DISTRIBUTION OF ORGANIC MATTER IN MARINE SEDIMENTS AND ITS AVAILABILITY TO FURTHER DECOMPOSITION*

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It has been shown, in previous contributions (*1*) from this Institution, that the organic matter of the marine bottom has a characteristic chemical composition, similar in many respects to the humus of field and garden soils. This organic matter is not inert but can undergo slow but gradual oxidation, a process shown (*2*) to be largely biological in nature. In shallower bottoms and closer to land, the organic matter was found to be oxidized more readily than that of deep seas. The non-nitrogenous constituents decomposed more readily than the nitrogenous substances, with the result that the carbon-nitrogen ratio of the organic matter tended to become narrower.

In the following experiments, an attempt has been made to extend the above studies, especially with reference to deep sea formations.

The muds used in these experiments were collected on the Oceanographic boats *Atlantis* and *Asterias*, by the use of a modified Ekman mud sampler, 3 inches in diameter and twenty four inches long. The cores of mud varied from 10 to 23 inches in length. The brass section of the mud sampler above the core tube was weighted with molded lead and fitted with a one way valve which prevented water from flushing out the mud as it was being hauled to the surface. The tube containing the mud was disconnected from the rest of the sampler and the mud forced upwards by a modified wooden ramrod which was fastened to the deck. If desired the bottom water directly above the mud with the very light brownish ooze which is ordinarily lost with other types of samplers could be siphoned into a jar and saved for chemical analysis and for oxidation studies. Ordinarily the mud was taken from the core tube in an undisturbed condition. The thin layer of mobile brownish ooze which was sometimes almost slimy was saved together with the highly viscous surface mud and included with the top section; the latter varied from one half to one inch in thickness.

The ramrod was fitted with a collar which could be lowered as desired thus preventing the mud from slipping out of the core tube. This permitted inspection of 3 to 4 inch layers of the mud while being removed. These sections were kept in clean glass jars until used. The sections which appeared to be high in organic matter or with an excess water were stored on ice.

* Contribution No. 238 of the Woods Hole Oceanographic Institution.

When brought to the laboratory, the mud was carefully mixed and representative portions suspended in definite volumes of aged sea water. Considerable shaking and stirring with a glass rod was required to suspend the mud. It is believed that this treatment satisfied at least for the moment the chemical affinity which certain marine muds are known to have for oxygen. Among the factors causing this phenomenon are extremely low oxidation reduction potentials, large amounts of hydrogen sulphide, as well as reduced or partly reduced iron present in the mud.

The sea water was collected at considerable distances from land in order to avoid terrestrial contamination. After filtering through several layers of fine silk cloth, the water was stored for at least a month in the dark, then aerated several times, and, after the oxygen reached an equilibrium, used as dilution water.

Aliquot portions of diluted mud were added to several 225 ml. oxygen bottles, as well as to dried filter paper; the latter were dried at 105° C. to ascertain the weight and moisture contents of the sample used. The oxygen bottles were carefully filled with aged sea water. Some of the bottles were analyzed for oxygen after 1 to 2 hours; others were incubated in a water bath in the dark for 5, 10 and 15 days; they were shaken daily for the first 5 days and then every other day. When ready for analysis, the supernatant liquid was siphoned into smaller 125 ml. oxygen bottles and Winkler reagents added. Only the 15 day results are reported in the Tables.

The organic carbon content of the mud was determined by a modification of the Schollenberger method (*1*). Since marine muds, especially the surface of the cores, contain considerable amounts of sea-water, silver sulphate was added to arrest decomposition of the NaCl by the chromic acid. All samples were analyzed in duplicate with and without the addition of silver sulphate. With this modified method, the carbon equivalents of the respective mud were found to be lower by a fraction of a milligram to a few milligrams except in those cases where the moisture content of the mud was very low; the carbon content was then about the same with and without the addition of silver sulphate. Nitrogen was estimated by the Kjeldahl method using potassium persulphate as a catalyst.

The muds used in this study came from 35 to 43 degress North Latitude and from 67 to 70 degrees West Longitude, varying in depth from a few meters to over 5,100 meters. The muds from the higher latitudes were covered with water of arctic origin, whereas the southern muds were covered with highly saline tropical water. Whenever possible, muds were collected in an undisturbed state, and divided into at least 3 sections: top, intermediate and bottom. The respective layers varied from one half to four inches in length. At other times cores were divided into their natural stratified layers. The availability of the organic matter in the mud was calculated on the basis of oxygen consumed per 1 gram of organic carbon in the mud.

