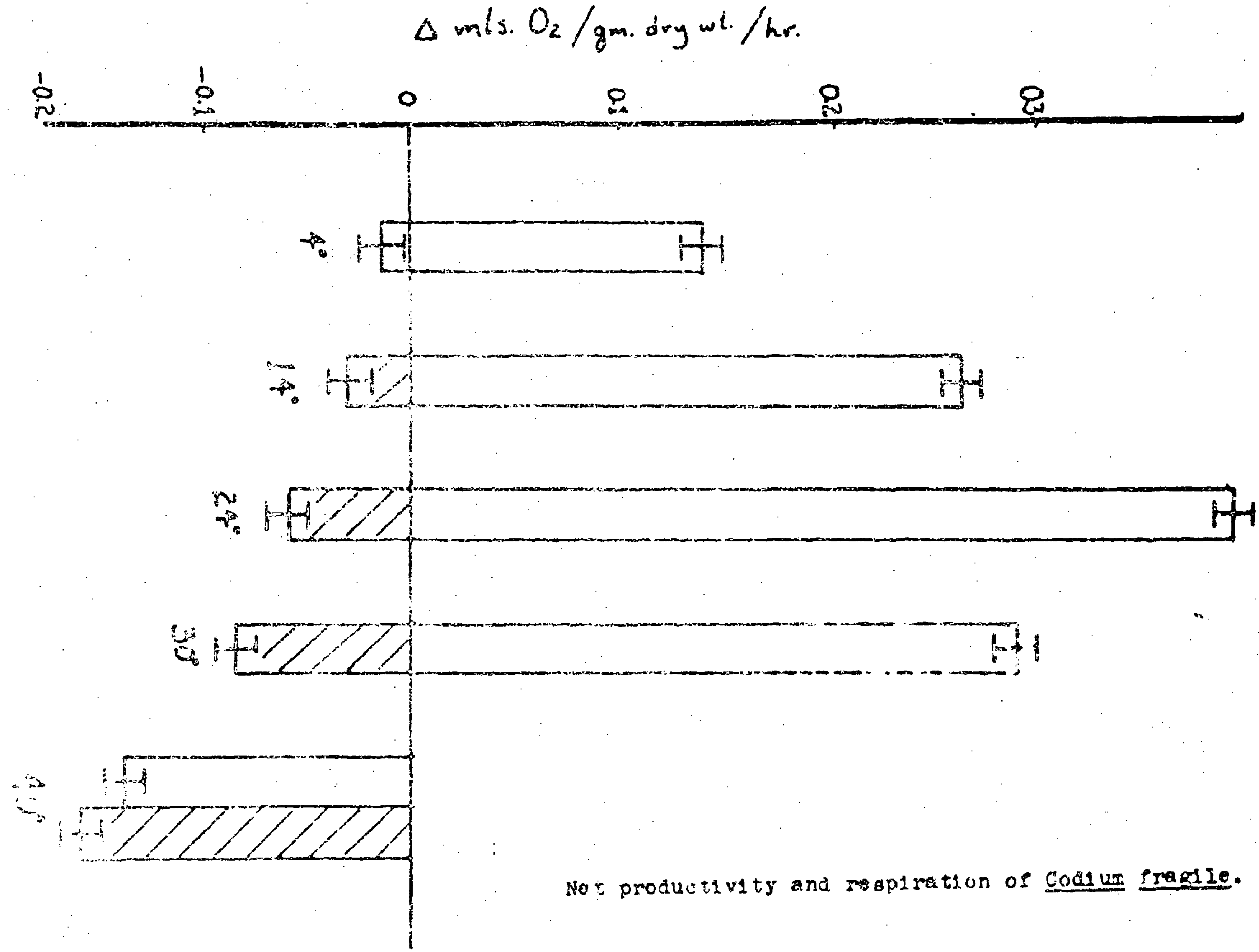
618 animals/200 mls x 1600 mls in jar/100 l.
= 49.44 animals/liter

