Zooplankton respiration and vertical carbon flux

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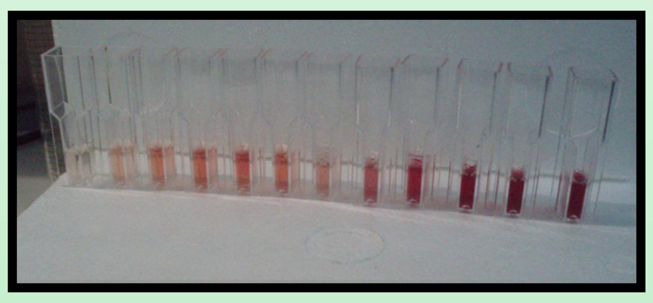
Introduction The transport of carbon from ocean surface waters to the deep sea is critical in calculations of planetary carbon cycling and climate change. This vertical carbon flux supports all the respiration in the dark water column below, including the respiration of the benthos, and carbon lost to burial. Accordingly, for conditions where benthic respiration and carbon burial are small relative to the water column respiration and where horizontal fluxes are known or negligible, the carbon flux can be calculated by integrating the vertical profile of the water-column plankton respiration rate. We have done this in the Gulf of Maine from microplankton ETS activity, but there we did not measure zooplankton respiration. Here, we use previously published zooplankton ETS in water column profiles made in the NE Atlantic (4) and NE Pacific (3) Oceans. From them we calculated zooplankton respiration depth profiles and the mathematical functions that best describe them. Then, integrating these profiles from the respiratory maximum to a deep-water minimum we calculated zooplankton carbon flux profiles for these two regions.

I help keep C & N in the water column!

Meganyctiphanes norvegica



Formazan produced from tetrazolium (INT) in the ETS assay. Reaction strength is proportional to the red color.

R/V T G Thompson

Concept The idea that the sum of all the dark ocean respiration is equal to the sum of the organic matter sinking out of the surface waters goes back to Gordon Riley in 1951 (8). Many oceanographers have used the concept to address different aspects of the oceanic carbon cycle, but the mathematics was always simple. In 1980, Erwin Suess (9) pointed out that, mathematically, the first derivative of a carbon-flux profile yielded the deep-ocean respiration profile and Bill Jenkins (1) demonstrated that integrating deep-ocean respiration profiles from the bottom of the surface mixed layer to infinity yielded carbon flux from that mixed layer. We expanded on this idea with microplankton in the Gulf of maine showing that one can derive a mathematical function for vertical carbon flux from the respiration profile. Then, using that function in a definite integral one can calculate carbon flux at any level in the water column. Here we show that the same concept can be used with zooplankton.

Carbon Flux Calculation from Respiration

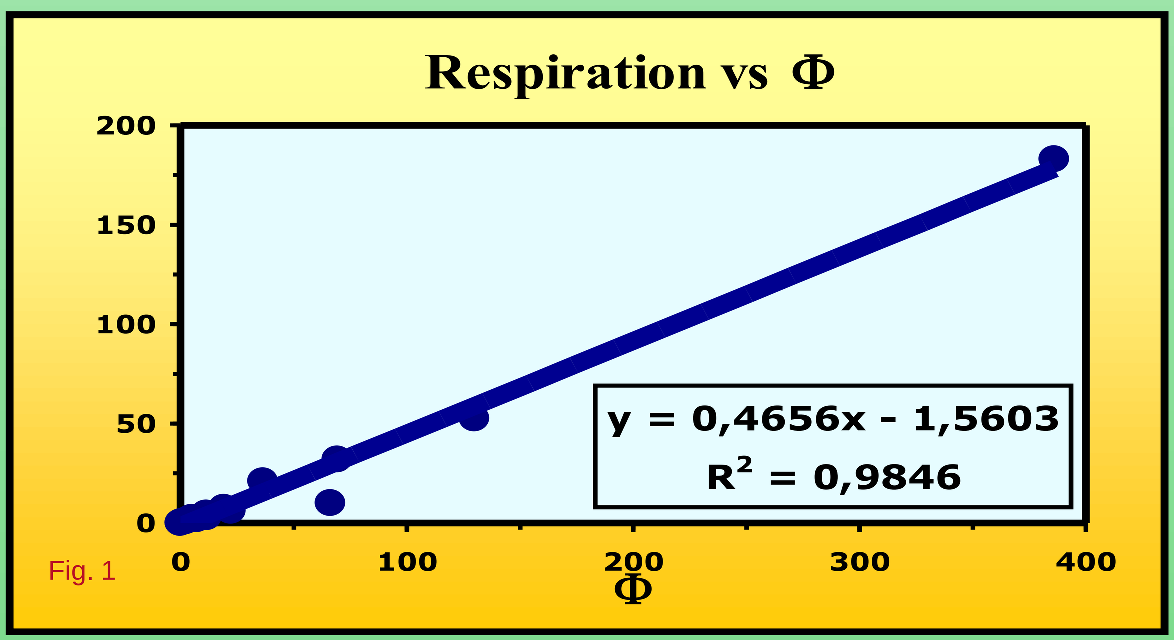
1. **Plot the respiration (R) as a function of the normalized depth (z), [normalized by the depth of the respiration maximum] and find the best mathematical model for data.**
2. **Solve definite integral (Eq. 1, Box 1), between discrete depths (z_t) and bottom (z_s) for carbon flux (F_{t-s}) through each depth. Plot these as in Fig. 2.**
3. **Find best mathematical model for the profile (a power function, $C_f = 13.7z^{-0.7188}$ for Fig. 2).**

