

STUDIES ON THE PHYTOPLANKTON OF THE WEST COAST OF INDIA

Part III. Seasonal Variation of the Phytoplankters and Environmental Factors*

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INTRODUCTION

IN this part of the studies, the seasonal distribution of the constituent elements of the phytoplankton as also the meteorological and hydrological conditions during the concerned period are presented based on data gathered over a period of five years by examination by the senior author of over 1,000 samples of plankton collection.

The methods employed have already been described in Parts I and II of this series (Subrahmanyan, 1959 *a, b*), and a list of species recorded on the west coast may be had from Subrahmanyan (1958 *b*). It may be pointed out here that the compilation given here of the various species is based on enumeration data only.

As an arrangement of all the species each month during a period of five years according to their order of abundance would be a formidable task, in the text of the paper, the picture has been abridged and the first twelve species alone which contribute to the bulk of the flora each month have been shown in their order of abundance taking into consideration all the respective months during the period of investigation; all the species, however, have been classified and incorporated in a table.

The several species of phytoplankton found each month, belonging to the different classes, were classified into four different categories. The species usually found to be dominant in most of the collections for the month, or through greater part of the month, are classed as "abundant species (*a*)". There is no constancy for the occurrence of species under the category "rare species (*r*)"; some of the species may not occur at all in certain years; the number of individuals present may be very few; and some of them may occur earlier or later to the expected period. However, it is believed, that as the observations have been continuous over the same area over a considerable number of years, the anomalies would have ironed themselves out, leaving an

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overall reliable picture. The data presented here are such a picture of the records made during the respective months during the period May 1949 to April 1954.

While we have a fairly good picture of the seasonal distribution of phytoplankton for several regions abroad (Cupp, 1937; Dakin and Colefax, 1940; Johnstone *et al.*, 1924; Kokubo, 1932; Kokubo and Tamura, 1938; Kow, 1953; Lillick, 1937, 1938 and 1940; Margalef, 1951 *a, b*; 1957 *a, b*; Margalef and Duran, 1953; Margalef *et al.*, 1952, 1957; Ostensfeld, 1913; and Sheard, 1949)* the same cannot be said for the Indian waters, though there have been attempts at compilation of such accounts (Aiyar *et al.*, 1936; Chidambaram and Menon, 1945; George, 1953; Menon, 1931; Menon, 1945; Prasad, 1958). Be that as it may, most of the accounts are based on observations carried over a short period only; and the identification of the organisms has been, generally, up to the genus level only, in most of the instances. In the present account, identifications up to species level are given as otherwise it was felt that the wealth of species under many genera (*e.g.*, *Coscinodiscus* and *Chaetoceros* of Bacillariophyceæ, and *Ceratium* and *Peridinium* of Dinophyceæ), the seasonal variation and cyclical occurrence of many of them will lead to confusion and leave a wrong picture of the real state in the waters if only the genera are listed. Further, an account with identification up to genera only will not be of much use to fishery biologists, particularly in their search for indicator organisms for a rational exploitation of the fishery resources. The value of detailed studies in this regard is well emphasised by Le Mare (quoted by Hardy, 1958, pp. 168-69). Zenkevitch (1958, p. 29) also rightly stresses the great significance of the seasonal trends in the qualitative and quantitative changes of plankton. He states that "If we possessed a general picture of the quantitative and qualitative distribution for a whole ocean, we would be able to apply, with much greater success, mathematical methods of calculation and prognosis of the biological processes taking place in the ocean-waters". An attempt has been made in the earlier accounts (Subrahmanyam, 1958 *a*; 1959 *a, b*) to contribute to an understanding of the total quantitative distribution of the microflora and its relationships; in this account an attempt is made towards elucidations of the seasonal variation in the nature and quantity (within broad limits) of the phytoplankton elements on the west coast of India. It is hoped that the data presented here will prove of great practical value in fisheries research. It is proposed to deal with the cyclical occurrence and ecological relationships of the most important species in another account.

* Only some select; geographically representative, references are given here.

RESULTS

The relevant data collected during the investigation are presented below. It may be noted that under the biological aspect, the most abundant twelve species are given in their order of occurrence and in a separate table (Table I) all the organisms are listed and their relative quantitative abundance shown by indices.

TABLE I
Seasonal variations of the phytoplankton organisms*†

No.	Name of species	Months												
		J.	F.	M.	A.	My.	Jn.	Jy.	Ag.	S.	O.	N.	D.	
BACILLARIOPHYCEÆ														
1	<i>Melosira sulcata</i>	..	o	o	o	r	r	r	r	r	r	—	—	r
2	<i>Stephanopyxis palmeriana</i>	—	o	o	r	r	o	r	—	r	—	—	—	—
3	<i>Skeletonema costatum</i>	..	c	a	r	r	a	a	a	a	r	a	c	a
4	<i>Coscinosira polychorda</i>	r	r	—	—	r	r	o	a	r	r	—	—	—
5	<i>Thalassiosira decipiens</i>	..	r	—	r	r	r	r	o	r	c	r	r	—
6	<i>T. hyalina</i>	..	r	r	r	r	r	r	r	c	c	r	r	r
7	<i>T. baltica</i>	..	r	r	—	—	r	r	r	r	r	r	r	r
8	<i>T. kryophila</i>	..	o	r	r	o	o	o	o	c	c	c	r	r
9	<i>T. subtilis</i>	..	o	c	r	r	a	a	—	r	—	r	—	—
10	<i>T. nana</i>	..	a	c	o	a	o	r	r	—	—	r	—	r
11	<i>Cyclotella meneghiniana</i>	—	—	—	—	—	—	—	—	—	—	r	—	—
12	<i>C. striata</i>	..	c	c	r	o	o	r	o	c	c	c	o	o
13	<i>Ethmodiscus gazella</i>	..	—	r	r	r	—	r	—	—	—	—	—	—
14	<i>Coscinodiscus excentricus</i>	o	c	o	o	c	o	c	c	c	c	c	r	r

* The forms are arranged in their taxonomic order. Explanations of abbreviations used:
a = abundant = > 1,000,000 cells per vertical net haul.
c = common = 10,000–1,000,000 cells per vertical net haul.
o = occasional = 1,000–10,000 cells per vertical net haul.
r = rare = < 1,000 cells per vertical haul. Usually very few, represented only by stray cells.
— = not recorded/absent.

† See Subrahmanyam (1946, 1958 b) for authority relating to the species.

TABLE I (Contd.)

No.	Name of species	Months												
		J.	F.	M.	A.	My.	Jun.	Jy.	Ag.	S.	O.	N.	D.	
15	<i>C. excentricus</i> var. <i>fasciculata</i>	..	—	r	—	—	—	r	—	r	r	—	—	—
16	<i>C. lineatus</i>	..	r	r	r	r	r	r	a	c	o	r	r	r
17	<i>C. sub-lineatus</i>	..	—	—	—	—	—	—	—	—	—	—	r	—
18	<i>C. marginatus</i>	..	o	o	r	o	r	r	—	r	r	o	—	r
19	<i>C. radiatus</i>	..	o	o	o	r	r	o	r	r	—	r	r	r
20	<i>C. granii</i>	..	r	—	—	—	—	r	—	—	—	—	—	—
21	<i>C. granii</i> var. <i>aralensis</i>	..	—	r	—	—	—	—	—	—	—	—	—	—
22	<i>C. jonesianus</i>	..	—	—	r	—	—	—	—	—	—	—	—	—
23	<i>C. concinnus</i>	..	o	o	r	o	o	o	r	r	r	r	r	r
24	<i>C. thorii</i>	..	o	—	—	—	—	—	—	—	—	—	—	—
25	<i>C. schimperi</i>	..	r	—	—	—	—	—	—	—	—	—	—	—
26	<i>C. centralis</i>	..	—	o	r	r	r	—	r	r	r	r	—	—
27	<i>C. perforatus</i>	..	r	r	r	—	—	r	r	r	r	—	—	r
28	<i>C. perforatus</i> var. <i>pavillardii</i>	..	o	r	o	o	r	r	c	c	c	c	o	r
29	<i>C. apiculatus</i>	..	—	—	—	—	r	—	r	—	—	—	—	r
30	<i>C. asteromphalus</i>	..	o	o	c	o	o	o	c	o	c	c	o	o
31	<i>C. oculus-iridis</i>	..	o	o	o	c	c	o	o	c	c	c	o	o
32	<i>C. oculus-iridis</i> var. <i>borealis</i>	..	—	—	r	r	—	—	—	—	—	r	—	r
33	<i>C. gigas</i> var. <i>prætexta</i>	..	r	r	r	r	r	r	—	r	—	r	r	r
34	<i>C. janischii</i>	..	o	r	o	o	o	r	a	c	c	c	r	r
35	<i>Planktoniella sol</i>	..	o	o	o	c	c	c	c	o	r	r	r	r
36	<i>Actinoptychus undulatus</i>	..	r	r	r	—	r	o	a	a	c	c	o	r
37	<i>Asteromphalus flabellatus</i>	..	—	—	—	r	r	—	—	—	—	—	—	—
38	<i>A. wyvillei</i>	..	—	—	r	—	—	—	—	—	—	r	—	—
39	<i>Gossleriella tropica</i>	..	—	—	r	—	—	—	r	r	—	—	—	—
40	<i>Actinocyclus ehrenberghii</i>	..	r	—	—	r	—	r	—	—	—	r	r	r

TABLE I (Contd.)

