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A. Lugliè, F. Fiocca, G. Ceccherelli, N. Sechi

Dipartimento di Botanica ed Ecologia Vegetale, Università di Sassari,
Via F. Muroni 25, 07100 Sassari, Italia.

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Abstract

Water samples and environmental data were examined at four stations at biweekly or monthly intervals, depending on the period, from February 1990 to December 1999. Phytoplankton composition was estimated in these samples.

The abiotic parameters revealed a difference in environmental conditions between the outer area of the lagoon and those closer to the coast. Phytoplankton structure was quite consistent among different areas of the lagoon. Absolute abundance was very different among classes, with Chlorophyceae much more abundant than Bacillariophyceae. Haptophyceae and Chrysophyceae were the least represented classes. Density of classes reached peaks in different periods of the year, suggesting a recurrent pattern in taxa succession.

Key-words: *coastal lagoons, phytoplankton succession, species composition.*

Introduction

Coastal lagoons are autonomous dynamic systems with a high productivity potential and a number of common geo-morphological and ecological features (Nixon, 1982). These areas have naturalistic importance but also play a great economic role: in the Mediterranean, for example, more than a half of the larger lagoons are used for aquaculture (for both fish and shellfish) (Bacher *et al.*, 1995, Sorokin *et al.*, 1999). In coastal lagoons dominant primary producers vary mostly in relation to morphological characteristics of the site, hydrodynamics and nutrient supply; depending on the climatic region in which they are located, different alternation in seasonal dominant component occurs (Knoppers, 1994).

Santa Giusta Lagoon (Fig. 1), the widest brackish basin of the west Sardinia (Italy), seems a macroalgal-based lagoon where the dominance of macroalgae (mainly *Ulva* spp.) and phytoplankton alternates depending mostly on life cycle characteristics of the former species and the successive nutrient recycling. In these last 15 years, the enhanced nutrient availability due to urban waters and industrial discharges has caused marked changes in the environment, with a progressive increase in summer dystrophic crisis, macroalgal blooms and extensive fish mortality (Sechi *et al.*, 2000).

In this paper we define the intra-annual dynamics of phytoplankton and the most important environmental parameters by analysing 10 years data obtained through biweekly and monthly collection since 1990.

