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CHEMICAL CHANGES IN SEA WATER OFF PLYMOUTH DURING 1957

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(Text-figs. 1–3)

Analyses of sea water collected during 1957 at the International Hydrographic Station E 1 (lat. 50° 02′ N., long 4° 22′ W.) are given here in the same form as in earlier reports (Armstrong, 1954, 1955, 1957, 1958). The methods of collection and of analysis for phosphorus and silicon are substantially unchanged. Some analyses were made for ammonia by a vacuum distillation method (Riley, 1953), and for inorganic nitrogen (nitrate + nitrite + ammonia) by reduction of nitrate and nitrite with nickel (Riley & Sinhaseni, 1957) to ammonia, which was vacuum distilled. Salinities were determined by the Government Chemist's Department.

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RESULTS

Temperature and salinity

The vertical distribution of temperature during the year is shown in Fig. 1. The lowest surface temperature recorded was 9·7° C. on 15 February, and the highest was 16·11° C. on 16 July. Some vertical irregularities of temperature and salinity occurred in March and April, being most marked on 24 April, when water of salinity higher than on 11 April, higher than in the layers above, and marked by its lower silicate content, was present at 50 and 70 cm. (Table 2). As is seen there was a temperature minimum at 20 m, but the densities show the vertical stability.

A sharp thermocline between 15 and 20 m was established by 11 June, and persisted with some change of level until September. From October until the end of the year the water column was isothermal.

Phosphate

Vertical distribution is shown in Fig. 2, and integral mean concentrations in Table 1. The winter maximum found was 0·47 μg atom P/l. on 15 February, and the lowest concentrations were 0·08–0·09 μg atom P/l. at the 5 and 10 m levels in May and June. Phosphate remained low in the upper 20 m until September; the vertical distribution had become uniform by 15 October, and so remained until the end of the year.

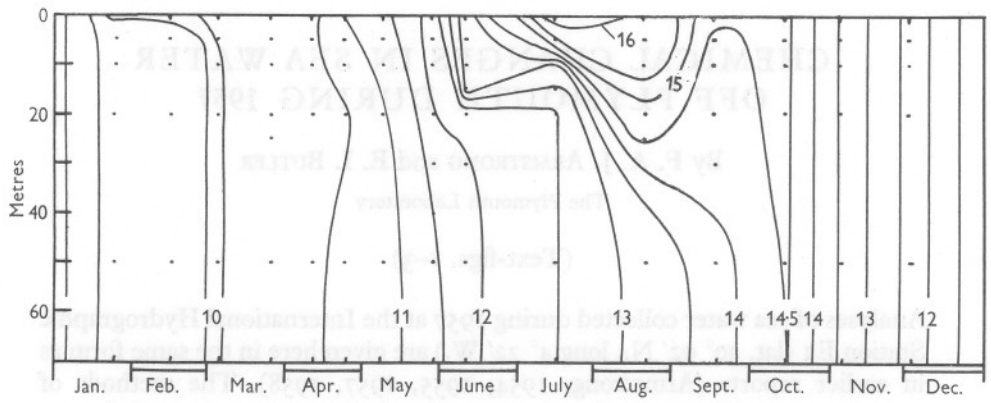

Fig. 1. Vertical temperature distribution at International Hydrographic Station E1, 1957. Contour lines at 0·5° C intervals.

