THE ECOLOGY OF THE PLANKTON
OF THE CHESAPEAKE BAY

PROGRESS REPORT

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1. *Swift, D. G. and W. Rowland Taylor. 1974. Growth of Vitamin B-12 limited cultures: Thalassiosira pseudonana, Monochrysis lutheri and Isochrysis galbana. Jour. of Phycology. 10: 385-391.
2. **Taft, J. L. and W. Rowland Taylor. 1975. Phosphorus distribution in the Chesapeake Bay. Chesapeake Science, in press.
3. **Taft, J. L., W. Rowland Taylor and J. J. McCarthy. 1975. Uptake and release of phosphorus by phytoplankton in the Chesapeake Bay estuary. Submitted to Marine Biology
4. **Storms, S. E. 1974. Selective feeding, ingestion and assimilation rates, and distribution of the copepod Acartia in Chesapeake Bay. Ph.D. thesis. Johns Hopkins University. 162 pp.
5. **Taft, J. L., M. E. Loftus and W. Rowland Taylor. 1975. Kinetics of phosphate uptake from phosphomonoesters by phytoplankton in the Chesapeake Bay. Manuscript in preparation for Limnology and Oceanography.

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6. **Taft, J. L. 1975. $^{14}\text{CO}_2$ recovery at high gas flow rates from a CHN analyzer. Note in preparation for Limnology and Oceanography.

*Reprints included with this report.

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1. GENERAL INTRODUCTION

This continuing project is concerned with a comprehensive study of the Chesapeake Bay estuarine system. It includes the entire estuary over all seasons, it involves studies of both phytoplankton and zooplankton, and it combines field and laboratory work. Both chemical and physical measurements are being made concurrently with the biological measurements. There has been a considerable amount of valuable research on the estuary's plankton from the University of Maryland's Chesapeake Biological Laboratory (Solomons, Md.), the Virginia Institute of Marine Science (Gloucester Point, Va.) and the Chesapeake Research Consortium field station on the Rhode River. However, these studies have tended to be local in character in that the work has been mostly limited in the area of study to the immediate environment near those laboratories. To our knowledge, this research project is the only plankton study of the entire Chesapeake Bay that has been attempted.

The Chesapeake Bay is a partially mixed coastal plain estuary. Its physical circulation and mixing patterns have been described by Pritchard (1967, 1968). Carpenter et al. (1969) have reported on the spatial and temporal variations of the major inorganic nutrients in the northern half of the bay, while Schubel (1969) has described the behavior of the suspended sediments in much of the same area.

Our research on the estuarine phytoplankton has involved an extensive program of measuring primary productivity. A series of 12 stations along the longitudinal axis of the Chesapeake Bay were visited on a

monthly basis over a two-year period. The rate of photosynthesis was measured by the carbon- 14 uptake method described by Strickland and Parsons (1972) using a simulated in situ incubation technique. During the early cruises, the ^{14}C was assayed with a gas flow counter, but the assay time and precision were improved when a scintillation counting system was placed in use. Total available inorganic carbon for the productivity measurements was obtained by gas chromatography using helium carrier and a Fisher Gas Partitioner. During a few incidents of instruments failure, total inorganic carbon was calculated from titration alkalinity determinations. Incident sunlight was continually monitored with an Epply phyheliometer, while light through the water column was measured with a submersible photometer. All of the computations for the primary productivity measurements have been completed and checked. We are still in the process of analyzing this mass of data in the hopes of constructing a model, but this procedure has taken more time than was anticipated. The nutrient analyses on water samples collected concurrently with productivity measurements are completed and a data report will be available in the near future.

During the past year we have continued studies of the recycling rates of the various forms of phosphorus and our progress is reported in Section 2 of this document. Concurrent with these studies, we are conducting a study of the nitrogen recycling but the analyses of samples already collected is being delayed while a new method of ^{15}N recovery is developed. This latter work is being supported by the National Science Foundation.

The results of the zooplankton feeding experiments are included in Section 2 of this report. This aspect of secondary productivity follows logically from our primary productivity studies and, when combined with a distribution which we have previously completed, should give a reasonable indication of the transfer of energy from the producers to the dominant herbivores.