Oyster Creek

648 animals/200 mls x 1600 mls in jar/100 l.
= 51.84 animals/liter

II. Benthic Algae

Qualitative samples were collected at nine stations on a north-south transect, starting at Stout's Creek and ending at Buoy G below Waretown. Samples from each station were collected using a "poacher" dredge during the months of June, July, August, September, November, February, April and May. The samples were returned to Nelson Labs for sorting and identification. Wet weight and dry weight was determined for each species; this data was then converted to relative or percentage dry weight. A total of 38 samples have been completely sorted to date by Dr. E.T. Moul, yielding only 17 species of benthic macro-algae. Less emphasis has been placed on the smaller microscopic forms of epiphytes because of time limitations. The dominant species continue to be *Codium fragile*, *Ulva lactuca* and *Gracillaria sp.*. For each species, tabulations have been made of its relative abundance through time and station. In addition, diversity indices have been computed for each sample. The index varies from 0.307 (August, off mouth of Forked River) to 1.702 (June, at Buoy F, Waretown). We are presently performing an analysis of variance to see if there are any significant changes in the diversity of benthic algae from station to station, or from time to time in Barnegat Bay. Generally speaking, we have found no large differences in the abundance or variety of algal species for 1969 in comparison to previous years. *Codium fragile* has continued to spread in a southerly direction and has now been recorded for Brant Beach. For some unknown reason *Codium* has yet to appear in any other estuary of New Jersey, to the best of our knowledge. We have spent a considerable amount of time this past year studying the thermal effects on productivity in *Codium fragile* in our laboratory. Samples of *C. fragile* were collected in Barnegat Bay during the Fall of 1969 and cultured in our Instant Ocean at 11-13°C. at a salinity of 32‰. Determinations of Qo_2 were made at temperatures ranging from 4-40°C. Oxygen determinations were performed using the Chesapeake Bay Institute modification of the standard Winkler Method. Net productivity increases for *Codium* from 4° to 24°C. where it reaches its peak; it then decreases at higher temperatures, with lethality occurring at 40°C.. Respiration continues to increase until 40°C.. It is proposed that we continue this study of *Codium* using the same thermal series, but we will now alter the salinity. In this way, we hope to generate a response surface for *Codium* for the normal range of temperature and salinity found in Barnegat Bay.



Net productivity and respiration of <u>Codium fragile</u>.

III. Benthic Invertebrates

We have been increasingly aware of the problem of quantifying accurately the benthic populations of invertebrates. Therefore, some effort was made to correlate the volume and area of sample obtained from single Ponar dredge hauls with the type of sediment found. As would be expected, there is a great amount of variance in collecting efficiency by the Ponar for hard sandy sediments, with decreasing variance in "silty" sediments. A thorough study was made of the collecting efficiency of the Ponar by Mr. Phillips in June of 1969, however, the details of his study have not yet been made available to our group. We will eventually be able to estimate the actual size of every sample taken since June 1968, since we have routinely analyzed the sediments for every sample taken. At the moment, all of our data on benthic invertebrates is expressed as organisms per Ponar (≈0.1M^2). We have routinely measured the following characteristics of every sample: number of Ponar hauls, estimated size of sample in field, volume of sample (occasional), wet weight of sorted sample (total and individual species), dry weight of sorted sample (total and individual species), number of individuals per species in sample, percentage contribution of each species to the sample, average diversity of the sample (H) and maximum diversity of the sample (H_{max}). In addition several species have been singled out for more detailed study---they include the two dominants in the bay, Pectinaria and Mulinia.

We have characterized the principle regions of the bay by the dominant species present for that region. It is interesting to note that the areas around Route 9 on Forked River and Oyster Creek show the greatest changes in benthic invertebrates. Although no invertebrates were collected at either place during the early phase of this study, benthic invertebrates are routinely collected for those areas. A phenomenon which we have designated as "gigantism" seems to have occurred at Forked River near Route 9---specimens of the bivalve species Mullinia taken from this area are extraordinarily large in comparison to other regions of the bay. We have analyzed 87 samples of Mullinia from Stout's Creek, Forked River and Oyster Creek; in each case 50 animals were randomly chosen and measured for both length and width. The mean sizes ranged from 3.3-7.0mm for Oyster Creek, 3.8-5.1mm for Stout's Creek and 2.3-9.5mm for Forked River. Furthermore, it appears that there is a linear correlation between the variance in length and the mean length of the sample. Effects of position within the bay and season of collection have yet to be isolated in the analysis--we are simply attempting to characterize with accuracy the individual populations of Mullinia for three regions of the bay.

