THE COMMUNITY STRUCTURE OF PHYTOPLANKTON AS INDICATOR OF COASTAL WATER QUALITY IN THE TOURIST AREA

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With 6 figures

ABSTRACT. An annual evaluation (June 1994-July 1995) of the water quality from Punta de Tenefé to Punta de Taozo (Gran Canaria, Canary Islands) was done, as a part of an environmental assessment program in tourist coast. The ecological parameters to evaluate were chosen as representative of the human pressure exerted on the coast (crowded beaches, direct wastewater falls or emissaries, marinas) and were: qualitative and quantitative analysis of phytoplankton community structures, biomass and nutrients. The aim was to characterize the conflictive points as regard to seasonality, climatology and oceanographic conditions.

The phytoplankton (biomass and species) negatively correlated to nutrient species, particularly to silicate which decree as increased diatoms. Maximum biomass was observed by March when *Rhizosolenia stolteforthii*, *R. setigera*, *Chaetoceros decipiens y Ch. debilis* proliferated. Cosmopolitan species such as *Nitzchia closterium*, *N. seriata*, *Navicula sp.*, *Fragilaria* sp., *Licmophora* sp among others were always present.

In spite of being scarce compared to diatoms; Dinoflagellate representatives *Protoperidinium sp*., *Ceratium sp*. and *C. furca* increased by summer. *Gonyaulax* sp., indicator-species of chemical and physical alterations, was observed in samples from stations located near underwater emissary exits.

RESUMO. Uma avaliação anual (Junho de 1994 a Julho de 1995) da qualidade da água do mar foi realizada entre a “Punta de Tenefé” e a “Punta de Taozo” (Gran Canária, Ilhas Canárias), como parte de um programa de estudos ambientais sobre a costa turística.Os parâmetros ecológicos avaliados foram escolhidos conforme sua representatividade em relação à pressão humana exercida sobre a costa (praias abarrotadas, descarga de efluentes, emissários, marinas). São eles: análise qualitativa e quantitativa da estructura da comunidade fitoplanctônica, biomassa e nutrientes. O objetivo era caracterizar zonas de conflito, relacionadas à sazonalidade, climatologia e condições oceanográficas.

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O fitoplancton (biomassa e espécies) apresentou-se negativamente correlacionado aos tipos de nutrientes, particularmente ao silicato, o qual decresce com um incremento de diatomáceas. As maiores biomassas foram observadas em março quando *Rhizosolenia stolteforthii*, *R. setigera*, *Chaetoceros decipiens* y *Ch. debilis* proliferaram. Espécies cosmopolitas *Nitzchia closterium*, *N. seriata*, *Navicula sp*., *Fragilaria sp*., *Lichmophora sp*., entre outras, estavam sempre presentes.

A pesar de serem escassas quando comparadas com diatomáceas, as espécies de dinoflagelados, representados por *Protoperidinium* sp., *Ceratium* sp., e *C. furca*, aumentaram no verão. *Gonyaulax sp*., uma espécie indicadora de alterações químimcas e físicas, foi observada em amostras de estações localizadas próximas ao emissário submarino existente.

INTRODUCTION

Phytoplankton is the group of floating single-cell organisms which carry out photosynthesis in water. The principal taxa of planktonic producers in many of the world's oceans are diatoms, dinoflagellates, coccolithophores, silicoflagellates and blue-green bacteria (VALIELA, 1995). In ocean waters, average quantities of 20 to 200 cells per milliliter are found and although they may belong to several taxonomical groups, almost 95% of them can be classed as dinoflagellates, while the diatoms being the most represented group in coastal waters (MARGALEF, 1982;1992).

Numerous studies exist dedicated to the study of primary production or biomass indicated by the concentration of photosynthetic pigments, both in the waters of the Canary Islands and in the waters of the West Coast of the Africa (BRAUN, 1980; BRAUN & REAL, 1986; DE LEÓN & BRAUN, 1973; FERNÁNDEZ DE PUELLES & BRAUN, 1989; MINAS et al., 1982; REAL et al., 1982). However, papers dedicated to the study of the composition or identification of the species which make up the phytoplanktonic community in the coastal areas of the Canary Islands are scarce (CORRAL & GENICIO, 1970; BRAUN et al., 1985; OJEDA, 1985).

The aim of this study is to found seasonal variations as well as possible effects of emission of residual waters and the massive utilization of the beaches taking into account the different climatological and oceanographic conditions. Besides the data will be used to evaluate the environmental situation of the coast in the surface waters of the South of the island of Gran Canaria (tourist area).

MATERIAL AND METHOD

Six points were chosen for sampling after the inspection of the centers of contamination previously detected in the southeast-southwest zone of Gran Canaria, which goes from the Punta de Tenefé to the Punta de Taozo (Fig. 1).

