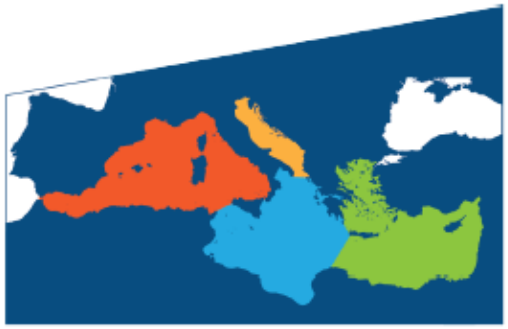

MEDREGION

SUPPORT MEDITERRANEAN MEMBER STATES TOWARDS IMPLEMENTATION OF THE MARINE STRATEGY FRAMEWORK DIRECTIVE NEW GES DECISION AND PROGRAMMES OF MEASURES AND CONTRIBUTE TO REGIONAL/SUBREGIONAL COOPERATION

Phytoplankton biomass and composition as useful tools for assessing the impact of early anthropogenic pressure in the Western Mediterranean

Anne Goffart

Rome, 14 th February 2020

LIÈGE université

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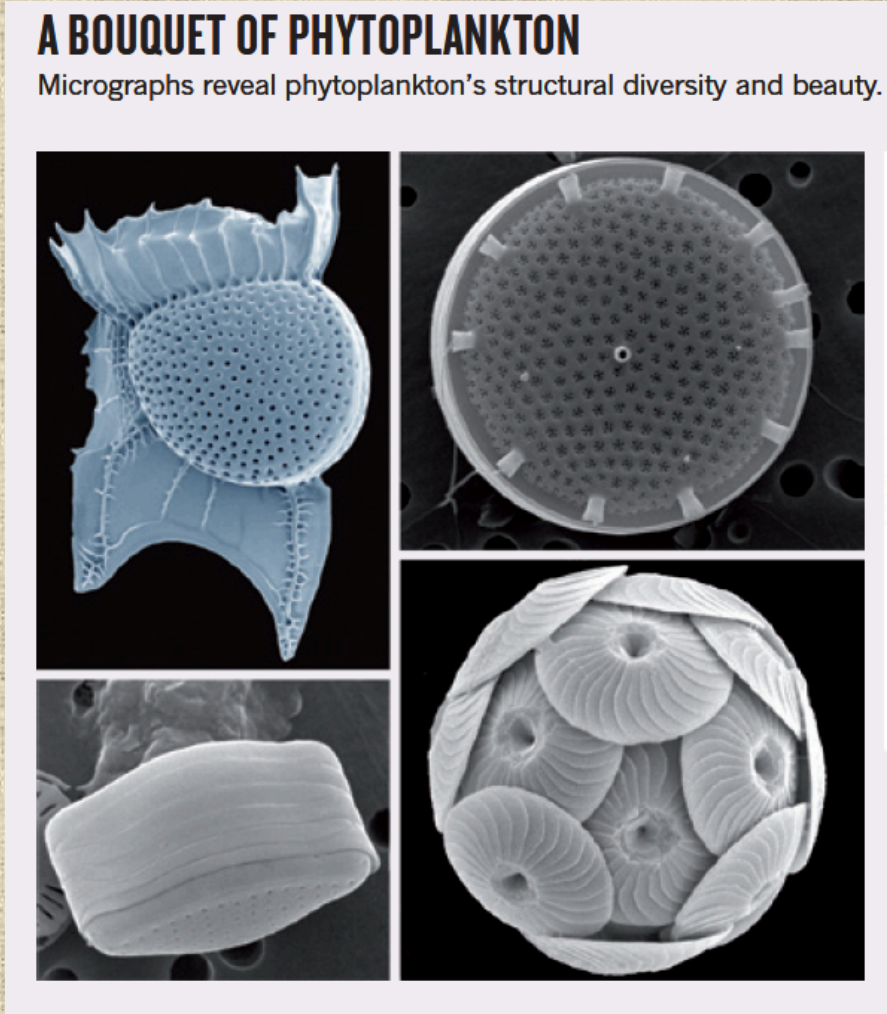
14 02 20

Who I am

- Biological oceanographer - work at sea;
- Senior scientist at the University of Liège (Belgium);
- Expertise in phytoplankton dynamics (Western Mediterranean and Southern Ocean);
- Main interest : to understand how phytoplankton responds to impact of climate variability and human disturbance through comparative analysis of coastal ecosystems and long-term (42 years) time series in the Bay of Calvi (Corsica, NW Med).



Falkowsky 2012

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Objectives

In the framework of the MSFD implementation, the general objective of this presentation is to discuss the effects of climate variation and anthropogenic pressure on phytoplankton, focusing on the results obtained in the Corsican coastal waters.

Good Environmental Status

1. Biological diversity
2. Non-indigenous species
3. Population of commercial fish/shellfish
4. Elements of marine food webs
5. Eutrophication
6. Sea floor integrity
7. Alteration of hydrographical conditions
8. Concentrations of contaminants
9. Contaminants in fish/seafood for human consumption
10. Marine litter
11. Introduction of energy including underwater noise

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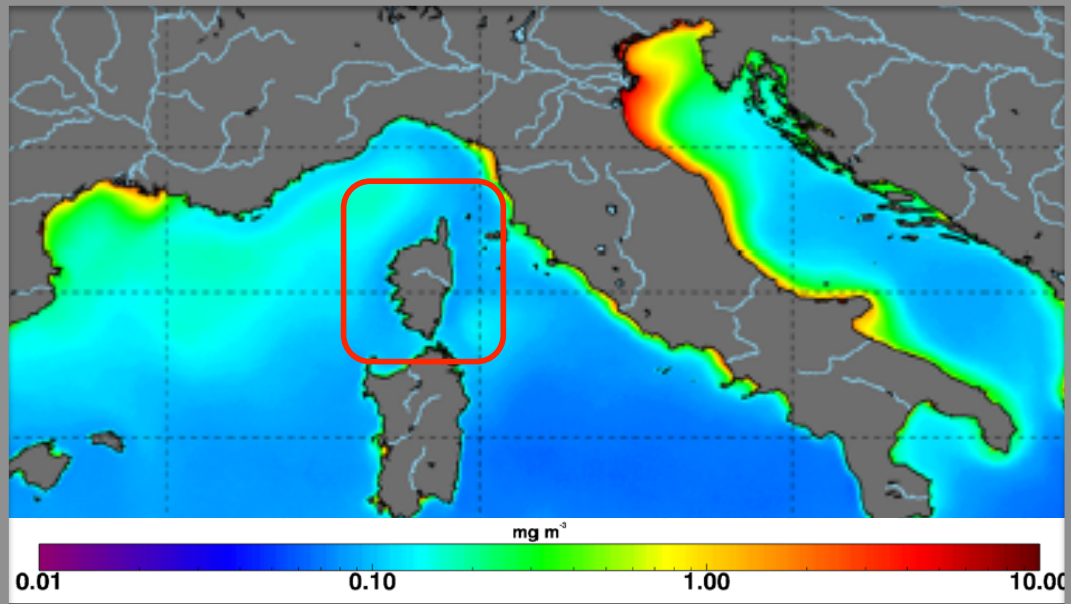
Main characteristics of the Corsican coastal waters

- Typology : Island-W
- Salinity > 37.5
- Oligotrophic waters
- Water masses in very good conditions, but some problems of early eutrophication in enclosed gulfs and near ports.