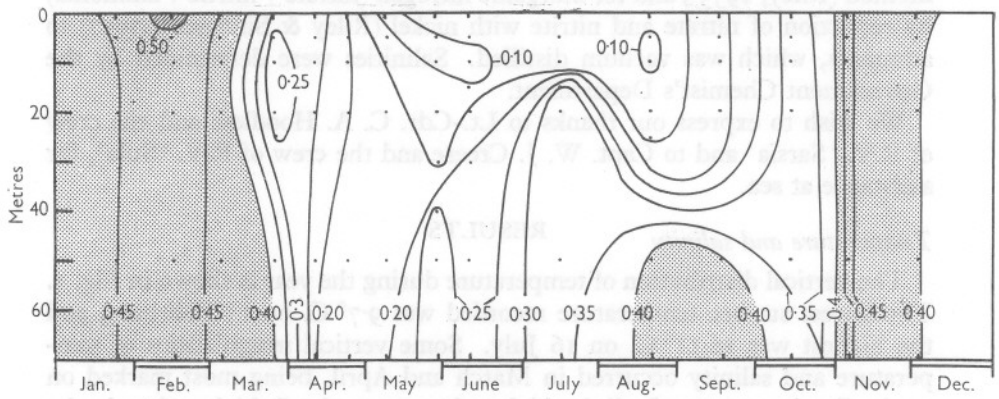

Fig. 2. Vertical distribution of phosphate at International Hydrographic Station E1, 1957. Contour lines at 0·05 μg atom P/l. intervals.

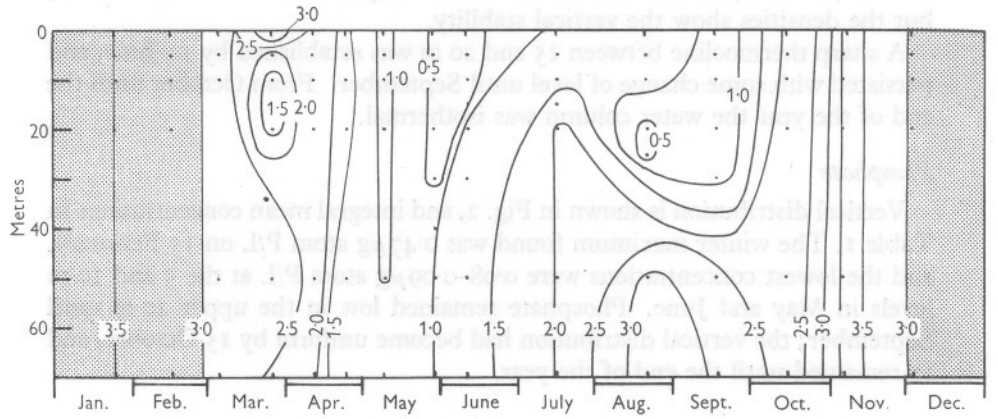

Fig. 3. Vertical distribution of silicate at International Hydrographic Station E1, 1957. Contour lines at 0·5 μg atom Si/l. intervals.

'Total phosphorus'

Determinations were made in January, February and March only, to find the winter maximum value. This was 0·63 μg atom P/l. on 15 February.

Silicate

Vertical distribution is shown in Fig. 3, and integral mean concentrations in Table 1. The maximum found at the beginning of the year was 3·5 μg atom Si/l. on 24 January. On the whole, higher silicon concentrations than usual were maintained during the year, as Table 1 shows. Values of less than 0·5 μg atom Si/l. were found only on 29 May and 11 June, above the thermocline, and, surprisingly, at 20 and 25 m on 21 August. These low values came between considerably higher ones in the water above and below, as shown in Table 3.

TABLE 1. INTEGRAL MEAN CONCENTRATIONS IN WATER COLUMN AT STATION E1, 1957

Date	Phosphate (μg atom P/l.)	'Total-P' (μg atom P/l.)	Silicate (μg atom Si/l.)	Ammonia (μg atom N/l.)	Inorganic N (μg atom N/l.)
24 Jan.	0·45	0·52	3·47	0·7	9·8
15 Feb.	0·47	0·63	3·35	—	9·6
5 Mar.	0·43	0·54	2·71	—	—
26 Mar.	0·31	—	2·30	0·7	1·7
11 Apr.	0·24	—	2·25	—	—
24 Apr.	0·21	—	1·22	—	—
9 May	0·16	—	1·07	—	—
29 May	0·20	—	0·72	1·1	2·6
11 June	0·18	—	1·03	0·7	1·6
16 July	0·30	—	1·83	—	—
21 Aug.	0·26	—	1·87	—	—
17 Sept.	0·31	—	1·62	1·2	6·9
15 Oct.	0·31	—	2·28	1·2	—
6 Nov.	0·44	—	3·58	—	—
3 Dec.	0·42	—	3·07	0·4	3·7

