SESAME PROGRAM : RECENT EVOLUTION OF PHYTOPLANKTON COMMUNITIES IN NORTH-WESTERN MEDITERRANEAN COASTAL WATERS

Bernard Queguiner [1]*, Mathias Girault [1] and Beatriz Beker [2]
[1] Laboratoire d'Oceanographie Physique et Chimique / Centre d'Oceanologie de Marseille, 13288, France - bernard.queguiner@univmed.fr
[2] Service d'observation, Centre d'Oceanologie de Marseille, 13288, France

Abstract
Results obtained during the SESAME program emphasize major changes in phytoplankton communities. The nutrient limitation is characterized by an increased duration of limitation by phosphate which has gradually extended from January to all the first 6 months of the year between 1996 and 2007. Taxonomic data collected since 1994 shows a high variability of phytoplankton developments. Bloom seasonality is slightly marked although it tends to occur during winter and spring when the environment is replenished with nutrients. A long-term of biodiversity loss is observed as well as a disruption marked by decreasing cell concentrations around 1996-1997. The evolution of a few phytoplankton species of diatoms and dinoflagellates indicates another change around 1998-1999. Results are interpreted with reference to the North Atlantic Oscillation.
Keywords: Phytoplankton, Biodiversity, Coastal Systems, Nutrients, Gulf Of Lions

We have analyzed datafrom the CNRS-INSU SOMLIT observation program at three stations of the French Mediterranean coast, from Banyuls/mer to Villefanche/mer. The 3 stations show different trends. With regard to nutrient limitation, the time-series of Banyuls/mer and Marseille both show a gradual change that results in an increased period of limitation by phosphate which has gradually extended from January to the first 6 months of the year between 1996 and 2007. The situation appears more stable in the bay of Villefranche/mer. This contrast partly reflects changes in river flows during the last decade in the Gulf of Lions. Recently, Ludwig *et al.* (2009) documented a drastic increase of the NO_3/PO_4 ratio of Rhône River freshwater from ~20 to ~80 in between 1990 and 2000. This trend is a general feature of the Mediterranean Sea and appears related to mitigation strategies for urban pollution treatment targeting the reduction of phosphorus emissions. Ludwig *et al.* (2009) also highlight the increase of potential limitation of marine primary production by both phosphate and silicic acid, the latter being more a problem for coastal phytoplankton community changes (shift from diatoms to flagellates). An examination of taxonomic data collected since 1994 on a fortnightly basis shows a high variability of phytoplankton developments in coastal waters. Seasonality of blooms is only slightly marked although they tend to occur during winter and spring when the environment is replenished with nutrients after strong wind (mistral) events. The data set shows a disruption marked by decreasing cell concentrations of microphytoplankton around the years 1996-1997.

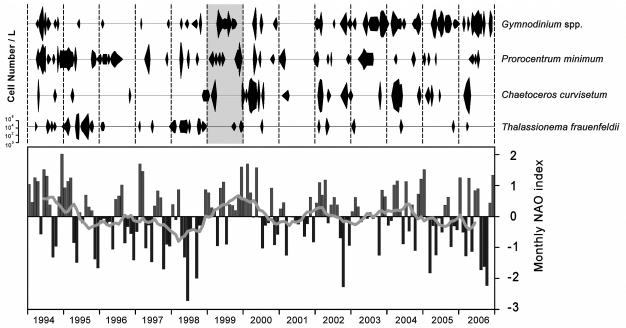

Fig. 1. Evolution of 4 sentinel species of the Bay of Marseille in parallel to that of the monthly NAO (North Atlantic Oscillation) index (the green curve represents 12 months central moving average of the monthly NAO index).

Of the 228 taxa of diatoms and of dinoflagellates that were observed in the Bay of Marseille, only a few show an interesting development that is manifested by their appearance or disappearance from the ecosystem. The dinoflagellate *Prorocentrum minimum* decreased sharply after 1999, while the genus *Gymnodinium* seemed to find more favourable conditions for its development. For diatoms, from the same period, *Chaetoceros curvisetum* became very common while *Thalassionema frauenfeldii* almost disappeared in the records. These species can be considered sentinel species whose presence or absence is a reflection of changes in environmental conditions. It is interesting to note that the period shift corresponds well to a persisting maximum in the monthly NAO (North Atlantic OScillation) index temporal evolution.

Changes in diversity showed a surprising contrast with changes in the NAO index. The period 1999-2000, characterized by a positive NAO index, corresponds to a large decrease in the Shannon index and the Pielou evenness concomitant with evolution of the sentinel species mentioned above. The decrease of diversity also matched the seasonal extension of potentially limiting conditions for phosphate although available nutrient data do not offer a sufficient background to describe accurately the evolution of the nutritional environment of phytoplankton for the period prior to 1996. It is therefore possible that anthropogenic changes have directly influenced the microphytoplankton community structure, including the dissolved Si/P ratio known to control the seasonal succession. However, the system does not appear to have suffered from severe disturbance, as no proliferation of flagellates has so far been observed over the study period. A second sharp decrease of diversity was observed in 2004, particularly marked for the H index, and occurring in parallel with an increase in phytoplankton bloom intensity (in terms of biomass) in the Bay of Marseille. The accumulation of phytoplankton biomass reflects the imbalance between the production processes and the consumption processes including grazing by zooplankton and the shift in phytoplankton species and biodiversity could be linked to changes in the community of grazers (Katechakis *et al.*, 2002). It is therefore possible that the trend observed at the end of the series is a reflection of profound changes in the pelagic ecosystem.

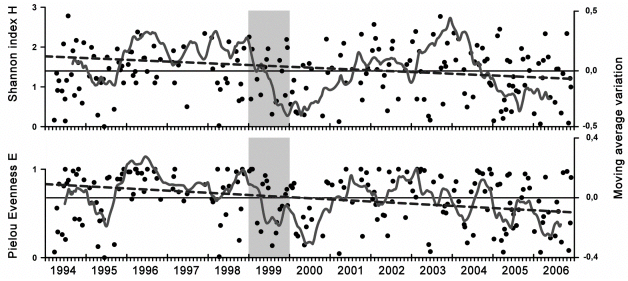

Fig. 2. Long-term evolution of the Shannon (1948) index (H) and of the Pielou (1966) evenness (E) of microphytoplankton in the Bay of Marseille. The grey curves show the variations of the 6 months central moving average of daily interpolated data normalized against the average of each data set. The dotted lines represent the trends of declining diversity for the 1994–2006 period.

References
1 - Katechakis A., Stibor H., Sommer U., Hansen T., 2002. Changes in the phytoplankton community and microbial food web of Blanes Bay (Catalan Sea, NW Mediterranean) under prolonged grazing pressure by doliolids (Tunicata), cladocerans or copepods (Crustacea). *Marine Ecology Progress Series*, 234:55-69.

2 - Ludwig W., Dumont E., Meybeck M., Heussner S., 2009. River discharges of water and nutrients to the Mediterranean and Black Sea: Major drivers for ecosystem changes during past and future decades? *Progress In Oceanography*, 80:199-217.