$$F_{t-s} = \int_{Z_t}^{Z_s} R_t(z/z_t)^b \, dz = [R_t/((b+1)(z_t)^b)]\,[(z_s^{b+1}) - (z_t^{b+1})]$$

Equation 1

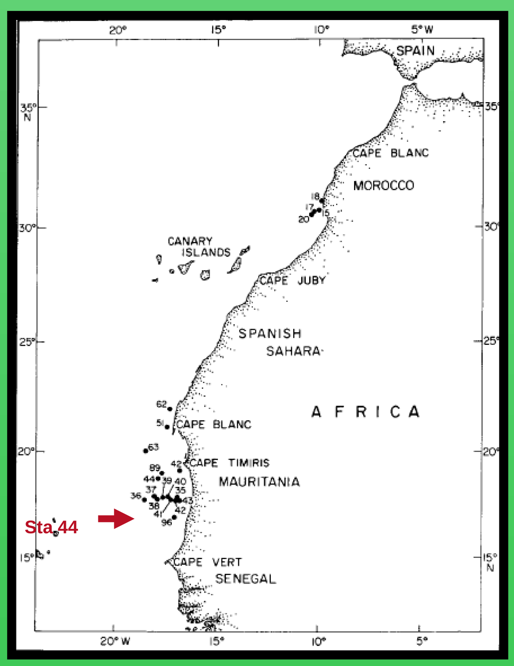
$$F_{t-s} = [R_t/((b+1)(z_t)^b)]*[(z_s^{(b+1)}] - (z_t^{(b+1)}]$$

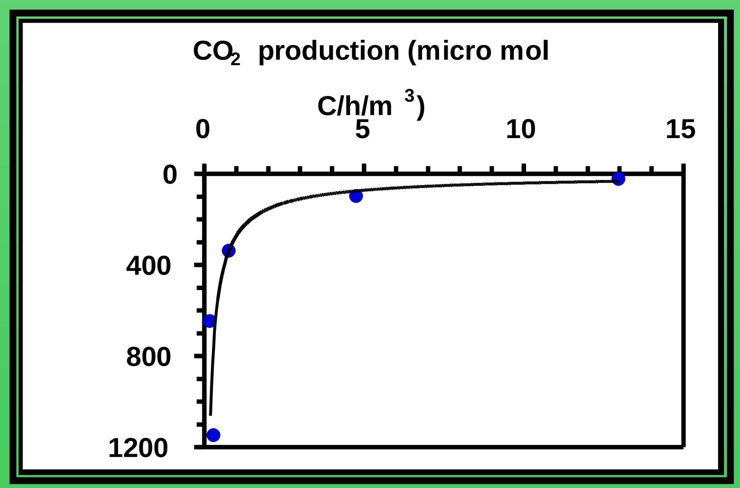
Box 1.- Carbon Flux Working Equation. R_t is the respiration at the respiration maximum, b is the exponent on the power function, z_t is the depth of the layer through which the carbon will flux, and z_s is the bottom depth (sea floor).



Zooplankton sampling and ETS activity measurements are described in references 3 and 4. Zooplankton were captured with wp-2 triplet nets (mesh size 200 micron) for the NW African profile and with 1 m closing net (mesh size 212 microns) hauled vertically at 15 m per min for the N E Pacific profile. ETS activity was measured immediately after the zooplankton were removed from the net. Samples were not frozen. The respiration calculations are described in ref. 6. Briefly, starting with potential respiration (ETS activity) in micro moles O_2 $h^{-1}m^{-3}$, use a R/ETS ratio of = 0.47 (fig. 1 , ref.7) to convert to respiration in O_2 units and a C/O_2 ratio of 0.71 (ref. 6 & 10) to convert to C units.

