The challenge of using phytoplankton composition for Mediterranean ecosystem health assessment

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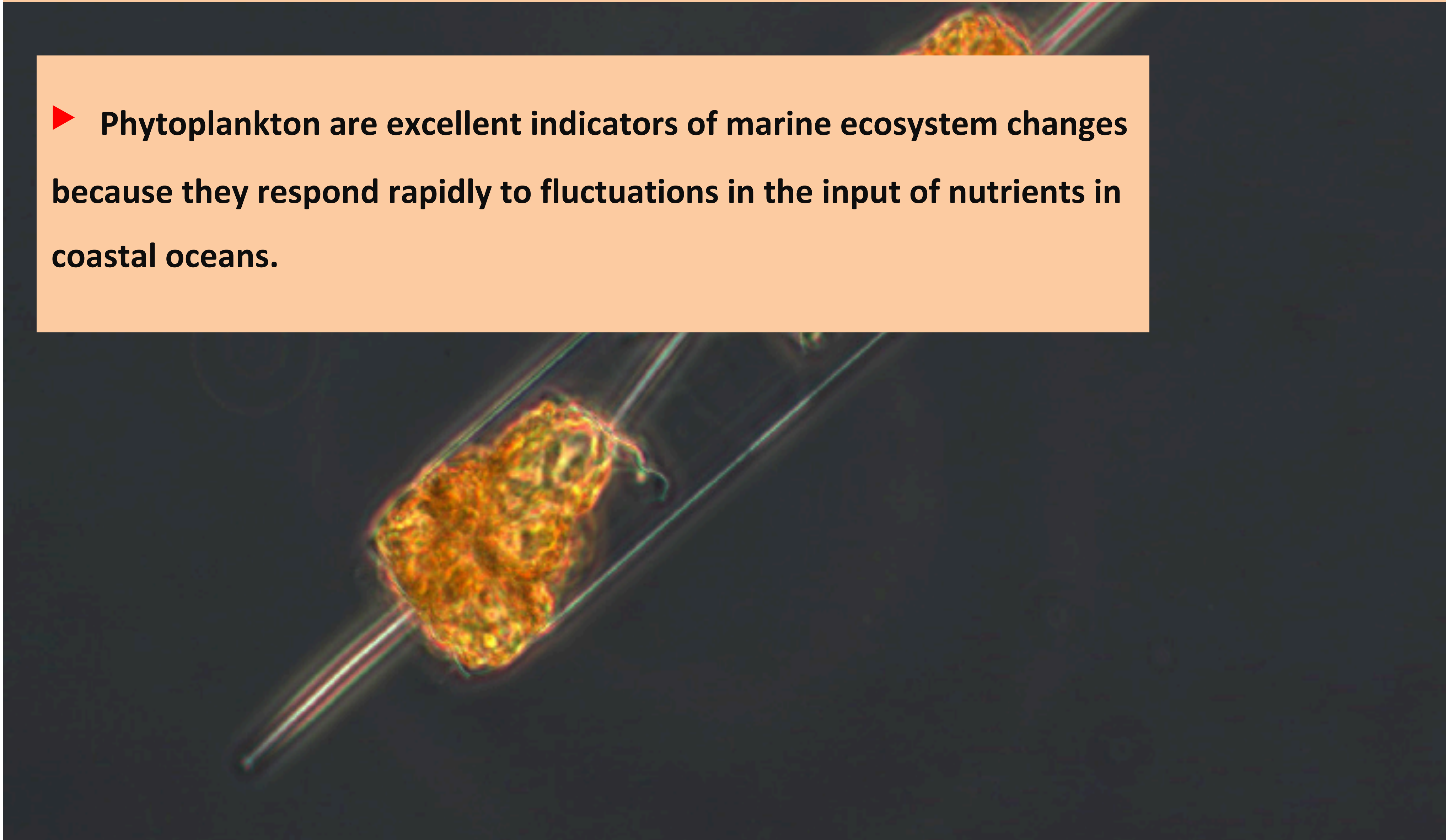
Marine phytoplankton : a bioindicator of ecosystem change

- Phytoplankton are excellent indicators of marine ecosystem changes because they respond rapidly to fluctuations in the input of nutrients in coastal oceans.



