Session S6

Climate change in the seasonal domain: impacts on the phenology of marine ecosystems and their consequences

Control of plankton phenology by climate variation in a Mediterranean coastal area: results from a long-term study (1979-2011)

Anne GOFFART, Amandine COLLIGNON and Jean-Henri HECQ

University of Liège, Belgium
A.Goffart@ulg.ac.be
Objectives

- To understand how physical forcing affects the timing, duration and magnitude of the winter-spring phyto- and zooplankton blooms in a well-preserved Mediterranean coastal area;

- To provide new insights on the regulation of the phyto- and zooplankton phenology by environmental factors.
The studied area: the Bay of Calvi, Corsica, Western Mediterranean

- 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
From 1979:
- water temperature and wind (continuous data)
- phytoplankton (18 years, continuous data from 2006)
- zooplankton (15 years, continuous data from 2003)

From 1988:
- nutrients (16 years, continuous data from 2006).

High sampling frequency during the winter-spring period:
- Phytoplankton and nutrients: daily to biweekly
- Zooplankton: weekly.
High interannual variability

The vertical dark bars identify the limits of the cold-water periods (≤13.5°C)
**Phytoplankton biomass**

Marked differences in the onset, date of maximum concentration, duration and intensity of the surface phytoplankton bloom

**BUT**

all blooming years share one key characteristic, *i.e.* Tchl a always increases and peaks during the cold-water period, when subsurface water is ≤13.5°C.

**Nutrients**

Nutrient enrichment of surface waters, although variable interannually in intensity, is driven every year by wind forcing during the cold-water period.

*(Goffart, Hecq, Legendre, in revision for Progress in Oceanography)*

The vertical dark bars identify the limits of the cold-water periods (≤13.5°C)
This led us to 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.

**Nutrients vs WII**

The plot of nitrate averaged over the cold-water periods as a function of WII shows highly significant linear relationship.

**Tchl a vs WII**

The plot of average Tchl a during the cold-water period as a function of WII is strongly related to WII, but not linearly.

*(Goffart, Hecq, Legendre, in revision for Progress in Oceanography)*
According to winter intensity, the trophic character of the Bay of Calvi varies from very oligotrophic (subtropical regime, low seasonal variability) to mesotrophic (temperate regime, well-marked increase in nutrient concentrations and chl a during the winter-spring period) during mild and moderate winters, respectively.

A third regime occurs during severe winters characterized by specific wind conditions (i.e. high frequency of northeasterly winds), when Mediterranean “high nutrient - low chlorophyll” conditions occurred.

(Goffart, Hecq, Legendre, in revision for Progress in Oceanography)
Control of phytoplankton composition and phenology by winter intensity

2010: a blooming year

The contribution of major phytoplankton groups was quantified using CHEMTAX (Mackley et al. 1996).

December - June
Control of phytoplankton composition and phenology by winter intensity

2007 : a non-blooming year
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).
Control of zooplankton composition and phenology by winter intensity

2010: a blooming year
December - June
Control of zooplankton composition and phenology by winter intensity

2007 : a non-blooming year
In contrast to phytoplankton, zooplankton phenology follows a replacement sequence of the main groups.
Conclusions

Based on the results provided by our long-term time series,

- we described a mechanism that links winter physics, nutrient replenishment of the surface layer and plankton dynamics under the different combinations of meteorological conditions that occur in the Bay of Calvi (PHYTOCLY station),
- we showed that plankton phenology is highly controlled by winter intensity and climate variation.
Thank you for your attention!