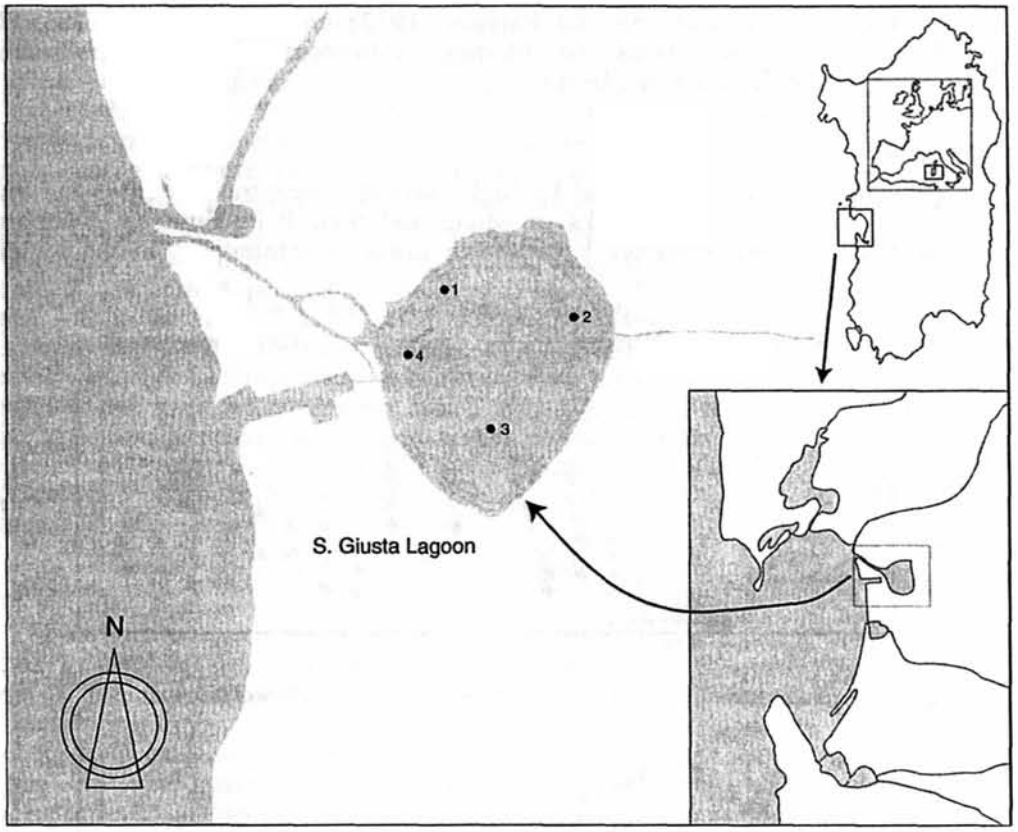

Fig. 1 - Santa Giusta Lagoon showing the sampling stations and its position in Sardinia.
La Laguna di Santa Giusta, stazioni di campionamento e localizzazione in Sardegna.

Materials and methods

Santa Giusta lagoon (39°52'N 8°36'E) has a surface area of about 8 km^2 and a mean depth of 1 m. The lagoon is almost circular and choked, divided from the sea by a sandy barrier; it communicates with the sea mainly through Pesaria Channel (about 3 km long). Half-way down the Pesaria Channel, a fish catch system was built and it caused a considerable depth and width reduction, with heavy consequences on the tide exchange volume. Water exchange period was bimonthly, due to an inflow of 170 x 10^6 m^3 y^{-1}, whose 30 were freshwater.

Water samples and ambient physical and chemical data were examined at four stations at biweekly and monthly intervals, depending on the period, from February 1990 to December 1999. Station 1, 2, 3 correspond to the inner areas while station 4 to the outer area.

Temperature and salinity were measured using a multiparameter probe Idronaut. For phytoplankton analysis, water samples were collected at surface (0.5 m depth) and fixed using 4% neutralised formalin. Other samples were transferred to the laboratory where total inorganic N (ammonium + nitrate + nitrite nitrogen), total

P, reactive silica (Strickland and Parsons, 1972) and chlorophyll *a* (SCOR-UNESCO, 1966) were measured. Phytoplankton composition was estimated following Utermöhl method (1931).

Results

The lagoon was characterised by high nutrient concentrations (Fig. 2), with inorganic total N reaching peaks in winter and total P in February. Temporal fluctuations of these variables have shown lower concentrations in the middle

