Phytoplankton dynamics in a coastal area in front of Barcelona (NW Mediterranean)

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INTRODUCTION

Coastal marine environments receive freshwater inputs from the continent, associated with high nutrient concentrations. These water inputs change substantially the physico-chemical conditions of the coastal zone and have a direct effect on primary producers. The quantity and quality of coastal freshwater inputs affect phytoplankton dynamics and play a key role in the functioning of coastal Mediterranean ecosystems. This work analyzes two years of oceanographic data taken off the Barcelona coast, and explores the relationships with meteorological variables.

MATERIAL & METHODS

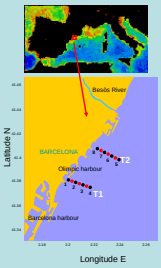


Fig. 1 - Study area and the location of the sampled stations along two transects (T1 and T2).

Sampling area: - Barcelona coast under the influence of freshwater inputs mainly from the Besòs River discharge.

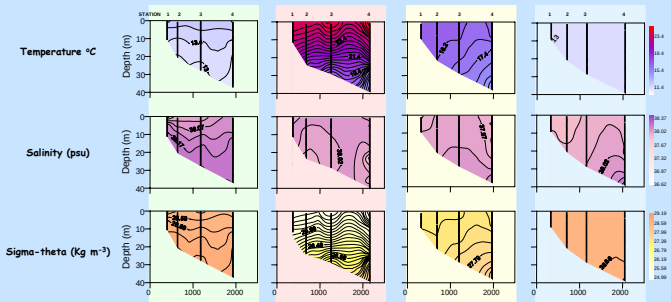
Sampling period: - March 2002 to March 2004 (approximately every month; 21 surveys).

Sampled variables:
- Salinity - at surface in all the stations, analyzed with an AUTOSAL salinometer.
- Inorganic nutrients - at surface in all the stations, analyzed with an AA3 autoanalyzer (Grasshoff *et al.* 1999)
- Chlorophyll *a* (Chl *a*) - at surface in all the stations, measured by fluorometry in acetone extracts (Yentsch & Menzel 1963).
- CTD casts - in 8 station (●), to obtain Salinity and Temperature information. Sigma-theta was calculated using the SeaBird software.
- Phytoplankton - at surface of stations 1 and 4, fixed with Lugol or formol-hexamine solutions and counted using the inverted microscope technique (Utermöhl 1958).

Statistics: - using Statistica 6.0 programme.

Photograph of the studied area realized with an ARGUS video system. The freshwater front can be seen.

SEASONAL HYDROGRAPHIC CHARACTERISTICS OF THE ZONE



Spring: moderate water column stratification | **Summer**: strong water column stratification | **Fall**: moderate water column stratification | **Winter**: water column total or partially mixed

Fig. 2 – Typical distributions of hydrographycal variables for each season along Transect 1 (T1 – Fig. 1)

ENVIRONMENTAL VARIABLES

Table 1 - Mean statistics for surface data of hydrochemical variables, Chl *a* and Diatom:Dinoflagellate ratio.

	Spring			Summer			Fall			Winter		
	Mean ± SE	N	Range	Mean ± SE	N	Range	Mean ± SE	N	Range	Mean ± SE	N	Range
Temp	**17.85** ± 0.40	38	14.14 - 21.50	**24.54** ± 0.20	64	22.34 - 28.10	**18.23** ± 0.44	64	13.85 - 23.60	**13.34** ± 0.09	58	11.74 - 14.70
Sal	**37.70** ± 0.06	41	36.42 - 38.08	**37.97** ± 0.02	85	37.59 - 38.59	**37.64** ± 0.05	84	36.51 - 38.23	**37.71** ± 0.08	70	35.01 - 38.31
PO_4 (µM)	**0.28** ± 0.05	44	0.05 - 1.41	**0.10** ± 0.01	85	0.00 - 0.53	**0.23** ± 0.02	84	0.00 - 0.90	**0.22** ± 0.03	70	0.06 - 1.51
DIN (µM)	**8.18** ± 2.30	44	0.04 - 68.76	**1.94** ± 0.27	85	0.03 - 13.92	**3.10** ± 0.22	84	0.06 - 10.36	**6.92** ± 0.89	70	0.73 - 50.49
H_2SiO_4 (µM)	**1.07** ± 0.23	44	0.03 - 8.34	**0.65** ± 0.05	85	0.00 - 2.02	**1.63** ± 0.08	84	0.12 - 3.78	**1.81** ± 0.24	70	0.16 - 12.47
Chl *a* (µg l^{-1})	**2.32** ± 0.14	44	0.76 - 3.86	**0.73** ± 0.04	85	0.10 - 1.80	**1.16** ± 0.04	83	0.24 - 1.97	**2.38** ± 0.16	70	0.60 - 5.03
Diat:Dinof	**30.82** ± 15.62	6	0.08 - 90.53	**2.52** ± 1.67	12	0.01- 20.56	**5.35** ± 2.97	10	0.04 - 28.41	**45.12** ± 15.98	10	0.05 - 171.25

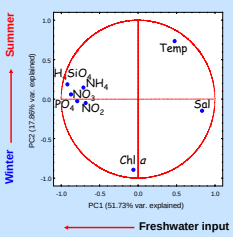


Fig. 3 - Principal Component analisys of environmental variables

The first principal component (PC1) is related to freshwater inputs carrying high nutrient concentrations.