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Marine phytoplankton : a bioindicator of ecosystem change

- Phytoplankton are promoted by various organizations (*e.g.* European Commission) as a tool to perform biomonitoring and evaluate the effects of anthropogenic pressure on the ecosystem.

However, most of indicators based on phytoplankton composition are NOT operational (wide range of scientific instruments, high level of expertise, high effort in time and cost, …).

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Context and objectives

1. To present a new phytoplankton composition index (PPCI) which is useful for assessing ecosystem status and water quality using field data and to illustrate its application with case studies;

2. To present case studies of PPCI applications;

3. To link *in situ* phytopigment concentrations and ocean color images in order to improve our knowledge of basin-scale phytoplankton diversity and to spatialize phytoplankton composition.

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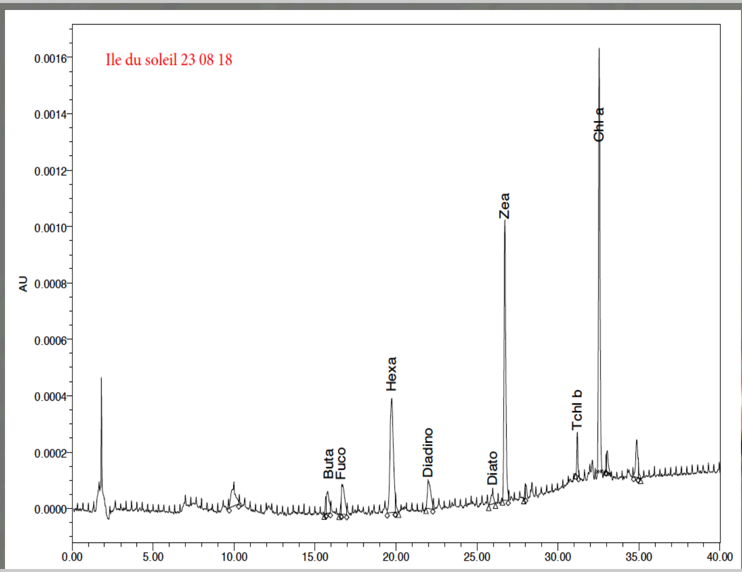
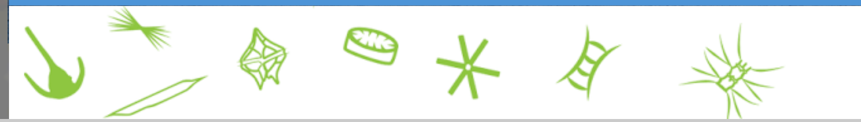
1. PPCI : a new phytoplankton composition index

- PPCI (Pigment Pressure Composition Index) is based on ***diagnostic pigments*** (carotenoids) of ***total phytoplankton***, which means that all size classes are considered (HPLC measurements).



The Bay of Calvi (W Corsica),
a phytoplankton reference site for WFD assessment



- PPCI was developed in the French coastal waters of the Med Sea where reference conditions are well known (Goffart et al. 2015, Goffart 2019). The index was developed in the framework of WFD assessment with the support of the ONEMA/AFB/OFB.

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1. PPCI : a new phytoplankton composition index

1.1 For one ecotype (*e.g.* WFD-ecotype 3W), only **pigments responding positively to pressures** (*i.e.* nutrient concentrations) are integrated into the composition index;

1.2 One pigment per group.

Significant Spearman's correlation coefficients between phytoplankton variables and nutrients

3W data set, monthly sampling frequency, sampling between 2009 and 2017

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

$$PPCI_{Medit} = (CI_{Peridinin} + CI_{Fucoxanthin} + CI_{Alloxanthin} + CI_{Prasinoxanthin}) / 4$$