Table I gives the results of top sections of cores collected at various distances from land. The sand, water sample and surface material of mud 158 were collected in Dr. Stetson's sand pans. The pans were weighted down so that they could not be easily moved and were fitted with a mechanical device that blocks off the opening into the pan as they are being hauled to the surface. A rope was attached to the pan and to a buoy so it could be found after being allowed to collect sand and silt for a day or so. The yield of sand in any one of these pans was rather small, so that a composite was made of the water and sand in several of these pans. The top water contained considerable amounts of light flocculent materials. This water was siphoned into oxygen bottles and oxygen determinations made after 5, 10, 15 and 34 days. It was found that 1.39 cc. of oxygen was consumed during the first 5 days, increasing to 1.66 cc. in 10 days and to 2.24 cc. per liter in 15 days; the latter figure held after 34 days. The supernatant liquid contained considerable flocculent material, in addition to a certain amount of fine sand; 195 cc. of oxygen were consumed per 1 gram of carbon in this material, while the sand consumed 260 cc. of oxygen per 1 gram of carbon present.

The organic carbon varied from 4.5 per cent in muds collected from Hadley Harbor, Naushon Island, to 0.5 per cent at considerable distance from land. The availability of the organic matter to bacterial decomposition is reported as cc. of oxygen utilized per 1 gram of carbon present in the mud. The oxygen consumption in 15 days varied from 260 cc., in sand collected near shore, to 23 cc. in mud collected at considerable distance from land. The availability of the organic matter in mud 9 containing 4.5 per cent organic carbon was only slightly greater than that of mud 135, which contained only 0.86 per cent carbon. Generally, however, the carbon became less available at greater depths and greater distances from land.

Table I indicates the type of record kept on muds collected off Nomans land. All sections of the respective cores were examined. For lack of space, certain intermediate sections of mud were not reported. These muds showed no significant differences from the layer above or below and served only as additional analysis or to indicate the trend, as determined by biological oxidation and by carbon and nitrogen content.

The first five muds were collected in the immediate vicinity of Woods Hole. Muds 42 to 78 are from Massachusetts Bay, in a line almost parallel to 43° North Latitude going east off the coast of Massachusetts and New Hampshire past the Isle of Shoals to a point about twenty five miles from land. Muds 91 to 111 are a line of stations going east from the northern part of Cape Cod Massachusetts. Muds 112 to 156 were collected along a line from Block Island, Rhode Island to within a hundred and fifty miles from Bermuda.

In order to obtain information on the effect of different types of organic

matter on bacterial decomposition, different sections of the same core were added to oxygen bottles and oxidation studies made. The rate and amount of oxygen consumed can be used as a measure of the availability of the organic matter in the mud. In considering the extent to which the organic matter was attacked by microorganisms only the 15 day period is reported.

One would ordinarily expect that the organic matter in the surface layer of the core would be most easily decomposed, the rate of decomposition gradually decreasing downwards. This was true in about half of the cores examined. In certain cases, as in samples 22, 24 and 25, the top and middle layers were equally available, oxygen consumption being 79 and 82 cc. respectively, whereas the intermediate layer consumed 107 cc. oxygen. In core 42, 44 and 45, the top was least resistant to oxidation, the intermediate most resistant, whereas the organic matter in the bottom layer was somewhat more available than the middle section.

In samples 62 to 66, it was necessary to remove the fine gravel before the mud could be suspended in water. In the top section 1000 cc. of oxygen were utilized per one gram of carbon. This is more than half the theoretical required for complete oxidation of all of the organic matter. This was nearly four times as great as the consumption of oxygen by the mud directly under it and about ten times that of most samples. It is quite probable that this sample of mud contained some fresh animal or fresh plant material.