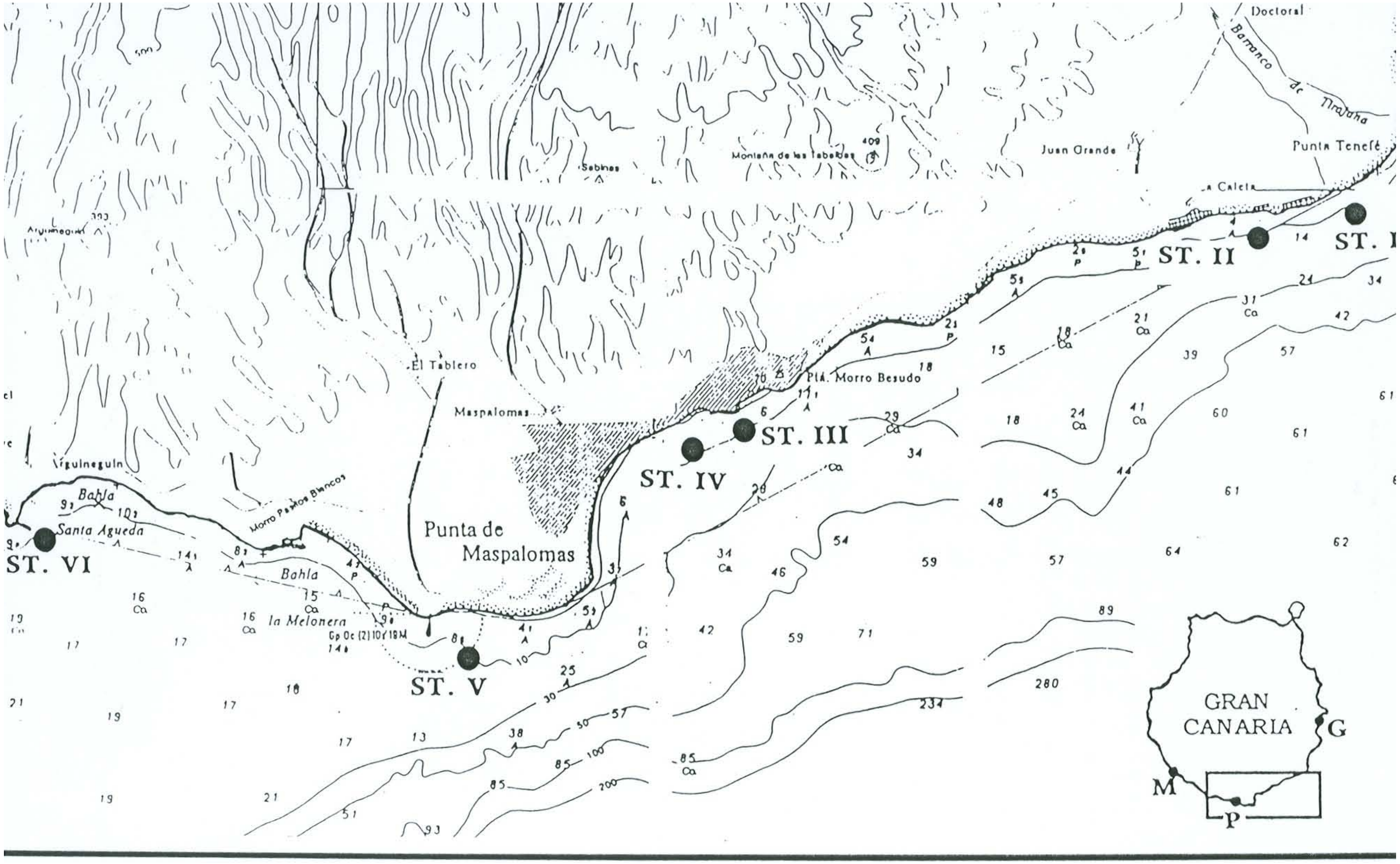


Fig. 1 - Area and localization the sampling points.

The sampling was carried out periodically from June 1994 to July 1995, trying to evaluate the seasonal distribution of contaminants in the coastal area. The samples of sea water are collected using Niskin oceanographic bottles of a 5 l capacity, equipped with an inverted, protected thermometer.

The method used for the pigmentary content was that described by JEFFREY & HUMPHREY (1975) which allows the determination of the concentrations of chlorophyllic pigments (chlorophyll *a*, *b* and *c*) and non-chlorophyllic pigments (carotenes).

At the same time, the quantity of the products of the degradation of the chlorophyll was estimated, that is to say the concentration of phaeo-pigments (phaeoforbide and phaeophytin), using the method described by LORENZEN (1967) as an indicator of the state of the algal population.

For the taxonomical and quantitative study of the phytoplankton in terms of number of cells and volume of the samples of sea water, the methodology described by Utermöhl (1931) was used. The information obtained from the different species was subjected to an canonical principal components analysis (CPCA) represented by a correlation matrix.

The analysis of nutrient content (nitrates, nitrites, phosphates and silicates) are made according to the methodology described by GRASSHOFF et al., (1983).

In each sampling point measures of wind velocity and direction were taken, also the meteorological parameters provided by the National Meteorological Institute from its stations situated in Gando (27º55’45"N 15º23’20"W), Pasito Blanco (27º44’48"N, 15º37’00"W) and Mogán (27º47’00"N, 15º43’00"W) which cover the period from January 1994 to August or September 1995, according to the parameter, and therefore for the whole period of study in question.

RESULTS

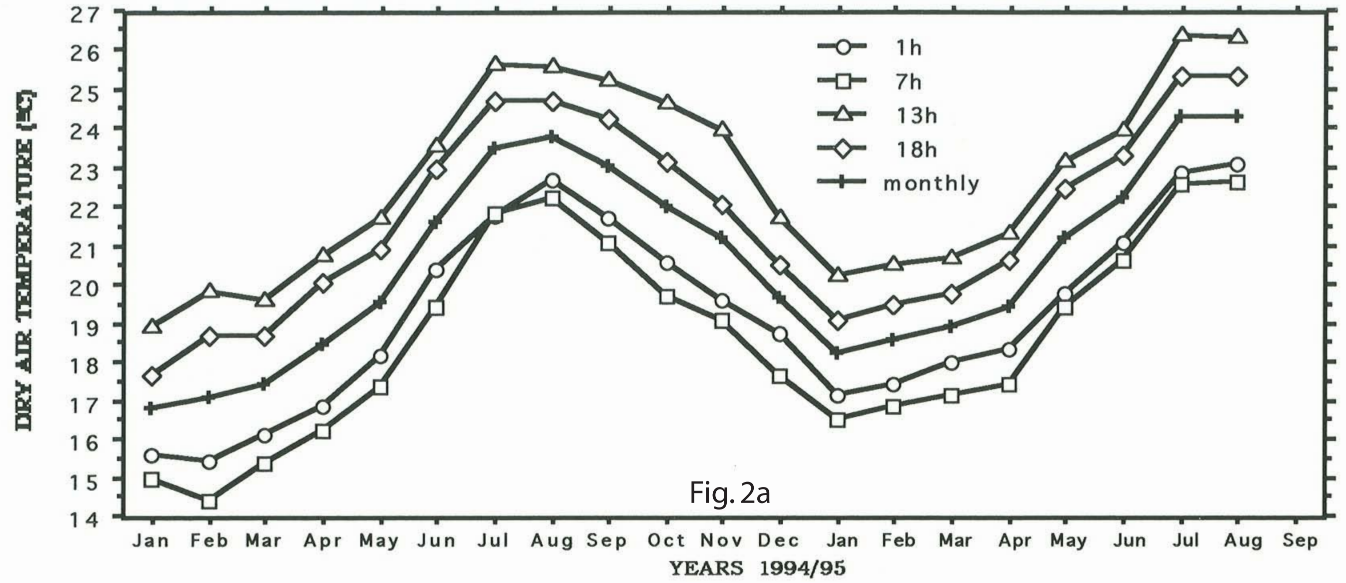
Meteorology

* Dry air temperature

The dry air temperature shows its minimum values in the months from January to March and the maximum values in the period from July to November as happens in the station at Pasito Blanco. The temperatures are higher in the months of 1995, reaching up to 2.7ºC in monthly average thermal increase for the common period between both years of the study (Fig. 2a and 2b).