Dinoflagellates — Diatoms — Cryptophytes — Prasinophytes

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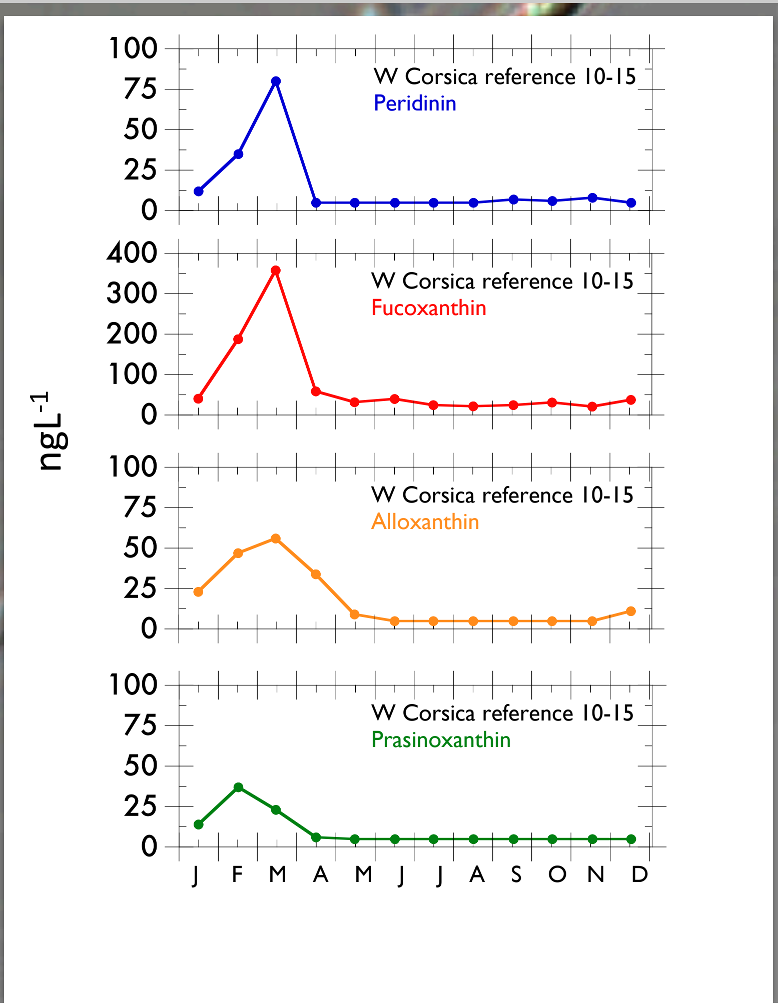
1. PPCI : a new phytoplankton composition index

1.3 Reference curves which describe the seasonal succession of the pigments included in the index are established. Ideally, they are calculated using 6 years of data (bi-monthly sampling frequency and moving reference).



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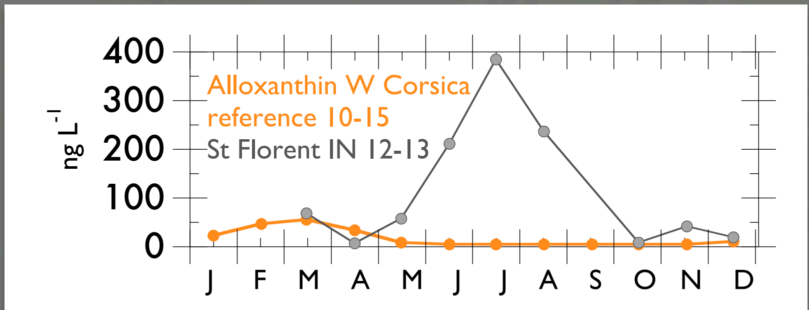
1. PPCI : a new phytoplankton composition index

1.4 Reference curves deliver a baseline against which data acquired at the monitoring stations are plotted, respecting the temporality.



5. The frequency of measurements situated above the reference and the relative importance of the overtakings are computed. The result is a score converted in EQR.