No.	Name of species	Months												
		J.	F.	M.	A.	My.	Jn.	Jy.	Ag.	S.	O.	N.	D.	
41	<i>Bacterosira fragilis</i>	..	r	—	—	r	r	r	—	r	—	—	—	r
42	<i>Corethron hystrix</i>	..	o	o	o	r	r	o	—	—	—	—	—	—
43	<i>C. inerme</i>	..	r	o	o	r	o	r	—	—	—	—	—	r
44	<i>Lauderia annulata</i>	..	a	c	a	c	a	a	a	c	o	o	c	o
45	<i>Schröderella delicatula</i>	..	a	a	a	a	a	a	r	r	r	r	r	o
46	<i>Leptocylindrus danicus</i>	..	a	c	o	o	a	a	c	c	c	o	o	r
47	<i>L. minimus</i>	..	c	o	r	r	r	r	c	r	r	r	o	r
48	<i>L. adriaticus</i>	..	r	o	r	o	r	o	r	r	r	r	r	—
49	<i>Guinardia flaccida</i>	..	c	c	o	a	c	o	o	c	c	o	r	r
50	<i>G. blavyana</i>	..	r	o	r	r	r	r	r	r	r	—	—	—
51	<i>G. victoriae</i>	..	r	r	r	r	r	r	o	r	r	r	r	r
52	<i>Detonula confervacea</i>	..	—	o	r	r	r	r	r	r	—	—	—	—
53	<i>Rhizosolenia fragilissima</i>	r	—	r	o	r	r	r	—	r	r	—	r	
54	<i>R. cylindrus</i>	..	r	—	r	r	—	—	r	—	—	—	—	
55	<i>R. bergonii</i>	..	—	—	—	r	r	r	—	r	—	r	—	
56	<i>R. stolterfothii</i>	..	c	c	o	a	a	a	c	o	o	o	r	r
57	<i>R. robusta</i>	..	c	c	c	o	o	c	o	c	o	r	o	o
58	<i>R. imbricata</i>	..	c	c	c	o	c	c	r	r	r	—	r	r
59	<i>R. styliformis</i>	..	r	r	r	r	r	r	r	—	—	r	—	—
60	<i>R. styliformis</i> var. <i>latissima</i>	..	o	o	o	r	r	r	r	—	r	r	r	r
61	<i>R. setigera</i>	..	c	o	o	r	c	c	c	r	a	o	o	r
62	<i>R. cochlea</i>	..	—	—	—	—	—	—	—	—	r	r	—	—
63	<i>R. calcaravis</i>	..	c	o	o	c	c	c	o	r	r	o	o	o
64	<i>R. crassispina</i>	..	c	c	o	c	c	c	c	c	o	r	r	r
65	<i>R. alata</i>	..	c	c	c	c	o	c	o	o	o	o	o	r
66	<i>R. alata</i> f. <i>gracillima</i>	..	o	o	a	—	r	r	c	c	c	c	o	r
67	<i>R. alata</i> f. <i>indica</i>	..	r	r	o	r	c	o	r	r	r	—	—	r

TABLE I (Contd.)

No.	Name of species	Months											
		J.	F.	M.	A.	My.	Jn.	Jy.	Ag.	S.	O.	N.	D.
68	<i>R. castracanei</i>	..	—	—	—	—	r	—	—	—	—	—	—
69	<i>R. castracanei</i> var. <i>rhomboidea</i>		r	r	o	c	r	—	—	—	—	—	—
70	<i>R. simplex</i>	..	—	—	—	—	r	—	—	—	—	—	—
71	<i>Bacteriastrum delicatulum</i>	a	c	o	o	c	c	c	r	—	—	r	r
72	<i>B. hyalinum</i>	..	—	r	r	—	—	—	r	r	r	—	—
73	<i>B. hyalinum</i> var. <i>princeps</i>	a	c	c	a	c	c	c	c	c	c	r	c
74	<i>B. varians</i>	..	o	o	r	r	r	r	—	r	r	r	r
75	<i>B. mediterraneum</i>	..	—	—	o	r	—	—	—	—	—	—	r
76	<i>B. elegans</i>	..	—	r	r	r	—	r	—	—	—	—	—
77	<i>B. comosum</i>	..	o	o	o	o	r	r	—	—	—	r	—
78	<i>B. simplex</i>	..	o	o	r	o	a	o	r	—	—	r	r
79	<i>B. solitaria</i>	..	—	—	—	—	r	—	—	—	—	—	—
80	<i>Chatoceros atlanticum</i>	..	r	r	—	—	r	—	—	—	—	—	—
81	<i>C. atlanticum</i> var. <i>neopolitana</i>	..	o	r	—	—	r	r	—	—	—	—	—
82	<i>C. eibenii</i>	..	—	—	—	r	r	—	—	—	r	r	—
83	<i>C. coarctatus</i>	..	c	o	o	o	r	o	r	r	r	r	c
84	<i>C. danicus</i>	..	o	r	o	o	r	o	o	r	c	r	o
85	<i>C. borealis</i>	..	o	o	r	r	r	o	a	r	r	—	c
86	<i>C. denticulatum</i>	..	c	o	o	r	o	o	c	r	r	r	o
87	<i>C. peruvianus</i>	..	c	c	o	o	c	o	o	r	c	r	c
88	<i>C. peruvianus</i> var. <i>robusta</i>	..	r	—	o	r	r	r	—	—	—	r	—
89	<i>C. decipiens</i>	..	o	o	r	r	c	o	o	c	a	c	r
90	<i>C. mitra</i>	..	r	—	r	—	r	r	r	c	—	r	r
91	<i>C. lorenzianus</i>	..	a	a	a	a	a	a	a	a	a	a	a
92	<i>C. lauderi</i>	..	c	c	c	c	c	c	o	r	r	c	c
93	<i>C. compressus</i>	..	a	c	a	a	o	c	a	c	a	a	a

TABLE 1 (Contd.)

No.	Name of species	Months												
		J.	F.	M.	A.	My.	Jn.	Jy.	Ag.	S.	O.	N.	D.	
94	<i>C. didymus</i>	..	o	r	o	r	r	o	o	o	c	a	o	o
95	<i>C. didymus</i> var. <i>protuberans</i>		r	—	—	—	—	—	—	—	—	r	—	—
96	<i>C. didymus</i> var. <i>heterosetoides</i>	..	—	r	—	r	r	r	—	r	—	—	r	r
97	<i>C. contortum</i>	..	a	a	a	o	a	i	o	r	—	—	r	a
98	<i>C. van heurckii</i>	..	—	r	o	—	r	—	r	—	—	—	—	r
99	<i>C. affinis</i>	..	a	a	r	o	c	a	a	c	c	a	a	c
100	<i>C. affinis</i> var. <i>circinalis</i>	—	—	—	—	—	—	—	r	—	—	—	—	—
101	<i>C. paradoxum</i>	..	—	—	—	—	r	—	—	—	—	—	—	—
102	<i>C. lascinosus</i>	..	c	c	o	a	r	o	c	o	o	a	c	a
103	<i>C. pelagicus</i>	..	r	o	r	a	a	a	r	r	—	a	r	r
104	<i>C. brevis</i>	..	c	c	o	r	c	c	a	a	r	r	r	r
105	<i>C. seriacanthus</i>	..	—	—	—	—	—	—	—	—	—	—	—	c
106	<i>C. holsaticus</i>	..	r	r	r	r	—	r	r	r	—	—	—	—
107	<i>C. diversus</i>	..	r	o	o	r	r	r	r	r	r	—	o	c
108	<i>C. laevis</i>	..	—	—	r	r	r	—	—	—	—	—	—	—
109	<i>C. ralfsii</i>	..	r	r	o	r	r	o	r	o	r	—	r	r
110	<i>C. messanensis</i>	..	—	r	r	r	r	—	—	—	—	—	—	—
111	<i>C. wighami</i>	..	r	r	r	—	—	—	r	—	—	—	—	r
112	<i>C. filiformis</i>	..	—	r	—	r	r	r	—	—	r	—	—	—
113	<i>C. curvisetus</i>	..	a	a	a	a	a	a	a	a	a	a	a	a
114	<i>C. filiferum</i>	..	r	—	—	—	—	—	—	—	—	—	—	c
115	<i>C. socialis</i>	..	a	a	r	a	c	a	c	r	a	a	c	c
116	<i>C. myriapodus</i>	..	—	—	—	—	—	—	—	—	—	c	—	—
117	<i>Eucampia zoodiacus</i>	..	r	o	r	r	r	o	r	r	r	—	i	r
118	<i>E. cornuta</i>	..	r	o	o	o	o	o	r	r	r	r	r	r
119	<i>Climacodium</i> <i>frauenfeldianum</i>	..	r	r	r	r	r	r	—	—	—	—	—	—

TABLE 1 (Contd.)

