Reports

Oceanic Detritus

Abstract. The quantity and chemical composition of oceanic detritus in the northeastern Pacific Ocean has been measured at different depths from the surface to 3000 meters. The results indicate that oceanic detritus must be considered as a source of food for secondary producers.

In 1939 W. E. Allen commented on the large amount of organic particulate debris or detritus which he found in a sample of sea water taken at oceanic stations in the northeastern subtropical Pacific (*1*). The amount of detritus was reported in some cases to exceed the combined proportion of animal and plant life, and the author suggested that detritus may serve as a source of food for some of the smaller zooplankton. Since then, appreciable amounts of detritus have been shown to be present in other oceanic areas (*2, 3*). The importance of this material as a source of food for secondary producers must depend on its abundance, composition, and distribution throughout the depths of the oceans. In the following report some analyses are given for sea water samples taken at several stations and at different depths in the northeastern subarctic Pacific Ocean.

Samples were collected from different depths in Van Dorn bottles. Particulate material was separated by filtration onto Millipore AA filters coated with magnesium carbonate, and analyses were performed as previously described (*4*). The nitrogen-to-protein conversion factor of 6.25 has been employed to demonstrate the order of magnitude of nitrogenous organic material in the detritus. A fuller investigation of the type of compounds involved, some of which may not be proteins, may require subsequent revision of the factor.

Table 1 shows the distribution of particulate organic material at three ocean stations. The concentration of particulate carbon found above the permanent pycnocline (approximately 100 to 200 m in this region) was 4 to 5 times greater than that found below it. This high proportion of particulate organic material in the euphotic zone cannot be attributed to the presence of phytoplankton. As was shown earlier (*2*), only about 15 percent of the particulate carbon in the euphotic zone of the northeastern Pacific can be attributed to living plant material. The amount of particulate carbon at 3000 m was not appreciably different from that at 300 to 500 m. At 1500 m, however, there appeared to be rather less particulate carbon than at the greater depths. The amount of protein, determined from nitrogen content, was greater than the amount of carbohydrate at all depths.

A more detailed analysis was made of the particulate material taken from composite samples at a depth of about 400 m. The detritus was concentrated by continuous centrifugation of approximately 150 liters of sea water. The amino acid, monosaccharide, and hexuronic acid contents of a hydrolyzate of the whole material were determined by paper chromatographic methods (*5*). Glucosamine, "crude fiber," and fat were determined as described previously (*4*). "Crude fiber," as reported here, represents the acid- and alkali-insoluble carbohydrate as determined by the anthrone reaction (*4*).

Glucose, galactose, mannose, arabinose, and xylose were the only sugars detected in an acid hydrolyzate of the detrital material. Glucose was the predominant sugar, being present to the extent of 50 percent of the total carbohydrate. Glucosamine and hexuronic acids were not detected in the acid hydrolyzate, which indicated an absence of appreciable amounts of chitin from crustaceans or hexuronides from marine plants, respectively. The crude fiber was found to be 70 percent of the total carbohydrate, which is a large amount when contrasted with an average value of about 15 percent obtained for pure cultures of phytoplankton cells (*6*). The amount of fat present in the detritus was less than 1 percent of the total organic matter. The amino acids detected by paper chromatography of an acid hydrolyzate of the material were characterized by a predominance of glycine and alanine. Glutamic acid, aspartic acid, lysine, arginine, serine, and proline were also detected. The recovery of total protein, determined by nitrogen analysis, in terms of the amino acids that were detected, was about 60 percent.

The principal conclusion that may be drawn from these findings in the northeastern subarctic Pacific is that the organic detritus is composed of a sufficiently diverse group of compounds to serve as a potential source of food for marine organisms. The existence of deep pelagic detritus feeding zooplankton has not been demonstrated to date. However, it is not unreasonable to suppose that at least those secondary producers that live at great depths would depend, either directly or indirectly, on detritus as a source of food. An indirect dependence on detritus might involve the growth of bacteria on detrital particles.

Table 1. Distribution of particulate organic material.

Depth (m)	Carbon (mg/m³)	Carbohydrate as glucose (mg/m³)	Protein, $N \times 6.25$ (mg/m³)
Lat. 48° 57′ N, long. 132° 30′ W, July 1961			
15–35	254	98	294
500	46	63	112
1500	32	21	98
3000	44	44	87
Lat. 51° 27′ N, long. 133° 20′ W, July 1961			
500	76	44	131
1500	40	25	110
2700	54	52	56
Lat. 50° 00′ N, long. 145° 00′ W, July 1961			
10	196		
55–65	150	131	144
300	53	63	100
1500	36	27	61
3000	68	27	31
Lat. 50° 00′ N, long. 145° 00′ W, August 1959			
0–50	160		
1000	70		

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Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to contributors" [*Science* **125**, 16 (1957)].

In the latter instance, it is apparent that marine bacteria are capable of attacking the less readily hydrolyzed polysaccharides and proteins of which detritus is undoubtedly composed (*7*).