Benthic Invertebrates

From 1 July 1969 through 31 December 1969, fourteen cruises were made on Barnegat Bay covering in general, Forked River—Light 4 to Route 9 Bridge, Oyster Creek—Light 3 to Route 9 Bridge, the area surrounding Light 1—Stout's Creek, and the areas between the three lights. At each light and at Route 9 Bridge (Forked River and Oyster Creek) a tight grid was sampled in order to characterize each area according to dominant species there.

In all, 110 qualitative and quantitative samples of benthic invertebrates were collected for analysis from 131 stations covered during the fourteen cruises.

Animals added to the check list since the last report are Retusa obtusa (111), Stylochus ellipticus (112), and Triphora (perversa) nigrocincta (113).

Dominant species are presented here in order of abundance for each area. For lights 1, 3, 4, a 100 yard radius about each light defines the sampling area.

Route 9 Bridge (F.R.)

Mulinia lateralis
Pectinaria gouldii
Ampelisca macrocephala

F.R. Beach Club Bridge

Ampelisca macrocephala

Dual Cove

Pectinaria gouldii
Mulinia lateralis

Light 1[illegible]

Pectinaria gouldii
Mulinia lateralis
Ampelisca macrocephala

Light 12

Ampelisca macrocephala
Pectinaria gouldii
Mulinia lateralis

Light 4

Mulinia lateralis
Pectinaria gouldii
Mitrella lunata and Retusa canaliculata
Bittium alternatum

Route 9 Bridge (O.C.)

Rhithropanopeus harrisi
Mulinia lateralis and
Pectinaria gouldii and
Ampelisca macrocephala
in equal numbers

E. of Oyster Creek Marina

Mulinia lateralis
Pectinaria gouldii
Ampelisca macrocephala

B & K Marina

Ampelisca macrocephala
Mulinia lateralis

Just off Loading Derrick

Mulinia lateralis
Pectinaria gouldii
Retusa canaliculata and
Mitrella lunata

Light 3

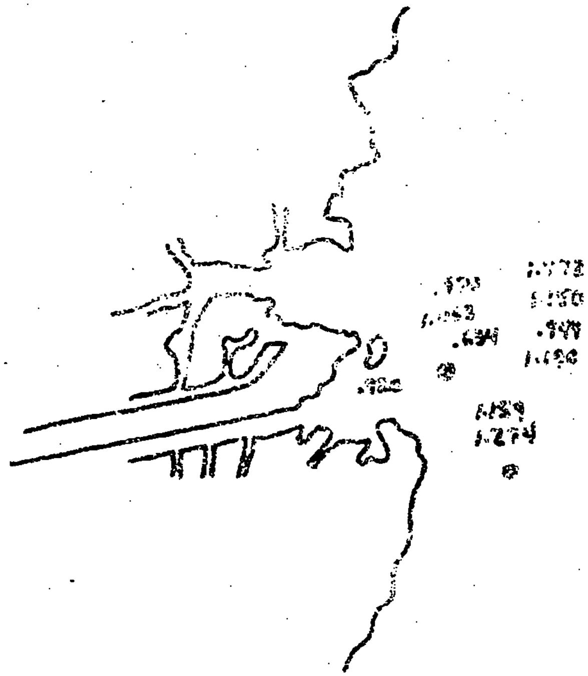
Mulinia lateralis
Pectinaria gouldii
Retusa canaliculata and
Mitrella lunata

Light 1—Stout's Creek

Mulinia lateralis
Pectinaria gouldii
Retusa canaliculata
Turbonilla sp.

