

Dissolved organic matter in the sea*

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WE HAVE little real information about the nature and amount of dissolved organic matter in the sea, especially in deep water. Among the few recorded determinations of dissolved organic carbon the limited number made by KROGH (1934) have seemed to us to be perhaps the most reliable. We are but slightly better off in our knowledge about dissolved organic nitrogen. In addition to a few determinations made by KROGH (1934), some results reported by VON BRAND and RAKESTRAW (1941), using the same methods, may perhaps be regarded with confidence. On the basis of these limited data it would appear that the concentration of dissolved organic matter in the open sea is fairly constant at about 5 mg per litre.

KROGH's work, just referred to, was carried out with the extreme care and attention to detail which was characteristic of all his microchemical analyses, but because of its limited extent (his carbon results were obtained from six samples collected from a single station) it has long seemed to us highly necessary to corroborate and extend it. His methods have never been used again until very recently, when KAY (1954) used a modification to obtain results in the shallow waters of the Kielerbucht.

Accordingly, in the spring of 1953, we assembled apparatus essentially similar to KROGH's and carried out the analyses shown in Table I, on samples from three stations off the coast of Southern and Lower California. The results are shown graphically in Figure 1, along with curves for temperature and for oxygen at Station 110.70. Two important conclusions emerge:

The general level of concentration of dissolved organic carbon which KROGH reported (two to three milligrams per litre) was confirmed at these stations. However, instead of being homogeneously distributed it is definitely less at intermediate depths. The significance of this fact is not clear; the data are too limited to conclude that it is related to the location of the oxygen-poor layer. In any event, it throws some doubt upon certain of KROGH's conclusions.

In the fall of 1953, samples were obtained from two stations on the "Transpac" expedition in the north-western Pacific. The results from these are tabulated in Table II and graphically shown in Fig. 1. It will be seen that these are rather more irregular in the upper layers and that the general level of concentration is distinctly lower than at the earlier stations. All samples except that from 506 m at Station T-P 99 were analyzed in duplicate. The samples from these two stations were frozen immediately and kept in this condition until analyzed several months later. While this introduces some uncertainty it nevertheless seems unlikely that significant oxidation took place in the meantime. Deep-sea water has been preserved for much longer times and at higher temperatures without appreciable consumption of oxygen (RAKESTRAW 1947). KEYS, CHRISTENSEN and KROGH (1935) have also shown that the dissolved organic

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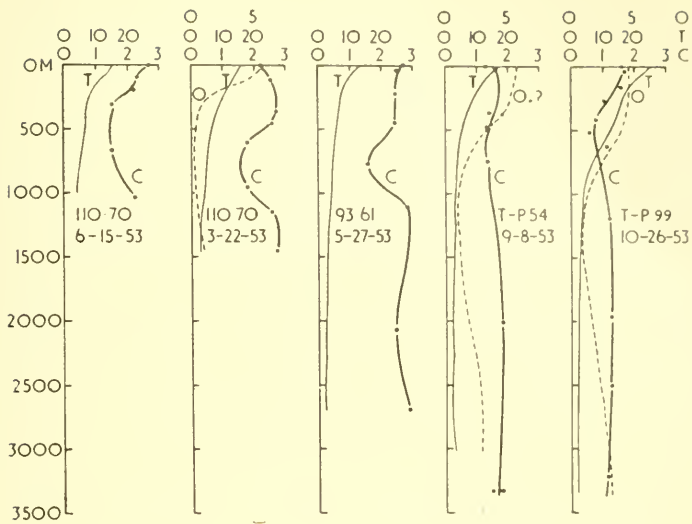


Fig. 1. Vertical distribution of dissolved organic carbon at two stations off the California coast (110.70 and 93.61) and two in the north-western Pacific (T-P 54 and T-P 99). Curves show carbon in mg/L (C), temperature °C (T) and dissolved oxygen ml/L (O).

