A specific bio-optical primary production model applied to the Kerguelen iron-enriched region

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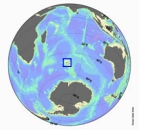
A. Context and objectives of the study



➢ **Objectives**

✓ To assess the phytoplankton community structure from HPLC pigment measurements

✓ To propose preliminary estimates of the contribution of different phytoplankton pigment-determined groups to the total primary production

➢ **Where?**

In two contrasted environments of the KEOPS cruise area (Kerguelen Plateau): bloom fertilized area vs. HNLC region

➢ **Why?**

To improve our knowledge of the phytoplankton community distribution and our predicting capability of carbon fluxes in the Southern Ocean

B. Using biomarker pigments to assess the size structure of the phytoplankton community

➢ **Method**

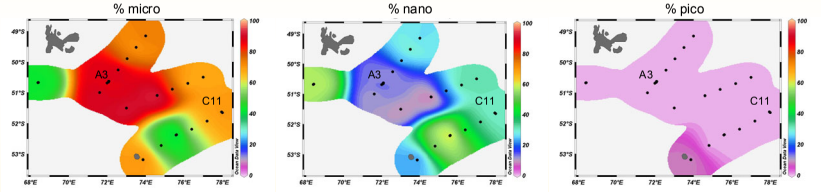
Diagnostic pigment	Taxinomic significance	Phytoplankton group	Contribution to the algal biomass
Fucoxanthin	Diatoms	Microphytoplankton (≈ > 20 µm)	% micro = (1.41 Fuco + 1.41 Peri) / wDP
Peridinin	Dinoflagellates		
Hex-Fuco, But-Fuco	Chromophytes, nanoflagellates	Nanophytoplankton (≈ 2-20 µm)	% nano = (1.27 19-HF + 0.35 19-BF + 0.60 Allo) / wDP
Alloxanthin	Cryptophytes		
Zeaxanthin	Cyanobacteria, prochlorophytes	Picophytoplankton (≈ < 2 µm)	% pico = (1.01 Tchlb + 0.86 Zea) / wDP
Total chlorophyll b	Green flagellates, prochlorophytes		

Sum of the weighted Diagnostic Pigment: wDP = 1.41 Fuco + 1.41 Peri + 1.27 19-HF + 0.35 19-BF + 0.60 Allo + 1.01 Tchlb + 0.86 Zea (wDP = Tchla)

Coefficients: estimated by multiple regression analysis based on a global dataset; they represent average Tchla / biomarker pigment ratio

Taxinomic significance of biomarker pigments: Jeffrey and Vesk (1997); methodology: Vidussi et al. (2001) and Uitz et al. (2006)

➢ **Results: Contribution of the three phytoplankton groups to the total algal biomass**



✓ Sampling area dominated by microphyplankton (i.e. diatoms) with almost exclusively large diatoms in the iron-enriched bloom region

✓ Contribution of nanophytoplankton of 20% to 60% outside the plateau

✓ Contribution of picophytoplankton very low (less than 10%)

➢ **Testing the reliability of the relationship between size and pigment content**

✓ Sampling and analysis: sea water samples were filtered through 10, 2 and 0.4 µm pore size filters. Phytoplankton pigments were determined by HPLC for each size fraction.

✓ Biomarkers of microplankton mostly found in the > 10 µm fraction

✓ Biomarkers of nanoplankton found in the small (< 10 µm) fraction

✓ Biomarkers of picoplankton exclusively found in the < 2 µm fraction (but concentrations of Zea and Tchlb were very low)

	0.4 - 2 µm	2 - 10 µm	> 10 µm
% Fuco	5.5 ± 5.2	27.5 ± 16.3	67.0 ± 18.7
% Peri	1.5 ± 7.1	60.0 ± 40.3	38.6 ± 44.4
% 19-HF	59.3 ± 22.4	30.7 ± 16.6	10.1 ± 13.7
% 19-BF	35.5 ± 20.3	21.1 ± 12.3	43.4 ± 12.2
% Allo	51.1 ± 44.8	44.4 ± 42.6	4.4 ± 17.2
% Zea	95.8 ± 18.7	0.0 ± 0.0	4.2 ± 18.7
% Tchlb	100.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