There was a significant fall in salinity in the upper 10 m between July and August. This may show that water at this level has been replaced by other of different chemical properties, for although phosphate fell, silicate rose slightly, at the same time. There were also slight changes in the composition of the bottom water, but the change of salinity here may not be a significant one, and the changes in phosphate and silicate could be put down to a normal regeneration of these nutrients. The data are insufficient to explain the curious vertical distribution of silicate.

Layering of water masses at this station (apart from the annually developed thermocline) has been found from time to time in the past 8 years, having been revealed by irregularities in the silicate figures. Occasionally, laminar as well as bodily displacements of water must occur at E1.

TABLE 2. OBSERVATIONS AT STATION E1, 24 APRIL 1957

Depth (m)	Temperature (° C)	Salinity (‰)	Density *in situ*	Phosphate (μg atom P/l.)	Silicate (μg atom Si/l.)
0	11·0	35·19	26·94	0·20	1·5
5	10·88	35·13	26·91	0·19	1·5
10	10·83	35·14	26·93	0·20	1·4
20	10·45	35·16	27·01	0·21	1·8
50	10·73	35·29	27·06	0·17	0·8
70	10·65	35·30	27·09	0·25	0·8

TABLE 3. OBSERVATIONS AT STATION E1, 16 JULY AND 21 AUGUST 1957

Depth (m)	Salinity (‰)		Phosphate (μg atom P/l.)		Silicate (μg atom Si/l.)	
	July	Aug.	July	Aug.	July	Aug.
0·5	35·13	35·12	0·11	0·11	1·2	1·6
5	35·16	35·10	0·15	0·09	1·3	1·4
10	35·17	35·08	0·14	0·10	1·3	1·4
15	35·18	—	0·36	—	1·7	—
20	35·20	35·16	0·34	0·12	2·0	0·2
25	—	35·16	—	0·14	—	0·3
50	35·20	35·17	0·33	0·43	2·0	3·2
70	35·21	35·18	0·34	0·42	2·0	3·3

Nitrogen

Enough analyses to draw an isopleth could not be done, and integral mean values only are given here. The vertical distribution did, however, resemble that for phosphate. The values (Table 1) in winter and summer resemble those obtained at E1 by other methods in earlier years (Cooper, 1933). The winter (maximum) ratio, N/P = 20/1 by atoms or 9·2/1 by weight, was a little higher than the 16 or 17/1 atomic ratio found in 1931 by Cooper.

Integral mean concentrations

The spring decreases representing consumption of nutrients were: phosphate 0·29 μg atom P/l., silicate 2·75 μg atom Si/l., inorganic nitrogen 8·0 μg atom N/l. The ratio N/P consumed was 27·6/1 μg atoms or 12·4/1 by weight and is rather higher than the mean ratio, 16·3/1, for a number of analyses of plankton from this area (Cooper, 1937).

SUMMARY

The results of analysis of sea-water samples from the International Hydrographic Station E1 during 1957 are given in graphical form and as integral mean values for the water column of 70 m. The seasonal variation shows the consumption of nutrients during the spring growth of plants to have been: phosphate 0·29 μg atom P/l., silicate 2·75 μg atom Si/l., inorganic nitrogen 8·0 μg atom N/l. At the time of winter maximum the N/P ratio was 20/1 by

atoms or 9·2/1 by weight. The ratio of these elements consumed was 27·6/1 by atoms or 12·4/1 by weight.

Unusual vertical distributions of silicate were found in April and August, and are attributed to laminar water movements.

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