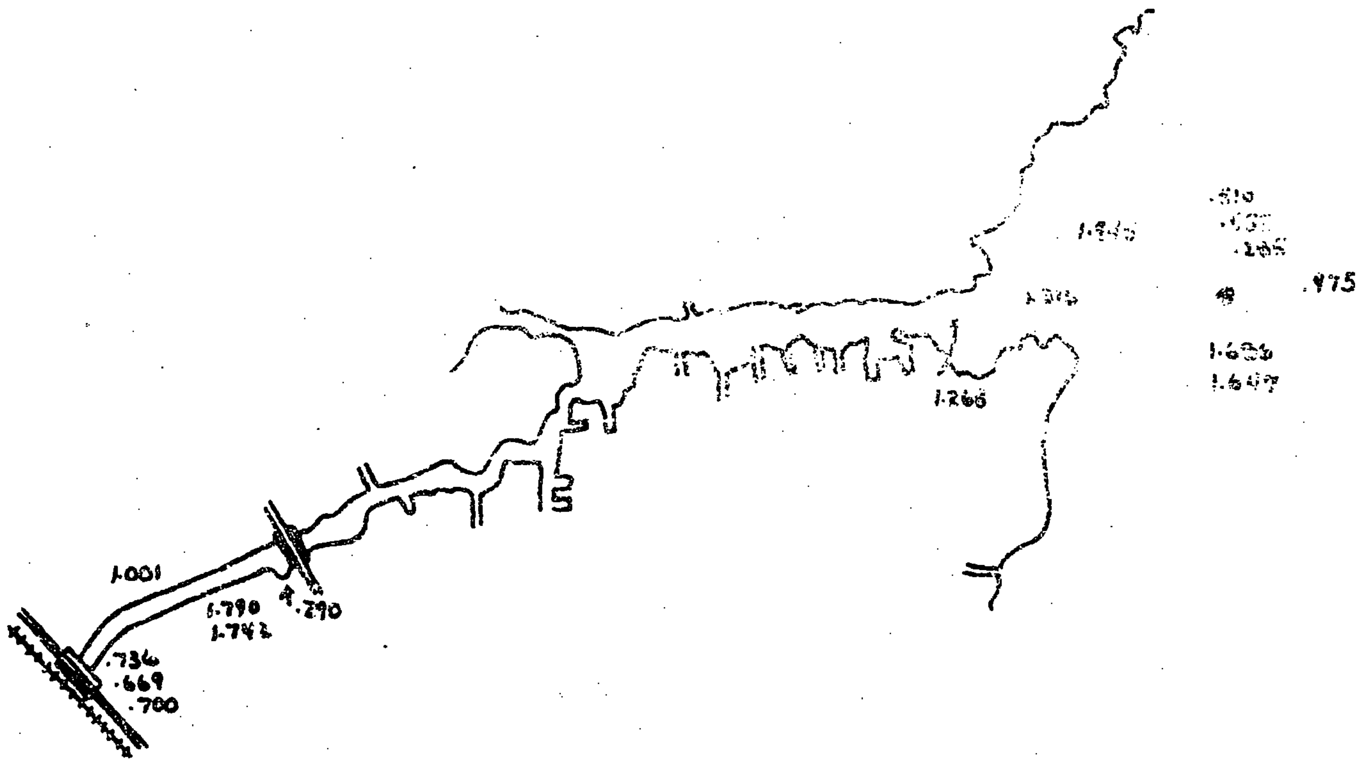
We are continuing our study of the relationship between the grain size of the Pectinaria tube and the grain size of the surrounding sediments. Insufficient analysis of the data on this project prohibits definite conclusions.

Finally, we have performed diversity calculations for a large number of benthic invertebrate samples. Generally speaking, the diversity index for samples taken from the area around Oyster Creek tend to be lower than comparable samples for Forked River or Stout's Creek. We are presently attempting to use the diversity index as the most accurate method of comparing samples from different regions collected at different times. If the diversity index proves to be normally distributed we will use this index as a criterion of significance in all of our station comparisons. Some of the results of these calculations follow on separate sheets. We have also listed the species of invertebrates found in 1969 on a separate sheet (this listing includes the period of January-May 1969).