In muds 91 to 95 the moisture was exceptionally low and the respective layers appeared to be rather homogeneous i. e., without evidence of stratification. The carbon content was rather uniform throughout the entire 15 inches, while the nitrogen decreased from 0.078 to 0.056 per cent in the bottom sample. The maximum oxygen consumption, 198 cc. per gram of organic carbon, occurred in the intermediate layer, it decreased to 86 cc. in the surface and 127 cc. in the bottom. Here again the organic matter which had been buried for some time under anaerobic conditions was two and one half times more easily decomposed than the carbon in the surface mud, while the organic complex in the bottom material was more available than the surface material but only 60 per cent as easily decomposed as the intermediate layer.

Samples 112, 114 and 118 were conspicuous because of the absence of decomposable organic matter below the 5 inch layer. The organic carbon in the top inch was twice as available as that in the next layer. The nitrogen content was uniform namely, 0.03 to 0.04 per cent throughout the core.

Samples 120, 126 and 127, one hundred ninety five miles from land and 2873 meters deep, were decidedly different from the muds 112–118, in that they contained considerable decomposable organic matter. The surface ooze consumed the greatest amount of oxygen.

Samples 142, 145 and 148 were 100 miles from land and 384 meters deep. The oxygen consumed increased from 23 cc. in the top material to 49 in the

8 to 12 inch section and to 105 cc. in the 19 to 23 inch layer. The 15 to 19 inch portion was a whitish clay, whereas the mud, both above and below this layer was sandy, that of the top being coarser than the bottom.

Mud 150 to 156 was in sight of Block Island and 67 meters deep. The top 1 inch layer consumed 55 cc., the 8–12 inch 102 cc. and the 12–16 inch 44 cc., increasing to 113 cc. at the bottom of the core.

Some idea may be gained concerning the nature of the different types of organic matter, if the amounts of oxygen consumed after 15 days are examined. The degree of oxidation depends on the availability of the organic matter. The spread of oxygen consumption is very great varying from zero to 1000 cc. per one gram of carbon present in the bottom sediment. If all the 131 samples tested are put in classes depending on their organic carbon content, it will be found (Figure 67) that there are two distinct groups of sediments. Twenty-five per cent of the muds contained between 0.67 and 0.99 per cent carbon, and 50 per cent contained 0.34 to 1.32 per cent carbon. The other large class of sediments contained 1.99 to 2.31 per cent of carbon, 26 per cent of the samples were within this range, whereas 38 per cent contained between 1.66 and 2.64 per cent carbon.

Similarly if the muds are classified according to the amount of oxygen consumed, it will be seen (Figure 67) that 29 per cent of the sediments utilized between 74 and 93 cc. of oxygen and 76 per cent utilized between 37 and 130 cc.

Since these curves are almost the antithesis of each other, it is apparent that there is no correlation between the amount of oxygen consumed and the amount of organic carbon present in the sediment, except when the carbon is low, namely below 0.3 per cent, when little or no oxygen will be utilized. According to theoretical calculations one gram of organic carbon will utilize 1,860 cc. of oxygen for complete oxidation to carbon dioxide. The oxygen consumption and carbon utilization have been calculated in terms of each other. If the oxygen consumption curve is interpolated in terms of per cent carbon utilization in the respective sediments, it is found that in the case of 29 per cent of the sediments, between 4 and 5 per cent of the carbon was oxidized and in case of 76 per cent 2 to 7 per cent of organic carbon was thus available.

Some idea of the rate of this oxidation may be gained if the oxygen utilization figures are averaged after 5, 10 and 15 days on the 131 samples on which complete oxidation studies were made. In 5 days, an average of 59 cc. of oxygen were utilized in 10 days 83 cc. and in 15 days 112 cc. corresponding to 3.2 per cent of the carbon in 5 days, 4.5 per cent in 10 days and 6.1 in 15 days.

Many of the muds reported in this investigation were analyzed by Waksman and Hotchkiss (*2*) in 1937. They reported the oxygen consumption per 1 gram of dry mud. These data have been recalculated to ascertain the