	High		Good	Moderate	Poor	Bad
ICPP Médit	1	0.90	0.70	0.50	0.20	0

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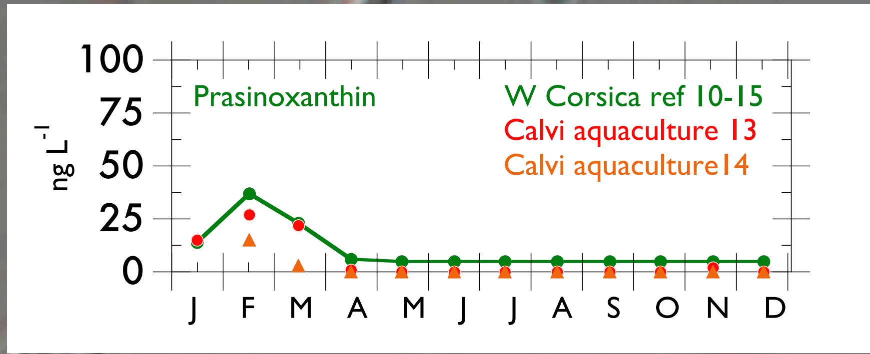
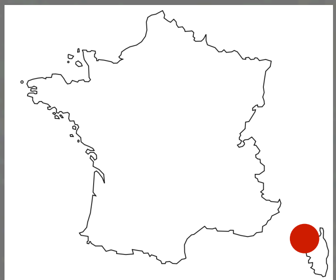
2. Application of the PPCI to Mediterranean coastal sites

- **Study cases : small fish aquaculture (production : 40 T y^{-1}, Calvi Bay, Corsica, W Med)**





	High	Good	Moderate	Poor	Bad
ICPP Médit	1 0.90	0.70	0.50	0.20	0

No detectable impact on phytoplankton composition

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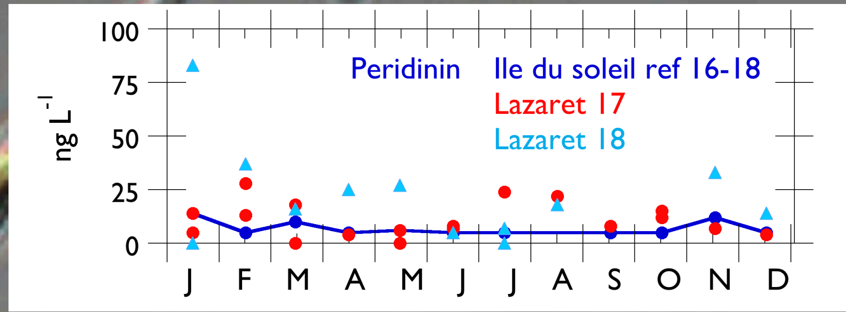
2. Application of the PPCI to Mediterranean coastal sites

- **Study cases : mussels farms in a highly urbanized area (Lazaret Bay, France, W Med)**



High	Good	Moderate	Poor	Bad
1 0.90	0.70	0.50	0.20	0

Phytoplankton composition is strongly affected by human pressures

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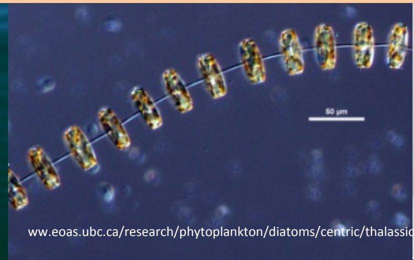
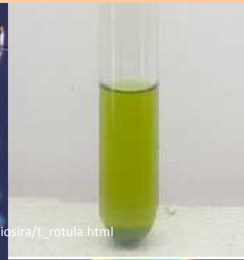
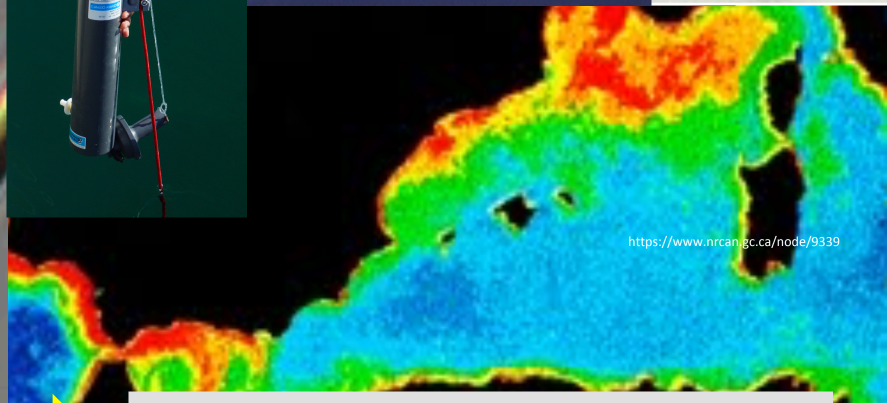
3. Linkage between *in situ* phytopigment data and ocean color images