The minimum monthly values for dry air temperature, between 14.17ºC (± 1.67) and 15.48ºC, were recorded at 07.00 and the maximum, from 24.97ºC (± 1.54) to 26.36ºC at 13.00 depending on the meteorological station during the entire period of study (January’94 / August’95).

The thermal difference between the average monthly values of the measurements recorded at 07.00 and 13.00 is no higher than 3ºC in the station at Pasito Blanco, reaching 5.5ºC in the stations at Gando and Puerto de Mogán.



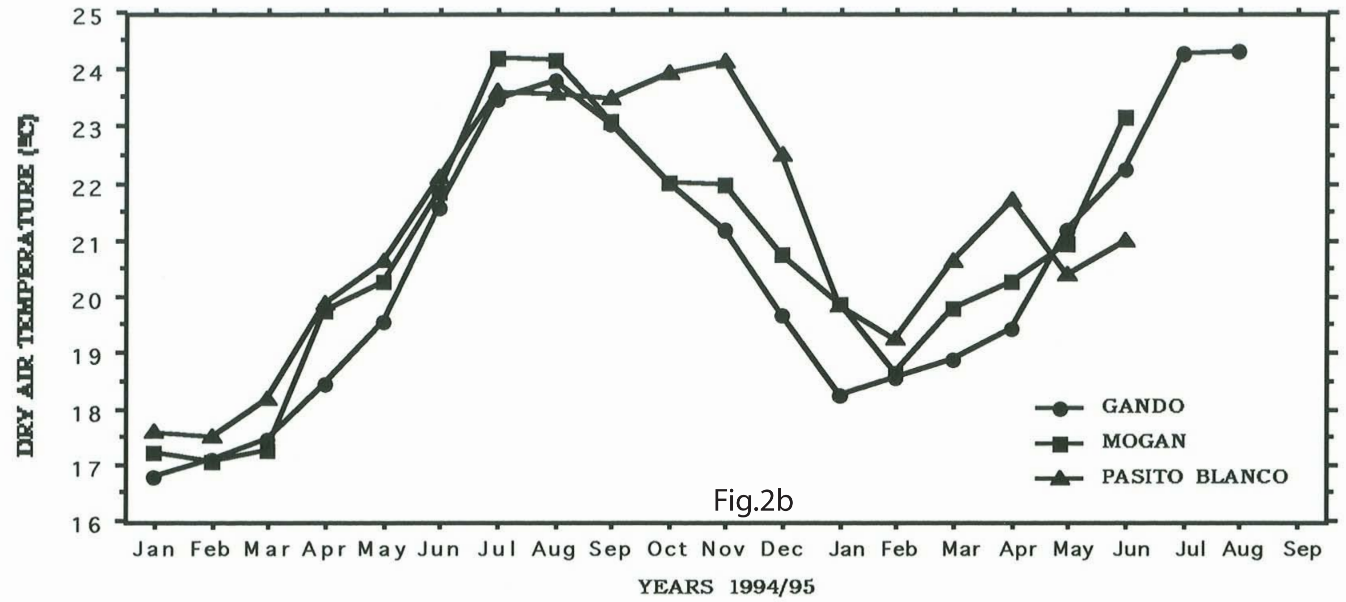


Fig. 2b - Dry air temperature (ºC) at the meteorological stations situated at east (Gando), south (Pasito Blanco) and southwest (Mogán) of Gran Canaria.

* Wind intensity

The parameter of wind intensity shows two types of monthly distributions according to the localization of the meteorological stations, one corresponding to the station at Gando situated in the east of the island with minimums in the winter months and maximums in the summer period while the opposite happens in the stations at Pasito Blanco and Mogán situated to the south and southwest of Gran Canaria, respectively (Fig. 3a).