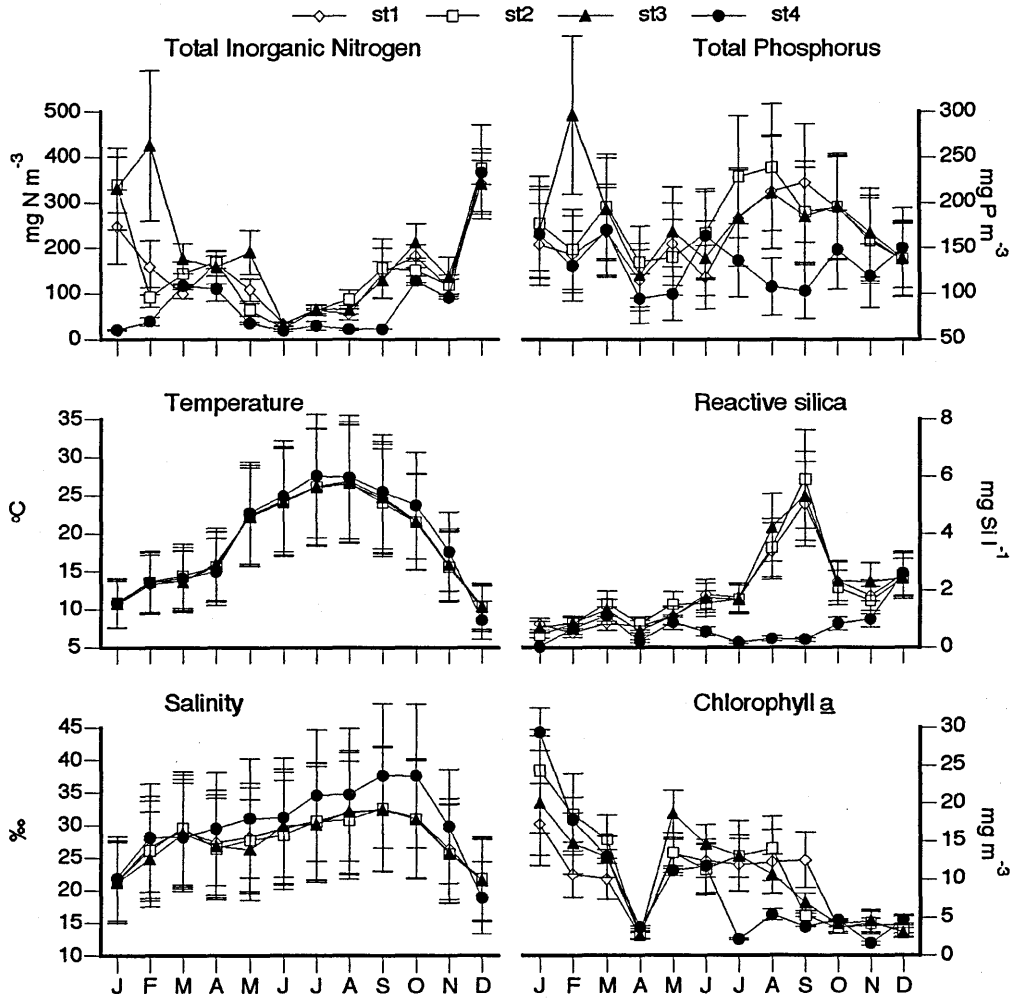

Fig. 2 - Temporal distributions of abiotic data (temperature, salinity, reactive silica, total inorganic N, total P, Chlorophyll *a*) in each station: monthly means and SE were calculated from 10 years of data (1990-1999).

Fluttuazione temporale dei parametri abiotici (temperatura, salinità, silice, N totale inorganico, P totale, clorofilla a*) in ogni stazione: le medie mensili e l'ES sono state calcolate dai dati raccolti in 10 anni (1990-1999).*

area of the lagoon than in the coastal area. Reactive silica greatly increased in summer; values relative to the outer part did not undergo seasonal fluctuations.

Clear seasonal fluctuations were evident for water temperature and salinity, as expected. Slightly different values were observed for the outer station that probably is more influenced by marine conditions. Chlorophyll *a* also fluctuated greatly during the year, showing maximum values in January sharply decreasing until April and increasing again during summer. In autumn chlorophyll *a* concentration was very low, in the whole lagoon.

Phytoplankton dynamics was class-specific since peaks relative to each taxon occurred in different periods of the year (Fig. 3). The species responsible for peaks within the single classes often change depending on the year, except for Chlorophyceae for which the abundance of *Chlorella* sp. always determined the greatest density. Chlorophyceae dominated with high densities during the first months of the year, when nutrient supply was high and temperature and salinity were low. Bacillariophyceae showed higher density during January and August; the latter peak corresponded to high concentration of reactive silica. The other classes showed short peaks that occurred mostly during summer and early autumn.

Discussion

The abiotic parameters evidenced that in Santa Giusta Lagoon a difference occurs in ambient condition between the outer area of the lagoon and the ones closer to the coast. This feature suggests that the former area is more influenced by marine conditions and the latter ones are more influenced by fresh water discharges. Overall environmental conditions indicate the high trophic status of the lagoon and rapid variations in nutrient concentration, salinity and temperature.

Phytoplankton structure was quite consistent among areas of the lagoon, suggesting that good mechanisms of homogenisation operate at the site. Absolute abundance was very different among classes, being Chlorophyceae much more abundant than Bacillariophyceae. Haptophyceae and Chrysophyceae were the least represented classes.

Density of classes reached peaks in different periods of the year, suggesting a trend in taxa succession. Winter and summer maximum values correspond to periods of high nutrient availability, in the former period because of high rainfall and consequent freshwater supply from the catchment area next to the lagoon, and in the latter period because of macroalgae decomposition.

Riassunto

In questo studio è stata esaminata la distribuzione temporale dei maggiori gruppi di microalghe e dei parametri ambientali dal febbraio 1990 al dicembre 1999. Con cadenza quindicinale o mensile, a seconda del periodo, sono stati prelevati campioni d'acqua in 4 stazioni nell'ambito della laguna sia per la determinazione delle caratteristiche ambientali che per l'analisi del fitoplancton.

L'andamento dei parametri ambientali considerati ha evidenziato una differenza tra l'area lagunare più esterna e quelle più vicine alla costa. Nonostante ciò la struttura del fitoplancton è risultata abbastanza uniforme tra le stazioni della laguna. L'abbondanza assoluta è molto diversa tra classi. Le Chlorophyceae sono state molto più abbondanti delle altre classi. Le Haptophyceae e le Chrysophyceae sono le classi meno rappresentate. La densità delle classi ha raggiunto picchi di abbondanza in differenti periodi dell'anno suggerendo un andamento ricorrente nella successione dei taxa.