- **Main objective : to identify the phytoplankton functional groups from space in order to define « *phytoplankton landscape maps* » and to tend towards a spatialization of the PPCI index in the French Mediterranean coastal waters.**

- **First developments focused on the oligotrophic Bay of Calvi where time series of *weekly pigments data* are available.**

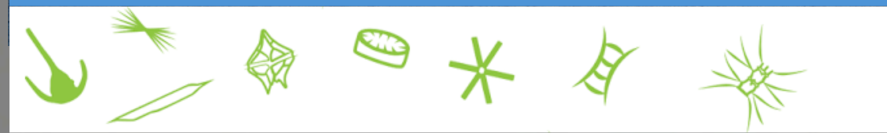






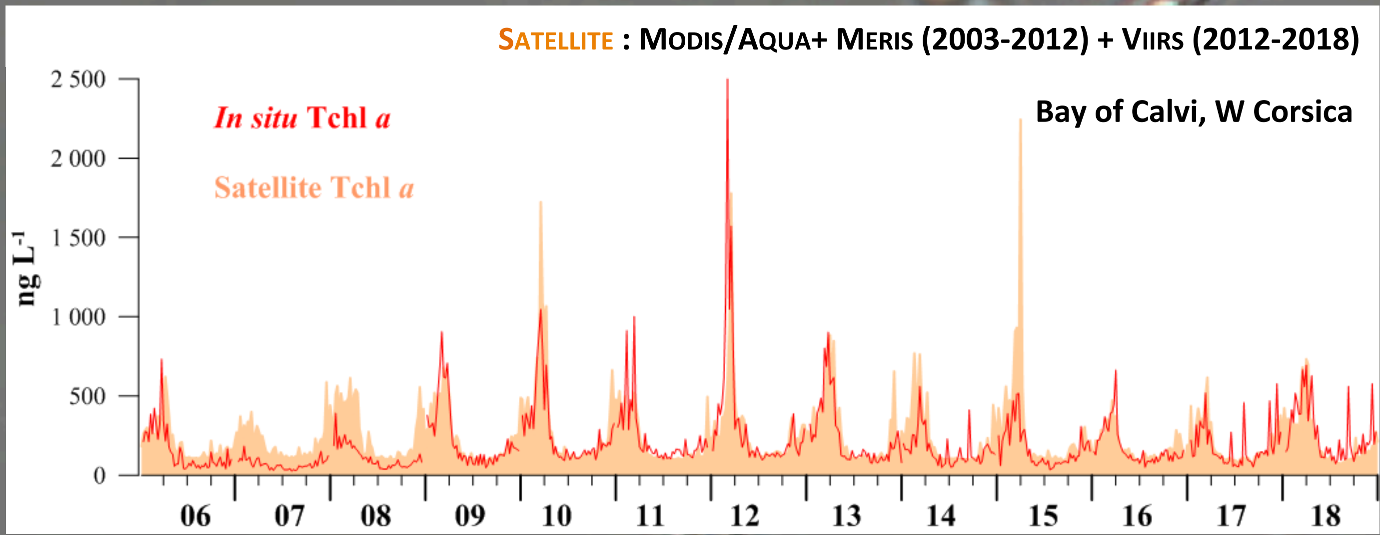
Total biomass and composition

The Bay of Calvi (W Corsica),
a phytoplankton reference site for WFD assessment



3. Linkage of *in situ* data and ocean color images

3.1 Biomass (Tchl *a*) : application of OC5-MED algorithm developed by IFREMER