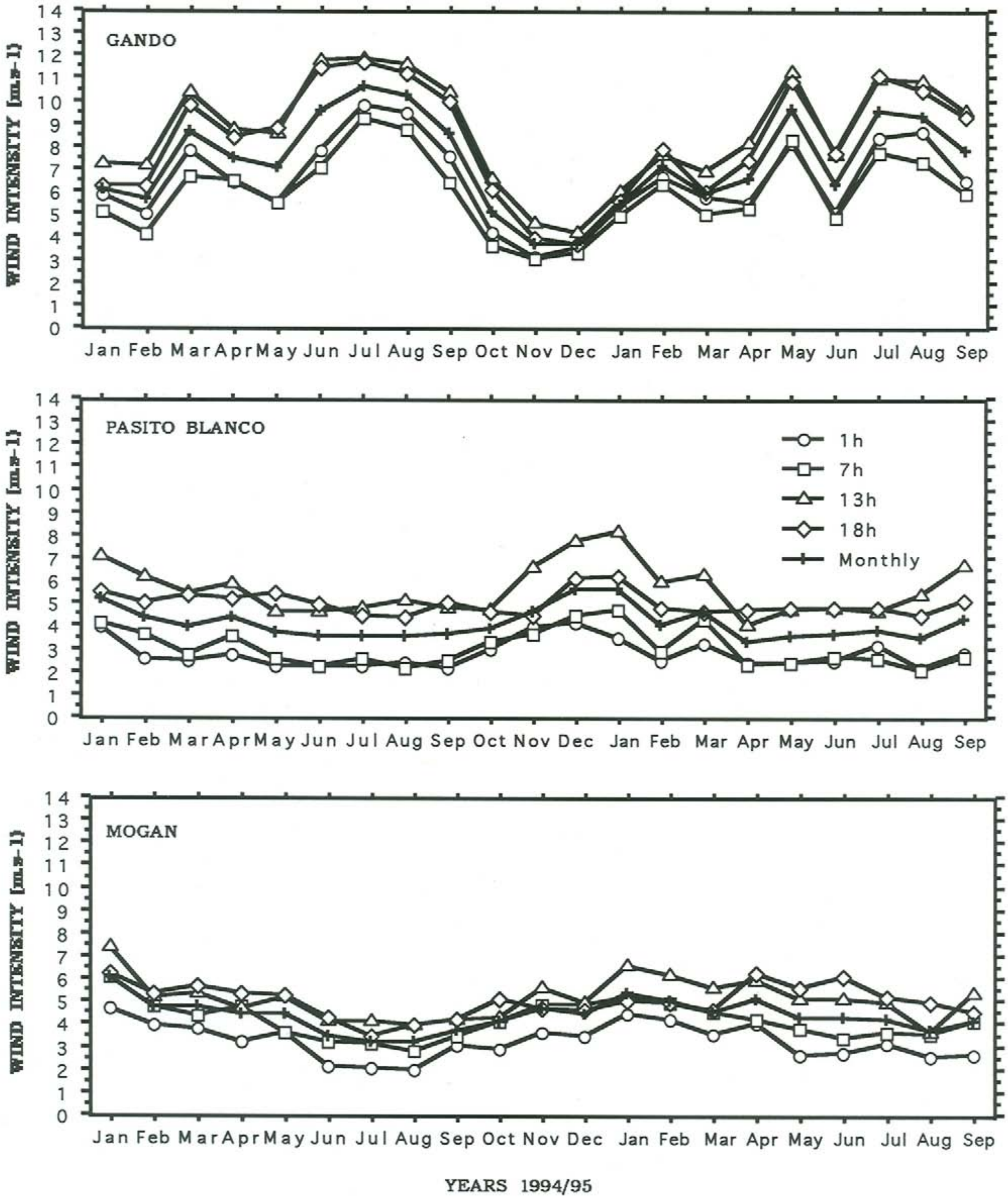


Fig. 3a - Wind intensity (m.s^{-1}) in the meteorological stations situated at east (Gando), south (Pasito Blanco) and southwest (Mogán) of Gran Canaria.

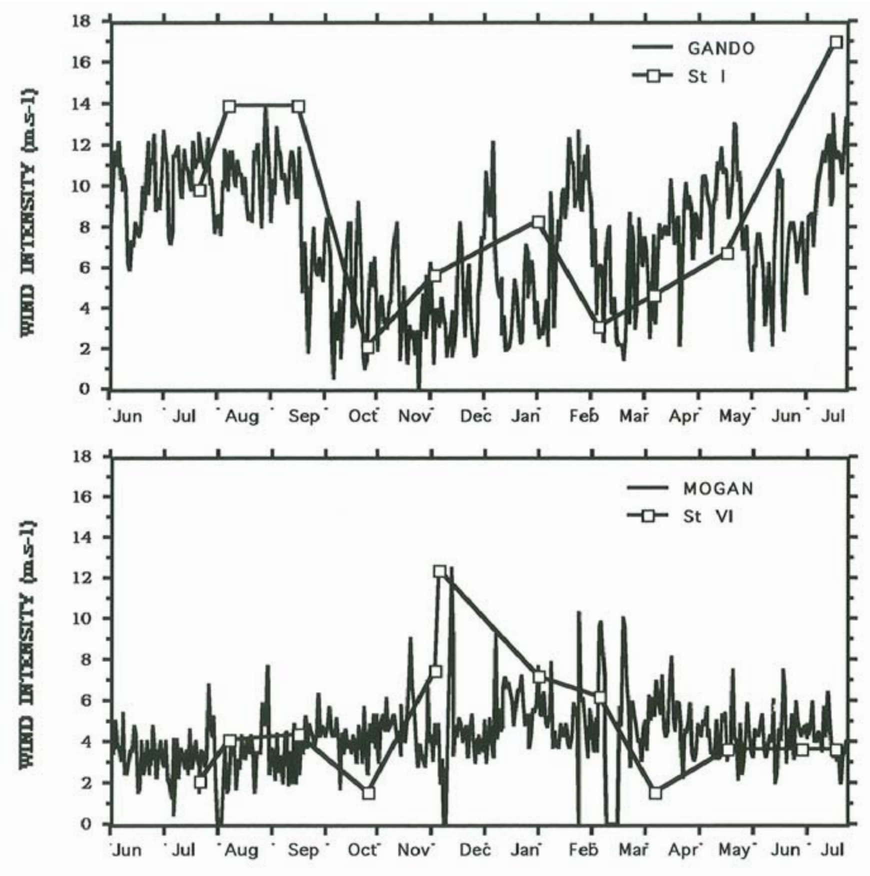


Fig. 3b - Wind intensity ($m.s^{-1}$) in the meteorological stations and oceanography stations ("in situ").

The hourly wind measurements taken at different hourly intervals show a similar distribution in the course of the months in the station at Gando where we can emphasize two periods: the night time with minimums and the day time when the highest wind speeds are recorded. This distribution is not so clear in the station at Mogán where the winds are more constant throughout the day, although of lesser intensity.

As regards the measurements recorded in the stations "in situ", we have an average wind intensity of only 2.17 $m.s^{-1}$ (±0.70) for the whole area in the month of October. The monthly distribution of wind intensity is going to correspond to the situation of the sampling stations (Fig. 3b), exposed to or sheltered from the dominant winds, and in this way we find that it is in the month of October when there is the transition with the two types of monthly variation described.

Taking into account the localization of the stations, we find that the maximum wind intensities are recorded in August (13.38 $m.s^{-1}$ ±1.33) - September (12.99 $m.s^{-1}$ ±0.65) for the whole group of stations (St. I, II, III and IV) situated in the southeast, emphasizing the 16.98 $m.s^{-1}$ measured in station I in the month of July. In contrast, for station VI situated in the southwest of the area, the greatest intensity of wind speed is recorded in December.

* Seawater temperature

The surface temperature of seawater measured in the months during the sampling oscillates between the 18.1ºC recorded in March to the 23.8ºC recorded in October (Fig. 4). There is practically no spatial variation in the temperature of the seawater in the area under study. The greatest range of variation is of 1ºC which is obtained in October, the month with the highest seawater temperature of 23.3ºC (±0.3), and it corresponds to the thermal difference between the measurements from station I, located in the northeast, and the station situated to the southwest of the area. In the same way as happens with the air temperature, an increase in the temperature of seawater is observed (0.5-1.4ºC) in the month of July, a fact which we can check by comparing the records from 1994 and 1995 in station I. As regards the distribution of the temperature with depth we find that the thermal slope is not superior to 0.6ºC between the surface and the measurement taken at 15m., which was obtained in October.

