RESPIRATION AND VERTICAL CARBON FLUX FROM WATER COLUMN ETS ACTIVITY

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Abstract

Carbon fluxes were calculated by integrating water column respiration from 30, 50 and 100 m to the bottom in the Gulf of Maine. These fluxes were 3, 2, and 1 μ mol C min^{-1} m^{-2}. Profiles of respiration ranging from 10 to 680 p mol O_2 L^{-1} min^{-1} over water columns as deep as 275 m were best described by power functions. Respiration correlated well with seawater turbidity and chlorophyll.

Keywords: electron transport, CO2 production, O2 consumption, metabolism

Carbon flux in the ocean can be calculated directly from sediment trap measurements and indirectly from models, the $^{234}Th/^{238}U$ method, and the vertical profile of plankton respiration (R). We integrate respiration depth profiles (R = f (z)) to calculate carbon flux (F). $F = \int R\, dz = \int f(z)\, dz$. The calculations do not include benthic respiration, benthic carbon burial, or the respiration of large plankton and nekton. Nevertheless, they represent 90% of the total carbon flux. Here we use Gulf of Maine ETS activity measurements to calculate vertical profiles of the oxygen utilization rate and vertical carbon fluxes from 30, 50, and 100 m depth.

ETS activity was measured by tetrazolium reduction in cell-free extracts from ocean particulate matter (1). Respiration (p mol O_2 h^{-1}L^{-1}) was calculated from the relationship between the ETS activity and seawater respiration for the euphotic zone of the Gulf of Maine. This unitless ratio of R-ETS activity is 0.260. Respiration increased from the surface to some subsurface maximum near the chlorophyll maximum (Fig. 1). Then it decreased by a factor of 20-50 as an inverse power function through the thermocline. Below it decreased more gradually and near the bottom it tended to increase.

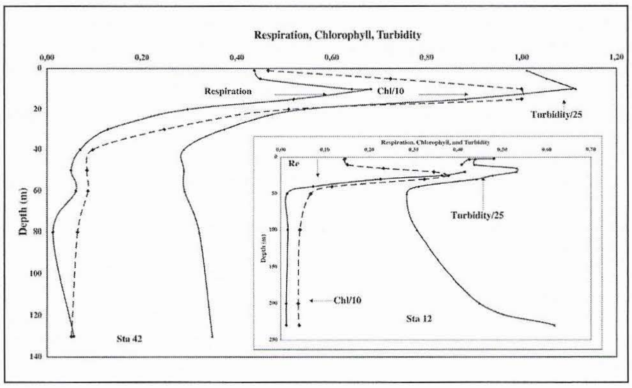

Fig. 1. Co-varying profiles of respiration, turbidity, and chlorophyll at Scotia shelf station 42. The units of respiration are n mol O2 L^{-1} min^{-1}, and for chlorophyll they are mg L^{-1}, turbidity is unitless. However, for scaling purposes, chlorophyll values have been divided by ten, and those for turbidity divided by 25. Inset: Profiles of respiration turbidity, and chlorophyll at Chattam Shelf station 14. The scaling factors and the units are the same as in the surrounding figure for station 42.

Carbon flux was calculated in three ways. (1) We integrated respiratory CO_2 production rates from either 30, 50, or 100 m to the bottom by trapezoidal approximation (F_{trap}). (2) We integrated the respiration-depth function as a definite integral from the upper depth (i.e. 30m) to infinity as the bottom depth. (3) We used the depth of the bottom as the lower boundary for the definite integral. The carbon fluxes from the 30 m level average 3.55 μ mol C min^{-1} m^{-2} by trapezoidal approximation, 2.62 μ mol C min^{-1} m^{-2} by integrating equation 1 to the bottom, and, 3.12 μ mol C min^{-1} m^{-2} by solving equation 2 for s= ∞. Other integrations are presented in Table 1.

By the ^{238}U / ^{234}Th method, carbon fluxes from the 50, and 100 m levels in the Gulf of Maine range from 0.2-25 (2), and 1.4-17 (3) μ mol C min^{-1} m^{-2}. Our fluxes from the 50 m and the 100m level range from 1.3 to 2.2 and 0.38 to 1.53 μ mol C min^{-1} m^{-2} (Table 1). These fall in at the low end of wide range of fluxes from the ^{238}U / ^{234}Th method. Note that the time scale inherent to each method is different. Fluxes from ETS activities and ^{238}U to ^{234}Th decay are based on minute-scale changes, fluxes from ^{3}He-^{3}H method are based on annual-scale changes, and fluxes from sediment traps are based on day-to-month scale changes. Thus, to compare the short-time-scale methods with the long-time-scale ones, time-series data for the short-time-scale methods is needed.

Table 1. Carbon flux (F_c) from 30, 50,and 100 m (z_t) in the Gulf of Maine. Mean values from 5 stations are presented.

CARBON FLUX from 30 m.			
	F_{trap}	F_{t-s}	F_{∞}
Mean	3.55	2.62	3.12
St. Deviation	1.24	1.51	2.00
CARBON FLUX from 50 m.			
	F_{trap}	F_{t-s}	F_{∞}
Mean	2.20	1.30	1.81
St. Deviation	0.54	0.76	1.31
CARBON FLUX from 100 m.			
	F_{trap}	F_{t-s}	F_{∞}
Mean	1.53	0.38	0.88
St. Deviation	0.23	0.23	0.81

(1) F_{trap}, is F_c from the upper boundary (z_t) calculated by trapezoidal approximation. The bottom respiration value used in this calculation was the same as the minimum measured value at each station. (2) F_{t-s} is the integration of the normalized power function, $R_z = R_c(z/z_t)^b$ between z_t and the bottom depth (z_s). $F_{t-s} = [R_c /((1+b)(z_t)^b)] [(z_s^{1+b}) - (z_t^{1+b})]$. (3) F_{∞} is the integration of the same equation between the z_t and infinity. All three calculations represent the portion of the F_c that is oxidized in the water column below z_t. All F_c values are given in m mol C min^{-1} m^{-2}.

References

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