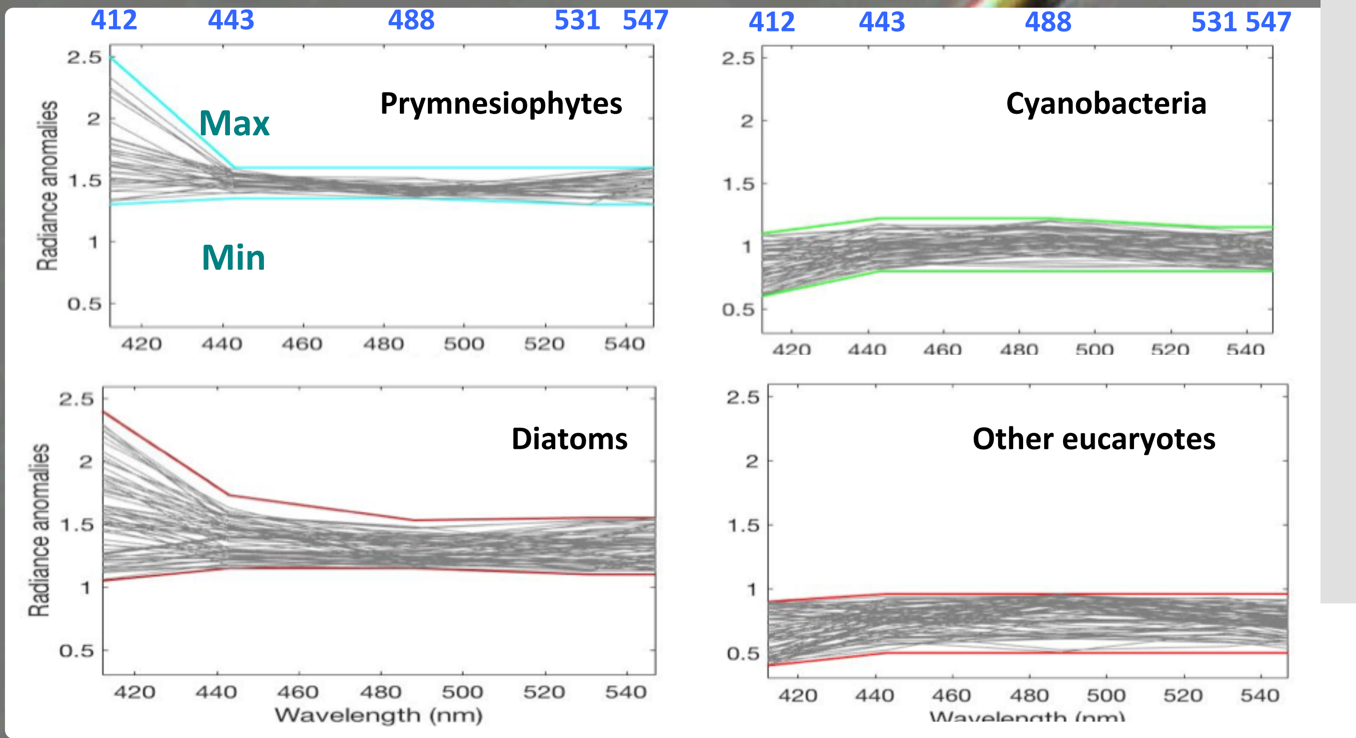
Strong similarities **between *in situ* measurements and satellite-derived Tchl *a* (Gohin et al. 2020, Goffart et al. in prep).**

International Group for Marine Ecological Time Series

Analysis and synthesis of global marine ecological changes as seen through biogeochemical and plankton time series.

3. Linkage of *in situ* data and ocean color images

3.2 Composition : *downscaling* and adaptation of the PHYSAT algorithm developed initially by Alvain et al. 2008 and Navarro et al. 2014



- **Analysis of the *normalized reflectance* (reflectance divided by Tchl *a*) derived from MODIS sensors allows to distinguish *4 dominant phytoplankton functional groups*.**