No.	Name of species	Months												
		J.	F.	M.	A.	My.	Jn.	Jy.	Ag.	S.	O.	N.	D.	
120	<i>Streptothecha indica</i>	..	c	c	o	o	o	c	o	r	r	r	r	o
121	<i>Bellerochea malleus</i>	..	r	r	r	c	a	—	—	—	r	—	—	r
122	<i>B. indica</i>	..	—	—	—	—	—	—	—	—	—	—	—	r
123	<i>Ditylum sol</i>	..	o	o	o	o	c	a	o	r	r	r	r	o
124	<i>Triceratium favus</i>	..	r	r	r	r	r	r	r	r	—	r	r	r
125	<i>T. dubium</i>	..	—	—	—	—	—	—	—	r	—	—	—	—
126	<i>Biddulphia sinensis</i>	..	c	c	c	c	c	c	c	r	r	o	r	r
127	<i>B. mobiliensis</i>	..	o	o	o	o	c	a	a	c	o	o	o	o
128	<i>B. heteroceros</i>	..	c	c	c	c	o	c	c	o	o	o	o	o
129	<i>B. japonica</i>	..	—	—	—	r	r	—	—	r	—	r	—	—
130	<i>B. rhombus</i>	..	—	—	—	—	r	r	—	—	r	r	r	—
131	<i>B. aurita</i>	..	r	r	—	—	r	r	r	—	—	—	r	r
132	<i>Cerataulina bergoni</i>	..	o	o	r	o	r	o	r	r	r	r	—	r
133	<i>Hemiaulus hauckii</i>	..	—	r	—	r	r	—	r	—	—	—	—	—
134	<i>H. sinensis</i>	..	r	o	o	r	o	c	—	—	—	—	r	r
135	<i>H. membranaceus</i>	..	r	r	o	o	o	r	—	r	—	r	o	o
136	<i>Hemidiscus hardmannianus</i>	..	r	r	c	r	o	r	r	r	—	r	c	r
137	<i>Fragilaria oceanica</i>	..	a	a	a	c	a	a	a	a	a	a	a	a
138	<i>Thalassionema nitzschioides</i>	..	o	o	r	r	c	a	a	o	r	r	r	r
139	<i>Thalassiothrix longissima</i>	..	c	o	o	o	c	c	c	o	c	c	o	—
140	<i>T. frauenfeldii</i>	..	o	c	a	o	c	a	a	a	o	c	c	o
141	<i>Asterionella japonica</i>	..	a	a	r	a	c	a	a	a	c	c	c	c
142	<i>Mastogloia exilis</i>	..	—	—	—	—	—	—	—	r	—	—	—	—
143	<i>Pleurosigma elongatum</i>	..	o	c	o	c	o	r	c	c	o	o	r	r
144	<i>P. normani</i>	..	o	—	c	c	o	r	r	r	r	r	—	r
145	<i>P. angulatum</i>	..	o	c	r	r	r	r	r	r	o	r	r	r

TABLE 1 (Contd.)

No.	Name of species	Months												
		J.	F.	M.	A.	My.	Jn.	Jy.	Ag.	S.	O.	N.	D.	
146	<i>P. æstuarii</i>	..	r	r	r	r	—	r	r	r	—	r	—	—
147	<i>P. directum</i>	..	—	—	—	—	—	—	—	r	—	—	—	—
148	<i>P. directum</i> var. <i>membranacea</i>	..	—	—	r	—	—	r	r	r	r	c	r	—
149	<i>Caloneis madraspatensis</i>	..	—	r	r	—	—	—	—	—	—	—	—	—
150	<i>Diploneis robustus</i>	..	—	—	—	—	—	—	—	—	—	r	—	—
151	<i>Navicula membranacea</i>	..	r	r	o	r	r	r	—	r	—	r	r	r
152	<i>N. alpina</i>	..	—	r	—	—	—	—	—	—	—	—	—	—
153	<i>Trachyneis aspera</i> var. <i>genuina</i>	..	r	r	r	r	r	r	—	—	—	—	r	r
154	<i>Amphiprora gigantea</i> var. <i>sulcata</i>	..	r	—	r	r	—	—	r	—	r	—	—	r
155	<i>Amphora pusio</i>	..	—	—	—	—	—	—	—	r	—	—	—	—
156	<i>Bacillaria paradoxa</i>	..	r	—	r	r	r	r	—	—	—	—	—	—
157	<i>Nitzschia pelagica</i>	..	r	r	—	r	—	r	r	r	r	r	r	c
158	<i>N. panduriformis</i> var. <i>continua</i>	..	r	—	—	—	—	—	—	r	—	—	—	—
159	<i>N. sigma</i> var. <i>indica</i>	..	c	c	c	c	c	o	c	c	c	o	c	o
160	<i>N. closterium</i>	..	r	o	o	r	—	r	r	r	o	r	o	r
161	<i>N. longissima</i>	..	—	—	—	—	—	r	—	—	—	r	r	r
162	<i>N. seriata</i>	..	a	a	a	a	a	a	a	c	c	a	c	c
163	<i>Surirella fluminensis</i>	..	r	r	r	r	r	—	—	—	—	—	—	—
164	<i>Campylodiscus iyengarii</i>	..	—	—	—	r	—	—	—	—	—	—	—	—
DINOPHYCEÆ														
165	<i>Exuviella compressa</i>	..	—	—	—	—	—	—	—	—	—	r	—	r
166	<i>Prorocentrum micans</i>	..	—	—	—	r	—	r	r	r	r	c	c	r
167	<i>Phalacroma rotundatus</i>	..	—	—	—	—	—	—	—	—	—	r	—	r
168	<i>P. dolychopterigium</i>	..	—	—	—	—	—	—	—	—	—	r	r	r

TABLE I (Contd.)

No.	Name of species	Months												
		J.	F.	M.	A.	My.	Jn.	Jy.	Ag.	S.	O.	N.	D.	
169	<i>Dinophysis ovum</i>	..	-	-	-	-	-	r	r	-	-	r	r	-
160	<i>D. acuminata</i>	..	-	-	-	-	-	r	r	r	r	r	r	-
171	<i>D. caudata</i>	..	o	o	c	c	c	a	c	c	c	o	o	c
172	<i>D. caudata f. acutiformis</i>	r	-	-	o	r	-	r	-	r	r	o	r	-
173	<i>D. miles</i>	..	-	-	-	-	-	-	r	-	-	-	-	-
174	<i>D. miles f. indica</i>	..	r	o	o	o	o	r	r	-	-	o	o	c
175	<i>Amphisolenia elongata</i>	..	-	-	-	r	-	-	-	-	-	-	-	-
176	<i>A. bidentata</i>	..	-	-	-	-	r	-	-	-	-	-	-	-
177	<i>Ornithocercus magnificus</i>	o	r	-	r	c	c	r	r	r	r	c	c	c
178	<i>Gymnodinium gelbum</i>	..	-	-	-	-	-	r	r	r	-	-	-	-
179	<i>G. marinum</i>	..	-	-	-	-	r	r	-	r	r	-	r	r
180	<i>G. mirabile</i>	..	r	-	-	-	r	r	-	r	r	-	r	-
181	<i>G. splendens</i>	..	-	-	-	r	-	r	r	r	r	r	r	r
182	<i>G. uberrimum</i>	..	r	-	-	r	-	-	r	r	r	-	r	-
183	<i>G. variabile</i>	..	-	-	-	-	-	-	-	r	-	r	r	-
184	<i>Massartia glauca</i>	..	-	-	-	-	-	-	r	-	-	-	-	-
185	<i>Gyrodinium lingulifera</i>	..	-	-	-	-	-	-	-	-	-	-	r	-
186	<i>G. obtusum</i>	..	-	-	-	r	-	-	-	-	-	-	-	-
187	<i>G. pitogue</i>	..	-	-	-	r	-	-	-	-	-	-	-	-
188	<i>G. spirale</i>	..	-	-	-	-	-	-	r	r	-	-	r	-
189	<i>Polykrikos schwarzi</i>	..	-	-	-	-	-	-	-	-	-	-	r	-
190	<i>Noctiluca miliaris</i>	..	o	r	o	a	c	a	c	c	c	c	c	c
191	<i>Paulsenella chatoceratis</i>	-	-	r	-	-	-	-	-	-	-	-	-	-
192	<i>Pyrophacys horologicum</i>	r	r	r	o	o	r	c	o	r	r	o	o	-
193	<i>P. horologicum var. steinii</i>	r	-	r	r	r	r	r	r	r	r	r	r	-
194	<i>Glenodinium lenticula</i>	..	-	-	-	r	-	-	-	-	-	-	-	-
195	<i>G. lenticula f. minor</i>	..	-	-	-	-	-	-	r	r	-	r	-	-
196	<i>G. lenticula f. asymmetrica</i>	..	c	a	o	c	c	a	o	o	r	o	c	o

TABLE I (Contd.)

