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Phytoplankton composition and abundance assessment in the Nador lagoon (Mediterranean coast of Morocco)

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Abstract – We evaluated phytoplankton abundance, composition and trophic state of the Nador lagoon (Morocco) on the basis of data taken in the period November 2007 to August 2008. Sampling was performed at 11 stations (bottle samples at 0.5 m depth and horizontal plankton net tows with mesh size of 20 μm). Among seven identified phytoplankton classes, diatoms and dinoflagellates dominated with 133 and 169 species, respectively. Frequent phytoplankton blooms were contributed by one to three species in the lagoon. Abundance and seasonality of phytoplankton characterized the Nador lagoon as a highly eutrophicated environment.

Keywords: Mediterranean Sea, Nador lagoon, Phytoplankton, diversity, eutrophication,

Introduction

Taxonomic composition and size structure of phytoplankton is regulated by eutrophication in coastal lagoons (PÉREZ-RUZAFA et al 2002). Eutrophication can induce massive blooms (coloured water) of phytoplankton species and the reduction in diversity. In our study, both the qualitative and quantitative aspects were considered in order to determine (a) the actual phytoplankton community structure of the Nador lagoon, (b) the spatial distribution and (c) the temporal succession of the dominant species.

Description of the study area

The Moroccan Nador lagoon is a semi-enclosed coastal ecosystem with a surface area of about 115 km^2 (Fig. 1). The lagoon is isolated from the Mediterranean Sea by a 25 km long sand bar (le Lido), crossed by one channel (Boccana). It is located in a region characterised by a Mediterranean climate with, often, a low and irregular rainfall – (annual mean

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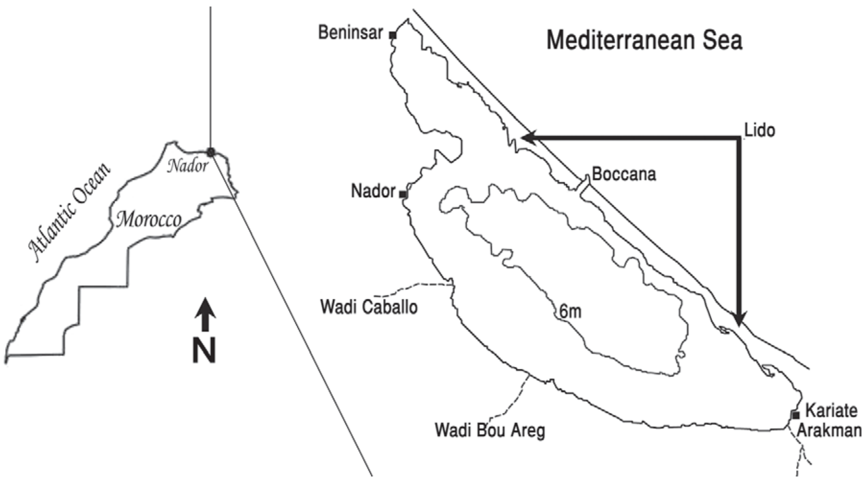

Fig. 1. The bathymetric map of Nador lagoon and its geographic position.

116–430 mm). During the year, there is a distinction between the rainy season from November to March and the dry season from April to October (Fig. 2).

The average depth of the lagoon is 4–7 m (Fig. 1). The depths increase from edges to the middle part of the lagoon. The salinity range is 32.7–40.2 in the confined extremity of the lagoon where the mixing of the water column is very low (Benbrahim 2009). The water temperature variation closely follows the temperature of the air (Lakhdar et al. 2005) and generally ranges from 11 °C in January to 30 °C in August. Stratification of the water column is weak.