LSIS-Université de Toulon et IFREMER, laboratoire ODE/LERPAC

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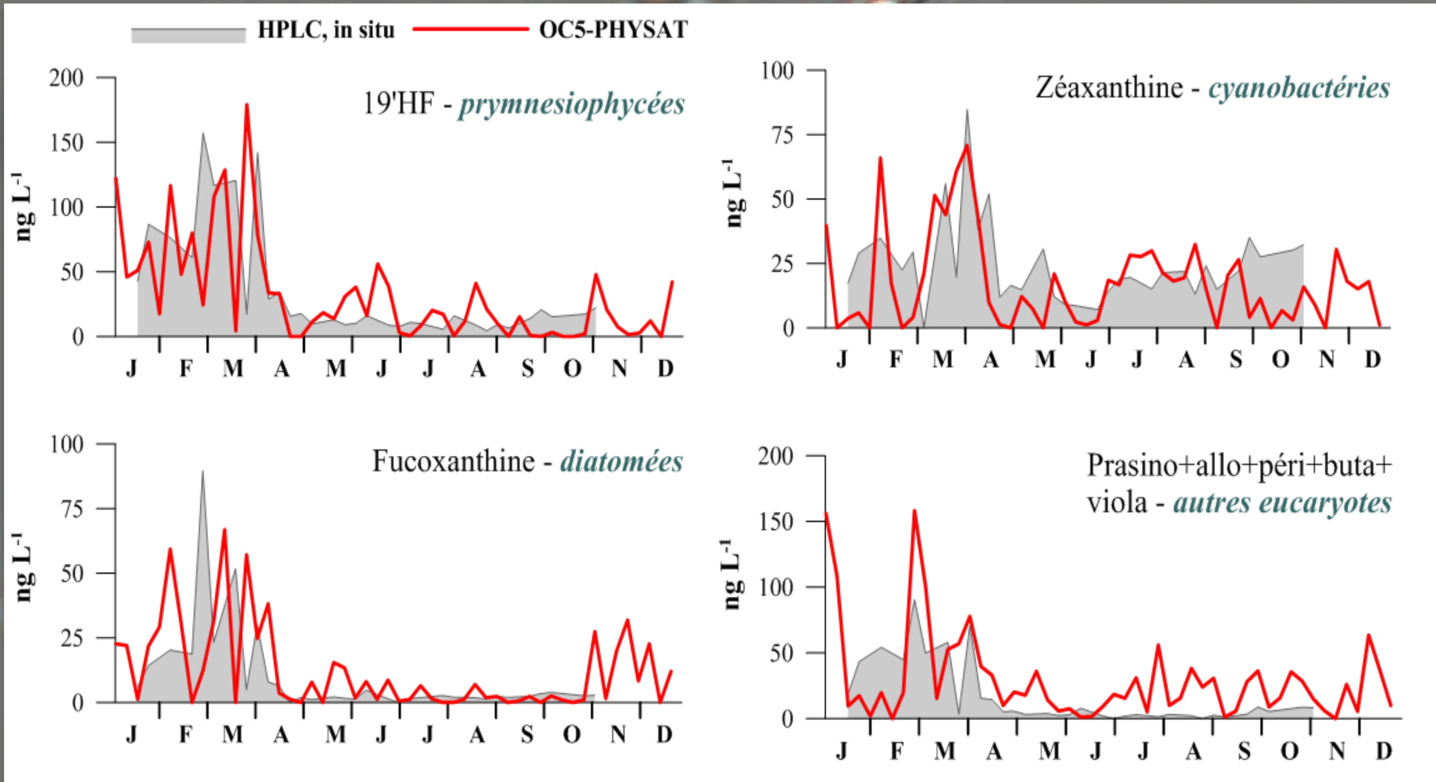
3. Linkage of *in situ* data and ocean color images

3.3 Comparison between *in situ* and ocean color phytoplankton composition (Bay of Calvi, Canyon head station, *reference year : 2015*)



In situ samples collected weekly in the framework of the STARECAPMED program

► **The OC5-PHYSAT method successfully reproduces the temporal pattern of the major phytoplankton groups.**

