Papers in Marine Biology and Oceanography, Suppl. to vol. 3 of Deep-Sea Research, pp. 58-67.

Seasonal changes in the phytoplankton as indicated by spectrophotometric chlorophyll estimations 1952-53

By Pamela G. Jenkins

(Introduction by W. R. G. Atkins)

Summary—Estimations of the chlorophyll content of the phytoplankton in the English Channel at station E1 were continued from September 1952 until August 1953 at ten depths from 0 to 70 m. As before, the species of the phytoplankton were identified by a culture method.

Minima of about 2 mg/m³ occur in winter and in June. Maxima at particular depths can occur in March, April or May, thus in 1952 the maximum was in a March surface sample, 34·2 mg/m³, whereas in 1953 sinking of the cells gave, in May, 78·8 mg/m³. The quantity found can be much influenced by the date of sampling. An autumn maximum late in September 1952 gave 21·1 mg/m³ at the surface.

The collodion filter disks varied in colour from dark grey or chocolate to a light sandy colour and examination with a low-power microscope shows phytoplankton, stray fibres and sometimes copepods and other animals. Copepods were counted in spring and summer, a maximum of 24 on one disk being found at 25 m on April 27, got from two litres of water. The figures for the column indicate about 300,000 per square metre down to 70 m.

The botanical composition of the phytoplankton was studied by the repeated examination, from first signs of growth onwards, of the chemically enriched samples placed in diffuse daylight. Fifty-four species of Bacillariphyceae were recorded. As before *Skeletonema costatum*, a *Navicula sp.* and *Nitzschia closterium* were the most common. Many species of *Chaetoceros* were identified in the autumn of 1952.

Six species of the Chlorophyceae, five of the Chrysophyceae, one of the Cyanophyceae and three of the Cryptophyceae were recorded. The most common species of the first class was a *Chlorella*, and of the second a species of *Coccolithophora* grew in each sample. *Phaeocystis globosa* grew from January to May. The member of the Cyanophyceae was an *Oscillatoria*. Neither this nor *Phaeocystis* was recorded for E1 in the previous year. *Hemiselmis rufescens* appeared once more.

INTRODUCTION

In this " Festschrift " number it may well be pointed out that the roots of the science of the sea are sunk deep in time. The adequate study of the sea involves all the exact sciences, including even astronomy, and all the biological sciences.

It is not, as often considered, a preserve for zoologists. The early devotees of the study of marine life were just biologists, mainly systematists, for of necessity one must follow Adam and name things. The beautifully illustrated papers of the early workers are highly educational, and remind one that it is not for us to misquote and say, " Surely we are the people and wisdom shall die with us ". I recall with sadness a morning in April 1941 when, in smoking Plymouth, I picked up one page of an old biological work—all that remained of our Athenaeum Library, which had housed so much of the older literature.

Perhaps Dr. Bigelow may be considered as having begun at about the end of the old era of amateur biologists. He was studying the phytoplankton of the Gulf of Maine in 1913. He found the entire basin occupied by a peridinian plankton, but never found diatoms in abundance in July or August except close along the coast and on Georges Bank.

So when, largely by his efforts, the Woods Hole Oceanographic Institution was founded, they could begin with a basic knowledge of the phytoplankton which is still lacking in Plymouth. But quantitative work on the production of phytoplankton in the English Channel has been carried out since 1921, first by calculation from the changes in hydrogen ion concentration brought about by photosynthesis (1922) and since 1922 from the consumption of phosphate (1923). The arrival of a modern spectrophotometer however made it possible to estimate the phytoplankton crop by extracting the chlorophyll from collodion filter membranes on which even the smallest green flagellates had been retained. This was done in the year 1951–52, and by a culture method, similar to that of bacteriology, the organisms were grown and multiplied so that even those originally very sparsely distributed were not missed (Atkins and Jenkins, 1953).

The chlorophyll method of course gives the phytoplankton content of the water when sampled, whereas the phosphate calculations give the amount produced over a period. The two may be very different. A beginning was thus made in obtaining a better knowledge of what plants were present—and of when they flourished—also such work provides a basis for the study of the movement of water masses tagged by a known algal flora.

I therefore asked my collaborator Miss P. G. Jenkins to continue this research and to give her results, which she has done as follows.

