NUTRIENT RETENTION EFFICIENCY, A NEW OCEAN METRIC FROM PLANKTON RESPIRATION & CARBON FLUX

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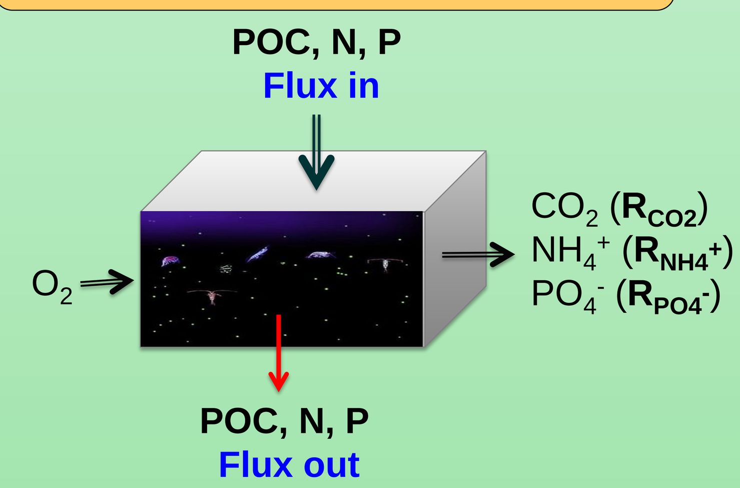
ABSTRACT Nutrient retention efficiency (NRE) is a new metric to quantify the capacity of an ocean layer to maintain its nutrients. Conceptually, it is the remineralization of inorganic nutrients associated with respiratory CO_2 production (R_{CO2}) within an ocean layer normalized by nutrients fluxing into that layer. It can be expressed as a ratio or a percent. Operationally, below the euphotic zone, it can be calculated either as the ratio, R_{CO2}/(carbon flux) associated with an ocean layer or the inverse of the carbon-flux transfer-efficiency through that layer. Furthermore, it is related to the maximum curvature (b) of the respiration-depth function [$R_{CO2} = (R_{CO2})_0\ z^{-b}$]. NRE increases when the absolute value of b increases. NRE associated with microplankton can be calculated from microplankton-ETS depth-profiles. NRE associated with zooplankton can be calculated from zooplankton-ETS depth-profiles. Conceptually total NRE equals the sum of the NREs associated with allplankton fractions. In the Peru upwelling the NRE, associated with the microplankton, displayed a minimum 40 km seaward of the upwelling center over sediments calculated to have high benthic respiration.

NRE Calculation from Respiration

NRE is the nutrient remineralization rate within an ocean layer normalized by nutrients entering that layer via particle flux. Below the euphotic zone it can be calculated as the inverse of the carbon-flux transfer efficiency. Also, it can be calculated from a plankton respiration profile (and the Redfield ratio). In the euphotic zone it is essentially the respiration to productivity ratio.

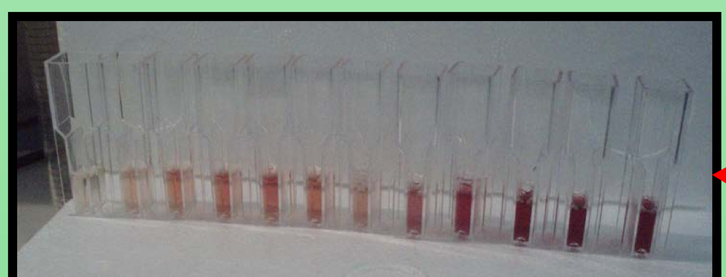
Conceptual Basis



EFFICIENCY WITH WHICH PLANKTON MINERALIZE POM

Permits nutrient recycling! **NRE =(ΔPOM Flux)/(Flux in)**

Microplankton CO_2 production decreases vertical particle flux by releasing DOC & DON!