Chl *a* concentration climatology relative to 1998–2009 time period (Collela et al. 2016)

Tableau 55. Résultats pour l'élément de qualité « Phytoplancton » des masses d'eau côtières (MEC) pour le district « Corse ».

		Biomasse			Abondance			Phytoplancton	
Code MEC	Libellé MEC	P90 Chl *a* ($\mu g.L^{-1}$)	EQR_b [IC]	Classe biomasse	Abondance (% bloom)	EQR_a [IC]	Classe abondance	EQR_{phyto} [IC]	Classe phyto
FREC02d	Plaine orientale	0,3	1 [1 ; 1]	1	7,5	1 [1 ; 1]	1	1 [1 ; 1]	1
FREC01ab	Pointe Palazzu - Sud Nonza	0,5	1 [0,55 ; 1]	1	1,4	1 [1 ; 1]	1	1 [0,77 ; 1]	1

Witkowski et al. 2017

Specific objectives

Focusing on the results obtained in the Corsican coastal waters, the specific objectives of this talk are :

1. to illustrate the diverse character of nitrate and Tchl *a* time series in response to climate variation;
2. to detect trends in environmental variables, subsurface nutrients and Tchl *a*;
3. to identify the main phytoplankton functional groups responding to fluctuations in the input of nutrients in coastal waters;
4. to identify main gaps in information required to implement the MSFD at a regional scale and to propose key directions to overcome them.

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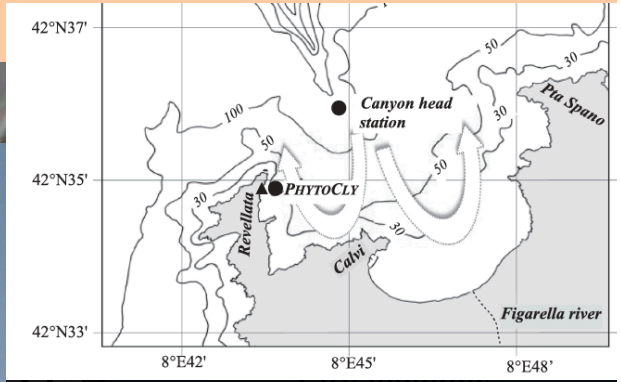
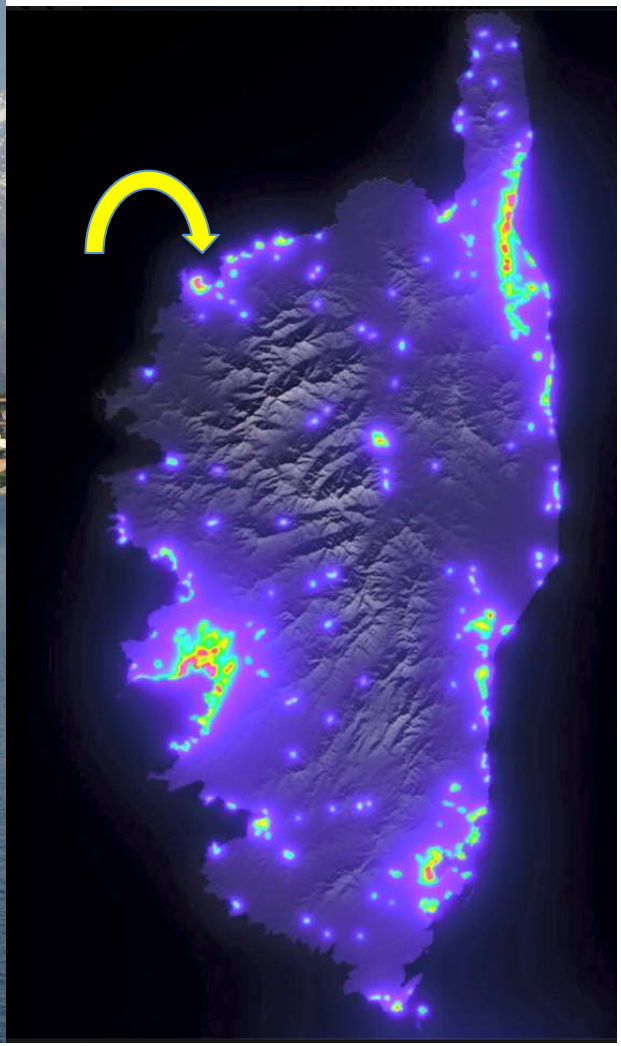
The Bay of Calvi





- Few anthropogenic pressures
- Low-runoff system
- Open bay and narrow shelf
- Presence of a deep canyon in front of the city of Calvi
- PhytoCly station : reference for the WFD

PhytoCly long-term time series (surface data, 1979-)

- **Water temperature and wind**

  Continuous from 1979

- **Total chlorophyll *a***

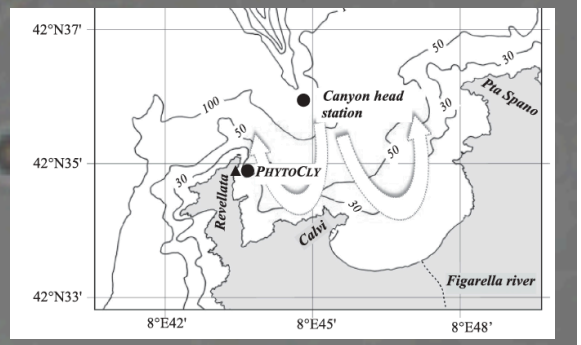
  From 1979, with interruptions until 2005, continuous from 2006

- **Nutrients**

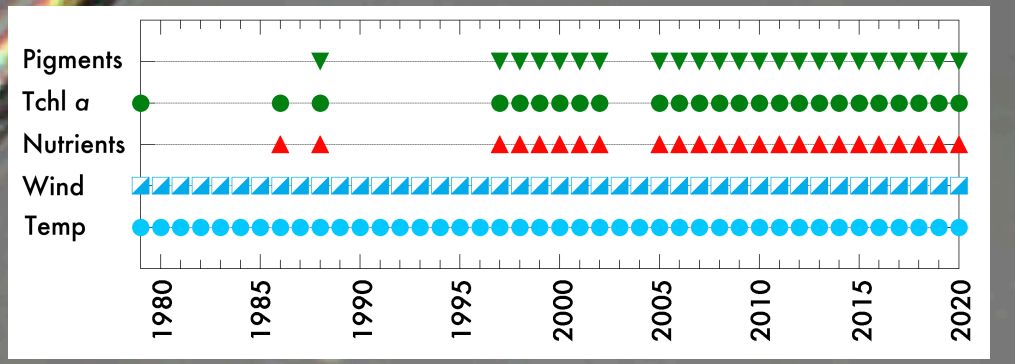
  From 1986, with interruptions until 2005, continuous from 2006

- **Phytoplankton pigments**

  From 1988, with interruptions until 2005, continuous from 2006.