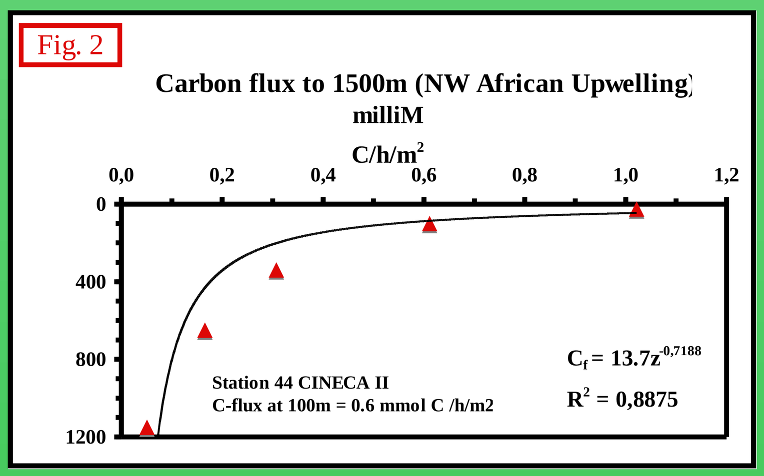
Fig.3 R/V Jean Charcot



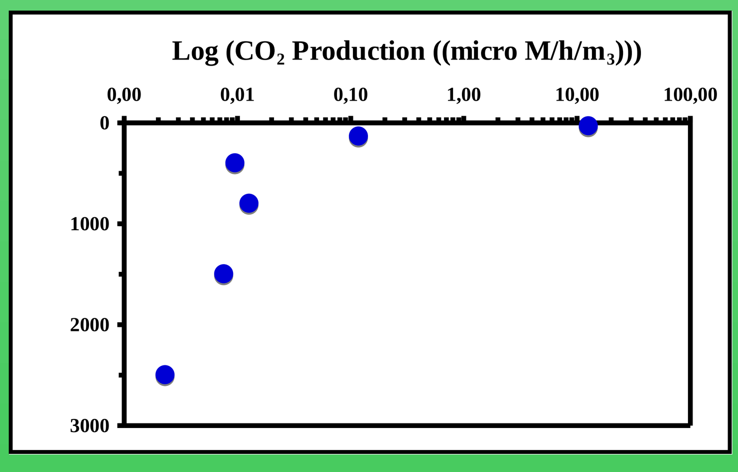


Respiration (not depth-normalized): station 44, NE Atlantic Ocean

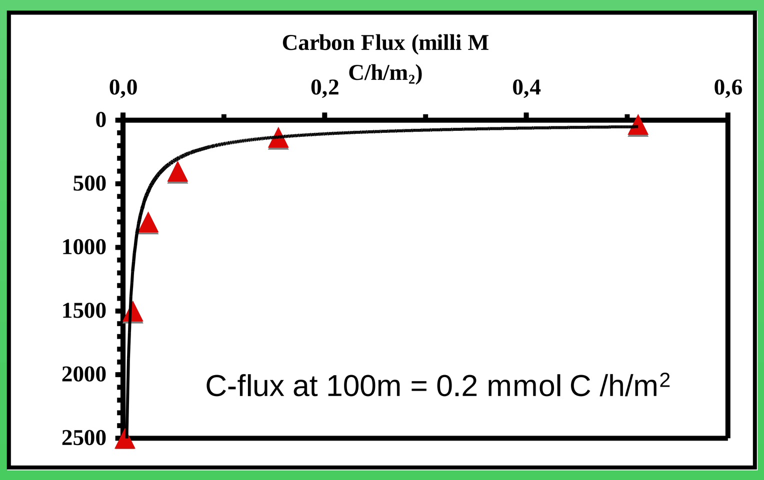
Fig. 2



Productivity: 8.1millimol C/h/m². So if 0.6 millimol/h/m² is the flux (F_{100-s}) from 100 m (by the zooplankton) F_{100-s} is 7% of productivity.



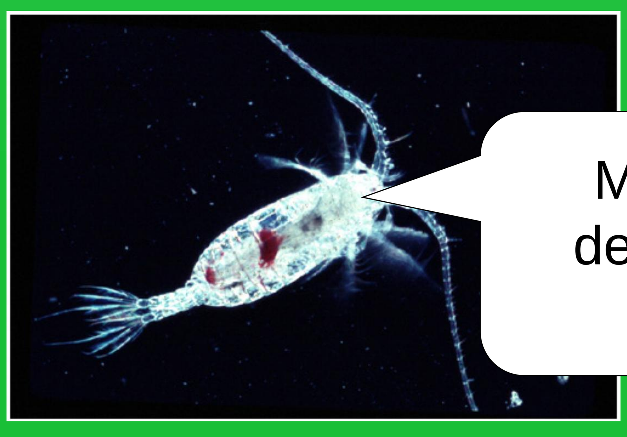
Respiration (not depth normalized) at station 20 in the NE Pacific Ocean.



The phytoplankton productivity here at station 20 (Pacific) was 4 milli moles C/h/m². If 0.2 milli moles C/h/m² is the F_{100-s} (by the zooplankton) then it represents 5% of the daily carbon productivity.

Conclusions

1. From water-column zooplankton samples we can calculate the zooplankton fraction of carbon flux.
2. Zooplankton carbon flux at 100 m is 5-7% of the phytoplankton productivity.



My CO_2 production decreases the vertical particle flux!

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