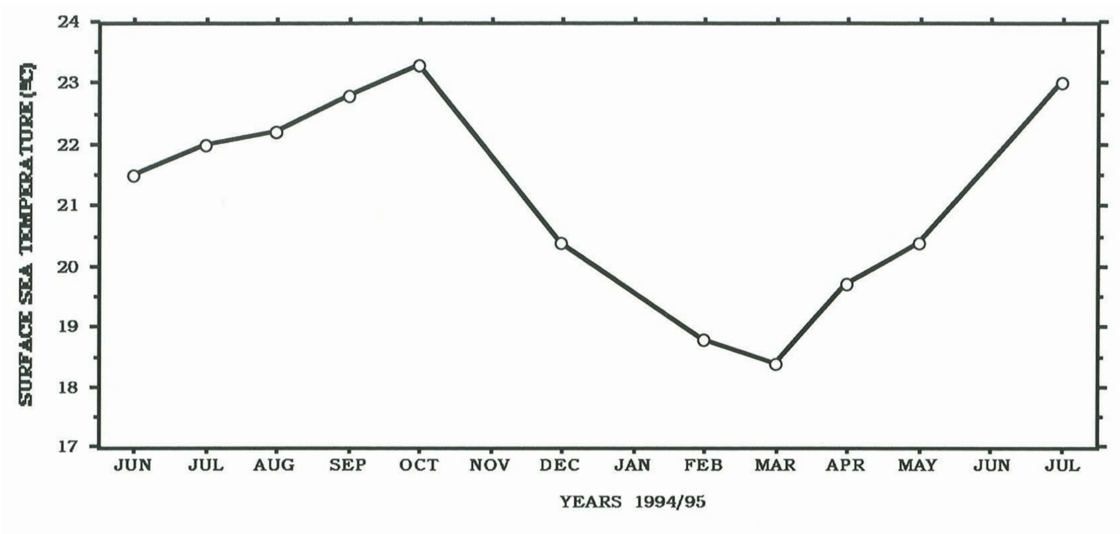


Fig. 4 - Sea surface temperature (ºC) in the area.

Phytoplanktonic Biomass

* Concentration of pigments

In general, the concentrations of chlorophyll *a* are higher in the two stations used in the study situated in the southeast (St I and II). At the said stations, a high biomass is obtained (0.66 mg Chl *a* .m^{-3}) in July which hides the spring bloom (0.30 mg Chl *a* .m^{-3}) observed in the month of March as well as in the remaining seasons (0.11-0.24 mg Chl *a* .m^{-3}), Fig. 5a.

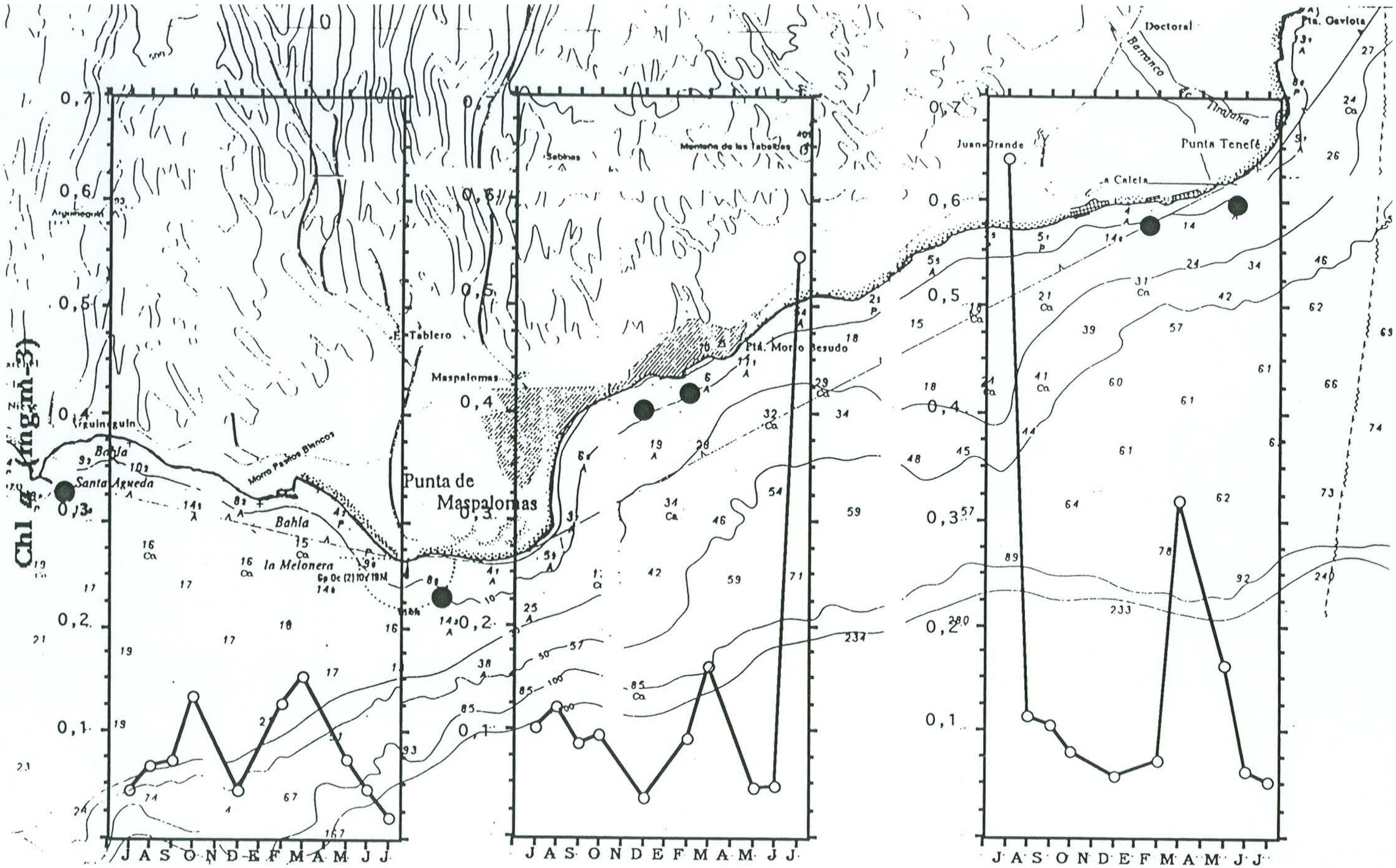


Fig. 5a - Phytoplankton biomass (mg Chl *a* .m^{-3}) in the stations sampling.