The total quantity of detritus beneath a square meter of sea surface appears to be at least 500 g of dry organic material. Judging from the chlorophyll content of the water, only about 1 g of this can be attributed to living plant material. There is no obvious decrease in the amount of detritus or its protein content with depth after the first few hundred meters. Visual inspection gives little indication of the nature of the material although it is probably predominantly animal in origin.

The role of detritus in the marine food chain in this part of the ocean and in other open ocean areas of the world requires further investigation.

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Insect Neurosecretory Material Separated by Differential Centrifugation

Abstract. The factor which accelerates the beating of the insect heart was found to be concentrated in a "large granule" fraction of the corpora cardiaca of the cockroach, *Periplaneta americana* (L.).

In a number of insect species, aqueous extracts of the corpora cardiaca have been shown to contain one or more factors which can markedly accelerate the heartbeat (*1*). Recent evidence indicates that the active factor may be a protein or a peptide (*2*). The object of the present investigation was to study the intracellular localization of this factor in the corpora cardiaca (*3*).

Corpora cardiaca, excised in the cold from adults of *Periplaneta americana* and dissected free of the corpora allata and other attached tissue, were rinsed and then accumulated in cold 0.4*M* sucrose. The corpora cardiaca from groups of 15 donors were homogenized in 0.2 ml of the sucrose solution, and then differentially centrifuged in 0.75-ml tubes, according to the schedule used by Blaschko *et al.* (*4*) for the mammalian adrenal medulla.

The milky homogenate was first spun for 10 minutes at 600*g*. The resulting supernatant was removed and recentrifuged for 20 minutes at 11,000*g*. The second centrifugation consistently yielded a compact bluish-white pellet (corresponding to Blaschko's "large granule" fraction). All of the centrifugations were carried out at about 2°C. For purposes of assay, each pellet was dispersed in an amount of sucrose solution identical in quantity and composition to that making up its supernatant. Each resuspended pellet and each supernatant was added to 3 ml of Yeager's saline (*5*), and frozen at −20°C until assayed.

Adult females of *P. americana* were used for the biological assay (*6*). The dorsal body wall, along with the attached heart, was placed in Yeager's saline in a tubular chamber (capacity 6 ml) adapted for perfusion and aeration. When the heart was beating at a steady rate, 1 to 2 ml of the test solution was introduced into the chamber with a hypodermic syringe. The heartbeat was then counted during alternate half-minute intervals until its increased rate had leveled off or started to decrease.

After the initial 600*g* centrifugation, heart-accelerating factor was found both in the supernatant and, in varying amounts, in the sediment. Centrifugation of this supernatant at 11,000*g* resulted in a sediment whose activity was markedly greater than that of either its own supernatant or the 600*g* sediment. Protein-nitrogen determinations (*7*) indicated that 10 to 70 percent more protein was present in the 11,000*g* supernatant than in the sediment, implying that activity in the sediment was not only greater but more concentrated.

The stability of the particulate localization of the factor was tested over short periods at various hydrogen ion concentrations. Sucrose (0.4*M*) was adjusted to each *p*H by the incorporation of various $10^{-2}M$ buffers, or by the addition of potassium hydroxide or hydrochloric acid. The pellet derived from the 11,000*g* centrifugation was resuspended in one of these solutions and recentrifuged at 11,000*g* for 20 minutes. The phases were then separated and tested as described above. The hypothetical particles appeared to be stable in sucrose within the *p*H range 6.2 to 9, but to lose the factor more or less completely to the supernatant at *p*H 3, 5, and 11. This sensitivity to acid conditions parallels that demonstrated for particles containing catecholamine from the adrenal medulla (*8*), for lysosomes from the mammalian liver (*9*), and for cytoplasmic granules from the rabbit polymorphonuclear leukocytes (*10*).

Several other highly active intracellular materials have been shown to be bound to particles, and current evidence suggests that these particles may often be identical with the electron-dense, membrane-limited vesicles conspicuous in electron micrographs of many neurosecretory and other organs (*11*). Such neurosecretory vesicles are plentiful in electron micrographs of cockroach corpora cardiaca (*12*), and also in electron micrographs which were made of their large granule fraction, obtained as described above by a single centrifugation at 11,000*g*. The vesicles appeared however to make up no more than about 40 percent (by volume) of the pellet. The color of this pellet is significant, since the bluish-white appearance of the corpora cardiaca themselves has frequently been attributed to their neurosecretory function. Moreover, Hodgson and Geldiay (*13*) were able to demonstrate a correlation between the disappearance of histologically detectable neurosecretory material from cockroach corpora cardiaca and the disappearance from the same organs of a factor capable of depressing the spontaneous nervous activity of the central nerve cord of the cockroach. The present work supports previous indications that the heart-accelerating factor of the corpora cardiaca is associated with neurosecretory vesicles.

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