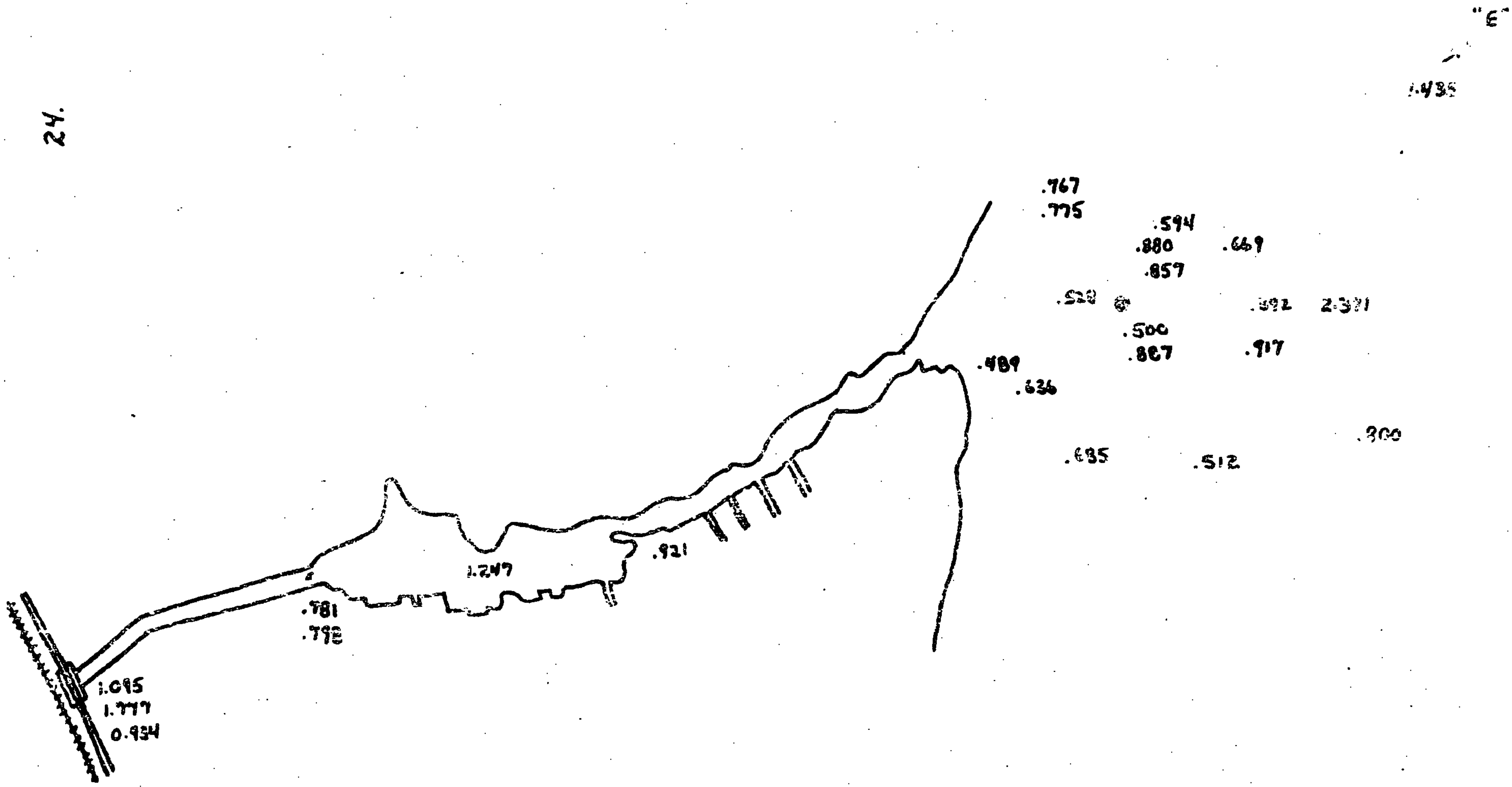


Diversity indices around
Stout's Creek & Light "1"

1.103 "D"



Diversity indices around
Forked River & Light "4"



Diversity indices around
Oyster Creek & Light "3"

Species collected from 1 July 1969 through 31 October 1969 for:

Route 9 Bridge (F.R.)