W. R. G. A.

ORIGIN OF SAMPLES AND THEIR EXAMINATION

Water was collected with a Nansen-Pettersson water bottle at the international hydrographic station England No. 1 (E1), twenty miles S.W. from Plymouth, at a series of depths from 0 m to 70 m bottom. Two litres of each sample were filtered through a collodion (Gradocol) membrane of average pore diameter one micron.

The phytoplankton cells and the suspended matter which remained on the disks were examined under the low-power microscope. Then 10 ml of an 80 per cent aqueous acetone solution was used to extract the plant pigments from each membrane.

A " Unicam " spectrophotometer with 4·0 cm cuvettes served to measure the minimum percentage transmission in the red between 640 and 670 mμ. These values were converted into concentrations of chlorophyll in mg/l read off from a graph of the transmissions of 80% aqueous acetone solutions of a dry commercial chlorophyll plotted against their concentrations. This graph and the absorption spectrum of the chlorophyll may be seen in the 1953 paper. Using 10 ml of the aqueous acetone to extract the plankton from a litre of water, it is obvious that the chlorophyll has been concentrated one hundred times, so 1 mg/l as read off is equivalent to 0·01 mg/l or to 10 mg/m^3. An allowance was of course made for the actual volume extracted.

In winter, i.e. November to February, the colour of the extracts was slightly yellow and the green was almost imperceptible. The colour deepened with the spring growth to a deep olive green, and lightened in the summer samples.

EXAMINATION OF THE PLANKTON ON THE DISKS

The disks varied in their intensity from a dark grey or chocolate to a very light sandy colour. It was impossible to deduce the amount of chlorophyll in the extracts from these shades. That deduction could only be made when the disks were a uniform faint green. They were often covered with diatoms of various species, and at times had green spots due to the presence of some species of the Chlorophyceae. The Dinoflagellate *Ceratium tripos* occurred at every depth on Aug. 10, 1953. Fibres were frequently seen. Many copepods were found on the disks and as they were so numerous in the spring of 1953, their numbers were counted and set out in Table 1. The totals in the second line from the bottom (Σ means) are based on the sum of the means for 2·5, 7·5, 12·5, . . . 67·5 m for 14 depths. This sum is then multiplied by 5 (for 5 m intervals) and the totals in the bottom line are expressed as the number of copepods in the column per square metre of surface, namely in 70 m^3. (The amounts of chlorophyll in the water column (Fig. 5) to be considered later were conducted in the same way.)

These totals were included because the phytoplankton and zooplankton crops are obviously related. In 1951–52 some medusae were found but none could be seen in the following year. Nudibranch veligers were found from June to August, though not previously seen on the disks.

*Table I—Numbers of Copepods found on collodion membrances from April until August 1953, in 2 litres of water at station E*1

Depth (*m*)	*April* 13*th*	*April* 27*th*	*May* 11*th*	*June* 22*nd*	*July* 20*th*	*August* 10*th*
0	0	4	16	4	11	0
5	4	6	14	5	4	0
10	—	—	—	—	—	3
15	3	10	22	6	15	2
20	10	7	14	7	15	9
25	7	24	3	12	18	8
30	10	6	10	1	14	6
40	6	9	5	—	12	0
50	3	7	4	6	4	3
70	5	9	14	0	3	0
Σ means*	70	124	148	62	130	45
thousands per m^2 in column	175	310	370	155	325	112

* See text, p. 59.

Table II—Diatoms identified in enriched cultures exposed to light

Signs: — Not found A present B more frequent
C plentiful D very plentiful O not found in one of the two cruises