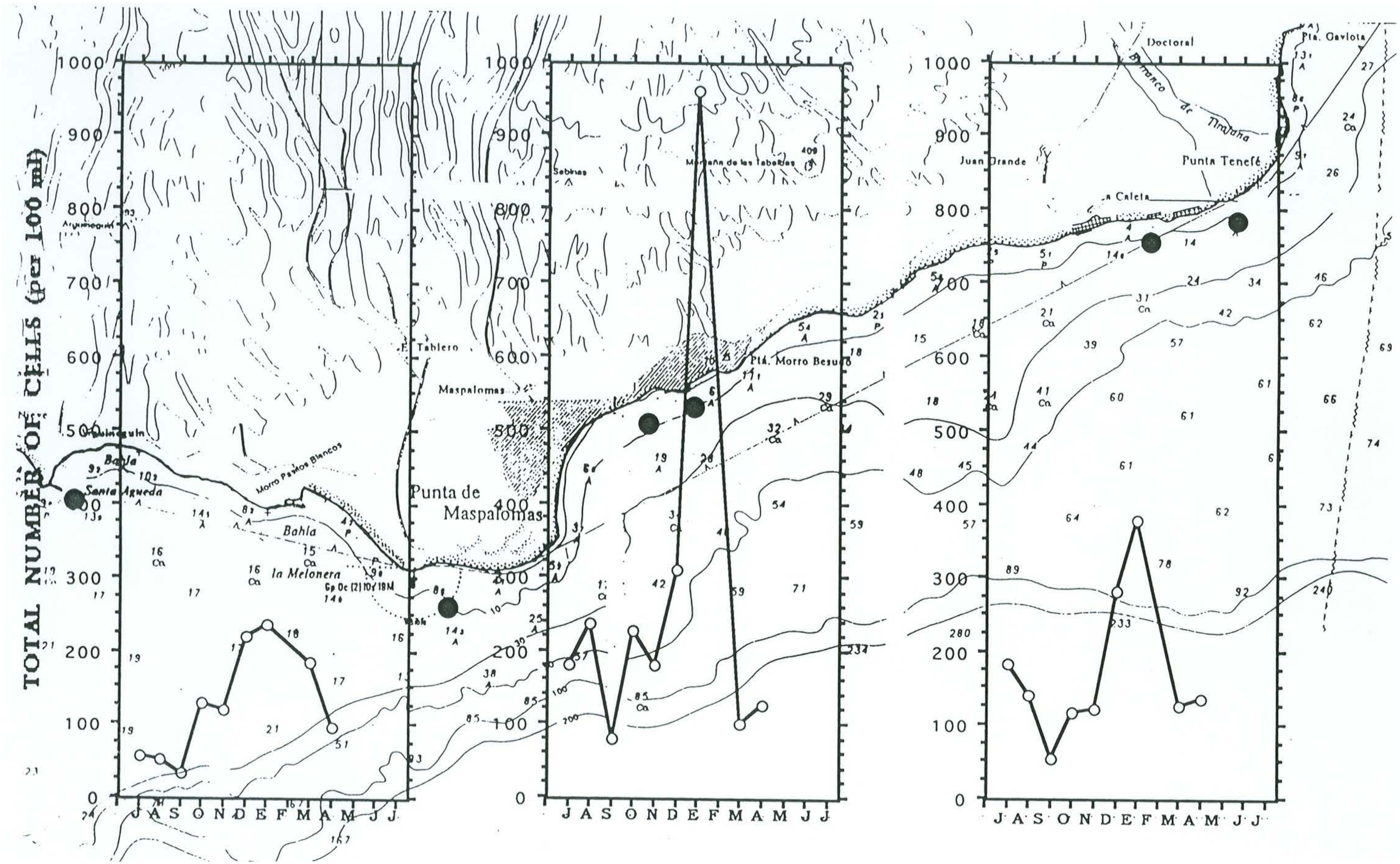


Fig. 5b - Phytoplankton biomass (cells/100ml) in the stations sampling.

In general, there is a correspondence between the biomass estimated as pigment concentration and that obtained from a cellular count, with a high concentration of chlorophyll obtained in station I in the month of July 1994.

* Counting and systematic identification

The values for total population density are low, no higher than 12 cells.ml^{-1}, and these values correspond to those quoted by MARGALEF (1983) for oligotrophic marine areas.

The maximum population density is obtained in the month of March, made up of Diatoms (principally *Rhizosolenia stolterforthii, R. setigera, Chaetoceros decipiens* and *Ch. debilis*) while in the summer period it consists of Dinoflagellates (*Protoperidinium sp*., *Ceratium furca* and *Ceratium* sp.), Fig. 5b. By station, the recount of the number of cells present has a high value in station III, highlighting the presence of the dinoflagellates *Gonyaulax* sp. in the summer months. With the exception of this fact, the distribution, according to the different seasons, essentially obeyed the same pattern, and did not show qualitative differences and/or dominance of species. During the entire period of study, other species also appear, such as *Nitzchia closterium, N. seriata, Navicula sp., Fragilaria sp.,* and *Licmophora* sp.

The analysis of the principal components allowed a relationship to be established between the number of individuals present - taxonomical groups and seasonality (Fig. 6a) - and localization of the sampling points, (Fig. 6b) giving rise to a distribution influenced by the seasonal analysis of the groups of species.

Since the data obtained was abundant, the detailed analysis of the population was carried out taking into account the presence of the species in a high number of samples, its abundance and the degree of reliability in its identification. Parallel to this, the species were classified according to their taxonomy into dinoflagellates, pennate diatoms and centric diatoms. Within this last group, at the same time, the families Rhizosoleniaceae and Chaetoceraceae were considered.