Ampelisca macrocephala
Mulinia lateralis
Pectinaria gouldii
Retusa canaliculata

Route 9 Bridge (O.C.)

Ampelisca macrocephala
Mulinia lateralis
Pectinaria gouldii
Rhrithropanopeus harrisi

Light 4 (F.R.)

Ampelisca macrocephala
Anadara ovalis
Balanus improvisus
Bittium alternatum
Crepidula convexa
Cyathura polita
Diopatra cuprea
Epitoneum rupicola
Eupleura caudata
Glycera americana
Hydroides dianthus
Lyonsia hyalina
Maldanopsis elongata
Membranipora
Mercenaria mercenaria
Mitrella lunata
Mulinia lateralis
Mya arenaria
Neopanope texana
Pectinaria gouldii
Retusa canaliculata
Rhrithropanopeus harrisi
Solemya velum
Stylochus ellipticus
Tellina agilis
Triphora nigrocincta
Turbonilla sp.

Light 3 (O.C.)

Ampelisca macrocephala
Anadara ovalis
Balanus improvisus
Bittium alternatum
Callinectes sapidus
Cerianthus americanus
Clymenella torquata
Crangon septemspinosus
Cyathura polita
Diopatra cuprea
Epitoneum rupicola
Eupleura caudata
Gemma gemma
Glycera americana
Grubia compta
Hydroides dianthus
Lyonsia hyalina
Membranipora
Mercenaria mercenaria
Mitrella lunata
Mulinia lateralis
Mya arenaria
Mytilus edulis
Neopanope texana
Pectinaria gouldii
Retusa canaliculata
Rhrithropanopeus harrisi
Solemya velum
Stylochus ellipticus
Tellina agilis
Tellina versicolor
Turbonilla sp.
Urosalpinx cinera
Yoldia limatula

Light 1 (S.C.)

Ampelisca macrocephala
Bittium alternatum
Cerianthus americanus
Clymenella torquata
Cyathura polita
Diopatra cuprea
Epitoneum rupicola
Eupleura caudata
Glycera americana
Hydroides dianthus
Lyonsia hyalina
Macoma tenta
Maldanopsis elongata
Membranipora
Mercenaria mercenaria
Mitrella lunata
Mulinia lateralis
Mya arenaria
Nassarius obsoletus
Pectinaria gouldii
Retusa canaliculata
Solemya velum
Tellina agilis
Turbonilla sp.

Additional new species from Barnegat Bay:

Acteon punctostriatus
Gyptis vittata
Haminoea solitaria
Sagartia luciae
Thyone briareus

Benthic Invertebrates of Barnegat Bay— 1970

Phylum Mollusca

Class Gastropoda:

Anachis avara
Bittium alternatum
Busycon canaliculatum
Cratena pilata
Crepidula convexa
Crepidula fornicata
Crepidula plana
Epitoneum rupicola
Eupleura caudata
Haminea solitaria
Mitrella lunata
Nassarius obsoletus
Nassarius vibex
Polinices duplicatus
Retusa canaliculata
Retusa obtusa
Triphora nigrocincta
Turbonilla sp.
Urosalpinx cinerea

Class Bivalvia:

Anadara ovalis
Anomia simplex
Ensis directus
Gemma gemma
Laevicardium mortoni
Lyonsia hyalina
Macoma baltica
Macoma tenta
Mercenaria mercenaria
Mulinia lateralis
Mya arenaria
Mytilus edulis
Nucula proxima
Pecten irradians
Petricola pholadiformis
Pitar morrhuana
Solemya velum
Tagelus divisus
Tellina agilis
Tellina versicolor
Yoldia limatula

Phylum Annelida

Class Polychaeta:

Amphitrite ornata
Capitella capitata
Cirratulis grandis
Clymenella torquata
Clymenella zonalis
Diopatra cuprea
Drilonereis longa
Glycera americana
Glycera dibranchiata
Goniada maculata
Harmothoe imbricata
Hydroides dianthus
Lepidonotus squamatus
Lumbrineris tenuis
Maldanopsis elongata
Marphysa sanguinea
Nepthys incisa
Nereis arenaceodonta
Nereis pelagica
Nereis succinea
Nereis virens
Notomastus latereus
Pectinaria gouldii
Pista cristata
Pista palmata
Podarke obscura
Sabella microphthalma
Sabellaria vulgaris
Scolopos armiger
Sthenelais leidyi (picta)
Sthenelais limicola
Stylarioides arenosa