Where two letters occur for one month, two cruises were undertaken

BACILLARIOPHYCEAE	*Years*	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
COSCINODISCACEAE													
Coscinodiscus sp.	1952	—	—	B	—	—	—	—	—	A	A	—	B
	1953	C	—	—	—	—	—	—	—	—	—	—	—
C. concinnus	1952	—	—	—	—	—	—	—	—	—	A	—	—
C. excentricus	1952	—	—	—	—	—	—	—	—	C	—	—	—
C. radiatus	1952	—	—	—	—	—	—	—	—	A	—	—	—
Melosira moniliformis	1952	—	—	B	D	C	B	—	A	B	—	—	—
	1953	A	—	CO	AO	—	—	—	—	—	—	—	—
Paralia sulcata	1952	—	B	—	—	—	—	—	—	—	A	—	—
	1953	—	—	AO	AO	—	—	—	—	—	D	—	—
Skeletonema costatum	1952	—	—	B	—	A	—	B	C	D	D	B	B
	1953	—	—	DO	BO	—	OB	A	B	D	D	D	D
Thalassiosira sp.	1952	—	—	—	—	—	—	—	—	—	B	—	—
	1953	—	B	BO	—	—	—	A	A	—	—	—	—
T. condensata	1953	—	—	BO	—	—	—	—	—	—	—	—	—
T. decipiens	1952	—	—	—	—	—	—	—	—	B	—	—	—
	1953	—	—	—	—	—	—	—	—	—	DD	D	D
T. gravida	1952	B	—	C	B	—	—	—	—	D	C	D	D
	1953	D	—	BO	—	—	—	—	—	—	—	—	—
T. nordenskioldii	1953	—	—	—	DO	—	—	—	—	—	—	—	D
T. subtilis	1952	—	—	—	—	—	—	—	—	C	—	—	—
	1953	—	—	AO	AO	—	—	—	—	—	DD	D	D
BIDDULPHIACEAE													
Biddulphia sp.	1952	—	—	—	—	—	—	—	—	—	—	A	—
B. regia	1952	—	—	—	—	—	—	—	—	A	—	—	—
B. sinensis	1952	—	—	—	—	—	—	—	—	—	—	A	—
Ditylum brightwellii	1952	—	—	—	—	—	—	—	—	B	D	C	A
	1953	A	—	—	—	—	—	—	—	—	OD	—	—
Eucampia zoodiacus	1953	A	—	—	—	—	—	—	—	—	—	—	—

(*Table II cont.*)

Bacillariophyceae	Years	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
Chaetoceraceae													
Chaetoceros sp.	1952	B	—	—	—	—	—	—	D	C	—	A	C
	1953	A	A	BO	—	—	OB	B	C	D	OD	—	—
C. affine	1952	—	—	—	—	—	—	—	—	A	—	—	—
	1953	—	—	—	—	—	—	A	—	—	—	—	—
C. ceratosporum	1952	—	—	—	—	—	—	—	—	A	A	A	—
	1953	A	—	—	—	—	—	—	D	—	—	—	—
C. compressum	1952	—	—	—	—	—	—	—	—	A	—	—	—
C. convexicorne	1952	—	—	—	—	—	—	—	—	A	—	—	—
	1953	—	—	—	—	—	—	B	—	—	—	—	—
C. convolutum	1952	—	—	—	—	—	—	—	—	A	—	—	—
C. curvisetum	1953	—	—	—	—	—	—	B	—	—	—	—	—
C. danicum	1952	—	—	—	—	—	—	—	—	A	—	—	A
	1953	—	—	—	—	—	OA	—	—	—	—	—	D
C. debile	1952	—	—	—	—	—	—	—	—	C	D	C	B
	1953	A	—	—	—	—	—	—	—	—	—	—	—
C. decipiens	1952	—	—	—	—	—	—	—	—	A	A	A	—
	1953	—	—	AO	—	—	OA	—	—	—	OD	D	—
C. densum	1952	—	—	—	—	—	—	—	—	A	—	—	—
C. didymum	1952	—	—	—	—	—	—	—	—	—	A	D	—
	1953	B	—	—	—	—	—	—	—	—	—	—	—
C. gracile	1952	—	—	—	—	—	—	—	—	B	—	—	—
C. laciniosum	1953	—	—	—	—	—	—	A	—	—	—	—	—
C. lorenzianum	1953	—	—	—	—	—	—	A	—	—	—	—	—
C. pseudocrinitum	1952	—	—	—	—	—	—	—	—	—	A	—	A
	1953	—	—	—	—	—	—	—	A	—	—	—	—
C. scolopendra	1952	—	—	—	—	—	—	—	—	A	A	—	—
C. septentrionale	1952	—	—	—	—	—	—	—	—	A	—	—	—
C. simplex	1952	—	—	—	—	—	—	—	—	A	—	—	—
	1953	A	—	—	DO	—	—	A	—	—	—	—	—
C. sociale	1952	—	—	—	—	—	—	—	—	A	—	—	—
	1953	—	—	AO	—	—	—	—	—	—	—	—	—
C. teres	1952	—	—	—	—	—	—	—	—	—	—	B	—
Leptocylindraceae													
Lauderia borealis	1952	—	—	—	—	—	—	—	—	—	—	—	B
	1953	C	—	DO	BO	—	—	—	A	—	—	—	—
Leptocylindricus danicus	1952	—	—	—	—	—	—	C	B	A	A	—	—
	1953	—	—	—	—	—	—	—	C	D	DD	—	—
Rhizosoleniaceae													
Rhizosolenia sp.	1953	B	—	—	—	C	—	—	—	—	—	—	—
R. alata var. *indica*	1952	—	—	—	—	—	—	A	C	A	A	—	—
	1953	—	—	—	—	—	OB	D	D	—	—	—	—
R. fragilissima	1952	—	—	—	—	—	—	—	—	—	A	—	—
R. hebetata	1952	—	—	—	—	—	—	—	B	—	—	—	—
	1953	—	—	—	—	—	—	A	—	D	DD	—	—
R. setigera	1953	—	—	—	—	—	OA	—	—	—	—	D	D
R. shrubsolei	1952	—	—	—	—	—	—	—	—	A	A	—	—
	1953	—	—	OA	—	—	OD	D	—	—	—	—	—
R. styliformis	1953	—	—	—	—	—	—	A	—	—	—	—	—
Fragilariaceae													
Asterionella japonica	1952	—	—	B	—	B	—	—	B	C	D	—	—
	1953	—	—	—	—	—	—	—	—	—	DD	D	—
Fragilaria sp.	1952	—	—	—	B	A	—	A	—	C	D	—	—
F. oceanica	1953	A	—	DA	AO	—	OD	—	A	A	—	—	—
	1952	—	—	—	—	—	—	—	B	B	—	—	—
F. striatula	1953	—	—	—	AO	—	—	—	—	—	—	—	—
Tabellariaceae													
Thalassionema nitzschioides	1952	—	—	—	—	—	—	—	A	D	C	D	—
	1953	A	—	BO	—	—	—	—	—	D	OD	D	D