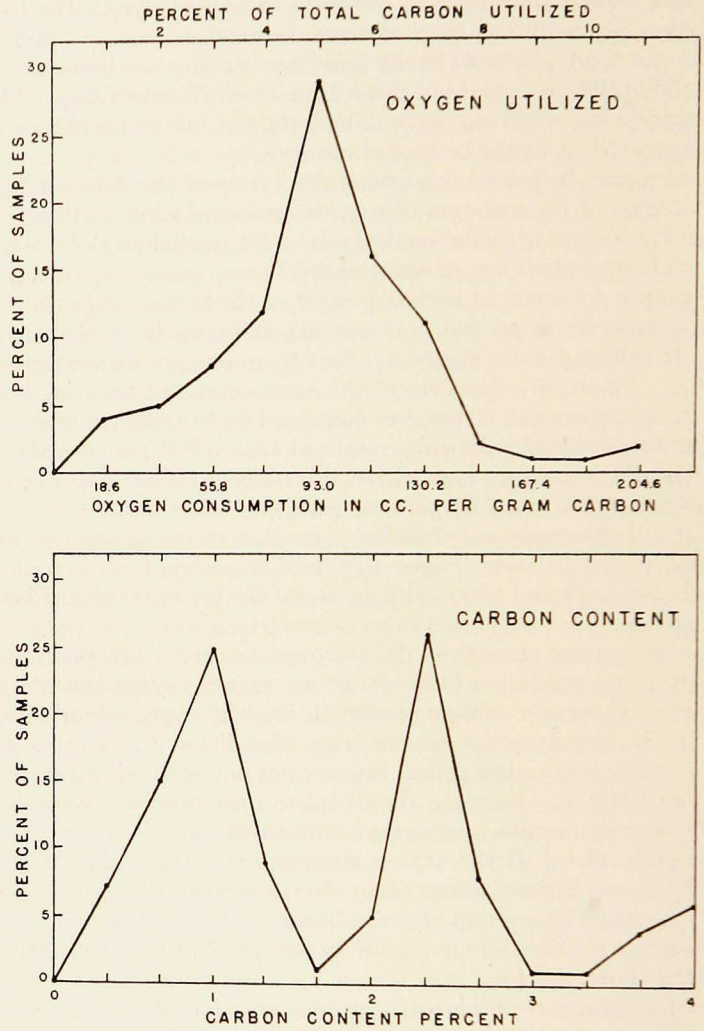

Figure 67. Oxygen consumption, carbon utilization and carbon content of marine mud.

amount of oxygen utilized per 1 gram of carbon present in the mud, compared with the muds collected from the same locality in this present investigation (1938), and reported in Table II. Since only the nitrogen content was reported for the 1937 data, the carbon content was calculated by using the factor 10 : 1. From an inspection of the data in Table I of this report

and from previous reports by Waksman and co-workers the ratio of carbon to nitrogen in most marine bottoms is between 8 : 1 and 12 : 1, a large majority of these being 10 : 1. Muds collected in 1937 and 1938, in a line of stations off the Isle of Shoals, in Massachusetts Bay, and off Cape Cod are compared in chemical composition and availability of the organic matter after 15 days oxidation. The location of these stations and nitrogen content are given in Table 9,[1] Vol. 1, page 114, Journal Marine Research, and are referred to here as station number. In case of Station 1, there was, in 1937, a decrease in oxygen absorption from top to bottom from 80 to 68 cc.; in 1938 (2 cores), there was a similar decrease from top to bottom from about 200 cc. to 92 cc. The nitrogen content of the two samples of 1937 mud was 0.193 and 0.139 per cent, whereas the nitrogen content of the samples taken in 1938 was only about half as large, decreasing from 0.090 and 0.114 at the surface to 0.072 and 0.024 in the bottom of the core.

In Station 2, the oxygen absorbed per 1 gram of carbon increased from top to bottom of the core, namely from 74 cc. to 86 cc. in 1937 and from 166 cc. to 238 cc. in 1938. Here again the surface material contained twice as much nitrogen in the 1937 samples than in the 1938 samples, whereas the bottom material contained about 18 per cent as much nitrogen as the sample collected in 1937.

The surface material in the mud from Station 3 collected in 1938 was very easily decomposed. One thousand cubic centimeters of oxygen were absorbed per 1 gram of carbon. The bottom material utilized 274 cc. of oxygen. In 1937 this mud utilized 70 cc. of oxygen in the surface material and increased to 96 cc. in the remainder of the core. Attention has already been called to the possible abnormality of the 1938 sample.

The mud from Station 4 (1937) increased in oxygen consumption from 47 cc. in the **A** layer to 105 cc. in the **B** layer; in 1938, the top layer utilized 137 cc., the intermediate 91 cc. and the bottom 36 cc. of oxygen. The nitrogen content of the surface material was almost the same during both years. namely 0.252 and 0.272 per cent, decreasing in 1937 in the **B** horizon to 0.192 and in 1938 to 0.136.