High sampling frequency (*i.e.* daily to biweekly) for nutrients and phytoplankton



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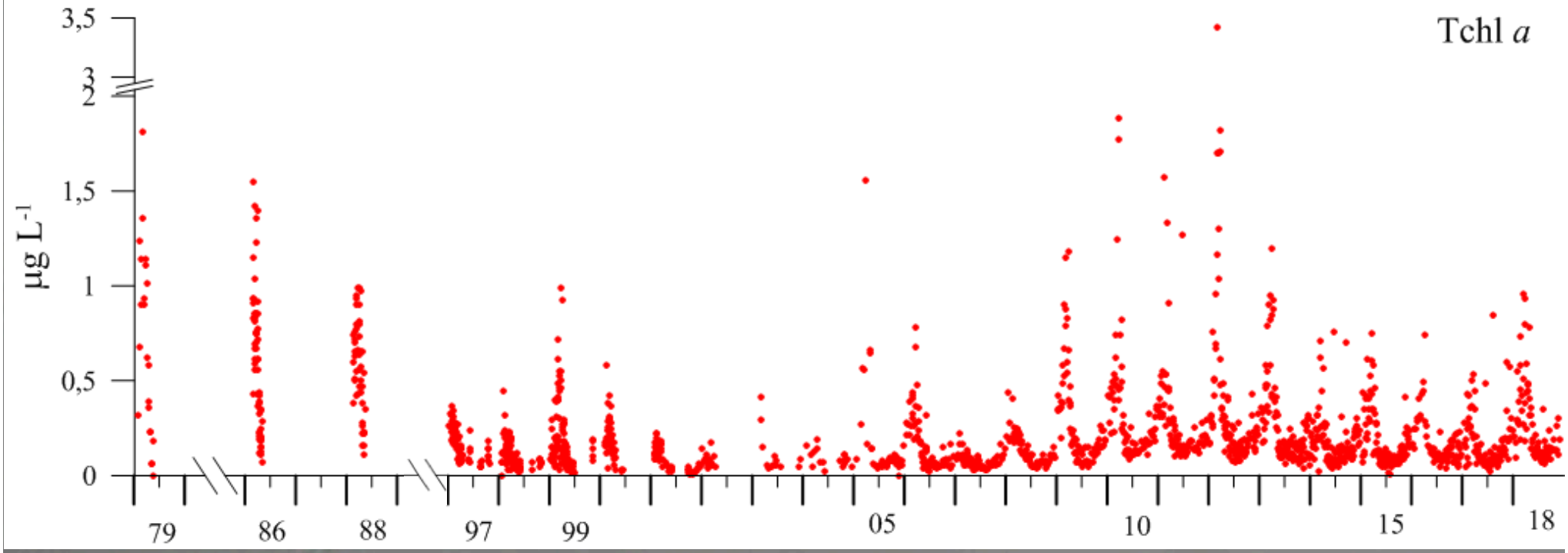
PhytoCly long-term time series (surface data, 1979-)

Subsurface Tchl *a* time series at the PHYTOCLY station, 1979 - 2018

IGMETS *International Group for Marine Ecological Time Series*

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



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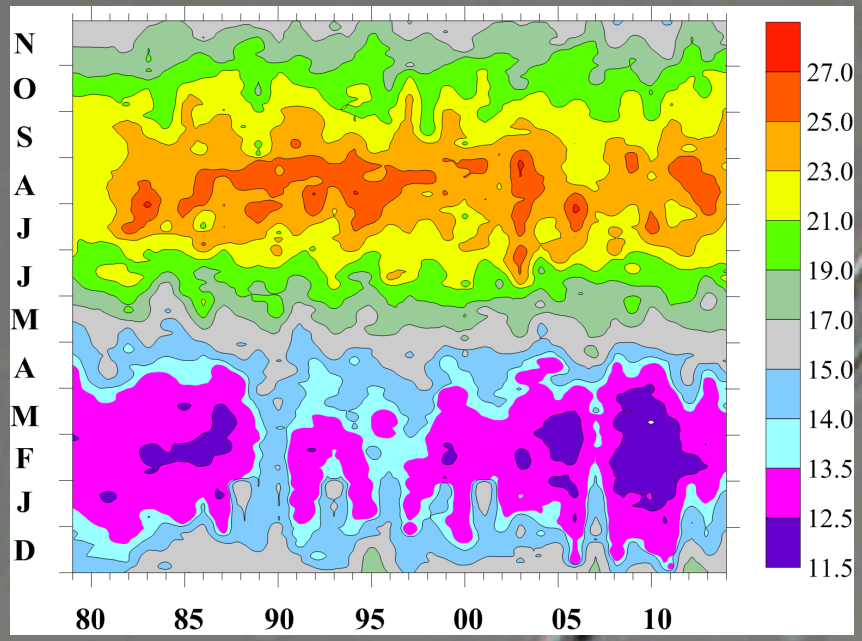
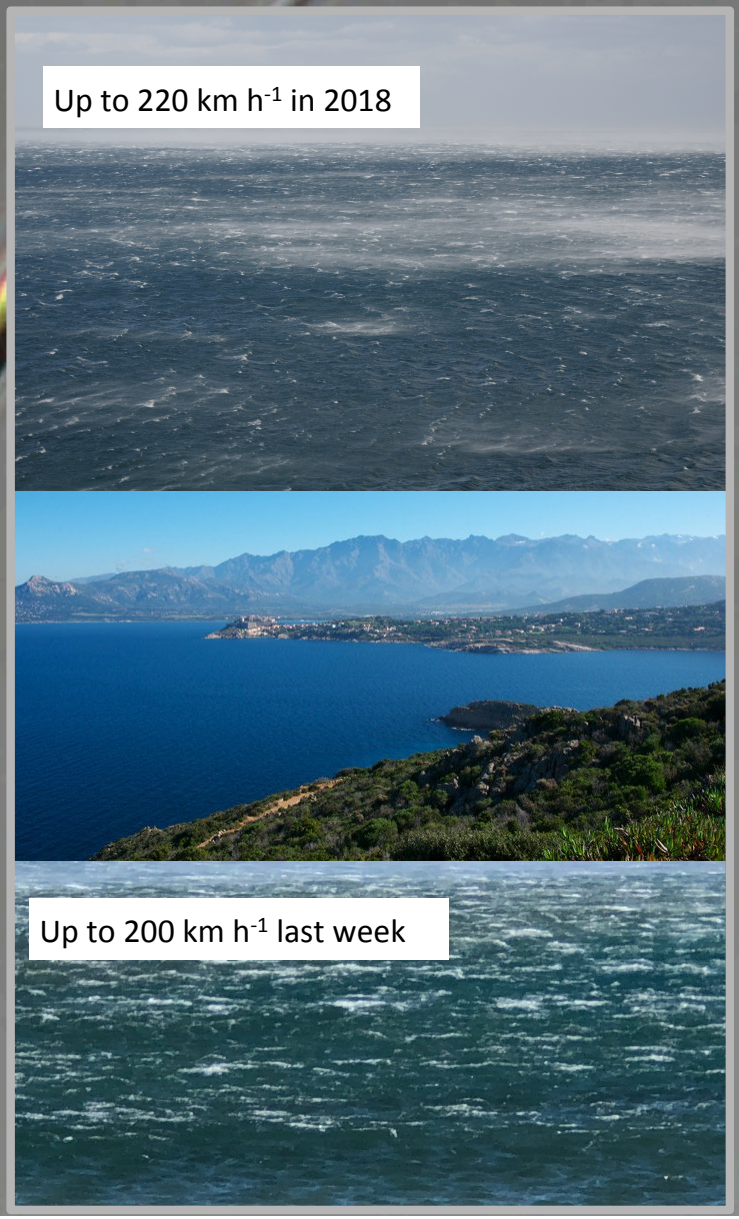
Response to climate variation

