Environmental drivers and bloom characteristics of *Alexandrium minutum* along the French coasts.

Guallar, Carlos[a]; Hernández-Fariñas, Tania[b]; Bacher, Cedric[c]; Chapelle, Annie[a].
[a] *Ifremer Dyneco/PELAGOS, BP 70, 29280 Plouzané, France.*
[b] *Ifremer Dyneco/VIGIES, BP 21105, 44311 Nantes, France.*
[c] *Ifremer Dyneco/BENTHOS, BP 70, 29280 Plouzané, France.*
Corresponding author details: Carlos.Guallar.Morillo@ifremer.fr

Summary

The dinoflagellate *Alexandrium minutum* is a toxic bloom-forming species that is distributed worldwide and frequently identified along the French coasts. It is important to define and understand the mechanisms that promote the formation of these blooms in order to assess the risks for ecosystem and human health. Most of previously published studies define the ecology of this species but usually focus on local and short-term scales. In this presentation, we examine *A. minutum* at broad temporal and spatial scales by using joint time-series of *A. minutum* and environmental parameters along the French coasts. The dataset used for the analysis is a long-term (1988-present) time series that combines environmental and phytoplankton variables from REPHY French monitoring program, satellite data (Irradiance) and climatic data (North Atlantic Oscillation index). We present the preliminary results obtained based on *i)* the definition of environmental niche of *A. minutum* populations, *ii)* the phenology of *A. minutum* events. Results showed that temperature and irradiance are important factors regulating the population dynamics of this species. They determine its ecological niche and influence the shape of its blooms.

Introduction

A. minutum is one of the responsibles of an increase of the Harmful Algal Bloom (HAB) events in the French coastal waters in the last decades. It causes Paralytic Shellfish Poisoning events and has a great impact on the aquaculture industry, human health and ecosystems. Until now, most studies of the ecology of this species have been carried out at local and short-term scales and hence, they are constrained by the boundaries of the temporal window and the ecosystem studied. Long term data sets may provide a new insight of *A. minutum* HABs and their dynamics through the detection of large scale spatio-temporal patterns.

Since 1987, the French programme for phytoplankton and phycotoxins monitoring (Rephy), managed by Ifremer, has been recording occurrences of toxic species and also environmental variables (salinity, temperature, turbidity, etc.). More than 25 years of data are now available to perform this study. Two different approaches are conducted: niche determination of *A. minutum* in the French coasts and phenology of its blooms. The first one identifies the environmental characteristics in which a viable population can be maintained, and the second determines and characterises the annual recurring life cycle events.

Materials & Methods

A. minutum and environmental data sets were obtained from the Rephy French monitoring programme. Sampling points along the French coasts are organised into a total of 123 marine zones. Data from stations with at least one occurrence of *A. minutum* higher than 10 000 cel./L. (threshold alert value) were gathered. Data include *A. minutum* abundances and environmental variables (temperature, salinity and turbidity). Sea Surface Irradiance (SSI), derived from METEOSAT visible imagery, tidal coefficient (Service Hydrographique et Océanographique de la Marine, SHOM) and daily and winter North Atlantic Oscillation index (NAO and NAOw) were also gathered.

To characterise the realized niche of *A. minutum* a standardised Principal Component Analysis (PCA) was performed on 4466 samples (station-date) to summarise the environmental variability information in a reduced number of axes. The first three axes of the analysis explained 65.8% of variability (PC1:

31.3%, PC2: 17.7%, PC3: 16.8%). Then, a kernel density estimation weighted by the abundance was applied to determine the smoothed occurrence density for the species in the *r* x *r* x *r* gridded environmental space defined by the PCA (Figure 1, Broennimann *et al.* 2012).

For the phenology analysis, *A. minutum* time-series data were split by years and stations. Then, they were log-transformed (y′ = log10(y +1)) and smoothed by means of smoothing splines method. Following, the phenology variables (Figure 2a) were obtained by fitting a Weibull function to a total of 38 station-year time-series (Rolinsky *et al.* 2007). Only those with more than 12 samples and 10 000cel./L of *A. minutum* abundances were selected to avoid incomplete data.