Phylum Arthropoda

Class Crustacea:

Ampelisca macrocephala
Ampithoidae
Balanus balanoides
Balanus improvisus
Callinectes sapidus
Callipallene brevirostris
Cancer irroratus
Caprella geometrica
Caprella linearis
Carcinus meanas
Crangon septemspinosus
Cyathura polita
Edotea triloba
Erichonella attenuata
Erichonella filiformis
Eurypanopeus depressus
Crubia compta
Heteromysis formosa
Hippolyte zostericolor
Idotea balthida
Libinia emarginata
Limulus polyphemus
Neomysis americana
Neopanope texana
Ovalipes ocellatus
Oxyurostylis smithi
Pagurus longicarpus
Pagurus pollicaris
Palaemonetes vulgaris
Rhithropanopeus harrisi

Phylum Echinodermata

Class Asteroidea:

Asterias forbesii
Asterias vulgaris

Class Holothuroidea:

Leptosynapta inhaerens

Phylum Porifera

Cliona celata
Halichondria bowerbanki
Microciona prolifera

Phylum Cnidaria

Campanularidae
Cerianthus americanus
Haloclava producta
Hydractinia echinata
Metridium senile
Obelia sp.
Pennaria tiarella
Tubularia crocea

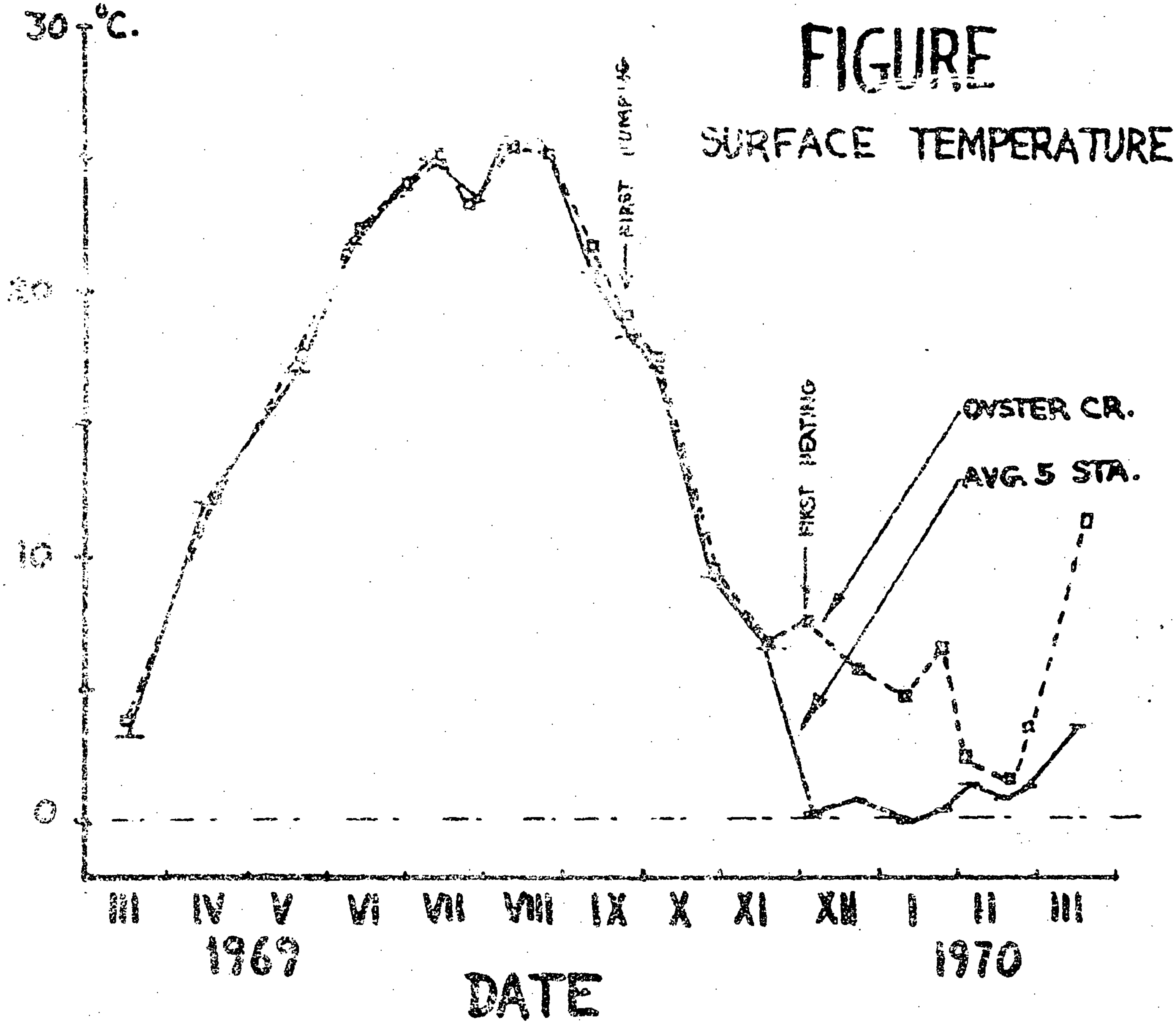
Miscellaneous

Amathia sp.
Botryllus schlosseri
Bugula turrita
Membranipora
Membranipora
Molgula manhattensis
Saccoglossus kowalevskii
Sagitta elegans
Stylochus ellipticus

IV. Hydrography

Routine hydrographic analyses have been performed throughout the year. These include measurements of temperature, salinity and extinction coefficient at every station. Primary emphasis has been placed on sediment analysis since it is our opinion that biological samples (especially benthic invertebrates) cannot be compared unless the sediments are known. Specific points within each region are so highly variable in their sediment composition, that we are placing more emphasis on the nature of the substrate rather than a point in space. Thus, we find it difficult to compare any biological parameter (population size, species lists, biomass, diversity, etc.) unless we also know that the samples came from similar sediment types. For example, if diversity indices are listed by region, there seems to be little correlation from sample to sample; if, however, we compare diversity indices for samples from similar sediment types, correlations become more