High seasonal and interannual variability in environmental variables

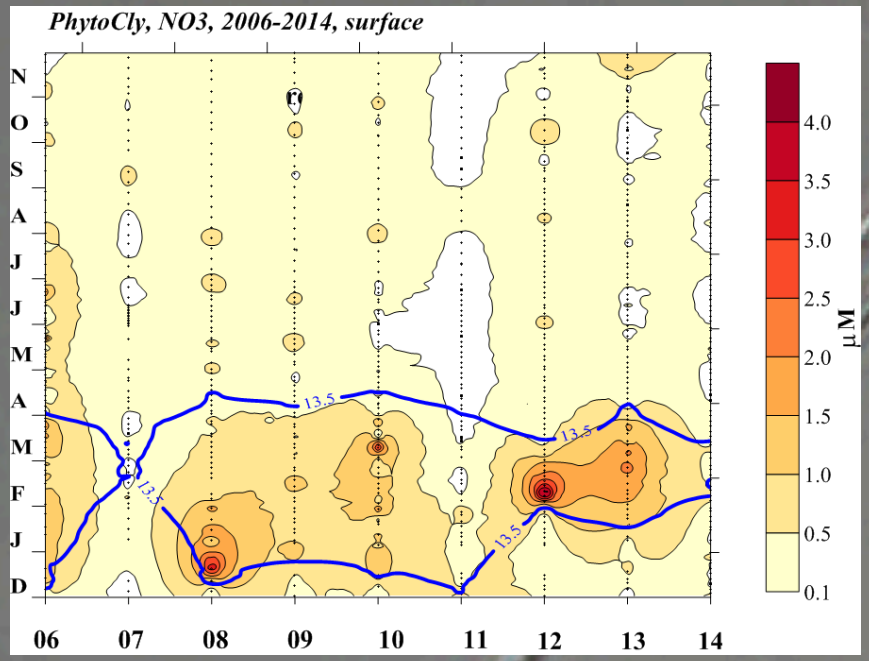


Temporal changes in subsurface temperature in the Bay of Calvi (1979-2014)



Response to climate variation

High seasonal and interannual variability in nutrients



Temporal changes in nitrate in the Bay of Calvi (2006-2014)

Importance of winter conditions to determine the state of nutrient contents and phytoplankton biomass in surface waters

Response to climate variation

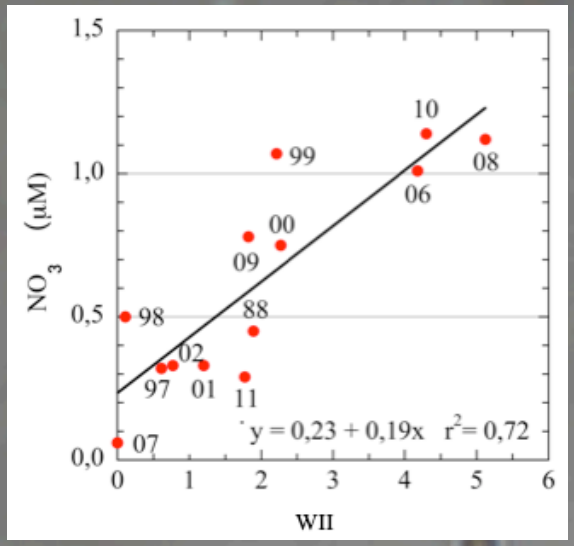
Nutrients as a fonction of WII, a winter intensity index

WII = (CW x WE) / 1000,

where CW is the duration (number of days) of the cold-water period (surface water ≤13.5), and WE is the number of wind events during the cold-water period (mean daily wind speed > 5 m s^{-1})

(Goffart et al., Progr in Oceanography, 2015).

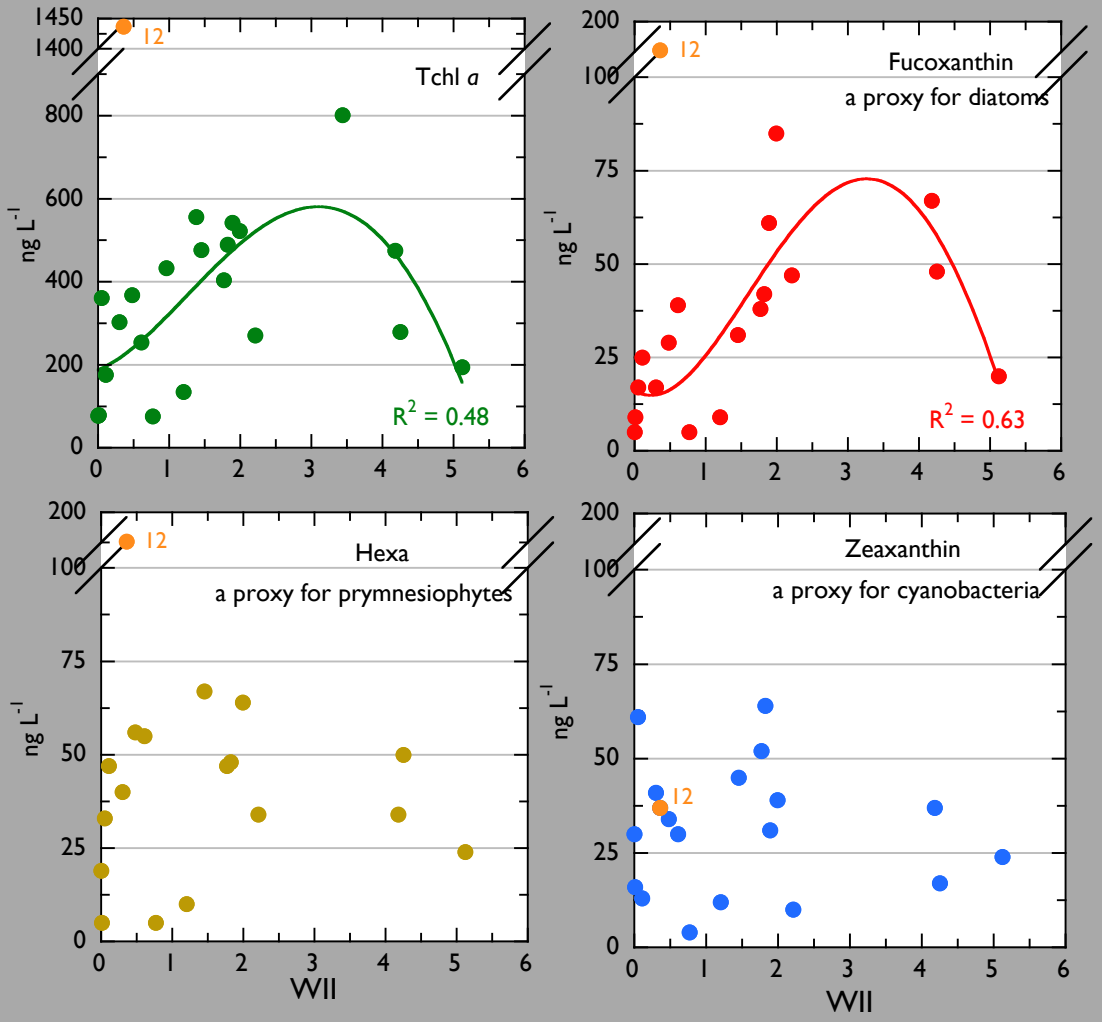
Winter intensity is a key driver of nutrient replenishment during the winter-spring period.



Goffart et al., 2015

Response to climate variation

Phytoplankton as a fonction of WII, a winter intensity index



Winter intensity is a key driver of phytoplankton dynamics during the winter-spring period. It influences both **winter-spring phytoplankton distribution and community structure**. Among the dominant phytoplankton functional groups, **diatoms** are very sensitive to winter intensity, while prymnesiophytes and cyanobacteria are not correlated with it.

Scatter diagrams of mean subsurface Tchl *a*, fucoxanthin, hexanoyloxyfucoxanthin (hexa) and zeaxanthin during the cold-water periods as a function of the Winter Intensity Index (WII). Data acquired between 1979 and 2018. Goffart in preparation.

