Interaction between climate forcing and plankton communities in a pristine NW Mediterranean site, the Bay of Calvi (Corsica) : a long term study

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Objectives

- To synthesize a long-term high-resolution study of environmental variables and surface plankton dynamics performed over the last four decades in a pristine NW Mediterranean coastal zone;

- To understand mechanisms controlling the interannual variability of phytoplankton bloom in a context of climate change;

- To detect trends, if any.
The studied area: the Bay of Calvi, Corsica, Western Mediterranean
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- Open bay and narrow shelf
- Presence of a deep canyon in front of the city of Calvi
- Few anthropogenic pressures
- Low-runoff system
- Reference for the WFD
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

**Microphytoplankton composition and mesozooplankton biovolume**
- Continuous from 2006
- Main zooplankton groups in some years.

**High sampling frequency:**
- Phytoplankton and nutrients: daily to biweekly
- Zooplankton: weekly.
Long-term time series (surface data, 1979-)

- Sampling at a fixed site (PHYTOCLY)

Subsurface Tchl a time series at the PHYTOCLY site, 1979 - 2016
Long-term time series (surface data, 1979-)

- **Sampling at a fixed site (PHYTOCLY)**
- **Phytoplankton observations in the Bay of Calvi are pertinent at the scale of the western coast of Corsica**

**Subsurface Tchl a at the PHYTOCLY site and at the Canyon head station, 2015.**

**Time averaged map of Tchl a (Modis-Aqua, 4 km), 31/10/2009 - 30/04/2010**

- Selected date range was 2009-Nov - 2010-Apr. Title reflects the date range of the granules that went into making this result.
High seasonal and interannual variability in environmental variables

Up to 220 km h⁻¹ in 2018
High seasonal and interannual variability in environmental variables

Temporal changes in subsurface temperature in the Bay of Calvi (1979-2014)
High seasonal and interannual variability in nutrient concentrations
We define a Winter Intensity Index $WII = \frac{CW \times WE}{1000}$, where $CW$ is the duration (number of days) of the cold-water period, and $WE$ is the number of wind events during the cold-water period (Goffart et al., Progress in Oceanography, 2015).
Control of winter-spring nutrient enrichment by WII

**Nutrients vs WII during the cold-water period**

The plots of nitrate averaged over the cold-water periods as function of WII show highly significant relationships (Goffart et al., 2015, Progress in Oceanography).

\[ y = 0.23 + 0.19x \quad r^2 = 0.72 \]
High seasonal and interannual variability in phytoplankton biomass
High seasonal and interannual variability in phytoplankton biomass
Control of winter-spring phytoplankton biomass by WII

Tchl α vs WII during the cold-water period

The plots of Tchl α averaged over the cold-water periods as function of WII show highly significant relationships (Goffart et al., 2015, Progress in Oceanography).

According to WII, the trophic character of the Bay of Calvi ranges from very oligotrophic (i.e. subtropical regime) to mesotrophic (i.e. temperate regime). A third regime is observed during severe winters characterized by specific wind conditions, when Mediterranean "high nutrient - low chlorophyll" conditions occur.
Control of annual phytoplankton biomass by WII

**Mean annual Chl a vs WII**

When phytoplankton was sampled over the entire year, strong positive correlations are observed between WII and annual mean concentrations, except in 2012.
Control of phytoplankton composition by WII

- Overall, prymnesiophytes, cyanobacteria and diatoms are the dominant groups
- Prymnesiophytes and cyanobacteria are present all over the year

Relative contribution (%) of each phytoplankton group at the PHYTOCLY station (2012 - 2015, pigments + CHEMTAX)
Control of phytoplankton composition by WII

- Diatoms develop only during the cold-water periods

*Our study is consistent with the report that, when occurring, diatoms peaks were added to the initial phytoplankton groups instead of replacing them (Barber & Hiscock 2006)*
Pseudonitzschia sp.

PhytoCly, diatoms and Pseudonitzschia sp., 2006-2014, surface

Pseudonitzschia sp. abundance
Cells L-1

- 75 to 450
- 451 to 10000
- 10001 to 30000
High seasonal and interannual variability in zooplankton
High seasonal and interannual variability in zooplankton
Control of plankton composition by winter intensity
Trends in WII?

Stable ecosystem  Warming  Extreme events

Limitation of fish recruitment (match / mismatch)?
Concluding remarks

• Winter intensity is a key driver of plankton dynamics over the year.

• The Bay of Calvi has undergone regime shifts (i.e. sudden, substantial and temporally persistent changes) in the late 1980s and in the late 1990s.

• Extreme WII values were observed in two consecutive winters during the last decade (2007 and 2008, respectively).

• There is a need to maintain long-term time series observations coupled with with satellite information (e.g. regionalization of phytoplankton composition).
Thank you for your attention!