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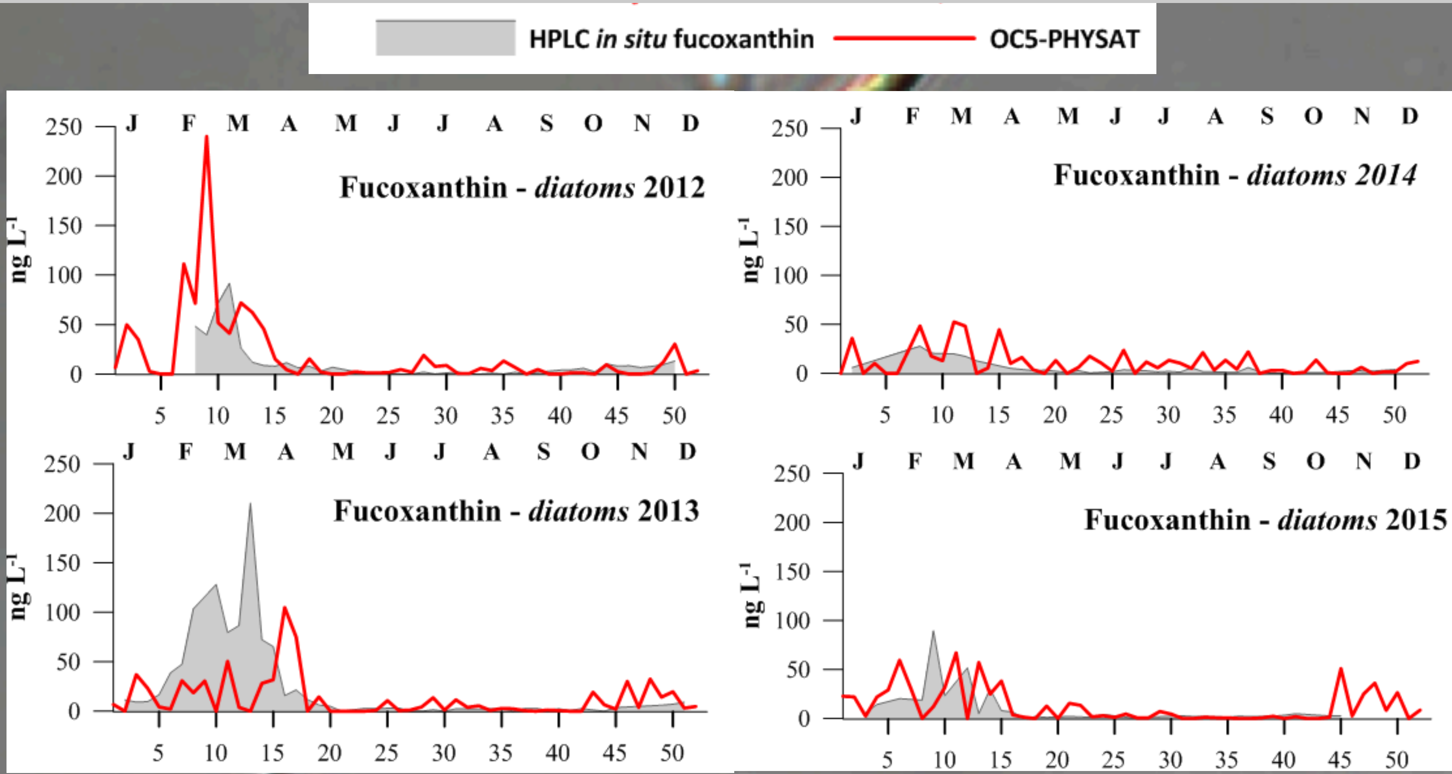
3. Linkage of *in situ* data and ocean color images

3.3 Comparison between *in situ* and ocean colour phytoplankton composition (Bay of Calvi, Canyon head station, interannual variability, *2012 - 2015 data set*) : example of diatoms



In situ samples collected weekly in the framework of the STARECAPMED program

► **The OC5-PHYSAT method successfully reproduces interannual variations of the major phytoplankton groups, except when the cloud cover is very important *(e.g.* spring 2013).**

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Perspectives

- To verify the adequacy of the OC5-PHYSAT method in the different hydrological landscapes with promising applications in the MSD implementation;

- To improve results (spatial and temporal resolutions) using SENTINEL3 data when they will be available (2021).