No.	Name of species	Months												
		J.	F.	M.	A.	My.	Jn.	Jy.	Ag.	S.	O.	N.	D.	
197	<i>G. pilula</i>	..	—	—	—	r	—	r	—	r	r	r	—	—
198	<i>G. trochoideum</i>	..	—	—	—	r	r	r	o	r	—	r	—	—
199	<i>Peridinium bulla</i>	..	r	—	r	r	r	r	r	r	r	r	—	r
200	<i>P. hylanium</i>	..	—	—	—	—	—	r	—	r	r	—	r	r
201	<i>P. minutum</i>	..	—	—	r	r	r	r	r	—	—	—	r	—
202	<i>P. thorianum</i>	..	r	—	—	—	—	r	—	r	—	—	—	r
203	<i>P. excentricum</i>	..	r	—	r	r	r	r	r	—	—	—	r	o
204	<i>P. globulus</i>	..	r	—	r	r	r	r	r	r	r	r	r	r
205	<i>P. globulus</i> var. <i>quarnerense</i>		r	r	r	r	r	r	r	r	r	—	r	r
206	<i>P. globulus</i> var. <i>ovatum</i>		r	r	—	—	—	r	—	r	r	r	r	—
207	<i>P. granii</i>	..	r	r	r	r	o	o	r	o	—	r	r	r
208	<i>P. steinii</i>	..	r	—	—	—	—	—	—	—	—	—	r	r
209	<i>P. steinii</i> var. <i>mediterraneum</i>	..	r	o	r	r	r	c	—	—	r	r	r	c
210	<i>P. breve</i>	..	—	—	—	—	—	—	—	—	—	—	r	—
211	<i>P. pedunculatum</i>	..	—	—	r	—	—	—	—	—	—	—	—	—
212	<i>P. brochii</i>	..	r	r	r	r	—	a	r	r	r	r	—	r
213	<i>P. brochii</i> var. <i>inflatum</i>		—	—	—	—	r	r	r	r	r	r	r	—
214	<i>P. crassipes</i>	..	r	—	r	r	—	o	o	r	r	r	r	—
215	<i>P. divergens</i>	..	r	r	—	r	r	r	r	r	r	r	—	r
216	<i>P. conicoides</i>	..	r	—	r	r	r	r	r	r	r	r	r	—
217	<i>P. conicum</i>	..	r	o	o	r	r	r	o	r	r	r	r	r
218	<i>P. humile</i>	..	—	—	—	—	—	—	r	—	—	—	r	—
219	<i>P. leonis</i>	..	—	—	r	—	—	r	r	r	r	r	r	—
220	<i>P. leonis</i> f. <i>matzenaueri</i>	..	r	r	r	r	r	r	r	r	r	c	r	r
221	<i>P. pentagonum</i>	..	r	r	—	r	r	r	r	r	r	r	—	—
222	<i>P. subinermis</i>	..	—	—	—	r	r	—	—	—	—	—	—	r
223	<i>P. claudicans</i>	..	—	—	—	—	r	—	r	—	r	—	r	r

TABLE I (Contd.)

No.	Name of species	Months												
		J.	F.	M.	A.	My.	Jn.	Jy.	Ag.	S.	O.	N.	D.	
224	<i>P. depressum</i>	..	a	c	o	o	c	c	c	c	r	o	c	c
225	<i>P. grande</i>	..	r	r	r	—	—	c	r	r	r	r	r	—
226	<i>P. elegans</i>	..	—	—	—	—	—	—	—	—	—	—	—	r
227	<i>P. murrayi</i>	..	r	—	r	r	—	r	—	—	—	r	r	r
228	<i>P. oceanicum</i>	..	r	o	r	r	r	o	o	r	r	r	o	c
229	<i>P. venustum</i>	..	—	—	—	—	—	r	r	—	r	r	r	—
230	<i>P. sinicum</i>	..	r	o	r	r	r	o	o	r	r	r	r	r
231	<i>Gonyaulax diegænsis</i>	..	r	—	—	r	r	r	—	—	—	r	r	r
232	<i>G. scrippsæ</i>	..	—	—	—	r	—	r	—	r	r	r	r	r
233	<i>Ceratium candelabrum</i>	..	—	—	—	—	—	—	—	—	—	—	r	—
234	<i>C. candelabrum</i> f. <i>curvatulum</i>	..	—	—	—	—	—	—	—	—	—	—	—	r
235	<i>C. furca</i>	..	r	—	—	—	—	—	r	r	—	—	—	—
236	<i>C. furca</i> f. <i>eugrammum</i>	..	o	o	r	o	o	o	r	r	r	r	o	c
237	<i>C. lineatum</i>	..	r	—	—	—	—	—	—	—	—	r	—	—
238	<i>C. setaceum</i>	..	r	r	r	—	—	r	—	r	—	—	r	r
239	<i>C. inflatum</i>	..	o	r	r	r	r	r	o	r	—	—	r	r
240	<i>C. longirostrum</i>	..	—	—	—	—	—	—	r	—	—	—	r	r
241	<i>C. fuscus</i>	..	c	o	o	c	o	c	c	c	c	c	c	c
242	<i>C. fuscus</i> var. <i>seta</i>	..	—	—	—	—	—	r	—	—	—	—	—	—
243	<i>C. dens</i>	..	o	o	r	r	r	r	r	r	r	—	r	r
244	<i>C. tripos</i>	..	a	c	a	c	c	c	c	c	r	o	c	c
245	<i>C. tripos</i> var. <i>atlanticum</i>	—	—	—	—	—	r	—	—	—	—	—	—	—
246	<i>C. tripos</i> f. <i>ponticum</i>	..	r	—	—	—	—	—	—	—	—	—	—	r
247	<i>C. tripos</i> f. <i>subsalsum</i>	..	—	—	—	—	—	r	—	—	—	—	—	—
248	<i>C. pulchellum</i> f. <i>semipulchellum</i>	..	r	—	—	r	r	—	r	—	r	r	r	r
249	<i>C. porrectum</i>	..	—	—	—	—	—	r	—	—	—	—	—	—

No.	Name of species	Months												
		J.	F.	M.	A.	My.	Jn.	Jy.	Ag.	S.	O.	N.	D.	
275	<i>P. lunula</i>	..	-	-	-	-	-	-	-	-	-	-	r	
CHLOROMONADINEÆ														
276	<i>Hornellia marina</i>	..	-	-	-	r	-	-	-	r	o-c	r	r	r
MYXOPHYCEÆ														
277	<i>Lyngbya astuarii</i>	..	-	-	r	r	-	-	-	-	-	-	-	
278	<i>Trichodesmium erythræum</i>		c	a	c-a	c-a	o	c	c	r	-	r	r	r
279	<i>T. thiebautii</i>	..	o	r	r	-	r	r	-	-	-	-	r	r
280	<i>T. contortum</i>	..	o	a	o	-	-	-	r	-	-	-	r	-
281	<i>Katagnymene spiralis</i>	..	-	-	-	-	r	-	-	-	-	-	-	
282	<i>K. pelagica</i>	..	-	-	-	-	-	-	r	-	-	-	-	
283	<i>Richelia intracellularis</i>	..	r	-	r	r	r	-	-	-	-	-	-	
EUGLENINEÆ														
284	<i>Protoeuglena noctiluca</i>	..	-	-	o-r	o	o	r	-	-	-	-	-	r
SILICOFLAGELLATÆ														
285	<i>Mesocena polymorpha</i> var. <i>quadrangula</i>	-	-	-	-	-	-	-	-	r	-	-	r	-
286	<i>M. polymorpha</i> var. <i>bioctonaria</i>	-	-	-	-	-	-	r	-	-	-	-	-	-
287	<i>Dictyocha staurodon</i>	..	-	-	-	-	-	-	r	-	-	-	-	
288	<i>D. fibula</i>	..	-	-	-	-	-	-	-	-	-	-	-	r
289	<i>D. fibula</i> var. <i>longispina</i>	-	r	-	-	-	-	-	-	-	-	-	-	
290	<i>Distephanus speculum</i>	..	-	-	-	-	-	-	-	-	-	-	r	-
COCCOLITHINEÆ														
291	<i>Rhabdosphaera longistylis</i>	-	-	-	-	-	-	-	-	r	-	-	-	-