obvious. Preliminary comparisons of 79 sediment samples analyzed for 1968 (dry sieving through standard meshes of the 62μ - 2000μ range) show few differences in sediment type in comparison to previous years. A noticeable difference, however, has occurred in the region near Route 9 for both Forked River and Oyster Creek. At both places, and especially in Oyster Creek, scouring by the high velocity of pumped water has removed most of the finer sediments, leaving only the sands and small gravels.

No attempt is made in this report to list all of the hydrographic data points. They are available on request and are being compiled along with hydrographic data for other people working on this project. A graph of temperature distribution for 1969 follows.



30
°C.
20
10
0
FIGURE
SURFACE TEMPERATURE
FIRST PUMPING
FIRST HEATING
OYSTER CR.
AVG. 5 STA.
III
IV
V
VI
VII
VIII
IX
X
XI
XII
I
II
III
1969
1970
DATE

V. Concluding remarks:

For the first time during this project we have been able to routinely collect from stations in the study area for every month of the year. We are presently on a ten-day schedule for plankton studies and a seven-day schedule for benthic invertebrates. We also feel more secure in the accuracy of our data and in our ability to typify an area of the bay. Unfortunately, there are variables in our work which we are unable to assess; these include currents, stage of tide, background organic pollution, effect of low concentrations of chlorine in the water, and radiation. Our primary objective is still to characterize the study area so thoroughly that we will be able to detect large changes in the composition and abundance of marine organisms with changes in temperature regimes. Hopefully, our technique will be refined to the point where subtle changes will also be detected by statistical analysis. We can make predictions regarding the nature of the benthic flora and fauna in the study area from season to season; however, the organisms will always be subjected to natural variations. We are hopeful that relative measurements, like diversity, will be less influenced by natural variation but more responsive to major changes in the biota.