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

$$(C_{t\text{-}s})_1 = (d(POC)/dz)$$

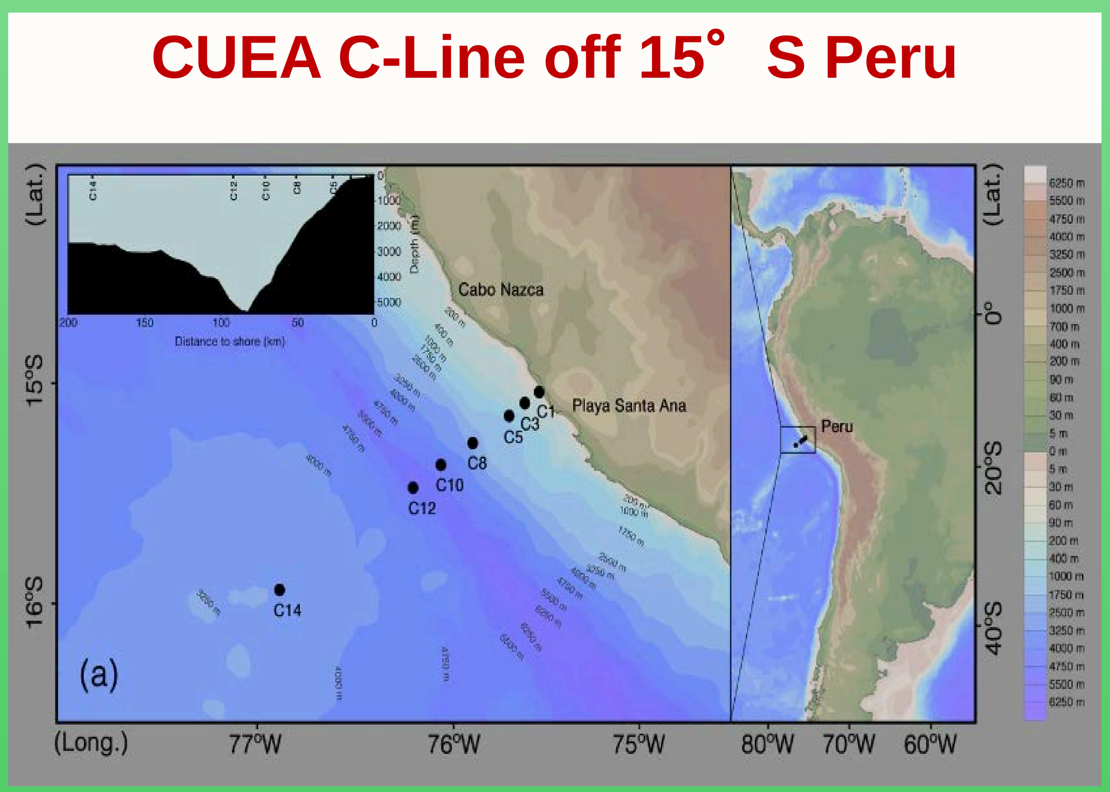