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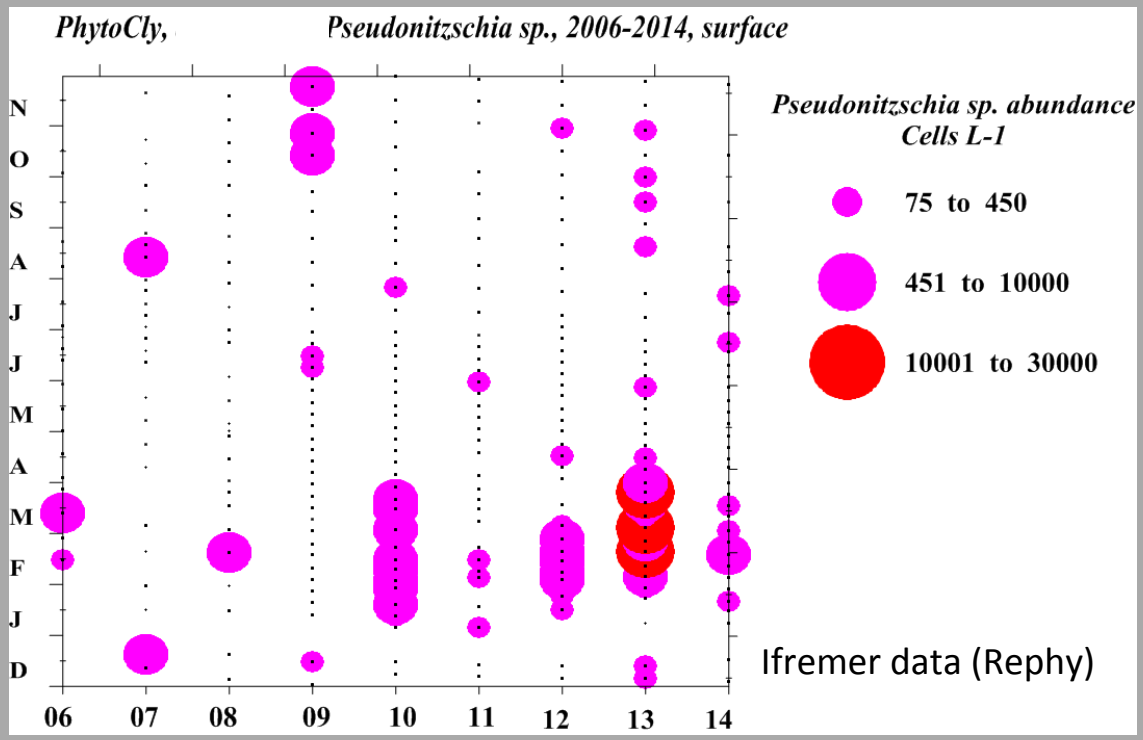
Response to climate variation

Phytoplankton as a fonction of WII, a winter intensity index



Winter intensity does not control abundance of **potentially toxic diatoms**.

Specific objectives

Focusing on the results obtained in the Corsican coastal waters, the specific objectives of this talk are :

1. **to illustrate the diverse character of nitrate and Tchl *a* time series in response to climate variation;**
2. **to detect trends in environmental variables, subsurface nutrients and Tchl *a*;**
3. **to identify the main phytoplankton functional groups responding to fluctuations in the input of nutrients in coastal waters;**
4. **to identify main gaps in information required to implement the MSFD at a regional scale and to propose key directions to overcome them.**

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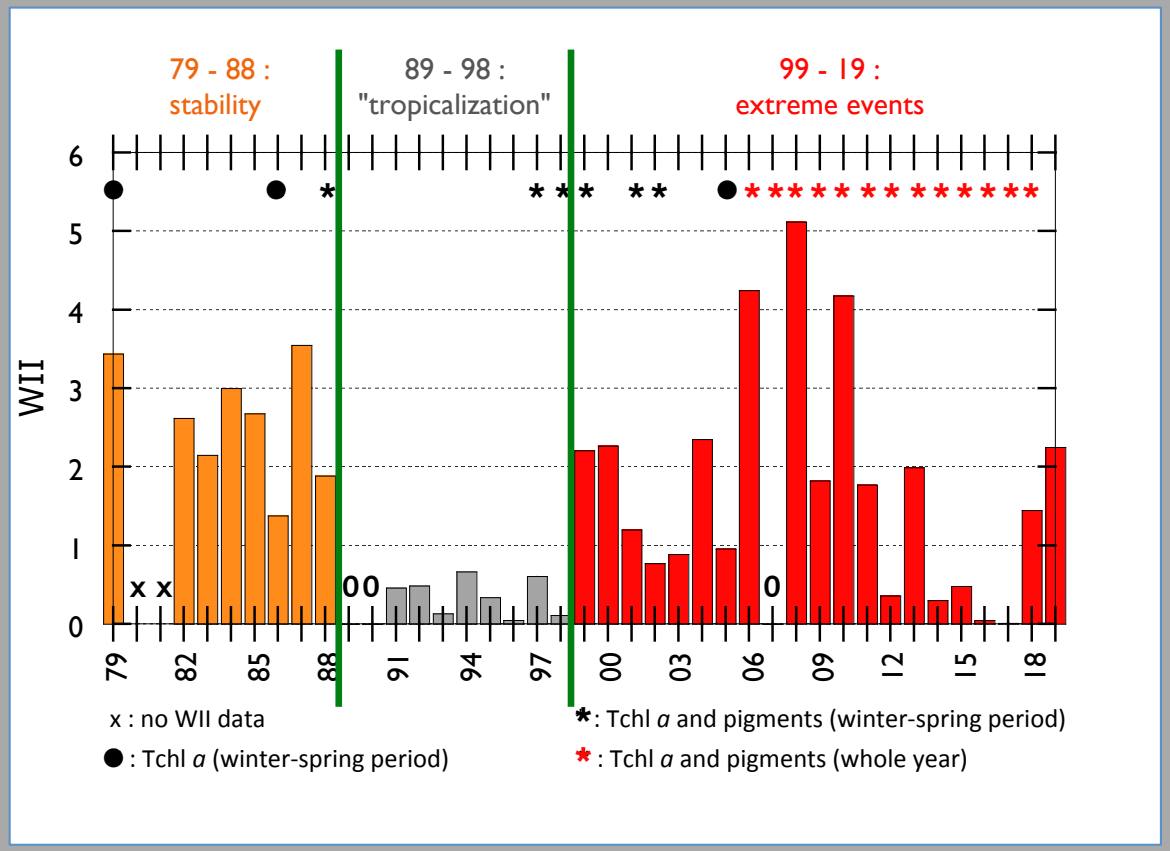
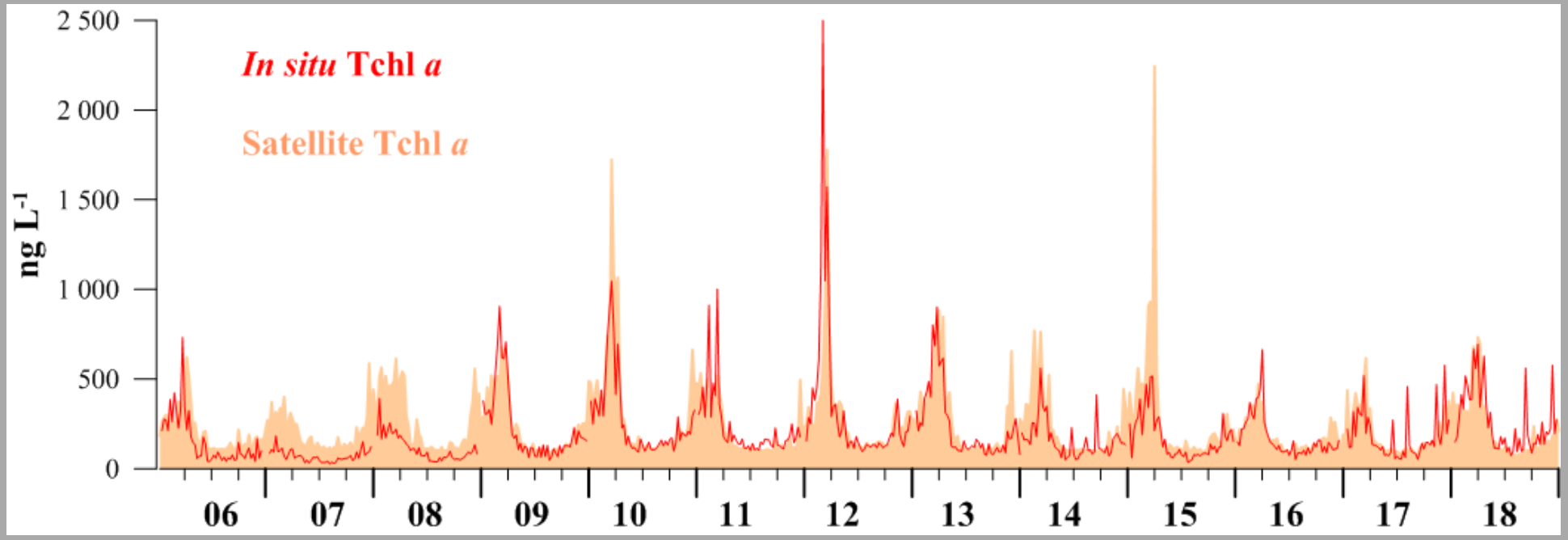
Trends over the 1979-2019 period