January—

1. *Rainfall*.—The driest month of the year. Varies from 0·5·1 mm. Mean, 1·6 mm.
2. *Humidity of the air*.—71–76%. Mean, 73%.
3. *Condition of the sea*.—Calm sea, water very clear.
4. *Wind*.—Mainly from north, north-west. Sometimes strong in the afternoons. Velocity 6–6·8 m.p.h.; mean, 6·4 m.p.h.
5. *Current*¹.—From north to south, steady.
6. *Hydrological data*:
 - (a) *Temperature*: (i) *Air*.—27·0–27·3° C. Mean, 27·15° C.
(ii) *Sea-water*.—27·5–28·7° C. Mean, 28·1° C.
 - (b) *Salinity of sea-water*: 31·68–34·45‰ at the surface and 31·95–34·75‰ at the bottom. Mean for water column 33·54‰.
 - (c) *Oxygen content*: 4·05–5·14 ml. per litre (saturation, 87–109·50%); Mean 4·48 ml. per litre (95·75% saturation).
 - (d) *Phosphate-Phosphorus*²: 0·150–0·656 $\mu\text{g. at/L.}$ at the surface and 0·184–0·771 $\mu\text{g. at/L.}$ at the bottom. Mean 0·440 $\mu\text{g. at/L.}$
 - (e) *Nitrate-Nitrogen*: 2·70–12·25 $\mu\text{g. at/L.}$ at the surface and 2·37–2·90 $\mu\text{g. at/L.}$ at the bottom. Mean, 4·434 $\mu\text{g. at/L.}$
 - (f) *Silicate-Silicon*: 6·30–22·21 $\mu\text{g. at/L.}$ at the surface and 8·75–33·12 $\mu\text{g. at/L.}$ at the bottom. Mean, 12·678 $\mu\text{g. at/L.}$
7. *Volume of plankton*³.—The plankton crop is generally poor during the month and remains at a low level. In some years, occasionally, an increase in volume may be noticed towards the end of the month.
8. *Quantity of phytoplankton in plant pigment units (Harvey units)*⁴.—Generally poor, an increase may be noticed towards the end of the month. Varies from 640–4,270 units per vertical net haul. Mean, 2,472 units.
9. *Dominant organisms*.—Zooplankters dominate the plankton. Phytoplankton is scarce, but may show an increase towards the end of the month.

¹ At the actual station of sampling.

² Values corrected for salt error.

³ A relative idea of the standing crop in terms of volume (based on horizontal hauls) may be had from George (1953).

⁴ Hereafter will be referred to as *Pigment units*.

10. *General nature of phytoplankton.*—Diatoms and Dinophyceæ common. Blue-green algæ may also occasionally be seen, sometimes dominant.

11. *Dominant phytoplankters*⁵.—*Chaetoceros socialis*, *Asterionella japonica*, *Chaetoceros contortum*, *Thalassiosira nana*, *Ceratium tripos*, *Chaetoceros lorenzianus*, *C. compressus*, *Fragilaria oceanica*, *Chaetoceros curvisetus*, *Nitzschia seriata*, *Schroederella delicatula*, *Peridinium depressum*.

February—

1. *Rainfall.*—0·0–43·2 mm. Mean, 13·9 mm.
2. *Humidity.*—Condition similar to the previous month. 71–76%. Mean 74%.
3. *Condition of the sea.*—Calm, water clear.
4. *Wind.*—Mainly from the north, north-west. Strong at times in the afternoons. Force varies from 6·9–8·7 m.p.h. Mean, 7·6 m.p.h.
5. *Current.*—From north to south, steady.
6. *Hydrological data.*—
 - (a) *Temperature:* (i) *Air.*—27·4–28·8° C. Mean, 28·1° C.
(ii) *Sea-water.*—28·1–29·2° C. Mean, 28·6° C.
 - (b) *Salinity.*—31·88–34·35‰ at the surface and from 32·76–34·57‰ at the bottom. Mean, 33·88‰.
 - (c) *Oxygen content.*—3·57–5·17 ml./L. (saturation, 77·50–110·23%). Mean, 4·62 ml./L. (saturation, 98·96%).
 - (d) *Phosphate-Phosphorus.*—0·299–0·759 µg. at/L. at the surface and 0·207–0·863 µg. at/L. at the bottom. Mean, 0·532 µg. at/L.
 - (e) *Nitrate-Nitrogen:* 2·14–13·67 µg. at/L. at the surface and 3·38–5·40 µg. at/L. at the bottom. Mean, 5·727 µg. at/L.
 - (f) *Silicate-Silicon:* 5·18–19·16 µg. at/L. at the surface and 6·67–22·20 µg. at/L. at the bottom. Mean, 10·476 µg. at/L.
7. *Volume of plankton.*—The volume shows a marked increase to a very high level in certain years owing to the secondary phytoplankton bloom. Otherwise volume is rather low.
8. *Pigment units.*—860–3,310 units per haul. Mean, 2,026 units. Pigment values not proportionate to bulk of phytoplankton as that will depend on the nature of the flora (Subrahmanyam, 1959 a).

⁵ The dominant species for all months are arranged in the order of their dominance. In some years the order may be different owing to life-history factors leading to a cyclical mode in their occurrence.

9. *Dominant organism.*—Generally zooplankton; but on some occasions phytoplankton dominates as a result of a bloom.

10. *General nature of phytoplankton.*—Blue-green algæ often very common, at times in swarms forming a surface scum. Diatoms and Dinophyceæ, as usual common.

1. *Dominant phytoplankters.*—*Trichodesmium erythraeum*, *Nitzschia seriata*, *Chaetoceros curvisetus*, *Schroederella delicatula*, *Chaetoceros socialis*, *C. lorenzianus*, *C. contortum*, *Skeletonema costatum*, *Chaetoceros affinis*, *Fragilaria oceanica*, *Glenodinium lenticula*, f. *asymmetrica*, *Asterionella japonica*.

March—

1. *Rainfall.*—0·0–20·4 mm. Mean, 7·4 mm.
2. *Humidity.*—68–74%. Mean, 72%.
3. *Condition of the sea.*—Calm, water clear.
4. *Wind.*—Mainly from the north, Strong at times in the afternoons. Velocity varies from 7·6–8·9 m.p.n.; mean, 8·2 m.p.h.
5. *Current.*—From north to south, steady.
6. *Hydrological data.*—
 - (a) *Temperature:* (i) *Air.*—On the increase. 28·8–29·4° C. Mean, 29·1° C.
(ii) *Sea-water.*—Increase compared with previous month. 29·2–30·0° C. Mean, 29·5° C.
 - (b) *Salinity:* Upward trend. 34·49–35·54‰ at the surface and 34·47–35·45‰ at the bottom. Mean, 34·65‰.
 - (c) *Oxygen content:* Values show downward trend. 3·68–4·56 ml./L. (saturation, 80·10–100·3t%). Mean, 3·88 ml./L. (saturation, 89·82%).
 - (d) *Phosphate-Phosphorus.*—Values show an increase. 0·22–0·933 µg. at/L. at the surface and 0·345–1·15 µg. at/L. at the bottom. Mean, 0·551 µg. at/L.
 - (e) *Nitrate-Nitrogen:* Values decrease. 0·89–11·61 µg. at/L. at the surface and 0·43–1·85 µg. at/L. at the bottom. Mean, 3·521 µg. at/L.
 - (f) *Silicate-Silicon.*—Downward trend. 5·60–12·98 µg. at/L. at the surface and 7·17–15·09 µg. at/L. at the bottom. Mean, 10·81 µg. at/L.
7. *Volume of plankton.*—Fluctuates. Generally low towards the end of the month.

8. *Pigment units*.—Fluctuates very widely. Vary from 380–6,860 units per net haul. Mean, 3,898 units.

9. *Dominant organisms*.—Most of the time zooplankton. Occasionally a bloom of phytoplankton occurs.

10. *General nature of phytoplankton*.—Diatoms and bluegreen algæ most-common. Dinophyceæ also occur noticeably.

11. *Dominant phytoplankters*.—*Chaetoceros curvisetus*, *C. compressus*, *Nitzschia seriata*, *Chaetoceros lorenzianus*, *Fragilaria oceanica*, *Thalassiothrix frauenfeldii*, *Chaetoceros contortum*, *Lauderia annulata*, *Schræderella delicatula*, *Rhizosolenia alata* f. *gracillima*, *Trichodesmium erythraeum*, *Ceratium tripos*.

April—

1. *Rainfall*.—Pre-monsoon showers occur. 26.0–175.3 mm. Mean, 122.7 mm.

2. *Humidity*.—74–76%. Mean, 75%.

3. *Condition of the sea*.—Calm, water clear. On some days breakers present.

4. *Wind*.—Mainly from the north. Velocity varies from 8.2–9.5 m.p.h. Mean, 8.7 m.p.h.

5. *Current*.—North to south, steady.