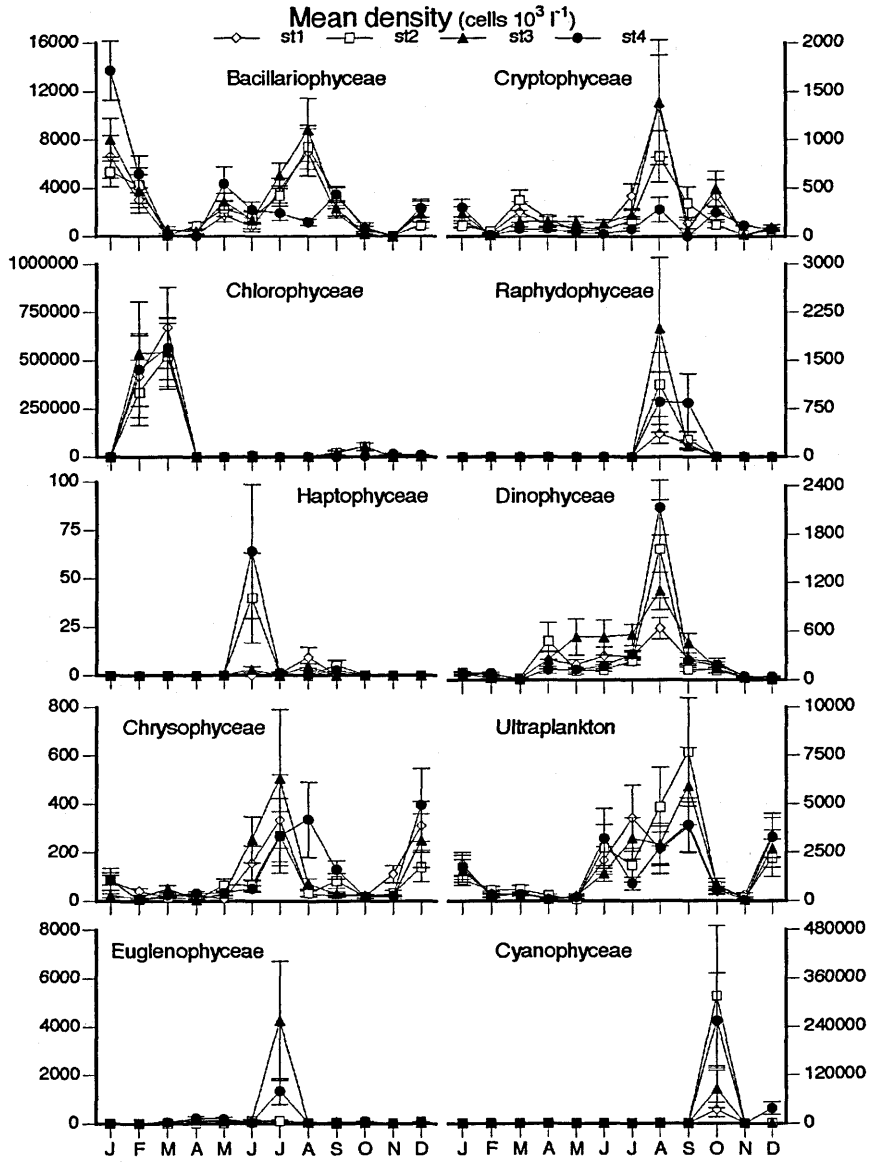

Fig. 3 - Temporal distributions of phytoplankton density of principle taxonomic groups in each station of Santa Giusta Lagoon. Bacillariophyceae, Chlorophyceae, Haptophyceae, Chrysophyceae, Euglenophyceae, Cryptophyceae, Raphydophyceae, Dinophyceae, Ultraplankton, Cyanophyceae monthly means and SE were calculated from 10 yeas (1990-1999) data (n=12-15).

Fluttuazione temporale della densità delle principali classi di fitoplancton in ogni stazione dello Stagno di Santa Giusta. Le medie mensili e l'ES per Bacillariophyceae, Chlorophyceae, Haptophyceae, Chrysophyceae, Euglenophyceae, Cryptophyceae, Raphydophyceae, Dinophyceae, Ultraplancton, Cyanophyceae sono state calcolate dai dati raccolti in 10 anni (1990-1999) (n=12-15).

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