The analysis of principal components according to the localization of the sampling points indicates that the composition of the samples presents geographical variations between stations III, II and the rest. This latter group incorporates those stations which show smaller differences between them (Fig. 6b).

The distribution corresponding to the seasonal variability indicates, at the same time, that the specific composition of the sample presents differential associations in October, February and the remaining months (Fig. 6a).

Therefore, these seasons and months were selected, together with station I and the month of March as respective representatives of the others with a greater degree of association (Fig.6b).

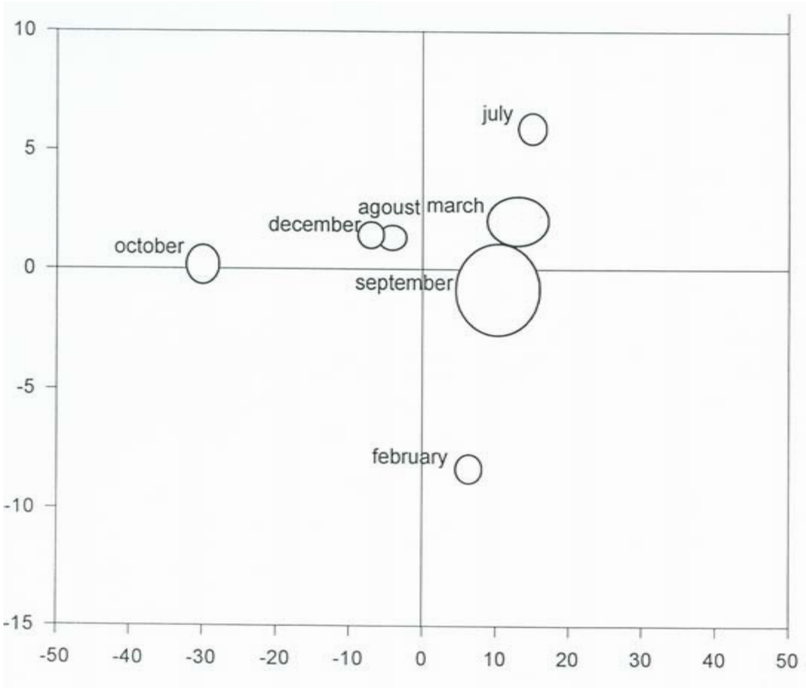


Fig. 6a - Monthly distribution by the taxonomical groups (five) and the sampling points.

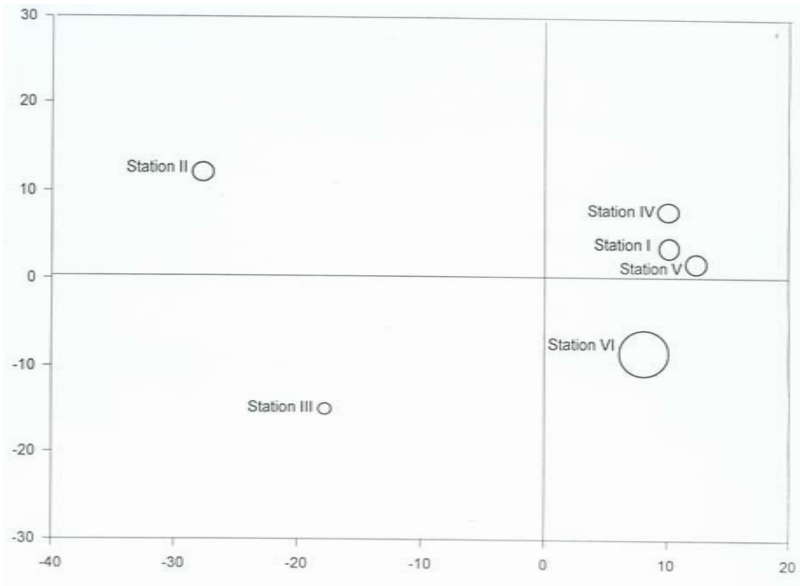


Fig. 6b - Distribution of the sampling points as function of the five taxonomical groups and the month.

DISCUSSION

The daily difference of dry temperature, that is to say between the maximum and minimum recorded both in Gando and in Mogán, is a degree higher than the range obtained by TEJEDOR (1991). The monthly distribution of the wind intensity for 1994 in the station at Gando corresponds to that given by MEDINA (1995) for the same station in the period from 1985/89. The annual average of the wind intensity in 1994/95 and the hourly intensities in Gando are in accordance with the results of the study by TEJEDOR (1991) for a period of thirty years and with the annual average obtained for 1976/85 by PÉREZ-MARTELL (1988) and for 1985/89 obtained by MEDINA (1995) in this same station.

The pattern of monthly distribution of wind intensity in the stations situated in the south of the island, Pasito Blanco and Mogán, corresponds to that described by MEDINA (1995) for the station of Mogán. For the station at Gando the predominant directions are north (22.8-41.5%) and north-northeast (19.1-59.3%) throughout an annual cycle (TEJEDOR, 1991; PÉREZ-MARTELL, 1988). In the station at Mogán the northerly direction is less frequent than that of southeasterly, southerly and westerly (PÉREZ-MARTELL et al., in press), which is due to the leeward situation of the station which is protected by the mountains from the action of the trade winds.

The recorded measurements of surface temperature of seawater and thus its monthly distribution can be placed within those given for the area by MEDINA (1995) with minimums in February/April and maximums at the end of August/October depending on the area and year of the study.

For the area of the Canary Islands, we have found an average concentration of Chl *a* of around 0.1 $mg.m^{-3}$, except during spring bloom which can reach up to 1 $mg.m^{-3}$ (BRAUN et al., 1982).

The high content of nutrients which is found in February descends rapidly in March corresponding to an elevated biomass. The fluctuation in quantity of the nutritive elements is due to selective absorption by organisms (TAIT, 1987), and in all the stations we can find a direct relation between low concentrations of silicates and a high percentage of diatoms.

The total concentration of phytoplankton (nº of cells/100 ml) showed temporal variability, in the same way as the concentration of chlorophyll (mg Chl *a*. m-3). The biomass expressed in number of individuals corresponds to that expressed in the concentration of chlorophyll *a*., with the exception of the month of July.

These divergent values obtained on measuring the biomass (recount of cells vs. concentration of pigment extracted) could be explained by the heterogeneity in the distribution of the phytoplankton (ESTRADA, 1982). In this sense, in station II, the different entries of biomass could be due to the fact that a high number of non-identified cells were counted, but they were hidden by the maximum of phytoplanktonic population present in March.