Table 1.—Vertical distribution of dissolved organic carbon

Station	Location	Date	Depth (m)	Carbon (mg/L)	Temp. °C	Dissolved oxygen (ml/L)
110.70	28° 40' N 118° 20' W	6 15 53	0	2.68	16.14	
			99	2.30	13.51	
			195	2.20	9.65	
			317	1.50	8.16	
			665	1.49	5.55	
			1043	2.27	3.93	
110.70	,,	3 22 53	0	2.14	15.62	5.53
			104	2.58	13.96	5.17
			381	2.73	7.78	0.72
			470	2.59	6.90	0.43
			566	1.92	6.22	0.33
			759	1.41	5.09	0.32
			955	1.71	4.23	0.52
			1147	2.58	3.66	0.74
1487	2.73	2.96	1.10			
93.61	32° 50' N 119° 45' W	5 27 53	0	2.67	14.36	
			32	2.48	12.94	
			235	2.43	7.73	
			446	2.49	6.12	
			767	1.52	4.59	
			1092	2.76	3.69	
			2077	2.31	2.02	
2690	2.82	1.73				
100.90	29° 45' N 120° 50' W	4 28 53	3000	2.50	—	

matter is very resistant to bacterial action and does not change significantly during storage of water.

We are unable to find any other systematic analytical error which would account for such a large difference in the average concentration in the deep water. On the other hand, it is difficult to explain such a difference, since the phosphate concentration, for example, is approximately the same in the regions concerned. The dissolved organic carbon, although in lower concentration at all depths, is not uniformly distributed vertically, being less in the intermediate zone, as it was in the eastern Pacific. In this case, however, the zone of lower carbon concentration seems to be somewhat above the steep oxygen gradient.

It is important that we learn more about the dissolved organic matter, since it is the largest fraction of the total organic matter in the sea. Although for the most part it seems to be resistant and unreactive we do not know what relation it has to the "oxidizable organic matter" which plays an important part in the distribution of dissolved oxygen. The work reported here will be continued and extended.

Table II.—Vertical distribution of dissolved organic carbon

Station	Location	Date	Depth (m)	Carbon (mg/L)	Temp. (° C)	Dissolved oxygen (ml/L)			
T-P 54	40° 34' N 170° 2' E	9/8/53	0	1.29	19.2	5.67			
			10	1.66	19.0	5.34			
			273	2.72	8.9	4.94			
			366	1.42	7.0	4.56			
			371	1.87	7.0	4.54			
			464	1.47	5.8	3.70			
			469	1.34	5.7	3.68			
			753	1.37	4.3	1.35			
			758	1.37	4.3	1.37			
			2020	1.78	2.4	1.87			
			3340	1.80	1.9	3.40			
			3345	1.48	1.9	3.40			
			T-P 99	31° 55' N 142° 12' E	10/26/53	0	1.57	25.4	4.58
						24	1.72	25.0	4.56
153	1.57	19.2				4.41			
257	1.03	17.1				4.61			
406	0.78	15.3				4.21			
506	0.59	12.9				3.96			
607	1.18	10.3				3.65			
803	0.88	6.3				2.24			
1190	1.27	3.7				0.94			
1995	1.27	2.3				1.76			
2504	1.27	2.1				2.34			
3220	1.12	1.9				3.03			
4177	1.08	1.9				3.44			
5254	0.98	1.9				3.67			
6290	1.18	1.9				3.71			

REFERENCES

- KAY, H. (1954), Untersuchungen zur Menge und Verteilung der organischen Substanz im Meerwasser. *Kieler Meeresforschungen*, **10**, 202-214.
- KEYS, A., CHRISTENSEN, E. H. and KROGH, A. (1935), The organic metabolism of sea water with special reference to the ultimate food cycle in the sea. *J. Mar. Biol. Assn. U.K.*, **20**, 181-196.
- KROGH, A. (1934), Conditions of life at great depths in the ocean. *Ecol. Mongr.*, **4**, 430-439.
- RAKESTRAW, N. W. (1947), Oxygen consumption in sea water over long periods. *J. Mar. Res.*, **6** (3), 259-263.
- VON BRAND, T. and RAKESTRAW, N. W. (1941), The determination of dissolved organic nitrogen in sea water. *J. Mar. Res.*, **4** (1), 76-80.