Results & Discussion

According to niche analysis (Figure 1), the favourable environmental conditions for *A. minutum* are warm temperatures and high irradiance. Lower turbidity and higher salinities could be also favourable but with less importance, and NAO and tidal coefficient have no apparently influence.

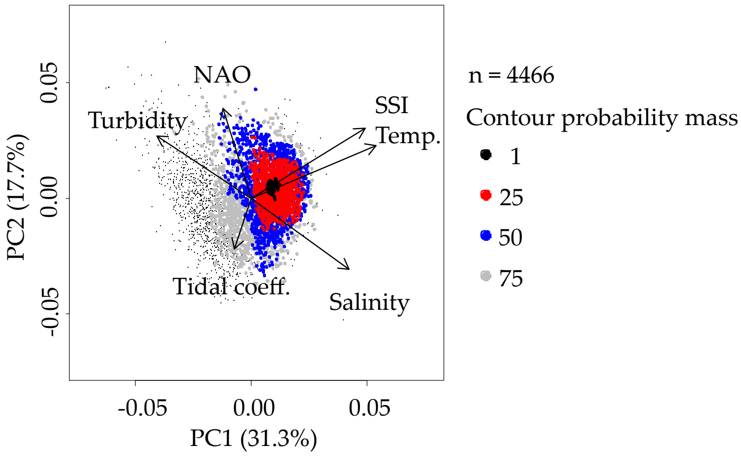

Figure 1. Niche representation of *A. minutum* on the variable projection on the first two axes of the PCA.

For the phenology analysis, temperature at the start of the HAB is significantly correlated with several bloom characteristics (steepness increase, r= 0.80, Figure 2b; length bloom, r= -0.76; length increase, r= -0.74; length decrease, r= -0.65; and steepness decrease, r= 0.51). Irradiance is also significantly correlated with the same variables in a lower degree.

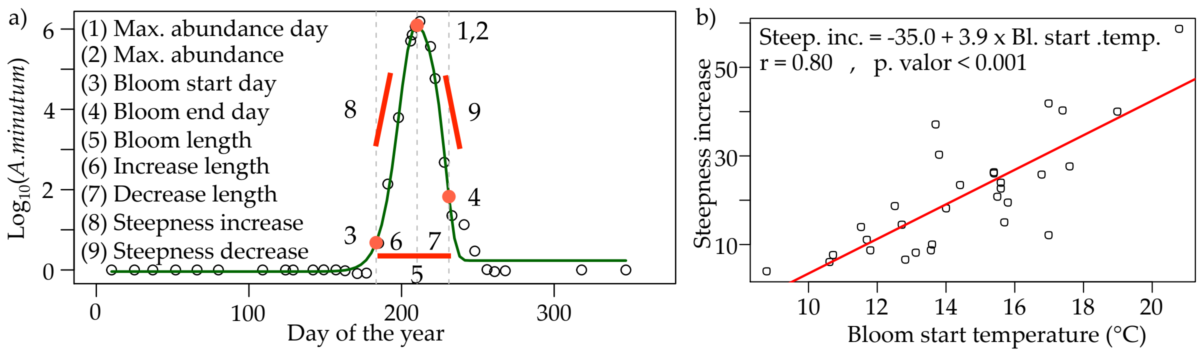

Figure 2. (a) Phenology bloom variables. (b) Scatter plot of steepness increase versus bloom start temperature.

According to the preliminary results obtained, mainly temperature and also irradiance are important factors regulating population viability of *A. minutum* and the shape of its blooms. The higher the temperature and irradiance at the start of the bloom is, the higher the steepness increase of the bloom and the shorter the length of the bloom.

Future perspectives: 1) study new variables for the niche determination (*i.e.* nutrients), 2) compare with other toxic species (*Pseudo-nitzschia* spp., niche overlap) and 3) develop predicting bloom models.

References

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