$$d(CO_2)/dz = R_{CO_2}$$

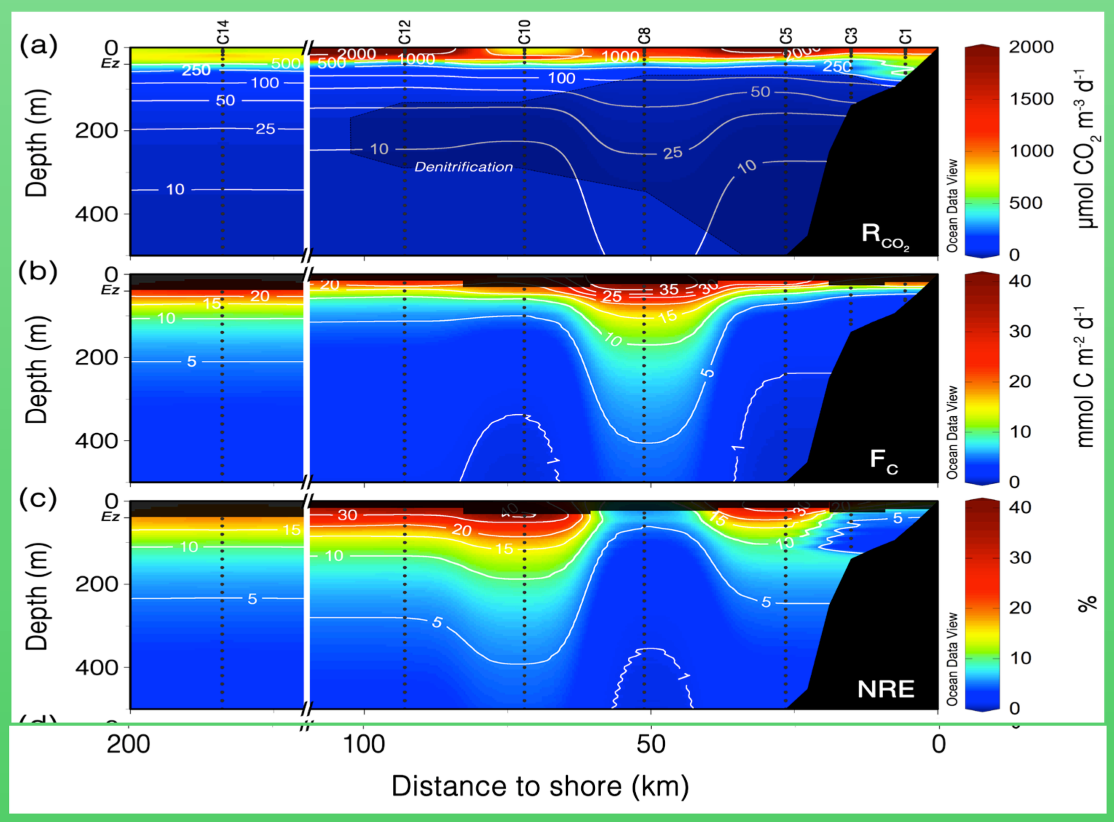
$$(C_{t\text{-}s})_2$$

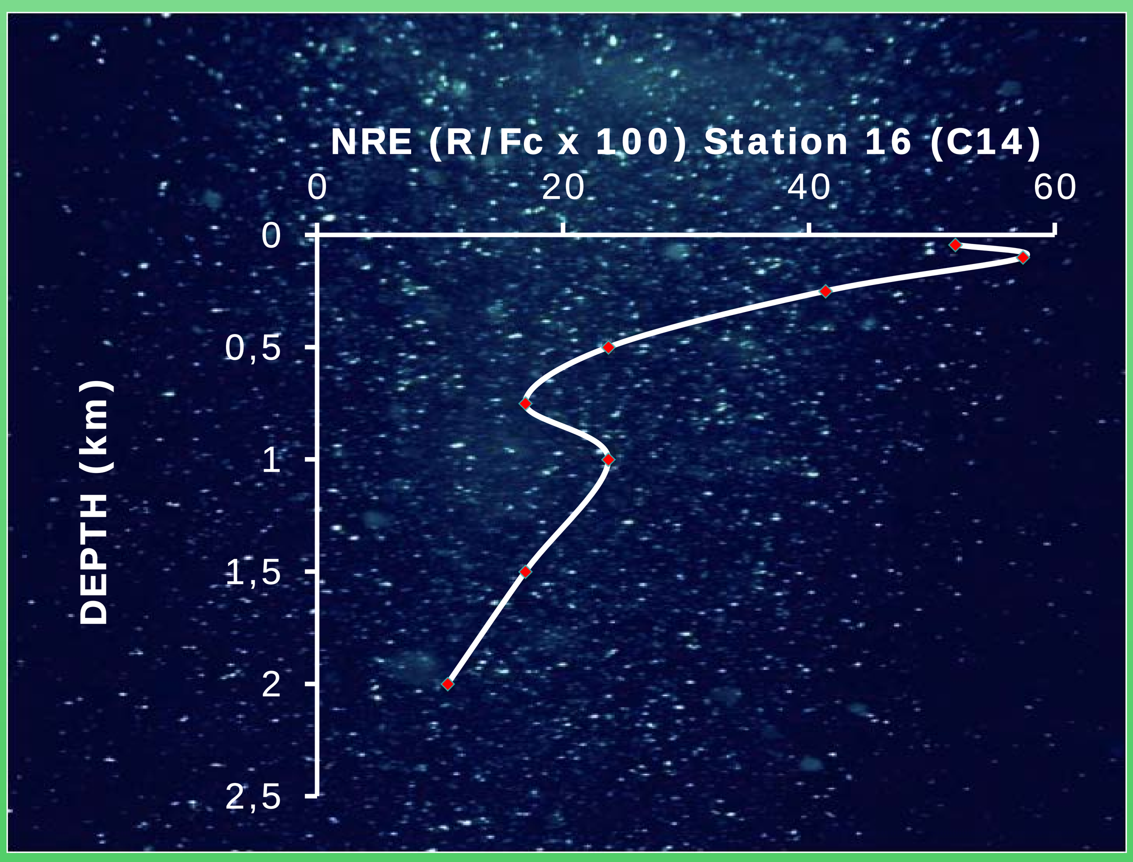