(*Table II cont.*)

BACILLARIOPHYCEAE	*Years*	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
NAVICULACEAE													
Navicula sp.	1952	—	B	C	D	D	D	C	B	C	D	D	B
	1953	A	A	AA	AB	C	DC	—	A	C	DD	—	—
N. membranacea	1952	—	—	—	—	—	—	—	—	—	A	—	—
N. vanhoffeni	1952	—	—	—	—	—	—	—	—	—	B	—	—
	1953	A	—	DD	AO	—	OA	C	—	—	—	D	—
Pleurosigma sp.	1952	—	—	—	—	—	—	—	—	A	C	D	—
	1953	B	A	AO	—	—	—	—	—	—	—	—	D
BACILLARIACEAE													
Bacillaria paxillifer	1952	—	—	—	—	—	—	—	—	B	—	—	—
Nitzschia closterium	1952	D	C	C	D	A	C	D	C	B	D	D	D
	1953	D	D	DB	DD	D	—	C	D	D	DD	D	D
N. delicatissima	1952	—	—	—	—	—	—	—	D	C	A	D	B
	1953	D	—	—	DB	B	AO	D	D	—	—	—	—
N. seriata	1952	—	—	—	—	—	—	—	B	D	D	—	A
	1953	—	—	—	AO	—	—	—	—	D	DD	D	D

SEASONAL VARIATIONS IN CHLOROPHYLL AND THEIR CONVERSION INTO WET WEIGHT OF PHYTOPLANKTON

Water samples were taken at intermediate depths from the surface down to 50 m from August to October 1952, then down to 70 m from November 1952 to August 1953.