There is **no continuous long-term trend** (increase, decrease) in WII and in phytoplankton biomass and composition over the 4 decades of observations.

Combining satellite data with *in situ* observations



Time series (2006-2018) of *in situ* and satellite derived Tchl *a* in Calvi area (weekly averages; Goffart et al., in prep; Gohin et al., in prep.).

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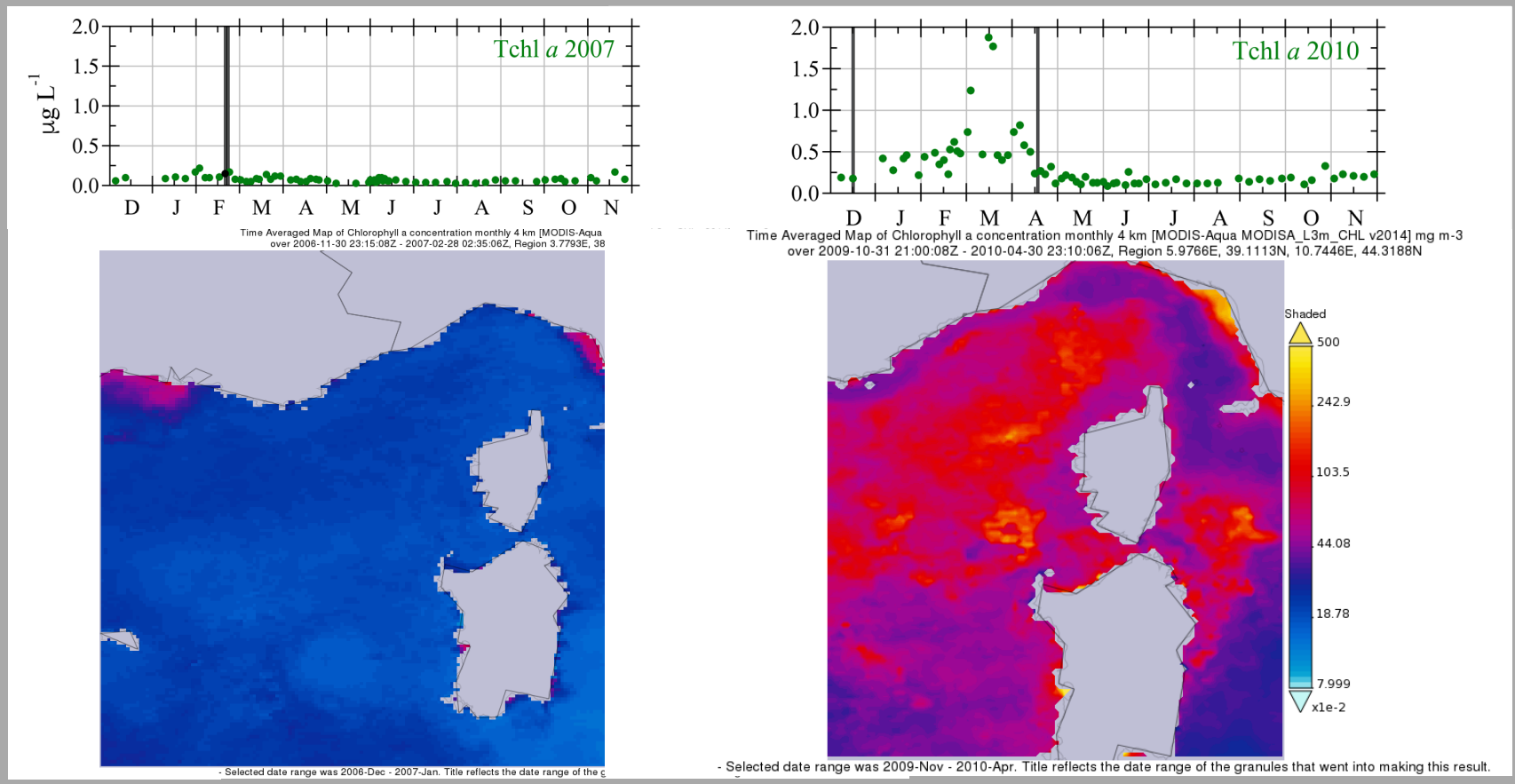
Combining satellite data with *in situ* observations



Observations from the Bay of Calvi can be extended to the western Corsican coast .

Remote sensing may represent an efficient and reliable solution to detect trends in phytoplankton dynamics and to synoptically control eutrophication, in order to maintain/achieve the good environmental status.