In Stations 6, 7 and 8, the organic matter collected in 1938 was more available than that collected in 1937, and was uniform throughout the entire core. Stations 9 to 12 were all from the same vicinity of a 99 fathom hole in Massachusetts Bay. In 1937, the nitrogen content of the top layer of the cores varied from 0.081 to 0.245 per cent. In other words, one sample of mud contained 3 times more than another sample a few meters away. Similarly the nitrogen content in the **B** layer varied from 0.051 to 0.228 per cent. The oxygen consumption per 1 gram of carbon present in the mud fluctuated from 8 to 106 cc. In 3 cases out of 4, the bottom material was

[1] Position reported W. Lat. N. Long. should have been N. Lat. W. Long.

more available than the top by about 2 times. In 1938, two cores were collected from this locality and analyzed. In general, there was a decrease in availability of the carbon from top to bottom. In one case, the middle layer was only half as available as either the top or bottom. One hundred seventy-nine cc. of oxygen were utilized in the top inch, 97 cc. in the 3–6 inch, and 224 cc. in the 10–15 inch section. In one sample the nitrogen decreased from 0.258 per cent in the top layer to 0.168 in the 9–15 inch layer; in another sample the decrease from top to bottom was from 0.126 to 0.040 per cent.

In Station 14, collected off Cape Cod in 1937, 77 cc. of oxygen were utilized in the **A** layer and 153 cc. in the **B** layer. In 1938 there was a similar increase in the availability of the organic carbon from top to bottom, namely 85 cc. in the surface material, 149 cc. in the 7–10 inch layer, and 127 cc. in the 10–15 inch layer. Fifty-four and 55 cc. of oxygen were utilized per 1 gram of carbon in the top and bottom layers of mud from Station 15 in 1937. In 1938, the oxygen consumption was somewhat higher but about the same range, namely 85 cc. in the top and 82 cc. in the 12–15 inch layer. In 1937, the nitrogen content was about the same throughout the core, whereas in 1938 the nitrogen decreased from 0.239 in the top to 0.183 per cent in the bottom layer.

In the mud collected from Station 16, there was an increase in oxygen absorption in the bottom material over the top, both years, namely from 47 cc. to 62 cc. in 1937, and from 64 cc. and 111 cc. in 1938. Here again, the nitrogen was uniform from top to bottom in the 1937 core, whereas, in the 1938, it decreased from 0.182 to 0.157 per cent from top to bottom. In 1938, more oxygen was absorbed per 1 gram of carbon present in the mud from Station 17 than in 1937. The 1938 sample showed a decrease from 111 cc. to 91 cc. in 16 inches, whereas in 1937 the oxidation of the mud increased from 45 cc. to 60 cc. oxygen in the **A** and **B** layer.

The amount of oxygen absorbed per 1 gram of carbon in 14 or 15 days was generally higher in 1938 than in 1937. In certain cases they compare favorably; in other cases the bottom mud was more available than the top one year, whereas the next year the top material was more available than the bottom. No explanation could be offered at present for these differences. Presumably, the experimental procedures were about the same both years. In 1937, the muds were collected in a glass tube about 15 mm. in diameter and the amount of material available for the respective experiments and for chemical analyses, particularly of the top material, was limited. In 1938, however, the muds were collected in a three inch core tube, ten to twenty times more material being thus collected, and should, therefore, be more representative. One may speculate further as to whether a small tube causes the light mobile surface material of the core to be pushed away from the cutting edge of the tube more easily than in the case of the larger tube.

More information is needed concerning the sedimentation of the bottom material and its chemical nature, before the significance of the oxidation of the organic matter can be interpreted.

The author is indebted to Dr. Bigelow and Dr. Renn for permission to use instrument for taking bottom cores and for assistance generously rendered in numerous ways, and to Dr. Waksman, for outlining the problem.