$$NRE = R_{CO_2}/(C_{t\text{-}s})_1$$

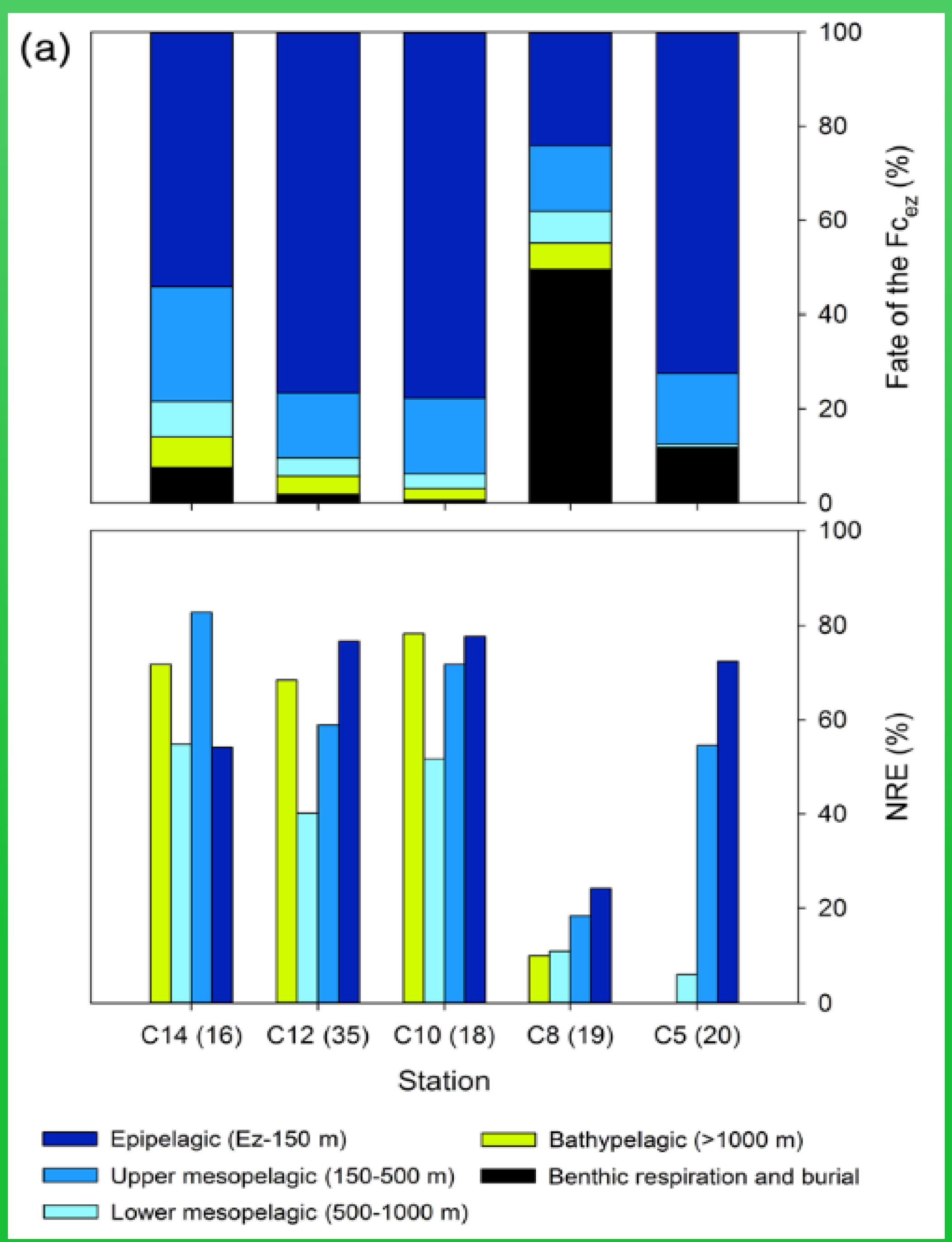
$$F_{t\text{-}s} = [R_t/((b+1)(z_t)^b]*[(z_s^{(b+1)})] - (z_t^{(b+1)})]$$