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Specific objectives

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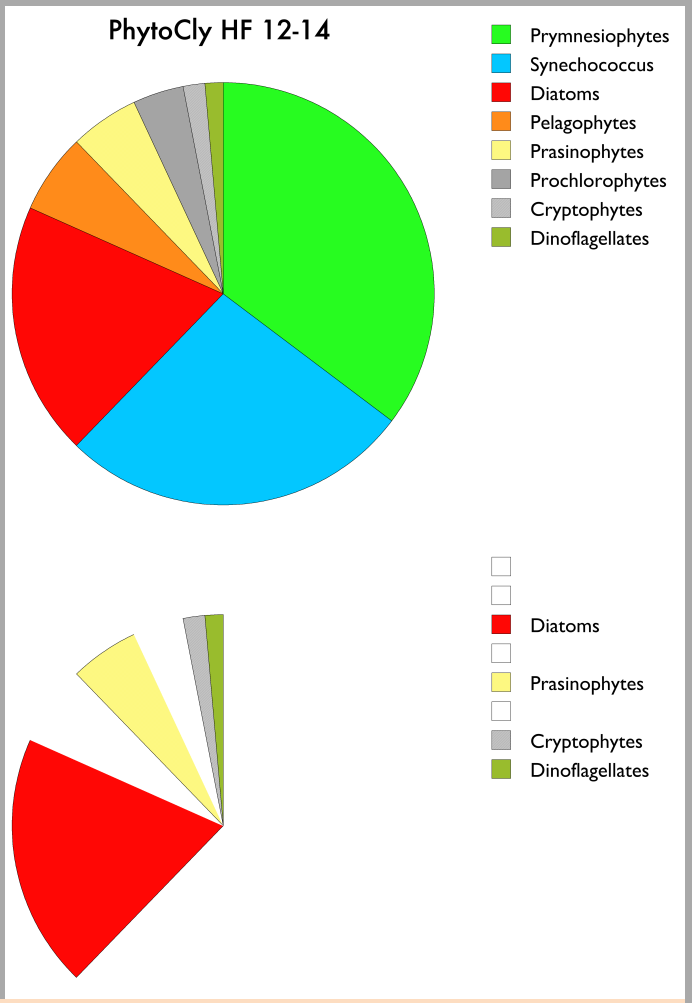
Pressure / pigments relationships

PHYTOCLY reference station (high sampling frequency)

Spearman's correlation coefficients (rho) between phytoplankton variables and nutrients at the PhytoCly reference station (2009-2014), 2 samples per week, $\alpha = 0.05$.

	NO_3^- n = 511	NO_2^- n = 511	$NO_3^- + NO_2^-$ n = 511	NH_4^+ n = 259	DIN n = 259	$Si(OH)_4$ n = 510
Tchl *a*	0.38	0.47	0.43	–	0.45	0.31
Chl *a*	0.39	0.48	0.44	–	0.45	0.31
Divinyl chl *a*	0.15	0.22	0.17	–	0.25	0.15
Peri	0.38	0.32	0.39	–	0.40	0.23
Buta	0.20	0.32	0.24	-0.12	0.24	0.31
Fuco	0.53	0.50	0.57	-	0.61	0.31
Neo	0.42	0.52	0.46	-	0.49	0.28
Prasino	0.50	0.60	0.55	-	0.57	0.37
Viola	0.33	0.32	0.34	-	0.32	0.18
19'HF	0.14	0.24	0.17	-	0.18	0.21
Allo	0.41	0.53	0.46	–	0.47	0.43
Zea	-	-	-	–	-	-
Tchl b	0.25	0.32	0.29	–	0.34	0.26
	P<0.0001	*P*<0.001	*P*<0.05	- NS		



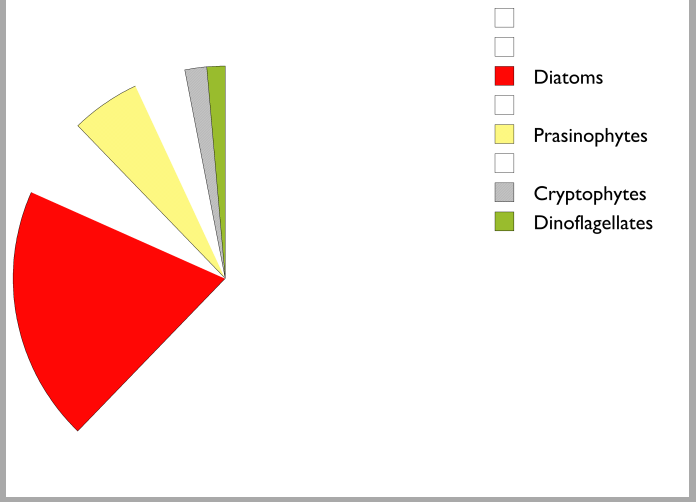
Tchl *a* and 4 groups, identified by their pigment signature, respond positively to "natural" pressures (Goffart, 2019).

Pressure / pigments relationships

Island and 3W data set (15 stations, monthly sampling frequency)

Spearman's correlation coefficients (rho) between phytoplankton variables and nutrients (Island and 3 W data set, one year sampling at a monthly frequency , $\alpha = 0.05$).

	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		



Tchl *a* and 4 groups, identified by their pigment signature, respond positively to "natural" pressures (Goffart, 2019).

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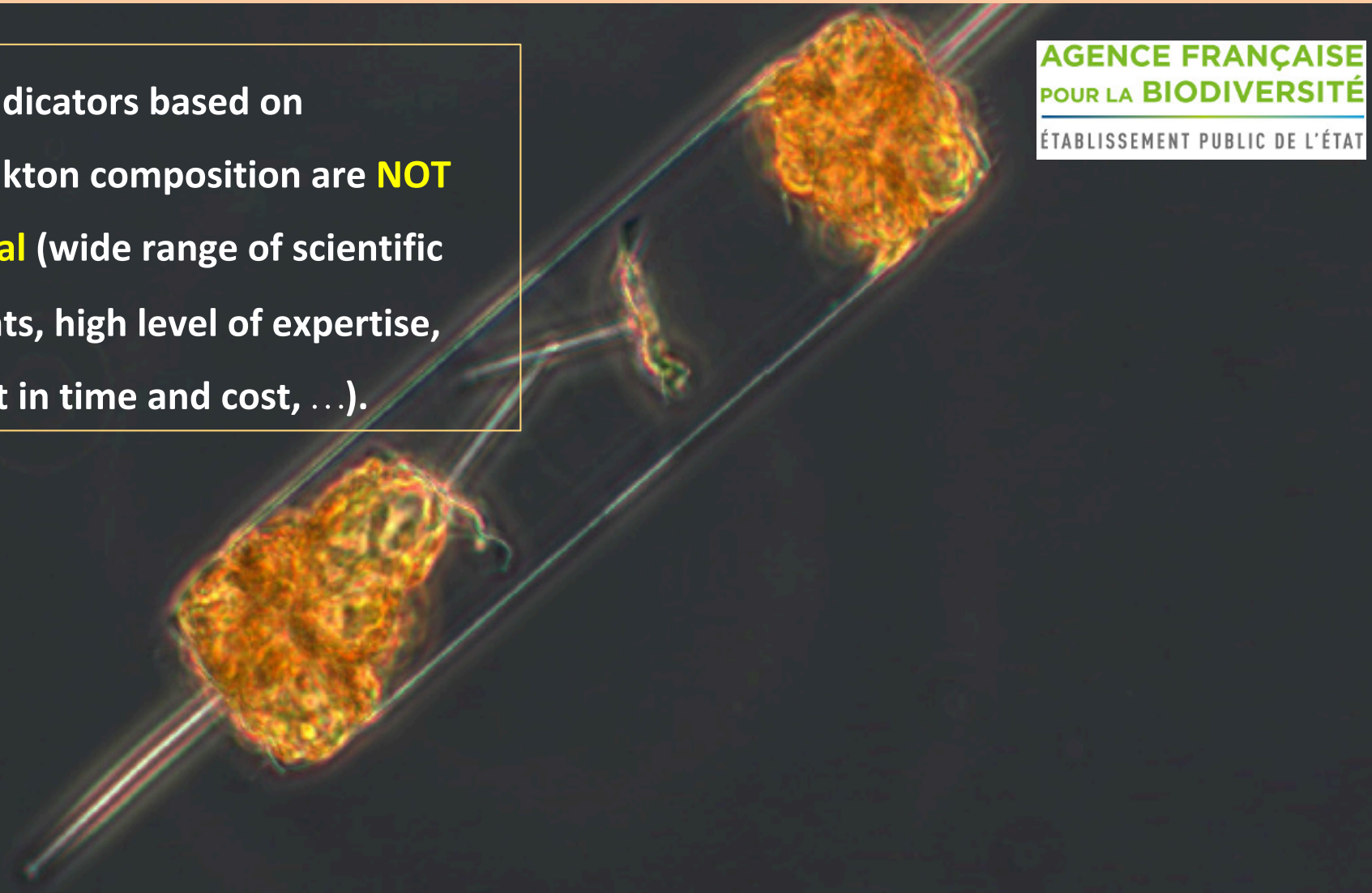
PPCI, a new phytoplankton composition index