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TABLE I

CHEMICAL AND BIOLOGICAL ANALYSIS OF MARINE MUDS

Sample number	*Location*	*Depth, meters*	*Distance from land, miles*	*Layer, inches*	*Moisture, %*	*Carbon, %*	*Nitrogen, %*	*Ratio C/N*	*Oxygen consumed, cc. per 1 gm. carbon in 15 days*
9	Hadley Harbor	6	.02	0–2	72	4.50	.318	14.1	51
11	Hadley Harbor	6	.02	0–1	73	4.32	.350	12.2	66
13	Hadley Harbor			3–8	62	3.33	.252	13.3	47
22	Buzzards Bay	15	2.0	0–½	64	2.35	.220	10.6	79
24	Buzzards Bay			2–4	52	2.10	.195	10.8	107
25	Buzzards Bay			4–6	51	2.46	.197	12.5	82
1	Buzzards Bay	15	1.0	0–½	—	2.11	.220	9.6	82
27	Buzzards Bay	15	2.0	0–8	59	2.16	.262	8.2	62
158	Buzzards Bay	5	.1	water	100	—	—	—	2.2**
158	Buzzards Bay	5	.1	*	92	.73	.076	9.6	195
158	Buzzards Bay	5	.1	sand	15	.11	.020	5.6	260
42	42° 57′ N., 70° 31′ W.	83	11.7	0–2	62	.99	.114	8.7	219

* Supernatant liquid plus ooze.

** Oxygen consumed cc. per liter.

TABLE I continued on next page.

TABLE I—*Continued*

CHEMICAL AND BIOLOGICAL ANALYSIS OF MARINE MUDS

Sample number	Location	Depth, meters	Distance from land, miles	Layer, inches	Moisture, %	Carbon, %	Nitrogen, %	Ratio C/N	Oxygen consumed, cc. per 1 gm. carbon in 15 days
44	42° 57′ N., 70° 31′ W.			5–9	42	.35	.024	14.1	92
45	42° 57′ N., 70° 31′ W.			9–14	44	.46	.032	14.3	128
39	42° 57′ N., 70° 31′ W.	83	11.7	0–1½	60	.84	.090	9.3	195
52	42° 57′ N., 70° 27′ W.	100	14.8	0–1	54	.91	.100	9.1	166
62	42° 57′ N., 70° 25′ W.	100	16.2	0–1	65	.46	.062	7.4	1000
65	42° 57′ N., 70° 25′ W.			13–16	40	.30	.024	12.5	266
67	42° 57′ N., 70° 22′ W.	140	18.3	0–1½	72	2.26	.272	8.3	137
71	42° 57′ N., 70° 20′ W.	159	20.0	0–1	73	2.26	.272	8.3	130
76	42° 57′ N., 70° 18′ W.	164	21.5	0–1	71	2.31	.246	9.4	103
77	42° 57′ N., 70° 18′ W.			1–3	57	2.23	.212	10.5	143
78	42° 57′ N., 70° 18′ W.			9–12	57	2.20	.242	9.9	117
81	42° 59′ N., 70° 15′ W.	155	22.7	0–1	74	2.30	.271	8.5	112
86	42° 59′ N., 70° 12′ W.	175	24.9	0–1	68	2.35	.252	9.3	90
29	42° 30′ N., 70° 18′ W.	168	16.5	0–½	71	2.34	.258	9.1	95
34	42° 30′ N., 70° 18′ W.	160	16.5	0–1	68	1.16	.126	9.2	197
36	42° 30′ N., 70° 18′ W.			3–6	34	.67	.062	10.8	97
38	42° 30′ N., 70° 18′ W.			10–15	42	.48	.040	12.0	214
91	42° 00′ N., 69° 46′ W.	150	12.9	0–½	42	.60	.078	7.7	85
93	42° 00′ N., 69° 46′ W.			3–7	34	.57	.052	10.9	198
95	42° 00′ N., 69° 46′ W.			10–15	30	.66	.056	10.8	127
97	42° 01′ N., 69° 43′ W.	165	14.3	0–1	73	2.06	.232	8.9	111
107	42° 01′ N., 69° 38′ W.	210	17.9	0–1	68	1.78	.182	9.8	64
111	42° 01′ N., 69° 38′ W.			13–16	57	1.77	.157	11.3	111
102	41° 59′ N., 69° 41′ W.	168	13.6	0–½	73	2.02	.239	8.9	85
106	41° 59′ N., 69° 41′ W.			12–15	58	2.19	.183	11.9	82
157	40° 37′ N., 71° 38′ W.	67	30	*	92	.94	.144	6.5	110
150	40° 37′ N., 71° 38′ W.			0–1	62	1.14	.116	9.8	55
153	40° 37′ N., 71° 38′ W.			8–12	38	.56	.092	6.1	102
154	40° 37′ N., 71° 38′ W.			12–16	42	.10	.090	11.4	44
156	40° 37′ N., 71° 38′ W.			19–22½	34	.10	.076	13.2	113
149	40° 13′ N., 71° 27′ W.	85	55	0–8	51	.49	.046	10.7	119
142	39° 57′ N., 71° 11′ W.	384	100	0–1	70	1.30	.142	9.2	23
145	39° 57′ N., 71° 11′ W.			8–12	37	.87	.082	10.6	49
148	39° 57′ N., 71° 11′ W.			19–23	38	.80	.072	11.1	105
140	39° 39′ N., 70° 53′ W.	2285	120	0–½	54	.86	.106	8.1	40
128	39° 17′ N., 70° 28′ W.	2800	150	0–½	65	.94	.058	16.2	23
127	39° 00′ N., 70° 16′ W.	2873	195	*	89	.85	.054	15.8	132
120	39° 00′ N., 70° 16′ W.			0–1	69	.73	.083	8.8	23
126	39° 00′ N., 70° 16′ W.			16–19	53	.86	.072	11.9	80
119	35° 05′ N., 67° 05′ W.	5233	450	*	89	.86	.066	13.0	23
112	35° 05′ N., 67° 05′ W.			0–1	49	.57	.036	15.8	51
114	35° 05′ N., 67° 05′ W.			5–8	46	.33	.030	11.0	0
118	35° 05′ N., 67° 05′ W.			17–20	47	.24	.038	6.3	0