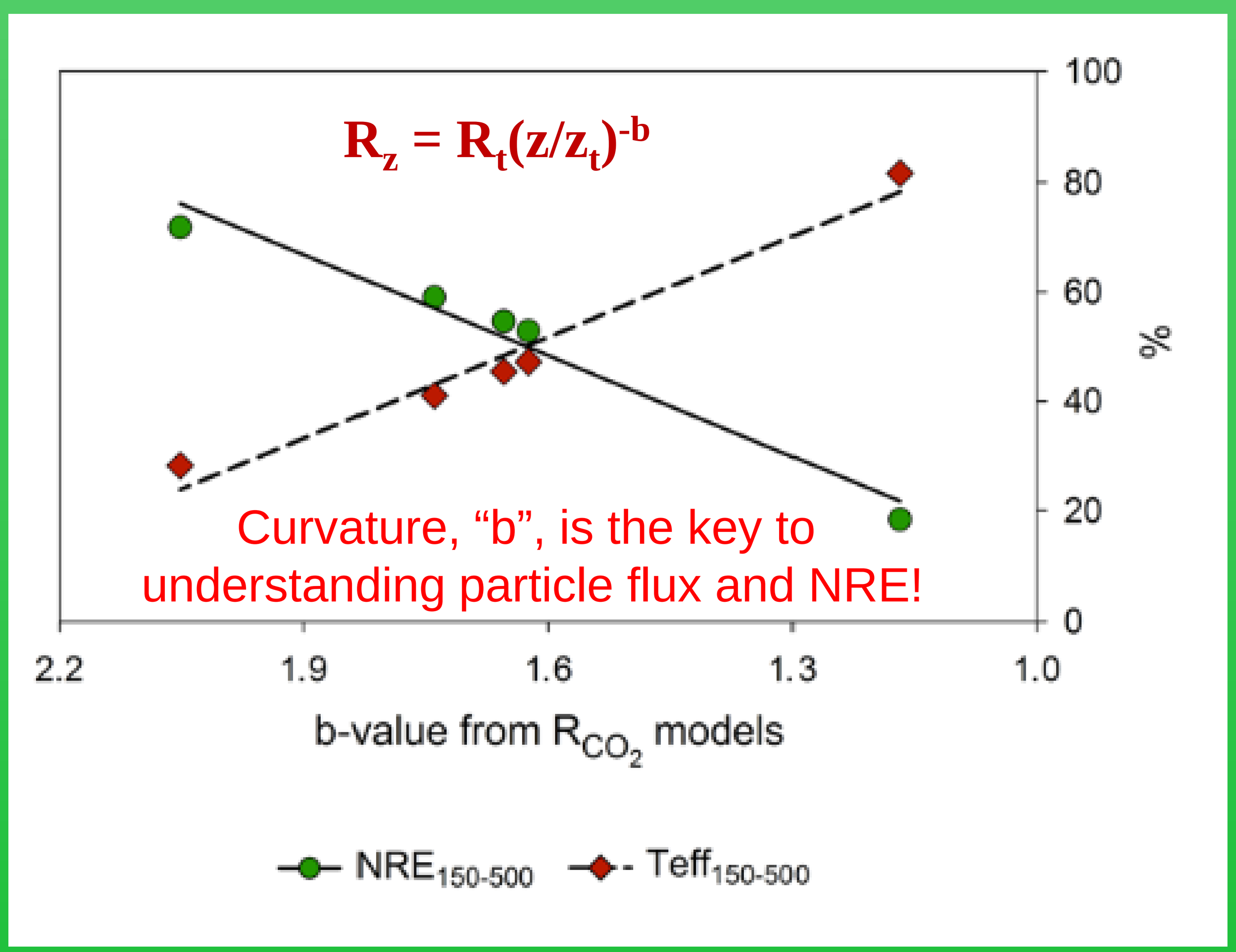
Box 1.- Carbon Flux Working Equation. R_t is the respiration at the respiration maximum, b is the exponent on the power function, z_t is the depth of the layer through which the carbon will flux, and z_s is the bottom depth (sea floor).