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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Background photo@Kudela Lab Biological Oceanography, University of California

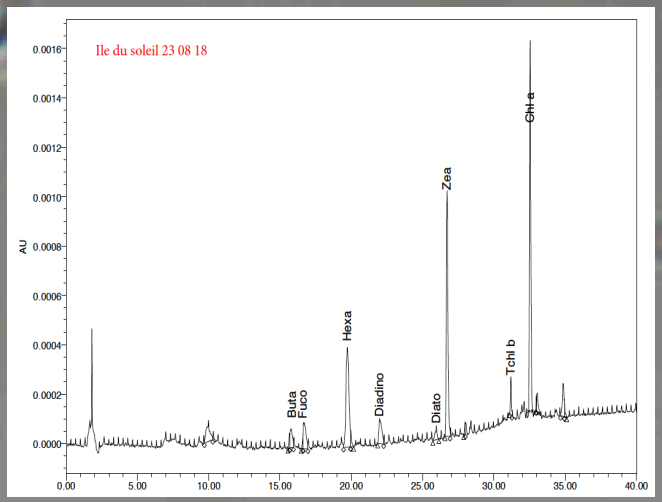
PPCI, a new phytoplankton composition index

- PPCI was developed initially in the French coastal waters of the Mediterranean Sea where a robust dataset of nutrients and phytopigments was collected in reference sites and impacted water masses (Goffart 2019, 15 stations, 744 pairs of samples);

- PPCI is based on phytopigments (carotenoids) that are diagnostic of phytoplankton functional groups (1 pigment ➔ 1 group);

- Phytopigments are separated and quantified by HPLC;

- Analyses are performed on total phytoplankton, which means that all size classes are considered.



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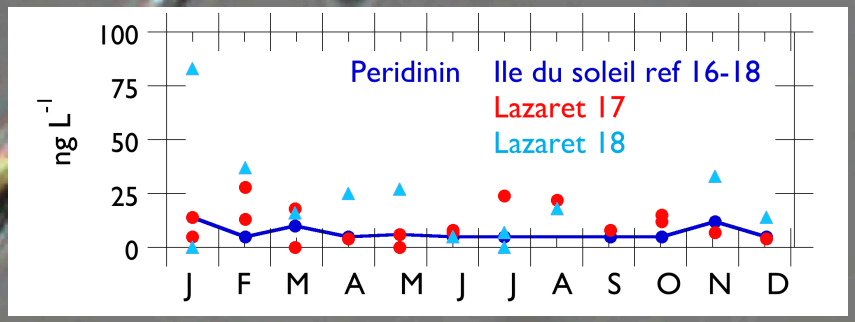
Application of PPCI to Mediterranean coastal sites

- **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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Background photo@Kudela Lab Biological Oceanography, University of California

Specific objectives

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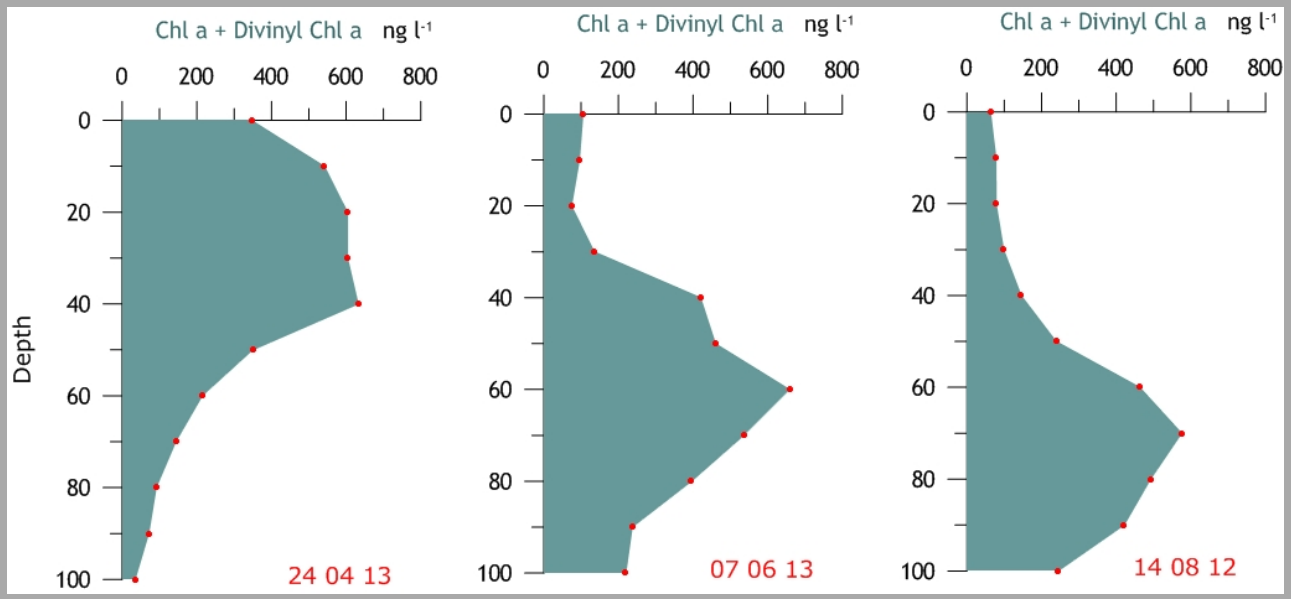
Vertical structure of the water column



Tête de canyon station, Bay of Calvi

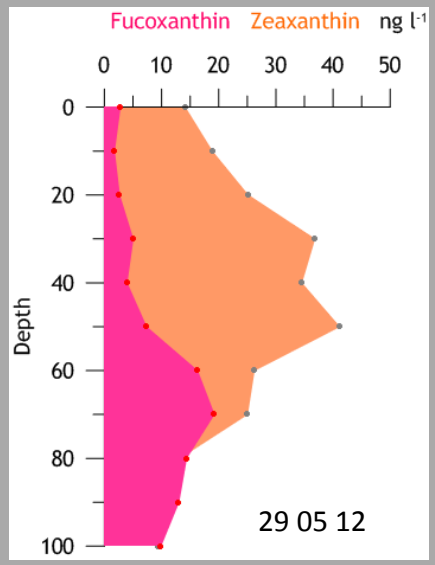
- **Very limited information (DCM)**
- **Surface assessment criteria NEED to be adapted for the water column.**

EC de type 3W - proposition de grille corse Anne Goffart

Référence (P90, 1ère valeur du mois, 1 valeur par mois pendant 6 an: 0.60 µg Chl a l-1

	Référence	High	Good	Moderate	Poor	Bad
P_{90} Chl a	0.60	< 0,75	0.75	1.22	2.44	4.88

Vertical structure of the water column



Tête de canyon station, Bay of Calvi

- **Need more *in situ* information in both reference and impacted areas;**
- **Modelling, …**

Thank you for your attention !