It was decided to extend sampling down to the lowest depth possible, 70 m to give a more accurate survey at E1, so that the chlorophyll content for 70 m was known and

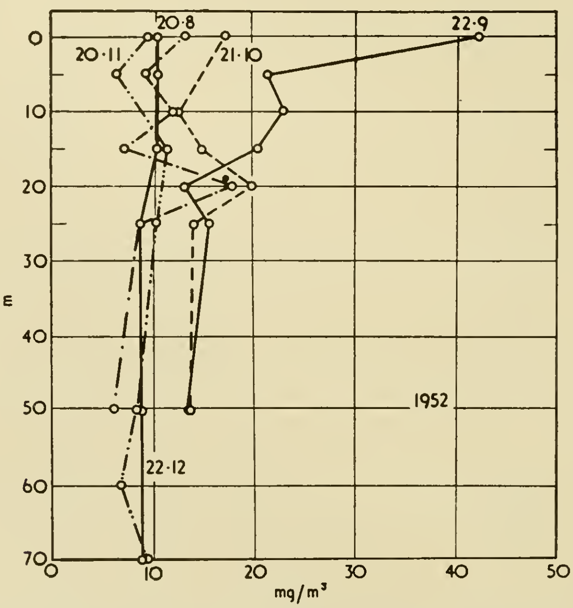

Fig. 1. Variation in chlorophyll from August–December 1952, at Station E1. Ordinates show depth of sampling in metres. Abscissae show concentration of chlorophyll in milligrams per cubic metre.

need not be assumed to be the same as at 50 m, which was done in the 1953 paper. Fig. 1 illustrates the autumn growth from August 1952 (linking up with ATKINS and JENKINS, 1953, Fig. 7) to October, with a surface outburst in September. Growth fell to a value almost uniform with depth during November and December in an almost isothermal water column.

Table III—Algae identified in enriched cultures exposed to light

Signs: — not found
A present
B more frequent
C plentiful
D very plentiful
O not found in one of the two cruises

Where two letters occur for one month, two cruises were undertaken

CHLOROPHYCEAE	*Years*	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
CHLAMYDOMONADACEAE													
Chlamydomonas sp.	1952	—	—	B	—	—	—	—	—	C	D	D	A
	1953	C	C	BB	OA	—	DA	—	—	B	—	A	—
POLYBLEPHARIDACEAE													
Pyramimonas sp.	1952			C	—	B	—	—	—	—	—	—	B
	1953	—	A	—	OC	—	—	A	—	—	—	—	—
CHLORELLACEAE													
Chlorella sp.	1952	—	—	D	D	D	C	B	A	A	D	C	D
	1953	D	B	BB	—	A	DB	—	—	—	—	—	—
ULOTRICHACEAE													
Stichococcus sp.	1952	—	—	C	D	C	C	B	—	—	—	—	—
	1953	—	—	OB	OA	—	DO	—	—	—	—	D	—
Ulothrix subflaccida	1952	—	A	—	—	—	—	—	—	—	—	—	—
	1953	—	A	AO	AO	—	—	—	—	—	—	—	—
CHAETOPHORACEAE													
Ectochaete sp.	1952	—	—	C	D	A	C	—	—	B	A	A	A
	1953	A	—	AO	—	—	OC	—	—	—	—	—	—
CHRYSOPHYCEAE													
Chrysomonad sp.	1952	—	—	—	—	—	—	B	—	—	—	—	—
	1953	B	C	—	—	—	—	—	—	—	—	—	B
Coccolithophora sp.	1952							D	D	D	D	D	D
	1953	D	D	CD	DC	D	DD	B	D	D	DD	D	D
ISOCHRYSIDACEAE													
Dicrateria sp.	1953	—	—	—	OC	—	BC	—	—	—	—	—	—
OCHROMONADACEAE													
Ochromonas sp.	1953	A	A	—	—	—	—	—	—	—	—	—	—
CHRYSOCAPSACEAE													
Phaeocystis globosa	1953	A	A	OC	DB	D	—	—	—	—	—	—	—
CYANOPHYCEAE													
OSCILLATORIACEAE													
Oscillatoria sp.	1953	A	—	—	OA	—	—	—	—	—	—	—	—
CRYPTOPHYCEAE													
Cryptomonad sp.	1952	—	—	—	—	—	—	B	—	—	—	—	B
	1953	—	—	—	BA	—	—	—	—	—	BB	A	A
Cryptomonas sp.	1952	—	—	—	—	—	—	—	—	—	—	A	—
	1953	B	C	—	—	—	—	—	—	—	—	—	—
Hemiselmis rufescens	1952	D	—	—	—	—	—	—	—	—	—	D	D
	1953	—	—	—	OC	—	—	—	—	B	OD	—	—