Literature Cited

- Carpenter, J. H., D. W. Pritchard and R. C. Whaley (1969). Observations of eutrophication and nutrient cycles in some coastal plain estuaries. In: Eutrophication: causes, consequences, correctives. pp. 201-221, National Academy of Sciences, Washington, D. C.
- Pritchard, D. W. (1967). Observations of circulation in coastal plain estuaries. In: Estuaries, pp. 34-44. Ed. by G. H. Lauff. Amer. Assoc. Adv. Sci., Washington, D. C.
- Pritchard, D. W. (1968). Chemical and physical oceanography of the Bay. In: Proceedings of the Governor's Conference on Chesapeake Bay. 11-13 Sept. 1968, Session II, pp. 49-74. Wye Institute, Wye, Maryland.
- Schubel, J. R. (1969). Distribution and transportation of suspended sediment in the upper Chesapeake Bay. 29 pp. Ches. Bay Inst. Tech. Rept. 60, Ref. 69-13.
- Strickland, J. D. H. and T. R. Parsons (1972). A practical handbook of seawater analysis. Bulletin 167, 2nd edition, Fisheries Research Board of Canada.

2. Release of Dissolved Organic Carbon by Phytoplankton from the Chesapeake Bay

Introduction

The release of newly formed organic carbon by "healthy" phytoplankton has been of concern because it leads to underestimation of primary productivity as measured by the ^{14}C method (Fogg, 1958; Eppley and Sloan, 1965, for example). Phytoplankton release newly fixed organic carbon in culture (Tolbert and Zill, 1956; Hellebust, 1965; Fogg and Watt, 1965) and in natural waters (Figg and Nalewajko, 1964; Watt, 1966; Anderson and Zeutschel, 1970; Thomas, 1971). In addition, glycolic acid has been recovered from natural waters (Shah and Wright, 1974).

Filtrates from ^{14}C incubations conducted during the "AESOP" program have been analyzed by the method of Thomas (1971) to assess the error in the ^{14}C uptake method. The results for these short term incubations indicate that release of newly fixed carbon is small (2 to 7%) in relation to carbon fixed. However, no data was collected in the dark or at other time intervals following incubation with ^{14}C .

The release of new organic carbon has obvious ecological significance. The primary producers may support some heterotrophic members of the community without themselves being consumed. Dissolved organic compounds are important to heterotrophic microorganisms as well (Wright and Hobbie, 1965; Williams, 1970; Williams and Gray, 1970; Andrews and Williams, 1971). Microzooplankton regenerate nutrients at increasing rates per unit biomass as the mass of the individual animal decreases, but most of the smallest animals (ciliates, other protozoans and small metazoans) probably cannot ingest most whole phytoplankton cells so they must consume cell fragments and bacteria as dietary staples.

Released photosynthate then may contribute to the support of these animals, via bacterial heterotrophy.

It has generally been observed that excretion of photosynthate in natural waters increases with decreasing nutrient availability. Thomas (1971), for example, observed that the percent of photosynthate released increased on a transect from the Georgia coast to the oligotrophic Sargasso Sea. But higher absolute values for release were observed in productive waters by Anderson and Zeutschel (1970). In that study there was little relationship between organic matter release and nutrients, as measured by nitrate. However, a direct, but non-linear, relation existed between the production of organic matter and the release of photosynthate.

Information in the literature suggests that release of newly fixed carbon could be a significant process in Chesapeake Bay because the Bay is both highly productive and subject to low inorganic phosphate concentrations during much of the year. Furthermore, the phosphorus dynamics study just completed suggests that ample phosphate is present in the euphotic zone to sustain limited carbon fixation even when population growth is severely reduced.

Status

Since the beginning of the current contract period we have received and brought into operation the Perkin-Elmer Model 240 elemental analyzer to process freeze-dried seawater samples by the method of Gordon and Sutcliffe (1973). This instrument is the primary tool for carbon analysis and for preparation of dissolved organic carbon-14 samples for scintillation counting. The method developed here for the latter process is described in Section 2, Document No. C00-3279-15. To date

two cruises have been conducted (November 1974 and February 1975) and samples from these cruises are now being analyzed. Spring and summer cruises are scheduled so data from this portion of the program will be reserved until all analyses are completed.

To gain familiarity with the instrument last fall, phytoplankton samples collected during December 1972 to November 1973 were analyzed for particulate carbon and nitrogen. These data are presented in Tables 1 and 2 and particulate atomic ratios of carbon to nitrogen are shown in Table 3. No comment about the data will be made at this time because a manuscript is being prepared which will discuss distribution of particulate C, N, Chlorophyll a, ATP and particle volumes.