The concentration of the populations of phytoplankton, in canarian waters, is situated between 13-65 $cells.ml^{-1}$, with a predominance of diatoms throughout the whole annual cycle (BRAUN & REAL, 1984; BORDES et al., 1992). However, an increasing number of individuals belonging to the dinoflagellates are found in the summer months, but without succession taking place between both taxonomical groups (OJEDA, 1985).

Throughout our sampling period, it is possible to observe this distribution, with higher concentrations, however, in the area of station III. This is characterized by the presence of dinoflagellates of the type *Ceratium sp*., and *Protoperidium* sp., as well as a notable abundance of *Gonyaulax* sp.

These variations are so small to speak about phytoplankton blooms but enough to develop monitoring programs to control the wastwater discharges and the deputation processes.

REFERENCES

BORDES, F. et al.:

1992. Cartografía y evaluación de recursos pesqueros de la plataforma y talud de Gran Canaria (Islas Canarias). Informe, Consejería de Pesca y Transportes del Gobierno Autónomo e Instituto Canario de Ciencias Marinas del Exc. Cabildo Insular de G. C..

BRAUN, J.G.:

1980. Estudios de producción en aguas de las Islas Canarias. I. Hidrografía, nutrientes y producción primaria. *Bol. Inst. Esp. Oceanogr*., 285, pp: 140-154.

BRAUN, J.G. & F. REAL:

1984. Estudios de producción en la bahía de Antequera: una comparación con aguas oceánicas. *Bol. Inst. Esp. Oceanogr*. 1(2), pp: 134-140.

1986. Distribución vertical de la clorofila en aguas de las Islas Canarias. *Bol. Inst. Esp. Oceanogr*. 3(2), pp: 97-106.

BRAUN, J.G., F. REAL & J.D. DE ARMAS:

1982. Production studies in Canary Island waters. *Rapp. P.-v. Réun. Cons. Explo. Mer*, 180, pp: 219-220.

BRAUN, J.G., I. ORZAIZ, J.D. de ARMAS & F. REAL:

1985. Productividad y biomasa del ultraplancton, nanoplancton y fitoplancton de red en aguas de las Islas Canarias. *Bol. Inst. Esp. Oceanogr*. 2(1), pp: 192-204.

CORRAL, J. & M.F. GENICIO:

1970. Nota sobre el plancton de la costa noroccidental africana. *Bol. Inst. Esp. Oceanogr*., nº 140.

DE LEON, A.R. & J.G. BRAUN:

1973. Ciclo anual de la producción primaria y su relación con los nutrientes en aguas canarias. *Bol. Inst. Esp. Oceanogr*., n. 167, pp: 1-25.

ESTRADA, M.:
1982. Ciclo anual del fitoplancton en la zona costera frente a la Punta Endata (Golfo de Vizcaya). *Inv. Pesq*. 46(3): 469-491.

FERNANDEZ DE PUELLES, M. & J.G. BRAUN:
1989. Dinámica de las comunidades planctónicas en una zona del Atlántico Subtropical (Isla de Tenerife). *Bol. Inst. Esp. Oceanogr.*, 5(2), pp: 87-100.

GRASSHOFF, K., M. EHRHART & K. KREMLING:
1983. *Methods of Seawaters Analysis*. Second, revised and extended edition. 419pp.

JEFFREY, S.W. & G.F. HUMPHREY:
1975. New spertrophotometric equations for determining chlorophylls *a*, *b*, *c1* and *c2* in higher plants, algae and natural phytoplankton. *Biochem. Physiol. Pflanzen.*, 167. pp: 191-194.

LORENZEN, C.J.:
1967. Determination of chlorophyll and phaeopigments: spectrophotometric equations. *Limnol. Oceanogr*., 12, pp: 343-346.

MARGALEF, R.:
1982. *Ecología* . Omega S.A., 951pp.
1992. *Teoría de los ecosistemas ecológicos*. Planeta S.A.. 255pp..

MEDINA, L.:
1995. *Análisis multidisciplinar del ecosistema costero insular, balance energético, capa de mezcla y modelo biológico*. Tesis Doctoral. Universidad de Las Palmas G.C.. 316pp.

MINAS, H.J., L.A. CODISPOTI & R.C. DUGDALE:
1982. Nutrients and primary production off Northwest Africa. *Rapp. P.-v. Réun. Cons. Int. Explor. Mer*, 180, pp: 148-183.

OJEDA, A.:
1985. Especies fitoplanctónicas identificadas en aguas litorales de las Islas Canarias Orientales. Simp. Int. Afl. O Afr., *Inst. Inv. Pesq.*, Barcelona, v. I, pp: 403 - 415.

PEREZ-MARTELL, E.:
1988. *Interacción vientos-corrientes en profundidades reducidas. Un modelo para la costa Este de Gran Canaria*. Tesis Doctoral. Universidad Politécnica de Canarias. 271 pp..

PEREZ-MARTELL, E., M.J. RUEDA & O. LLINAS:
IN PRESS. A study of the distribution of winds in the Canary Islands. Its application in surface marine dynamics. *Bol. Inst. Esp. Oceanogr*.

REAL, F., J.D. de ARMAS & J.G. BRAUN:
1981. Distribución espacial de la clorofila *a* y del carbono orgánico particulado en aguas costeras superficiales de las Islas Canarias. *Bol. Inst. Esp. Oceanogr*. Tomo VI, nº 292, pp: 109-115.

TAIT, R.V.:
1987. *Elementos de Ecología Marina*. Ed. Acribia, S.A. 446 pp.

TEJEDOR, B.:
1991. *Contribución al estudio de los fenómenos dinámicos de interacción atmósfera-océano en la costa oriental de Gran Canaria*. Tesis Doctoral, Univ. de Las Palmas G.C..

UTERMÖHL, H.:
1931. Neue wege in derquantitativen erfassung des planktons (mit besonderer berücksichtigung des ultraplanktons). *Verh. Int. Ver. Theor. Angew. Limnol.* 5(2), pp: 567-596.

VALIELA, I.:
1995. *Marine Ecological Processes*. 2nd Ed. Springer-Verlang, New York. 686pp.

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