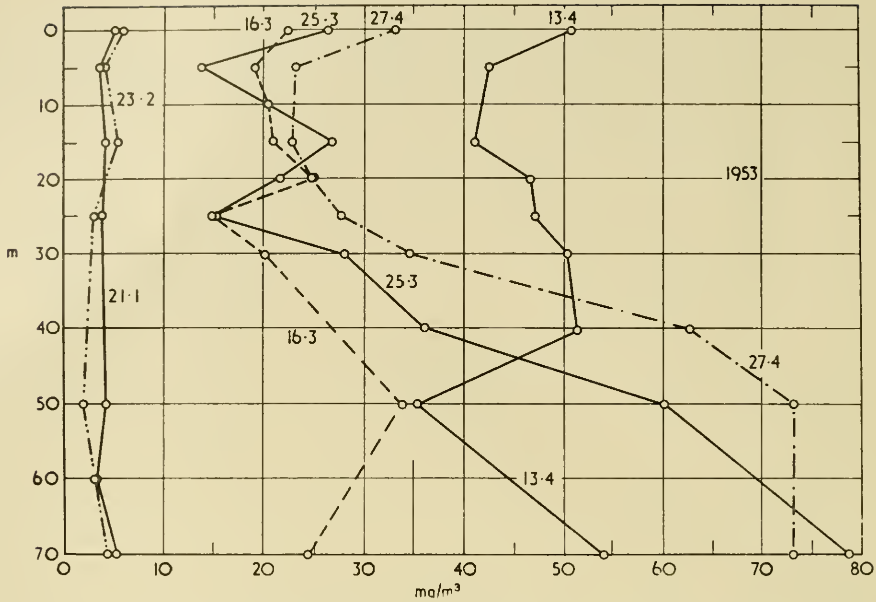

Fig. 2. Variation in chlorophyll, January–April 1953 at E1, in mg/m³.

The two winter months showed no appreciable change (Fig. 2), but from March onwards the samples gave a high value of chlorophyll at the surface and even at 70 m, giving a bottom maximum at 70 m of 78·8 mg/m³ on March 25th. These high readings for the lower depths showed that the cells must have sunk. RILEY (1941 B) observed this high concentration of chlorophyll from 40–70 m at Georges Bank during March and April. MARSHALL and ORR long ago (1928) reported that " during the spring

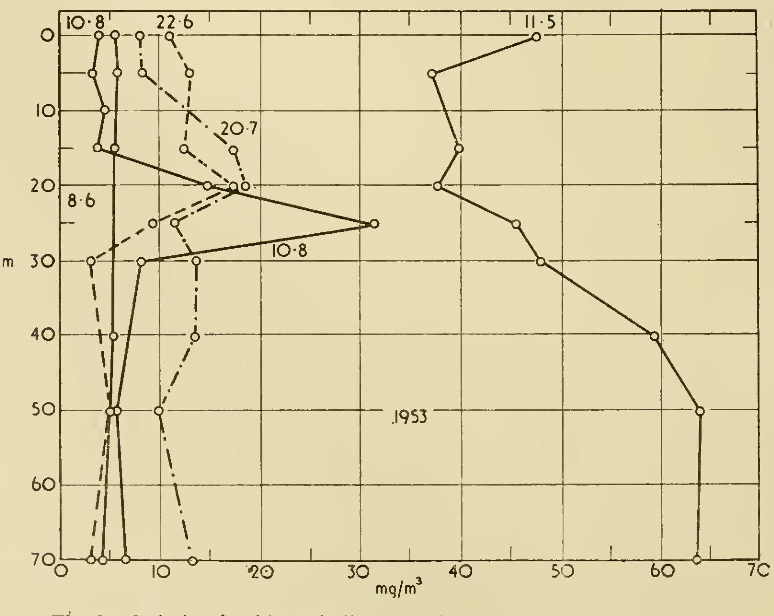

Fig. 3. Variation in chlorophyll, May to August 1953 at E1, in mg/m³.

months it was not uncommon in shallow water to find more plankton near the bottom than anywhere else ". They also found that during the spring outburst the phytoplankton caused such a great reduction in submarine illumination that the compensation point (or depth) was at times raised to 5 m or less.