6. *Hydrological data*.—

(a) *Temperature*: (i) *Air*.—Marked fluctuations in this month. Sudden fall at times owing to showers. 26.1–29.9° C. Mean, 28.6° C.

(ii) *Sea-water*.—Increase noticed. 29.2–30.5° C. Mean, 30.0° C.

(b) *Salinity*.—33.87–35.89‰ at the surface and 33.97–36.06‰ at the bottom. Mean, 34.92‰.

(c) *Oxygen content*: Values show an upward trend. 3.62–6.07 ml./L. (saturation, 80.00–131.90%). Mean, 4.53 ml./L. (saturation, 100.11%).

(d) *Phosphate-Phosphorus*: 0.322–0.886 µg. at/L. at the surface and 0.322–0.920 µg. at/L. at the bottom. Mean, 0.575 µg. at/L.

(e) *Nitrate-Nitrogen*: 1.36–6.70 µg. at/L. at the surface and 0.77–1.75 µg. at/L. at the bottom. Mean, 3.194 µg. at/L.

(f) *Silicate-Silicon*: 7.21–12.50 µg. at/L. at the surface and 9.17–14.71 µg. at/L. at the bottom. Mean 10.313 µg. at/L.

7. *Volume of plankton*.—Not much fluctuation.

8. *Pigment units*.—490–3,400 units per net haul. Mean, 1,280 units.

9. *Dominant organisms.*—Zooplankters predominantly.

10. *General nature of phytoplankton.*—Diatoms and Dinophyceans form the dominant phytoplankters. Blue-green algæ also seen.

11. *Dominant phytoplankters.*—*Chaetoceros lorenzianus*, *Guinardia flaccida*, *Chaetoceros socialis*, *C. curvisetus*, *Nitzschia seriata*, *Rhizosolenia stolterfothii*, *Thalassiosira nana*, *Asterionella japonica*, *Chaetoceros lascinosus*, *C. compressus*, *C. pelagicus*, *Trichodesmium erythraeum*.

May—

1. *Rainfall.*—South-west monsoon rains begin. Heavy during the second half of the month. 28·0–575·6 mm. Mean, 331·5 mm.

2. *Humidity.*—Increases. 76–81%. Mean, 79%.

3. *Condition of the sea.*—Occasionally rough. Water somewhat turbid.

4. *Wind.*—From north or north-west. Velocity varies from 7·7–9·9 m.p.h.; Mean, 8·6 m.p.h.

5. *Current.*—North to south.

6. *Hydrological data.*—

(a) *Temperature:* (i) *Air.*—29·6–30·3° C. Mean, 29·95° C.

(ii) *Sea-water.*—28·4–29·7° C. Mean, 29·2 C.

(b) *Salinity.*—34·74–35·65‰ at the surface and 34·69–35·72‰ at the bottom. Mean, 35·22‰.

(c) *Oxygen content:* 3·49–4·80 ml./L. (saturation, 75·83–106·13%). Mean, 3·94 ml./L. (saturation, 86·48%).

(d) *Phosphate-Phosphorus.*—0·334–0·805 $\mu\text{g. at/L.}$ at the surface and 0·460–1·334 $\mu\text{g. at/L.}$ at the bottom. Mean, 0·734 $\mu\text{g. at/L.}$

(e) *Nitrate-Nitrogen.*—Values show upward trend. 0·66–34·00 $\mu\text{g. at/L.}$ at the surface and 2·49–8·20 $\mu\text{g. at/L.}$ at the bottom. Mean, 9·436 $\mu\text{g. at/L.}$

(f) *Silicate-Silicon.*—7·73–13·06 $\mu\text{g. at/L.}$ at the surface and 11·11–19·42 $\mu\text{g. at/L.}$ at the bottom. Mean, 12·209 $\mu\text{g. at/L.}$

7. *Volume of plankton.*—Fluctuations common. Generally poor during the first half, but increases markedly in the latter half.

8. *Pigment units.*—830–2,900 units per haul. Mean, 2,060 units per haul.

9. *Dominant organisms.*—During the first fortnight, zooplankton dominates. In the latter half, phytoplankton begins to increase rapidly and there is an apparent decrease of zooplankters.

10. *General nature of phytoplankton.*—Diatoms dominant. Dinophyceæ common. Blue-green algæ occasionally seen.

11. *Dominant phytoplankters.*—*Chaetoceros curvisetus*, *Lauderia annulata*, *Rhizosolenia stolterfothii*, *Chaetoceros lorenzianus*, *Racteriastrum simplex*, *Bellerophon malleus*, *Schroederella delicatula*, *Skeletonema costatum*, *Thalassiosira subtilis*, *Chaetoceros pelagicus*, *Fragilaria oceanica*, *Nitzschia seriata*.

June—

1. *Rainfall.*—Heavy rain throughout the month. 416.6–1,379.3 mm. Mean, 841.5 mm.

2. *Humidity.*—Air very humid. 88–93%. Average, 90%.

3. *Condition of the sea.*—Rough seas with heavy breakers. Water turbid.

4. *Wind.*—Strong winds from seaward, west. Velocity varies from 5.7–7.5 m.p.h. Mean, 6.6 m.p.h.

5. *Current.*—Not steady, direction varies frequently.

6. *Hydrological data.*—

(a) *Temperature:* (i) *Air.*—24.9–26.5° C. A fall from previous month. Mean, 25.7° C. (ii) *Sea-water.*—26.5–28.4° C. Average, 27.4° C.

(b) *Salinity:* A drop noticed, particularly at the surface. 22.67–34.62‰ at the surface and 34.03–35.43‰ at the bottom. Mean, 32.72‰.

(c) *Oxygen content:* 2.48–5.43 ml./L. (saturation, 50.71–106.20%) Mean 3.99 ml./L. (saturation, 81.83%).

(d) *Phosphate-Phosphorus:* 0.23–0.897 µg. at/L. at the surface and 0.288–2.036 µg. at/L. at the bottom. Mean, 0.863 µg. at/L.

(e) *Nitrate-Nitrogen:* 3.20–20.70 µg. at/L. at the surface. (Bottom values not available.) Mean, 8.812 µg. at/L.

(f) *Silicate-Silicon:* 12.50–29.50 µg. at/L. at the surface and 10.42–40.47 µg. at/L. at the bottom. Mean, 20.019 µg. at/L.

7. *Volume of plankton.*—Upward trend during the month, values high.

8. *Pigment units.*—1150 to 5150 units per haul. Mean, 2824 units.

9. *Dominant organisms.*—Phytoplankton dominant.

10. *General nature of phytoplankton.*—Diatoms dominant. Some species at times constituting the bulk. Dinophyceæ common. Blue-green algæ occasional.

11. *Dominant phytoplankters.*—*Skeletonema costatum*, *Fragilaria oceanica*, *Schroederella delicatula*, *Chaetoceros socialis*, *C. curvisetus*, *Asterionella japonica*, *Lauderia annulata*, *Thalassiosira subtilis*, *Chaetoceros lorenzianus*, *Nitzschia seriata*, *Thalassionema nitzschioides*, *Thalassiothrix frauenfeldii*.

July—

1. *Rainfall*.—Heavy rain throughout the month. 445·6–1,163·4 mm. Mean, 800·9 mm.
2. *Humidity*.—High. 92–96%. Mean, 93%.
3. *Condition of the sea*.—Rather rough with heavy breakers. Water turbid.
4. *Wind*.—From seaward. Velocity varies from 5·7–7 m.p.h. Mean, 6·2 m.p.h.
5. *Current*.—Not steady; direction varies frequently.
6. *Hydrological data*.—
 - (a) *Temperature*: (i) *Air*.—25·6–25·8° C. Mean, 25·7° C.
(ii) *Sea-water*.—Fall noticed. 24·9–26·3° C. Mean, 25·3° C.
 - (b) *Salinity*: 20·74–31·90‰ at the surface and 33·02–34·53‰ at the bottom. Mean, 30·90‰.
 - (c) *Oxygen content*: 3·51–6·03 ml./L. (Saturation 70·22–116·74%). Mean, 4·25 ml./L. (Saturation, 84·65%).
 - (d) *Phosphate-Phosphorus*: 0·564–1·369 $\mu\text{g. at/L.}$ at the surface and 0·513–2·415 $\mu\text{g. at/L.}$ at the bottom. Mean, 1·216 $\mu\text{g. at/L.}$
 - (e) *Nitrate-Nitrogen*: Values high during the month. 1·28–26·20 $\mu\text{g. at/L.}$ at the surface. (Data for bottom not available.) Mean, 9·670 $\mu\text{g. at/L.}$
 - (f) *Silicate-Silicon*: 25·00–34·82 $\mu\text{g. at/L.}$ at the surface and 16·67–31·89 $\mu\text{g. at/L.}$ at the bottom. Mean, 27·204 $\mu\text{g. at/L.}$
7. *Volume of plankton*.—High values obtain.
8. *Pigment units*.—5,230–11,760 units per haul. Mean, 8,140 units.
9. *Dominant organisms*.—Phytoplankton dominates the bulk during the whole month, which reaches its peak of production.
10. *General nature of phytoplankton*.—Diatoms are the dominating elements of the bloom. At times one or two species far outnumber all others. Dinophyceæ common. Blue-green algæ often seen.
11. *Dominant phytoplankters*.—*Fragilaria oceanica*, *Asterionella japonica*, *Skeletonema costatum*, *Chaetoceros curvisetus*, *C. brevis*, *C. lorenzianus*, *C. compressus*, *Coscinodiscus janischii*, *Actinoptychus undulatus*, *Biddulphia mobiliensis*, *Thalassiothrix frauenfeldii*, *Thalassionema nitzschioides*.