The second component (PC2) is mainly due to seasonal variation and indicates low phytoplankton biomass in summer.

PHYTOPLANKTON BIOMASS AND PHYSICO-CHEMICAL ENVIRONMENT

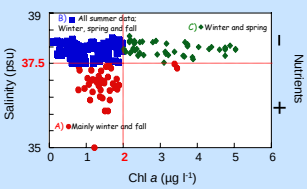


Fig. 6 - Salinity *vs* Chl *a*. The relative nutrient content is indicated along the right ordinate axis. Sections A), B) and C) are explained at right.

Based on physical-chemical-biological interactions, three different situations were found in this coastal zone:

A) ● - Salinity < 37.5 psu,
- Chl *a* < 2 µg l^{-1},
- relatively high nutrient concentrations,
- observed mainly in fall and winter.

B) ■ - Salinity > 37.5 psu,
- Chl *a* < 2 µg l^{-1},
- relatively low nutrient concentrations,
- Summer situation, but also observed in other seasons.

C) ◆ - Salinity > 37.5 psu,
- Chl *a* > 2 µg l^{-1},
- relatively low nutrient concentrations,
- corresponded to winter-spring blooms.

SALINITY AND PHYTOPLANKTON BIOMASS

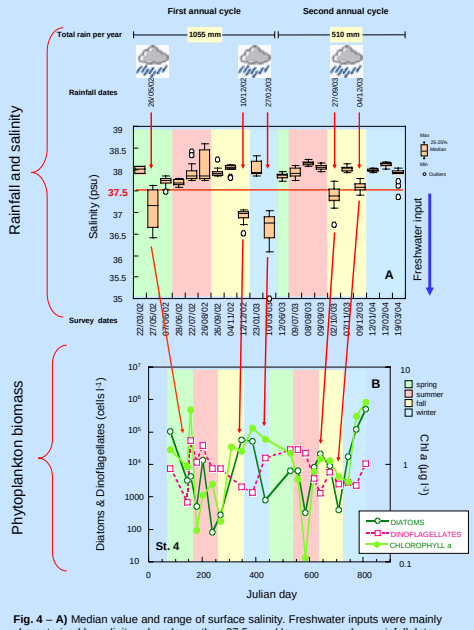


Fig. 4 – **A)** Median value and range of surface salinity. Freshwater inputs were mainly characterized by salinity values lower than 37.5 psu. Upper arrows show rainfall dates. The horizontal bars show the acumulated rain in each annual cycle.

B) Surface chl *a* and diatom and dinoflagellate abundances along the two sampled annual cycles. Arrows show the "dilution effect" of freshwater inputs on the phytoplankton biomass.

PHYTOPLANKTON COMPOSITION

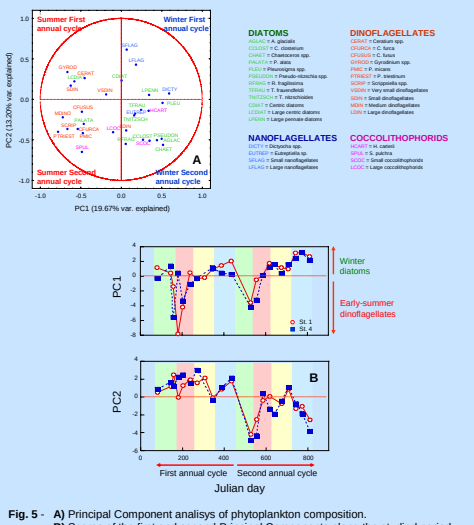


Fig. 5 - **A)** Principal Component analisys of phytoplankton composition.
B) Scores of the first and second Principal Components along the studied period.

The first principal component (PC1) shows negative correlations with dinoflagellates and positive correlations with nanoflagellates and most of diatoms. The scores of this component show a maximum during winter (predominance of diatoms) and a minimum in early summer (predominance of dinoflagellates).

The second principal component (PC2) shows negative correlations with diatoms and positive correlations with nanoflagellates. The scores of this component indicate a high contribution of nanoflagellates and diatoms in the first and second annual cycles, respectively.

RESULTS & DISCUSSION

Freshwater inputs lowered salinity (Fig. 4A), introduced nutrients into the studied area (Fig. 3), and produced a dilution effect on the phytoplankton community at surface (Fig. 4B; 6A).

At surface, the lowest phytoplankton biomass was found in summer in association with relatively low nutrient concentration, high salinities, strong water column stratification (Fig. 2; 6B; Table 1), maximum abundance of dinoflagellates and minimum cell numbers of diatoms (Fig. 4B; Table 1).

During the winter-spring period phytoplankton biomass reached maximum values, mainly due to diatom species (Fig. 4B; 5; 6C; Table 1).

However, phytoplankton species composition showed differences between the two annual cycles (Fig. 5). This variability may be due to differences in total freshwater inputs along each annual cycle (Fig. 4).

CONCLUSIONS

- A marked seasonality was observed in the surface phytoplankton dynamics: low biomass (mainly dinoflagellates) in summer; maximum abundances in the winter-spring period (mainly diatoms).
- However, in fall and winter, freshwater inputs affected phytoplankton in two ways: providing inorganic nutrients and producing a dilution of the populations.
- Notable differences in phytoplankton species composition were observed between the two annual cycles.

REFERENCES

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