The Nador lagoon is one of the largest costal lagoons on the Mediterranean coast that suffer from a substantial anthropogenic wastewater overload in organic matter, nitrogen and phosphorus in addition to other various kinds of chemicals including heavy metals and

months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation (mm)	45.8	48.4	36.7	27.7	17.5	10.4	1.4	3	9.1	22.1	32.2	32.5
Temperature (°C)	12.2	13.1	14.3	15.7	18.2	21.65	24.3	25.1	23.1	19.3	16.15	13.6

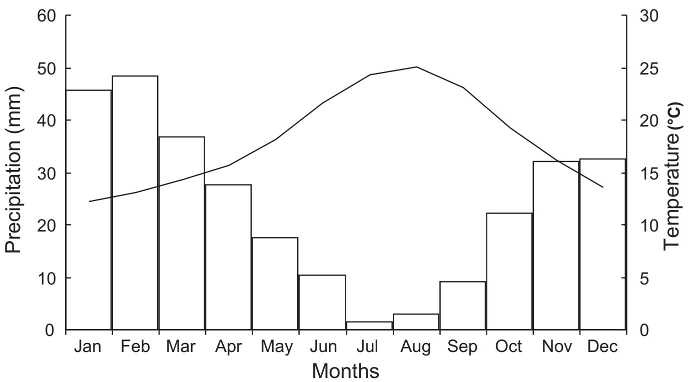

Fig. 2. Monthly mean rainfall and temperature in Nador city, in the period 1977–1996.

hydrocarbons (BLOUNDI 2005). This organic and inorganic complex may cause dysfunctions in the food web that might lead a total ecosystem imbalance, especially because of the low water exchange rate with the open sea. The turnover time of the water in the lagoon was estimated to be 80 days (HILMI 2005). However, despite the narrowness of the channel, the hydrological balance of this system shows a quasi-permanent predominance by sea water. In 1993 the channel (Boccana) was dredged and widened after a progressive accumulation of the sand that since 1987 had almost completely isolated the lagoon from the open sea; this was done in order to re-establish normal water circulation.

The macrophytes recorded in the lagoon, during the present study, belong to three groups (i) Climax phanerogams Cy*amodocea nodosa*, and *Nanozostera nolti* and the Chlorobiontes *Caulerpa prolifera*, (ii) the opportunist algae: *Ulva* spp, *Enteromorpha* spp, *Chaetomorpha linum* and (iii) the drifting Rhodophyceae species *Gracilaria gracilis and Alscidium corlinum*. Generally, the invasive macroalgae, *Caulerpa prolifera*, cover most of the bottom, except the central part that is devoid of macrophytes, restricting the seaweed *Cymodocea nodosa* to small bands in the shallowest areas surrounding the lagoon.

Diatoms are the dominant planktonic algae in the lagoon (EL MADANI et al 2001).

Several watercourses drain into the lagoon but most of them become functional only during episodic flood periods (MAHJOUBI 2003). Some of them, such as Wadi Caballo, Wadi Afelioune and Wadi Akhandouk, became true open wastewater collectors that may contribute to increase the organic matter and various kinds of chemical element input.

Materials and Methods

Surface phytoplankton sampling was conducted, five times, roughly each two months, at 11 stations along Nador lagoon, (Fig. 3). For qualitative study, samples were collected using a standard plankton net (20 µm mesh size), in a horizontal tow for about 2 minutes at

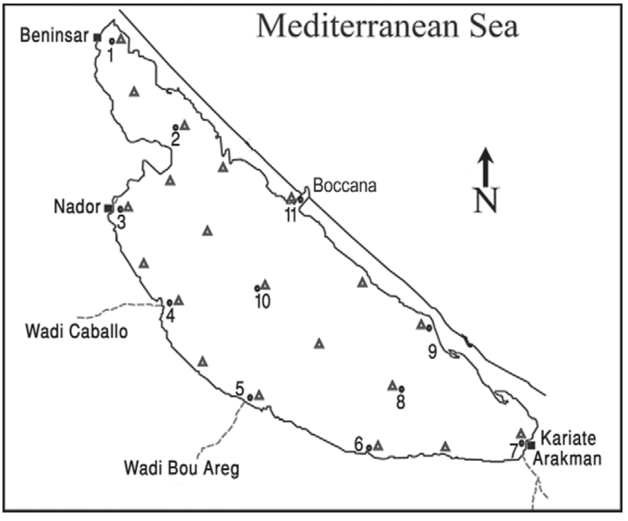

Fig. 3. The sampling plan at stations: phytoplankton (•); temperature and salinity (△).

each station. For quantitative plankton sampling a bottle was used. Once collected, samples were fixed immediately with neutral formalin. For identification and enumeration of phytoplankton an inverted microscope Leica DM-IRB was used.