August—

1. *Rainfall*.—Rain decreases. 182·9–528·4 mm. Mean, 345·0 mm.
2. *Humidity*.—88–93%. Mean, 91%.
3. *Condition of the sea*.—Rough, but virulence less. Slightly turbid.
4. *Wind*.—From the sea with less force. Velocity varies from 5·3–6·5 m.p.h. Mean, 5·8 m.p.h.
5. *Current*.—Direction north-east to south-west; or sometimes south-east to north-west.
6. *Hydrological data*.—
 - (a) *Temperature*: (i) *Air*.—26–27·1° C. Mean, 26·55° C.
(ii) *Sea-water*.—24·3–26·5° C. Mean, 25·2° C.
 - (b) *Salinity*.—Increases. 28·35–32·77‰ at the surface and 34·08–34·88‰ at the bottom. Mean, 32·46‰.
 - (c) *Oxygen content*.—3·60–5·03 ml./L. (saturation, 72·78–98·16%). Mean, 4·10 ml./L. (saturation, 81·37%).
 - (d) *Phosphate-Phosphorus*: 0·495–1·932 µg. at/L. at the surface and 0·598–2·427 µg. at/L. at the bottom. Mean, 1·363 µg. at/L.
 - (e) *Nitrate-Nitrogen*: Values show a very marked downward trend. 0·47–9·80 µg. at/L. at the surface and 2·21–5·95 µg. at/L. at the bottom. Mean, 5·263 µg. at/L.
 - (f) *Silicate-Silicon*: 22·16–47·22 µg. at/L. at the surface and 20·77–33·54 µg. at/L. at the bottom. Mean, 29·488 µg. at/L.
7. *Volume of plankton*.—Slight diminution compared with last month.
8. *Pigment units*.—1,580–5,620 units per haul. Mean, 3,335 units.
9. *Dominant organisms*.—Phytoplankton constitutes the bulk. Zooplankton tends to increase.
10. *General nature of phytoplankton*.—Diatoms, the dominating flora. Dinophyceæ very common, occasionally *Noctiluca* in large quantities, dominating the plankton.
11. *Dominant phytoplankters*.—*Fragilaria oceanica*, *Asterionella japonica*, *Thalassiothrix frauenfeldii*, *Chatoceros lorenzianus*, *C. curvisetus*, *Coscinosira polychorda*, *Actinoptychus undulatus*, *Skeletonema costatum*, *Thalassiosira hyalina*, *Chatoceros mitra*, *C. brevis*, *Pleurosigma elongatum*.

September—

1. *Rainfall*.—Diminishes. 15·8–472·5 mm. Mean, 223·6 mm.

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2. *Humidity*.—83–91%. Mean, 68%.
3. *Condition of the sea*.—Becomes calmer. Water clears.
4. *Wind*.—Variable, mostly from seaward. Velocity varies from 4·9–6·2 m.p.h. Mean, 5·6 m.p.h.
5. *Current*.—From north-east to south-west; at times north to south.
6. *Hydrological data*.—
 - (a) *Temperature*: (i) *Air*.—26·7–27·3° C. Mean, 27·0° C.
(ii) *Sea-water*: 24·5–26·2° C. Mean, 25·3° C.
 - (b) *Salinity*: 31·64–34·96‰ at the surface and 34·31–34·87‰ at the bottom. Mean, 33·95‰.
 - (c) *Oxygen content*: 2·97–4·97 ml./L. (saturation, 59·91–101·10%). Mean, 3·59 ml./L. (saturation, 72·68%).
 - (d) *Phosphate-Phosphorus*: 0·690–1·205 µg. at/L. at the surface and 0·851–1·564 µg. at/L. at the bottom. Mean, 1·078 µg. at/L.
 - (e) *Nitrate-Nitrogen*: 2·37–3·90 µg. at/L. at the surface and 0·36–1·20 µg. at/L. at the bottom. Mean, 2·140 µg. at/L.
 - (f) *Silicate-Silicon*: 15·11–40·58 µg. at/L. at the surface and 12·50–42·34 µg. at/L. at the bottom. Mean, 27·705 µg. at/L.
7. *Volume of plankton*.—Similar to August.
8. *Pigment units*.—Marked fluctuations. 480–6,000 units per haul. Mean, 2,908 units.
9. *Dominant organisms*.—Phytoplankton constitutes the bulk. Zooplankton on the increase.
10. *General nature of phytoplankton*.—Diatoms and dinophyceæ common. Swarms of certain Dinophyceæ or Chloromonadineæ may occur discolouring the water.
11. *Dominant phytoplankters*.—*Fragilaria oceanica*, *Chaetoceros compressus*, *C. curvisetus*, *Rhizosolenia setigera*, *Chaetoceros lorenzianus*, *C. decipiens*, *C. sociatis*, *C. didymus*, *Nitzschia seriata*, *Rhizosolenia alata* f. *gracillima*, *Chaetoceros danicus*, *Thalassiosira decipiens*.

October—

1. *Rainfall*.—North-east monsoon begins, Scattered showers. 136·2–396·8 mm. Mean, 263·2 mm.
2. *Humidity*.—82–87%. Mean, 85%.
3. *Condition of the sea*.—Calm, occasionally rough.

4. *Wind*.—Mainly from north-east. Velocity varies from 5.5–7.9 m.p.h. Mean 6.2 m.p.h.
5. *Current*.—Mainly from south to north; at times south-east to north-east.
6. *Hydrological data*.—
 - (a) *Temperature* (i) *Air*.—26.8–27.4° C. Mean, 27.1° C.
(ii) *Sea-water*.—26.1–29.2° C. Mean, 27.5° C.
 - (b) *Salinity*: 30.46–33.83‰ at the surface and 33.94‰ at the bottom. Mean, 33.20‰.
 - (c) *Oxygen content*: 3.56–5.06 ml./L. (saturation, 71.69–108.46%), Mean, 4.31 ml./L. (saturation, 92.12%).
 - (d) *Phosphate-Phosphorus*: 0.380–1.311 $\mu\text{g. at/L.}$ at the surface and 0.575–1.539 $\mu\text{g. at/L.}$ at the bottom. Mean, 0.949 $\mu\text{g. at/L.}$
 - (e) *Nitrate-Nitrogen*: Varies from 0.93–6.80 $\mu\text{g. at/L.}$ at the surface and 4.30–12.71 $\mu\text{g. at/L.}$ at the bottom. Mean, 5.007 $\mu\text{g. at/L.}$
 - (f) *Silicate-Silicon*: 9.60–31.96 $\mu\text{g. at/L.}$ at the surface and 8.92–21.13 $\mu\text{g. at/L.}$ at the bottom. Mean, 17.103 $\mu\text{g. at/L.}$
7. *Volume of plankton*.—Downward trend noticed.
8. *Pigment units*.—Downward trend. 780–2,230 units per haul. Mean, 1,286 units.
9. *Dominant organisms*.—Zooplankton prominent.
10. *General nature of phytoplankton*.—Diatoms and Dinophyceæ common. *Noctiluca* swarm common occasionally.
11. *Dominant phytoplankters*.—*Fragilaria oceanica*, *Chaetoceros pelagicus*, *C. didymus*, *C. lorenzianus*, *C. lascinosus*, *C. compressus*, *Skeletonema costatum*, *Chaetoceros curvisetus*, *Nitzschia seriata*, *Noctiluca miliaris*, *Thalassiothrix longissima*, *Chaetoceros lauderi*.

November—

1. *Rainfall*.—2.6–165.7 mm. Mean, 62.8 mm.
2. *Humidity*.—77–81%. Mean, 78%.
3. *Condition of the sea*.—Calmer than last month. Water slightly turbid.
4. *Wind*.—From north or north-east. Somewhat strong. Velocity varies from 5.4–6.2 m.p.h. Mean, 5.6 m.p.h.