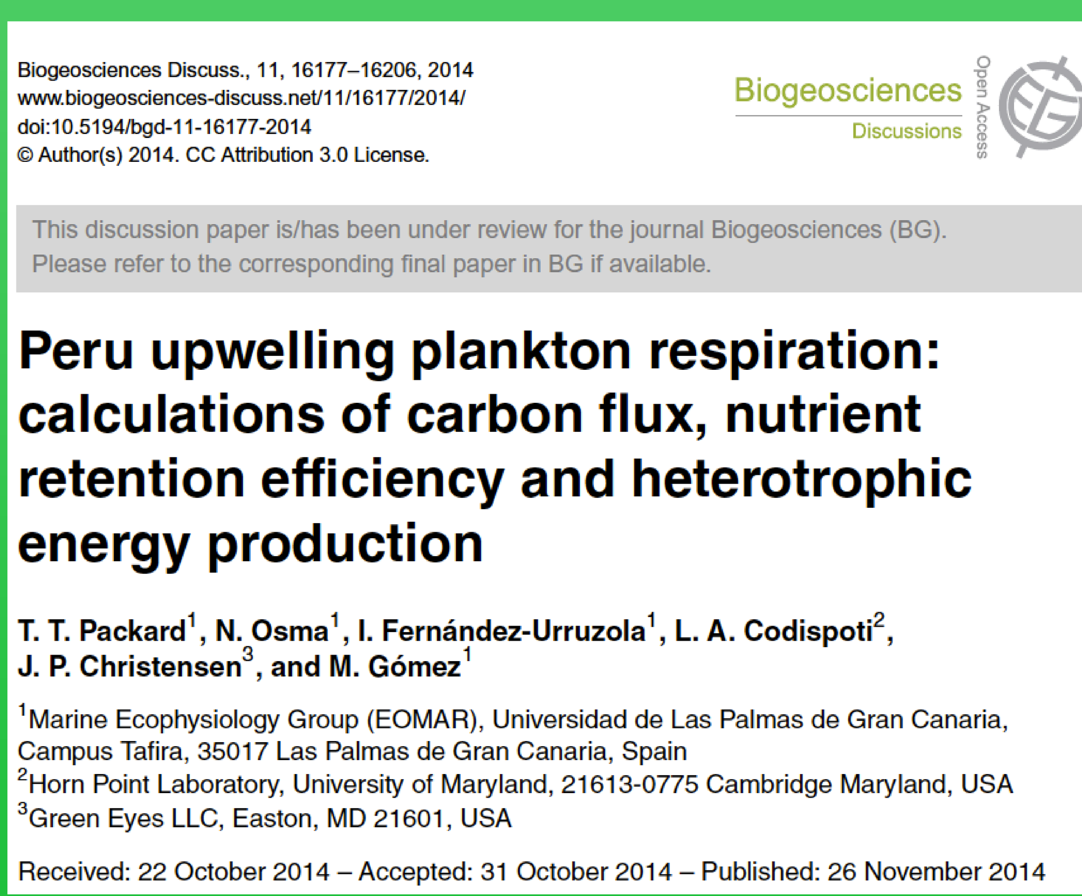












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Biogeosciences Discussions

This discussion paper is/has been under review for the journal Biogeosciences (BG). Please refer to the corresponding final paper in BG if available.

Peru upwelling plankton respiration: calculations of carbon flux, nutrient retention efficiency and heterotrophic energy production

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Conclusions:

1. NRE = (R in any ocean layer)/(Total water-column R from euphotic-zone bottom to sea floor.)
2. Exponent (b), the curvature of R=f(z), controls particle flux & NRE
3. Low water column NRE leads to high benthic respiration and carbon burial.