Table 1. Particulate carbon in Chesapeake Bay during December 1972 to October 1973. $\mu\text{g C liter}^{-1}$.

Station	December	February	April	June	August	October
904N	-	1465	822	1825	2063	621
853F	707	1255	1897	860	1432	816
834G	755	865	1042	728	767	1100
818P	764	1104	1166	758	1271	552
804C	1037	1253	769	841	1105	733
744	678	999	1046	743	1359	664
724R	-	836	774	587	1114	718
707Ø	497	974	-	626	836	591
Ø707V	-	602	406	499	239	479

Table 2. Particulate Nitrogen in Chesapeake Bay during December 1972
to October 1973. $\mu\text{gat N liter}^{-1}$.

Station	December	February	April	June	August	October
904N	-	15.4	7.9	23.4	27.4	11.2
853F	8.1	9.1	27.1	11.6	19.6	12.9
834G	9.6	13.2	14.1	8.4	11.7	11.0
818P	8.2	15.6	12.3	9.8	19.7	9.1
804C	10.9	11.9	10.2	12.4	15.0	12.4
744	10.0	12.1	12.8	10.4	17.9	8.9
724R	-	11.1	10.9	8.1	13.1	8.7
707Ø	6.8	13.1	-	7.7	11.5	7.5
Ø707V	-	7.2	6.4	3.0	2.8	4.4

Table 3. Carbon to Nitrogen Atomic Ratios for Phytoplankton in Chesapeake Bay during December 1972 to October 1973.

Station	December	February	April	June	August	October
904N	-	7.9	8.6	6.5	6.3	4.6
853F	5.6	11.5	5.8	6.2	6.1	5.3
834G	6.6	5.5	6.2	7.3	5.5	8.3
818P	7.8	5.9	7.9	6.5	5.4	5.0
804C	8.0	5.7	6.3	5.6	6.1	4.9
744	5.6	6.9	6.8	6.0	6.3	6.2
724R	-	6.3	5.9	6.0	7.1	6.9
707Ø	10.0	5.7	-	6.8	6.1	6.6
Ø707V	-	7.0	5.3	13.9	7.1	9.0

Literature Cited

- Anderson, G. C. and R. P. Zeutschell. 1970. Release of dissolved organic matter by marine phytoplankton in coastal and offshore areas of the northeast Pacific Ocean. *Limnol. Oceanogr.* 15: 402-407.
- Andrews, P. and P. J. LeB. Williams. 1971. Heterotrophic utilization of dissolved organic compounds in the sea. III. Measurement of the oxidation rates and concentrations of glucose and amino acids in sea water. *J. Mar. Biol. Ass. U. K.* 51: 111-125.
- Eppley, R. W. and P. R. Sloan. 1965. Carbon balance experiments with marine phytoplankton. *J. Fish. Res. Bd. Can.* 22: 1083-1097.
- Fogg, G. E., 1958. Extracellular products of phytoplankton and the estimation of primary production. *Rapp. P-V Reun. Cons. Perm. Int. Explor. Mer.* 144: 56-60.
- Fogg, G. E. and C. Nalewajko. 1964. Glycollic acid as an extracellular product of phytoplankton. *Verh. Internat. Verein. Limnol.* 15: 806-810.
- Fogg, G. E. and W. D. Watt. 1965. The kinetics of release of extracellular products of photosynthesis by phytoplankton. pp. 167-174. In C. R. Goldman (ed.), Primary Productivity in Aquatic Environments. Mem. Ist. Ital. Idrobiol., 18 Suppl. University of California Press, Berkeley.
- Gordon, D. C. and W. H. Sutcliffe. 1973. A new dry combustion method for the simultaneous determination of total organic carbon and nitrogen in sea water. *Marine Chemistry* 1: 231-244.
- Hellebust, J. A. 1965. Excretion of some organic compounds by marine phytoplankton. *Limnol. Oceanogr.* 10: 192-206.