5. *Current*.—From south-east to north-west; rarely north-east to south-east.
6. *Hydrological data*.—
 - (a) *Temperature*: (i) *Air*.—27·0–27·3° C. Mean, 27·15° C.
(ii) *Sea-water*.—27·8–29·4° C. Mean 28·5° C.
 - (b) *Salinity*.—31·36–34·5‰ at the surface and 33·69–34·84‰ at the bottom. Mean, 33·66‰.
 - (c) *Oxygen content*.—Values comparatively higher than previous month. 4·32–6·11 ml./L. (saturation, 92·60–128·65%). Mean, 4·88 ml./L. (saturation, 105·91%).
 - (d) *Phosphate-Phosphorus*: 0·311–1·449 $\mu\text{g. at/L.}$ at the surface and 0·518–1·679 $\mu\text{g. at/L.}$ at the bottom. Mean, 0·989 $\mu\text{g. at/L.}$
 - (e) *Nitrate-Nitrogen*: 2·37–10·78 $\mu\text{g. at/L.}$ at the surface and 5·60–9·62 $\mu\text{g. at/L.}$ at the bottom. Mean, 6·474 $\mu\text{g. at/L.}$
 - (f) *Silicate-Silicon*: 7·96–22·90 $\mu\text{g. at/L.}$ at the surface and 7·58–28·50 $\mu\text{g. at/L.}$ at the bottom. Mean, 12·90 $\mu\text{g. at/L.}$
7. *Volume of plankton*.—Downward trend. Poor values.
8. *Pigment units*.—760–2,680 units per haul. Mean, 1,751 units.
9. *Dominant organisms*.—Zooplankton dominant.
10. *General nature of phytoplankton*.—Diatoms and Dinophyceans common. *Noctiluca* in swarms at times.
11. *Dominant phytoplankters*.—*Chatoceros lorenzianus*, *C. curvisetus*, *C. compressus*, *Fragilaria oceanica*, *Chatoceros affinis*, *Ornithocercus magnificus*, *Nitzschia seriata*, *Chatoceros socialis*, *Nitzschia sigma* var. *indica*, *Asterionella japonica*, *Chatoceros lascinatus*, *Ceratium tripos*.

December—

1. *Rainfall*.—0·00–94 mm. Mean, 28·0 mm.
2. *Humidity*.—92–77%. Mean, 74%.
3. *Condition of the sea*.—Calm. Water clear.
4. *Wind*.—Mainly from north or north-east. Velocity varies from 5·5–6·0 m.p.h. Mean, 5·7 m.p.h.
5. *Current*.—From north-east to south-west or north to south.
6. *Hydrological data*.—
 - (a) *Temperature*: (i) *Air*.—26·2–27·1° C. Mean, 26·65° C.
(ii) *Sea-water*: 27·5–28·4° C. Mean, 28·1° C.

- (b) *Salinity*: 32.08–34.19‰ at the surface and 32.08–34.63‰ at the bottom. Mean 33.55‰.
- (c) *Oxygen content*: 4.07–4.67 ml./L. (saturation, 86.80–98.40%). Mean 4.34 ml./L. (saturation, 92.01%).
- (d) *Phosphate-Phosphorus*: 0.414–0.966 $\mu\text{g. at/L.}$ at the surface and 0.288–1.173 $\mu\text{g. at/L.}$ at the bottom. Mean, 0.710 $\mu\text{g. at/L.}$
- (e) *Nitrate-Nitrogen*: 2.20–10.00 $\mu\text{g. at/L.}$ at the surface and 2.97–5.90 $\mu\text{g. at/L.}$ at the bottom. Mean, 5.221 $\mu\text{g. at/L.}$
- (f) *Silicate-Silicon*: 5.17–18.75 $\mu\text{g. at/L.}$ at the surface and 5.30–21.54 $\mu\text{g. at/L.}$ at the bottom. Mean, 12.289 $\mu\text{g. at/L.}$
7. *Volume of plankton*.—Values poor.
8. *Pigment units*.—Vary from 530–2,590 units per haul. Mean, 1,525 units.
9. *Dominant organisms*.—Zooplankton dominant.
10. *General nature of phytoplankton*.—Diatoms and Dinophyceæ common.
11. *Dominant phytoplankters*.—*Chaetoceros lascinosus*, *C. lorenzianus*, *Fragilaria oceanica*, *Chaetoceros curvisetus*, *C. compressus*, *Skeletonema costatum*, *Chaetoceros contortum*, *C. filiferum*, *Ornithocercus magnificus*, *Chaetoceros socialis*, *Bacteriastrum hyalinum* var. *princeps*, *Peridinium depressum*.

GENERAL REMARKS

In the earlier accounts of this series (Subrahmanyam, 1958 *a*; 1959 *a, b*) the seasonal quantitative fluctuation of the total crop of phytoplankton and the magnitude of its production and related factors were discussed. The data presented in this account show the nature and quantitative variation of the constituent elements of the phytoplankton crop through the different months of the year.

In the course of over five years, about 29 species of Bacillariophyceæ, 7 species of Dinophyceæ and one of Cyanophyceæ have been recorded under dominant forms (a very small proportion only compared with a total of 226 species of the Bacillariophyceæ, 120 species of the Dinophyceæ and 7 of Cyanophyceæ *vide* Subrahmanyam, 1958 *b*), some of which contribute to the bulk of the flora during the different months of the year. Whether the order of ranking shown here would be constant every year for the months concerned cannot be stated with certainty as the abundance of each is governed by many factors although the ranking shown is based on five years' averages. The relative abundance of each species will be decided by the nature and the span of its life-cycle which brings about a cyclical abundance

in its occurrence as shown for *Fragilaria oceanica* by Subrahmanyam (1959 *a, b*). Particulars regarding fluctuations of individual species are available for some from Indian waters (Subrahmanyam, 1954 *a, b*) and also elsewhere (Wimpenny, 1926, 1946, 1956; Cushing, 1956).

In this connection, it may be mentioned that the importance of mass forms has been stressed by Zenkevitch (1958) also. He also states that the number of such mass forms which consummate 70-100% of the total biological processes is not likely to be very large and for plankton there may be only 20-30 forms. The present investigation also shows that 29 species of diatoms and 7 of Dinophyceæ (the latter is only of secondary importance) and one of Cyanophyceæ go to constitute the bulk (over 1,000,000 cells per vertical net haul) of the flora on the west coast of India (*refer* Table II). Nevertheless, it may be mentioned here that the possibility exists whereby the paucity of many or some of the species at least could be due to their depletion by

TABLE II
List of "Mass Forms"

BACILLARIOPHYCEÆ	
1	<i>Asterionella japonica</i>
2	<i>Bacteriastrium hyalinum</i> var. <i>princeps</i>
3	<i>Biddulphia heteroceros</i>
4	<i>B. mobiliensis</i>
5	<i>Chatoceros affinis</i>
6	<i>C. brevis</i>
7	<i>C. compressus</i>
8	<i>C. contortum</i>
9	<i>C. curvisetus</i>
10	<i>C. lascintosus</i>
11	<i>C. lauderii</i>
12	<i>C. lorenzianus</i>
13	<i>C. pelagicus</i>
14	<i>C. socialis</i>
15	<i>Coscinodiscus asteromphalus</i>
16	<i>C. oculus-iridis</i>
17	<i>Fragilaria oceanica</i>
18	<i>Guinardia flaccida</i>
19	<i>Lauderia annulata</i>
20	<i>Leptocylindrus danicus</i>
21	<i>Nitzschia seriata</i>
22	<i>N. sigma</i> var. <i>indica</i>
23	<i>Rhizosolenia alata</i>
24	<i>R. robusta</i>
25	<i>R. stolterfothii</i>
26	<i>Sceletonema costatum</i>
27	<i>Schrödereila delicatula</i>
28	<i>Thalassiothrix frauenfeldii</i>
29	<i>T. longissima</i>
DINOPHYCEÆ	
1	<i>Ceratium fuscus</i>
2	<i>C. macroceros</i>
3	<i>C. tripos</i>
4	<i>Dinophysis caudata</i>
5	<i>Glenodinium lenticula</i> f. <i>asymmetrica</i>
6	<i>Noctiluca miliaris</i>
7	<i>Peridinium depressum</i>
MYXOPHYCEÆ	
1	<i>Trichodesmium erythraum</i>

predators. Apparently, therefore, the scarcity of species in the waters should not lead to their being ignored.

One interesting point may be mentioned here. The highest number of species record in any month was 190 and the lowest 140. It would appear that always a good number of species are represented in the water, the variation being in the quantity of one or the other according to the seasons and factors affecting individual species.

SUMMARY

The seasonal distribution of the various phytoplankters on the west coast of India is given with indications as to their frequency of occurrence as also a catalogue of the relevant physical and chemical factors. It is shown that as against a total recorded species of 226 Bacillariophyceæ, 120 of Dinophyceæ, and 7 of Cyanophyceæ, only 29 of the Bacillariophyceæ, 7 of the Dinophyceæ, and 1 of the Cyanophyceæ are of consequence as regards bulk of occurrence and these are pointed out. A table is also given to indicate the relative distribution of all the species through the year.

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