C. Estimation of group specific primary production rates

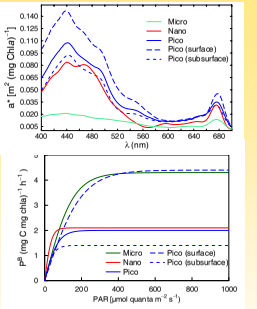
➢ **Method: Bio-optical model and specific photophysiological properties**

$$P_{group} \propto PAR\ Tchla_{group}\ a_{group}\ \Phi_{c,group}$$

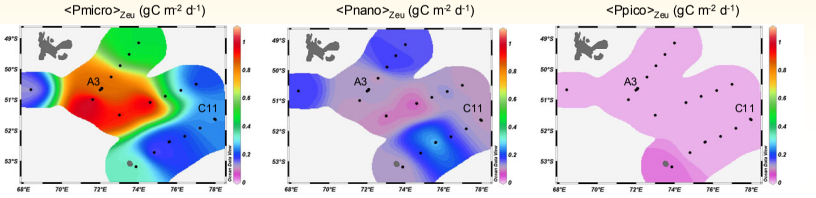
✓ Specific biomass ($Tchla_{group}$) derived from pigment measurements (cf. section B.)

✓ Specific photophysiological properties (a_{group} and $\Phi_{c,group}$) estimated by multiple regression analysis (according to Claustre et al., 2005) based on a large dataset

- Chlorophyll specific absorption coefficient of algae: $a(\lambda) = a^*(\lambda)$ micro-Tchla + $a^*(\lambda)$ nano-Tchla + $a^*(\lambda)$ pico-Tchla
- Photosynthetic efficiency: $\alpha = \alpha^B$ micro-Tchla + α^B nano-Tchla + α^B pico-Tchla
- Maximum P rate: $P_{max} = P^B_{max}$ micro-Tchla + P^B_{max} nano-Tchla + P^B_{max} pico-Tchla
- → Maximum quantum yield for photosynthesis $\Phi_{cmax} = \alpha / \bar{a}^*$ (with $\bar{a}^*$: mean chlorophyll specific absorption of algae weighted by the spectral distribution of the PAR used during the P-I experiments).



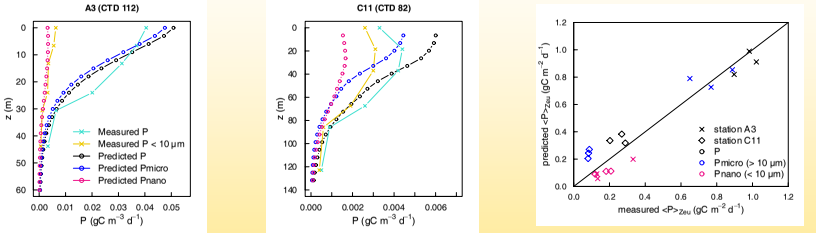
➢ **Results: Primary production specific of the three phytoplankton groups**



✓ Bloom region (A3): the contribution of microphytoplankton (i.e. diatoms) to total primary production is estimated to be 80-95%.

✓ HNLC region (C11): predictions indicate that the primary production is due both to microphytoplankton (65-73%) and nanophytoplankton (27-35%).

➢ **Results: Comparison with in situ primary production measurements**



✓Bloom region (A3): agreement between predictions and measurements (13C labeling).

✓ HNCL region (C11): overestimation of the surface primary production → likely due to an overestimation of P_{max} (predicted 0.71±0.17 vs measured 0.32 ±0.13 mg C m^{-3} h^{-1}).

✓ HNCL region (C11): Underestimation of the production associated to small (< 10µm) cells to the benefit of microphytoplankton → may be due to unrelevant photophysiological properties selected for nanoplankters and/or to the presence of small diatoms (< 10µm), which contribute to the micro- instead of the nanophytoplankton predicted production.

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