The sudden drop from spring growth, May 11th to the summer minimum, June 8th, is seen in Fig. 3. The May readings were very high due to the abundance of *Phaeocystis globosa.* Two filtrations were necessary because the disks became clogged, so ordinary filter paper was first used and then the special membrane. Each of these was extracted twice. The later cruises show the gradual growth near the thermocline, building up to the autumn maximum, with a peculiar outburst at 25 m on August 10th of 31·5 mg/m³. This outburst must have occurred in a region where light intensity allows photosynthesis to take place and its occurrence at only this depth is probably due to the absence of sufficient nutrient salts in the upper 15 m.

The results for surface and bottom chlorophyll throughout the year are seen in Fig. 4 with a surface maximum in September and April and a bottom maximum in

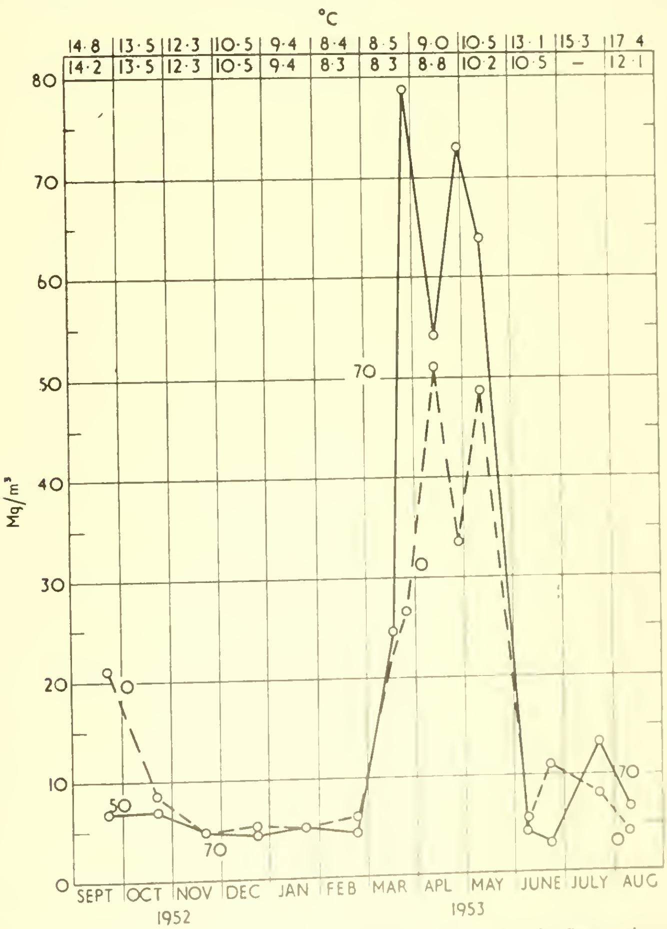

Fig. 4. Surface and bottom concentrations of chlorophyll for 1952–53. The September and November values of 1952 are for 50 m. The ordinates show concentration of chlorophyll at surface and bottom in mg/m³. The sea temperatures are for the surface, above, and for the bottom (70 m) just below the top line of the frame.

March, due to sinking. The thermoclines for the year were found on September 22nd, 1952, 15 m, 14·6° C; April 27th, 1953, 15 m, 12·5° C; June 22nd, 20 m, 13·0° C; August 10th, 15 m, 17·2° C.

In both 1951 and 1952 the autumn maximum (Fig. 5) was in September, the amounts being respectively 0·59 and 1·02 g/m². The spring minimum was in November 1951, but was three months later the following winter when it was reached in February 1953. But the values were identical, 0·25 g/m². The spring maximum in April 1952 was 1·33 g/m², but this value was obtained on the assumption that the amount of chlorophyll was uniform beyond the last depth examined, 50 m to 70 m, bottom. Later work showed that, on account of sinking of the cells, this was probably an underestimate. The maximum was in May in 1953, 3·68 g/m² (very much higher) with much Phaeocystis present. Both the summer minima fell in June, 0·15 g/m² for 1952 and 0·35 g/m² for 1953.