Phytoplankton identification was performed according to DODGE (1982), BALECH et al. (1984), RICARD (1987), BALECH (1988), LARSEN and MOESTRUP (1989), DELGADO and FORTUÑO (1991), HALLEGRAEFF (1991), HALLEGRAEFF et al. (1991), PAULMIER (1992, 1994), NEZAN (1996), NEZAN and PICLET (1996), TOMAS (1997), FAUST et al. (1999), MATSUOKA and FUKUYO (2000), HANSEN et al. (2001), SAR et al. (2002), KASHIMA (2002), KOENING and LIRA (2004).

The salinity and temperature measurements were made in situ (20 stations) with WTW *cond*-197i model conductivity-salinometer (Fig. 3).

Results

Water temperature and salinity

Salinity and temperature increase from January to August (Fig. 4). The salinity minimum is due to the rainfall maximum. If we consider spring the reference season, because of its moderate temperature and low rainfall, the normal salinity in the Nador lagoon is around 36.7 with small variations. The range between minimum and maximum water temperature is about 13 °C, and photoperiod seems to be the main limiting factors for the development of the phytoplankton community.

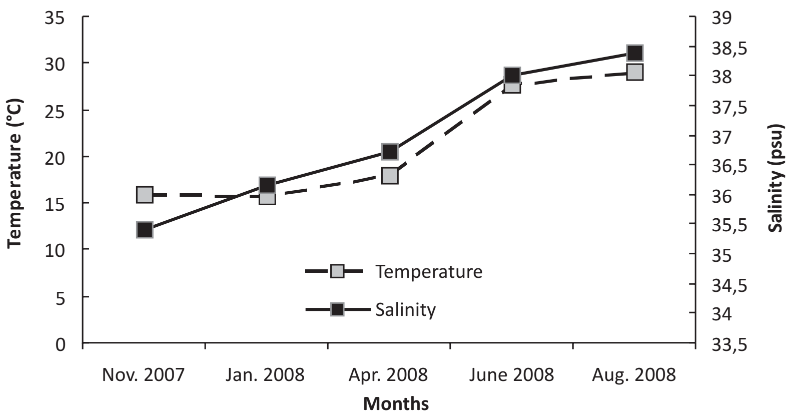

Fig. 4. Temporal variation of the means of the temperature and salinity of the lagoon waters during the study period.

Taxonomic composition

A total of 311 phytoplankton species belonging to seven groups were identified during the period of study; 133 diatom species, 169 dinoflagellates, 2 cyanophyceae, 2 dyctiochophyceae, 2 euglenophyceae, 1 chlorophyceae, 1 coccolithophorid species and 1 raphydophyceae (Tab. 1). Among phytoplankton species, the most dominant were diatoms, such as: *Chaetoceros* spp, *Pseudonitzschia* spp, *Nitzschia longissima, Skeletonema* sp, *Neocera-*

Tab. 1. The spatial distribution of phytoplankton taxa (result from five samplings during 2007 and 2008).