- Shah, N. M. and R. T. Wright. 1974. The occurrence of glycollic acid in coastal sea water. *Mar. Biol.* 24: 121-124.
- Thomas, J. P. 1971. Release of dissolved organic matter from natural populations of marine phytoplankton. *Mar. Biol.* 11: 311-323.
- Tolbert, N. E. and L. P. Zill. 1956. Excretion of glycollic acid by algae during photosynthesis. *J. Biol. Chem.* 222: 895-906.
- Watt, W. D. 1966. Release of dissolved organic material from the cells of phytoplankton populations. *Proc. Roy. Soc. Ser. B* 164: 521-551.
- Williams, P. J. LeB., 1970. Heterotrophic utilization of dissolved organic compounds in the sea. I. Size distribution of population and relationship between respiration and incorporation of growth substrates. *J. Mar. Biol. Ass. U. K.* 50: 859-870.
- Williams, P. J. LeB. and R. W. Gray. 1970. Heterotrophic utilization of dissolved organic compounds in the sea. II. Observations on the responses of heterotrophic marine populations to abrupt increases in amino acid concentration. *J. Mar. Biol. Ass. U. K.* 50: 871-881.
- Wright, R. T. and J. E. Hobbie, 1965. The uptake of organic solutes in lake water. *Limnol. Oceanogr.* 10: 22-28.

2. Potential Errors in the Measurement of Dissolved Organic Nitrogen in Sea Water.

Introduction

It was reported in a previous Progress Report (Document No. COO-3279-06, Section 1, Part 2) that the UV oxidation technique for dissolved organic nitrogen (DON) in Chesapeake Bay yielded values which appeared to be low. The method was influenced by the concentrations of inorganic nitrogen in the sample and it was found that nitrogen conversion to ($\text{NO}_2 + \text{NO}_3$) could be increased by diluting the sample with distilled water.

Acquisition of the Perkin-Elmer Model 240 elemental analyzer permits us to compare the UV oxidation technique with high temperature dry combustion. Preliminary results of this comparison are presented here along with a brief discussion of the problems associated with DON measurement in the CHN analyzer.

Method

Sea water samples were analyzed for dissolved N by the method of Gordon and Sutcliffe (1973). Since nitrate is a predominant ion in Chesapeake Bay during spring and early summer, artificial sea water was spiked with 0, 5, 10, 30 and 100 μg at $\text{NO}_3\text{-N}$ liter and processed as above to test for nitrate recovery. Frozen samples from one station in the "AESOP" series (Station 744, August 13, 1970) were thawed and processed as above.

Results

Data in Table 1 show that about 70% of the added $\text{NO}_3\text{-N}$ was detected by the Model 240. Increasing combustion temperature from 700°C to 950°C did not improve recovery.

Table 2 contains the data for Station 744. Sea water samples from Station 744 contained $<3 \mu\text{gat liter}^{-1}$ total inorganic nitrogen so this fraction was ignored as insignificant compared to the precision achieved. Although precision was poor, mean recoveries are similar to DON values found at 744 in August 1969 (Table 5, Part 2, Section 1, Document No. C00-3279-06) when those samples were diluted 1:5 prior to UV oxidation. At present we cannot compare the methods directly on the same sample but this will be accomplished in the near future with freshly collected sea water.

Dry combustion gives values for DON which are much higher than previously reported for undiluted Chesapeake Bay water. However, the combustion method is apparently subject to incomplete $\text{NO}_3\text{-N}$ recovery which suggests that other inorganic nitrogen sources may also be incompletely oxidized. In addition to checking these potential errors, we plan to directly compare the effect of dilution on N recovery with both UV and high temperature oxidation techniques.

Table 1. Recovery of Nitrate-Nitrogen from artificial sea water.

$\text{NO}_3\text{-N added}$ $\mu\text{gat N liter}^{-1}$	N recovered $\mu\text{gat N liter}^{-1}$	% Recovery
0	33.4	
	33.3	
	32.1	
5	0	0
10	12.2	122
30	20.9	
	22.3	72
	22.0	
100	68.4	68

Table 2. Nitrogen recovered by high temperature combustion of lyophilized sea water from Station 744, August 13, 1970.

Vial #	N recovered $\mu\text{gat N liter}^{-1}$	Mean N per vial $\mu\text{gat N liter}^{-1}$
<u>Surface</u>		
64	68.9	58.9
	48.9	
65	52.3	54.4
	56.4	
66	40.4	47.3
	54.1	
67	39.1	45.5
<u>0.5 m</u>		
61	83.9	90.7
	97.5	
62	133.7	90.7
	47.7	
63	51.7	62.4
	73.1	

Literature Cited

Gordon, D. C. and W. H. Sutcliffe. 1973. A new dry combustion method for the simultaneous determination of total organic carbon and nitrogen in sea water. Marine Chemistry 1: 231-244.