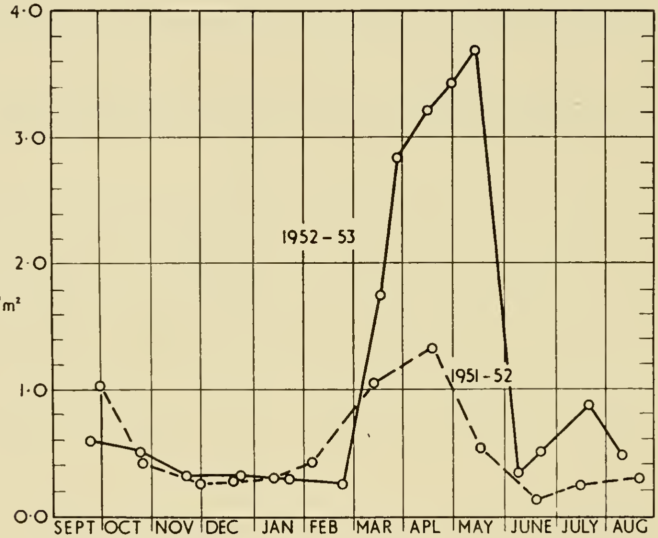

Fig. 5. Variation of chlorophyll in water column, 0–70 m, in grams per square metre for 1951–52 (broken line) and 1952–53 (full line). See text, p. 66.

These chlorophyll quantities may be converted into wet weights of phytoplankton as in the paper of 1953. Taking RILEY'S value 2·9% of chlorophyll (1941 A), calculated on the dry weight, and taking the dry weight as 20% of the wet weight, we arrive at a factor 172 by which one can multiply the weight of chlorophyll to convert it to wet weights of phytoplankton. It is recognized that these factors are somewhat arbitrary.

THE BOTANICAL COMPOSITION OF THE PHYTOPLANKTON AT STATION E1

Samples of water, 100 ml, from each depth were poured into conical flasks and enriched with Miquel's solution, 0·2 cc of solution A and 0·1 cc of solution B.

They were placed in a south window during winter and from spring to autumn were illuminated by a diffuse north light. The enrichment of the culture solution gave a better chance for species originally very sparsely represented to multiply and be detected. This amounts, in fact, to the common bacteriological technique.

Tables II and III are an attempt to indicate the relative amounts found in the earlier stages of the cultures, the comparison being between the same species, so different growth rates are not involved.

Table II shows the Bacillariphyceae, identified as named and classified in HENDEY'S list (1954). Fifty-four species were found, as compared with twenty species found in 1951–52, but the autumn growths cannot be compared with 1951–52 since the samples were not enriched and exposed until February 1952.

Skeletonema costatum, *Navicula sp.*, and *Nitzschia closterium* were again the most regular in occurrence. Species absent from our lists before 1953 were *Thalassiosira condensata* found in February, *Eucampia zoodiacus* in January, *Rhizosolenia setigera* in June, November and December, *R. styliformis* in July, also *Fragilaria striatula* in April.

The Algae listed in Table III are as named and classified in Parke's list (1953). The most regular occurrence of the Chlorophyceae were the *Chlorella sp.* and *Chlamydomonas sp.* The three others listed grew well in the spring, *Ulothrix subflaccida* which was found once in February, 1952, was present from February to early April in 1953.

Of the Chrysophyceae, the *Coccolithophora sp.* were always in the cultures. *Phaeocystis globosa*, which was absent from the 1952 cultures, grew in 1953, increasing to a great mass in May. This caused the blocking of the sea water filtration.

One member of the Cyanophyceae was present in January and late April in 1953, an *Oscillatoria sp.* The growth of such sessile forms as this and the *Ectochaete sp.*, *Ulothrix subflaccida*, and *Stichococcus sp.*, though not truly planktonic showed that some must have been present in the water at the time of sampling.

Hemiselmis rufescens, a species of the Cryptophyceae, which grew in January 1952, was very plentiful in November and December 1952, also in April and the early autumn of 1953.

I would like to express my thanks to Dr. M. V. LEBOUR, Dr. M. PARKE, Dr. T. J. HART and Mr. T. R. TOZER for much help in the identifications, also Mr. F. A. J. ARMSTRONG for the temperature observations. Finally for the collection of the sea water I have pleasure in thanking the captains and the crews of the R.V. *Sula* and the R.V. *Sarsia*.

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