		Stations										
		1	2	3	4	5	6	7	8	9	10	11
	Dictyochophyceae											
1	*Hermesinum adriaticum* O. Zacharias	–	+	+	+	+	+	–	+	+	+	+
2	*Dictyocha fibula* Ehrenberg	–	–	+	–	–	–	–	–	–	+	+
	Cyanophyceae											
3	*Oscillatoria* sp.	+	+	+	+	+	+	+	–	+	–	+
4	*Spirulina* sp.	+	+	–	–	–	–	–	–	–	–	–
	Chlorophyceae											
5	*Scenedesmus rastro-spinosus Chodat*	–	–	–	+	+	–	–	–	–	–	–
6	*Eutreptia* sp.	+	–	+	+	+	+	–	+	–	–	–
7	*Euglena* sp.	–	–	–	+	–	–	–	–	–	–	–
	Coccolithophorids											
8	*Calciosolenia murrayi Gran*	–	+	+	+	–	–	–	–	+	+	+
	Bacillariophyceae											
1	*Achnanthes brevipes Agadh*	+	+	+	–	–	–	–	–	–	–	+
2	*Achnanthes catenata* Bily et Marvan	–	+	+	–	–	–	–	–	–	–	+
3	*Actinoptechus* sp.	–	–	–	–	–	–	–	–	–	–	+
4	*Actinoptychus senarius (Ehrenberg) Ehrenberg*	–	–	–	–	–	–	–	–	–	–	+
5	*Actinoptychus splendens* (Shadbolt) Ralfs ex Pritchard	–	–	–	–	–	–	–	–	–	–	+
6	*Amphipleura pellucida*(Kütz.) Kütz.	+	+	+	+	+	+	+	+	+	+	+
7	*Amphiprora angustata* Hendey	+	–	–	–	–	–	–	–	–	–	–
8	*Amphiprora* sp.	–	–	–	–	–	–	–	–	–	–	–
9	*Amphora egregia* Ehrenberg	–	–	–	–	–	–	–	–	–	–	+
10	*Amphora hyalina* Kützing	–	–	–	–	–	–	–	–	–	–	+
11	*Amphora laevis* Gregory	–	–	+	–	–	–	+	+	+	–	–
12	*Amphora recta* Grunow	–	–	–	–	–	–	–	–	–	–	–
13	*Amphora* sp.	+	+	+	+	–	–	+	+	–	–	+
14	*Amphora ventricosa* W. Gregory	–	–	–	–	–	–	–	–	–	–	+
15	*Asterionella japonica* Cleve et Moller	+	+	–	+	–	–	–	–	–	–	+
16	*Auliscus sculptus* (W. Smith) Ralfs ex Pritchard	–	–	–	–	–	–	–	–	–	–	+
17	*Auliscus* sp.	–	–	–	–	–	–	–	–	–	–	+
18	*Bacillaria paxillifera* (Müller) Hendey	+	+	+	+	+	+	+	+	+	+	+
19	*Biddulphia edwardsii* Febiger ex Grunow	–	–	–	–	–	–	–	–	–	+	–
20	*Biddulphia pulchella* S.F. Gray	–	–	–	–	–	–	–	–	–	–	+
21	*Biddulphia rhombus* (Ehrenberg) W. Smith	–	–	+	–	–	–	–	–	–	–	–
22	*Biddulphia* sp.	–	–	–	–	–	–	–	–	–	–	+
23	*Biddulphia tuomeyi* (Bailey) Roper	–	–	–	–	–	–	–	–	–	–	+