TABLE II

COMPARISON OF OXYGEN CONSUMPTION AND CHEMICAL COMPOSITION OF BOTTOM MATERIALS FROM A LINE OF STATIONS OFF MASSACHUSETTS BAY, ISLE OF SHOALS AND CAPE COD, COLLECTED IN 1937 AND IN 1938

Station No.	*Layer*	*1937 Carbon % (calc.)*	*Oxygen consumed[1] cc.*	*Section inches*	*1938 Nitrogen %*	*Carbon %*	*Oxygen consumed[1] cc.*
1	A	1.93	80	0–1½	.090	.84	195
				0–2	.114	.49	219
	B	1.39	68	5–8	.072	.68	94
				5–9	.024	.36	92
2	A	2.09	74	0–1	.100	.91	166
	B	1.73	86	9–12	.032	.44	238
3	A	1.38	70	0–1	.062	.46	1000
	B	.48	96	9–13	.018	.27	274
4	A	2.52	47	0–1½	.272	2.26	137
				4–8	.162	2.14	91
	B	1.92	105	8–14	.136	2.04	36
5	A	2.91	42	0–1	.272	2.26	130
				6–9	.218	2.38	91
	B	2.54	54	9–12	.224	2.35	115
6	A	3.06	33	0–1	.246	2.31	103
	B	2.72	46	9–12	.242	2.20	117
7	A	2.88	55	0–1	.227	2.30	112
	B	2.27	58	9–13	.210	2.17	107
8	A	3.26	57	0–1	.253	2.35	90
				8–12	.150	2.21	94
	B	.81	38	12–16	.168	2.17	108
9	A	.81	8				
10	A	1.79	49	0–½	.258	2.34	95
				2½–5	.172	1.99	81
	B	.51	92	9½–15	.168	1.98	82
11	A	1.62	51	0–1	.126	1.16	197
				1–3	.124	1.00	81
	B	1.76	106	3–6	.062	.67	97
				6–10	.042	.63	112
12	A	2.45	54	10–15	.040	.48	204
	B	2.11	69				
14	A	.81	77	0–½	.078	.60	85
				7–10	.050	.69	149
	B	.47	153	10–15	.056	.66	127
15	A	2.60	54	0–½	.239	2.02	85
	B	2.61	55	15–15	.183	2.19	82
16	A	2.33	47	0–1	.182	1.78	64
	B	2.34	62	13–16	.157	1.77	111
17	A	2.26	46	0–1	.232	2.06	111
	B	2.04	60	12–16	.182	1.85	91

[1] Per 1 gram of carbon present in mud, in 14 days in 1937, and in 15 days in 1938.