PPCI $_{MED}$: A new phytoplankton composition index responding to anthropogenic pressure in the Mediterranean

Anne Goffart

Oceanology, FOCUS Research Unit, University of Liège, Belgium - A.Goffart@uliege.be

Context

Phytoplankton are changing rapidly in response to fluctuations in nutrient input in marine systems.

- **They are excellent indicators of marine ecosystem change;**
- **They are promoted by various organizations (*e.g.* European Commission) as a tool for biomonitoring and assessing the impact of anthropogenic pressures on the ecosystem;**
- **Most indicators of phytoplankton composition are *not operational* (wide range of scientific instruments needed, high level of expertise required, high effort in time and cost, …) or *do not respond to pressure*.**

Protocol for the calculation of PPCI $_{MED}$

Step 1

Selection of pigments responding positively to pressure (*i.e.* nutrient concentrations)

Only pigments that respond positively to nutrient concentrations are considered (criteria: Spearman correlations, rho ≥ 0.45, p value < 0.0001, 1 pigment per group). In our data set (French coastal waters of the Med Sea, including Corsica), 4 diagnostic pigments, peridinin, fucoxanthin, prasinoxanthin and alloxanthin, were selected. In the Med Sea, they identify photosynthetic dinoflagellates, diatoms, prasinophytes, and cryptophytes, respectively. Consequently, PPCI $_{Med}$ is composed of *4 sub-indexes (SI)* : SI $_{Peridinin}$, SI $_{Fucoxanthin}$, SI $_{Prasinoxanthin}$ and SI $_{Alloxanthin}$.

Spearman correlation coefficients (rho) – Corsica and French coastal waters, 2009-2017

	NO_3^- n = 261	NO_2^- n = 265	$NO_3^- + NO_2^-$ n = 270	NH_4^+ n = 270	DIN n = 266	$Si(OH)_4$ n = 255
Tchl *a*	0.48	0.58	0.51	0.25	0.52	0.41
Chl *a*	0.47	0.58	0.50	0.26	0.52	0.41
Divinyl chl *a*	0.16	0.23	0.20	-0.19	-	-
Peri	0.38	0.47	0.39	0.35	0.46	0.26
Buta	0.27	0.31	0.29	-0.13	0.19	0.20
Fuco	0.44	0.52	0.49	0.29	0.53	0.31
Neo	0.37	0.52	0.41	-	0.39	0.23
Prasino	0.46	0.61	0.51	0.18	0.49	0.27
Viola	0.27	0.40	0.31	0.21	0.36	0.13
19'HF	0.22	0.24	0.23	-0.18	0.12	0.16
Allo	0.48	0.57	0.52	0.23	0.51	0.44
Zea	-	-	-	-0.17	-	-
Tchl b	0.55	0.64	0.58	0.26	0.59	0.47
	P<0.0001	*P*<0.001	*P*<0.05	- NS		

PPCI $_{Med}$ =

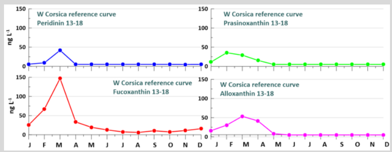
(SI $_{Peridinin}$ + SI $_{Fucoxanthin}$ + SI $_{Prasinoxanthin}$ + SI $_{Alloxanthin}$) / 4

Dinoflagellates | Diatoms | Prasinophytes | Cryptophytes

Step 2

Construction of reference curves

Reference curves are established for reference stations identified in the context of the Water Framework Directive monitoring or ongoing programs. For each selected diagnostic pigment, a reference curve is constructed. It describes the seasonal evolution of this pigment. Ideally, the curves are constructed from bi-monthly data acquired over a sliding 6-year period. Each curve comprises 12 values (1 value per month) obtained by calculating the monthly P_{90} of pigment concentrations and adding a 50% safety margin to account for natural variability. A minimum threshold of 5 ng L $^{-1}$ is imposed.



Step 3

Index calculation

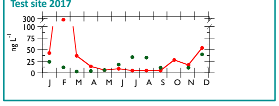
3.1. Compare the pigment concentrations at the site to be assessed with the reference values, respecting the temporality,

3.2. Calculate the frequency (%) of overpassings from the reference, the relative magnitude (%) of each overpassing during the observation period and the averaged overpassing (%),

3.3. Calculate a score for the considered pigment : score = (frequency of overpassings x averaged overpassing) / 1000,

3.4. Transform scores ≤ 20 into EQR by applying the formula : EQR = 1 (0.050 x score). If the score is > 20, EQR = 0. The threshold of 20 was defined on the basis of our field expertise.

Fucoxanthin reference curve (Eastern Corsica, 2016-2021)



Calculation of overpassings for a test point

Theoretical examples for *pigment A and month X* :

Reference :	**10 ng L^{-1}**	**10 ng L^{-1}**
Concentration at test site :	**25 ng L^{-1}**	**4 ng L^{-1}**
Overpassing :	**15 ng L^{-1}**	**0 ng L^{-1}**
Relative overpassing :	**150 %**	**0 %**

EQR Fucoxanthin calculation example

Site	Number of data	Number of overpassings	Frequency of overpassings %	Average relative overpassing %	Fucoxanthin score	EQR $_{Fucoxanthin}$
Test	11	5*	45 (A)	278 (B)	12.51	0.37

(*1 slight overpassing in May)

Fucoxanthin score = (A x B) / 1000

EQR Fucoxanthin = 1 - (0.050 x Fucoxanthin score) ; if score > 20, EQR = 0

EQRs boundaries and color codes for the different levels of Phytoplankton composition quality in the Western Mediterranean using the PPCI index

	High	Good	Moderate	Poor	Bad
PPCI $_{Med}$	1 0.90	0.70	0.50	0.20	0

Step 4

Final EQR calculation

Repeat step 3 for all selected pigments and calculate the final EQR. The final EQR is the arithmetic mean of the 4 sub-indexes EQRs. PPCI $_{Med}$ ranges from 0 (phytoplankton composition highly degraded) to 1 (phytoplankton composition in very good condition).

Highlights

- **We have developed a new phytoplankton composition index, PPCI $_{Med}$ (Pigment Pressure Composition Index) [1].**
- **PPCI $_{Med}$ uses diagnostic pigments of total phytoplankton measured by HPLC. Only pigments responding positively to pressure (*i.e.* nutrient concentrations) are considered. PPCI $_{Med}$ is adapted to the specificities of the *Western Mediterranean* coastal waters and *responds to pressures*.**
- **PPCI $_{Med}$ allows to detect the effects of anthropogenic disturbances on phytoplankton composition over different spatial and temporal scales. It can also be used to highlight the seasonality of disturbances and to measure improvements in environmental quality following restoration efforts.**
- **PPCI $_{Med}$ is designed to be scientifically robust yet easy to implement by stakeholders lacking expertise in phytoplankton biodiversity.**
- **PPCI is transferable to other coastal zones if pigments/pressure relationships are established.**

Perspectives

- **PPCI is transferable to other coastal zones if pigments/pressure relationships are established.**

[1] **Goffart A., 2019.** Rapport final de l'action 1 du projet « Indicateur de composition phytoplanctonique », Convention de subvention ONEMA – Université de Liège, 30 pp. https://hdl.handle.net/2268/235028