Tab. 1. – continued

		Stations										
		1	2	3	4	5	6	7	8	9	10	11
24	*Campylodiscus decorus* de Brébisson	–	–	–	–	–	–	–	–	–	–	+
25	*Cerataulina pelagica* (Cleve) Hendey	+	+	+	–	+	–	+	+	+	+	+
26	*Chaetoceros affinis* var. *willei* (Gran) Hustedt	–	–	+	–	–	–	–	+	–	–	–
27	*Chaetoceros brevis* Shütt	+	–	–	–	–	–	–	–	–	–	–
28	*Chaetoceros curvisetus* Cleve	+	+	+	+	–	–	–	–	–	+	–
29	*Chaetoceros danicus* Cleve	–	–	+	–	–	+	–	+	–	–	–
30	*Chaetoceros decipiens* Cleve	–	+	+	+	+	+	+	+	+	+	+
31	*Chaetoceros didymus* Ehrenberg	–	+	–	–	–	–	–	–	–	–	–
32	*Chaetoceros laciniosus* Schütt	–	–	–	–	–	–	–	+	–	–	–
33	*Chaetoceros laevis* Leuduger–Fortmorel	–	+	–	–	–	–	–	–	–	–	–
34	*Chaetoceros lauderi* Ralfs	–	–	–	–	–	+	–	–	–	–	–
35	*Chaetoceros mitra* (J.W. Bailey) Cleve	+	+	+	+	–	+	+	+	+	+	+
36	*Chaetoceros peruvianus* Brightwell	–	+	+	+	+	–	–	+	+	+	+
37	*Chaetoceros pseudocurvisetus* Mangin	–	+	–	–	–	–	–	–	–	–	–
38	*Chaetoceros simplex* Ostenfeld	–	–	–	+	–	–	–	–	–	–	–
39	*Chaetoceros* spp.	+	+	+	+	+	+	+	+	+	+	+
40	*Chaetoceros teres* Cleve	–	+	–	+	–	+	+	–	–	–	+
41	*Chrysanthemodiscus floriatus* Mann	–	–	–	–	–	–	–	–	–	–	+
42	*Climaconeis* sp.	–	–	–	–	–	–	+	–	–	–	–
43	*Cocconeis scutellum* Ehrenberg	–	+	–	–	–	+	–	+	–	–	+
44	*Cocconeis* sp.	+	–	+	–	–	–	–	–	+	–	+
45	*Corethron criophilum* Castracane	–	+	–	–	–	–	–	–	–	–	–
46	*Coscinodiscus* sp.	–	–	+	–	–	–	–	–	–	–	+
47	*Dactyliosolen fragilissimus* (Bergon) G. R. Hasle	–	–	–	+	–	–	–	–	–	+	–
48	*Diatoma mesodon* (Ehrenberg) Kützing	–	–	–	–	–	–	–	–	–	–	+
49	*Diploneis chersonensis* (Grunow) Cleve	–	–	–	–	–	–	–	–	–	–	+
50	*Diploneis* sp.	–	–	–	–	–	–	–	–	+	–	–
51	*Ditylum brightwellii* (T. West) Grunow	+	–	+	–	–	–	–	–	–	+	–
52	*Entomoneis alata (*Ehrenberg) Ehrenberg	+	–	+	–	+	+	+	–	+	–	–
53	*Entomoneis* sp.	+	+	–	–	–	–	–	–	–	–	–
54	*Epithemia turgida* (Ehrenberg) Kütz	–	–	–	–	–	–	–	–	–	–	+
55	*Goniothecium odontella* Ehrenberg	–	–	–	–	–	–	–	–	–	–	+
56	*Grammatophora angulosa* Ehrenberg	–	–	–	–	–	–	–	–	–	–	+
57	*Grammatophora marina* (Lyngbye) Kützing	–	+	+	–	–	–	–	–	–	–	–
58	*Guinardia delicatula* (Cleve) Hasle	–	–	–	–	–	+	+	–	–	–	+
59	*Guinardia flaccida* (Castracane) H. Peragallo	+	–	–	–	–	–	–	–	–	–	+
60	*Guinardia striata* (Stoltherfoth) Hasle	–	+	+	–	+	+	+	+	+	+	+

Tab. 1. – continued

		Stations										
		1	2	3	4	5	6	7	8	9	10	11
61	*Gyrosigma fasciola* (Ehrenberg) J.W.Griffith et Henfrey	+	+	–	+	+	–	+	–	–	+	–
62	*Gyrosigma scalproide* (Rabenhorst) Cleve	–	+	–	+	–	–	–	–	+	–	+
63	*Gyrosigma* sp.	–	–	–	+	–	+	–	–	–	–	–
64	*Gyrosigma wansbeckii* (Donkin) Cleve	–	–	–	–	+	–	–	–	–	–	–
65	*Hantzschia amphioxus* (Ehrenberg) Grunow	–	–	–	–	–	–	–	–	–	–	+
66	*Haslea wawrikae* (Husedt) Simonsen	–	+	+	+	–	+	–	–	–	–	+
67	*Hemialus hauckii* Grunow ex Van Heurck	+	+	+	+	+	+	+	–	+	+	+
68	*Hemiaulus sinensis* Greville	–	–	–	–	+	–	–	–	–	–	–
69	*Lauderia annulata* Cleve	–	–	–	–	–	–	–	–	–	–	+
70	*Lauderia* sp.	–	–	–	–	–	–	–	–	+	–	–
71	*Leptocylindrus danicus* Cleve	–	+	+	+	–	+	–	+	+	+	+
72	*Leptocylindrus minimus* Gran	–	+	+	+	+	+	+	+	+	+	+
73	*Licmophora flabellata* (Greville) Agardh	+	+	+	+	+	+	+	+	+	+	+
74	*Licmophora gracilis* (Ehrenberg) Grunow	+	+	+	+	+	+	–	–	–	+	+
75	*Licmophora* sp.	+	+	–	–	–	–	–	–	–	+	+
76	*Lioloma pacificum* (Cupp) Hasle	–	–	–	+	–	+	–	–	–	+	–
77	*Lioloma* sp.	–	+	–	–	–	–	–	–	–	–	–
78	*Melosira nummuloides* C.A. Agardh	–	+	–	–	–	–	–	–	–	–	–
79	*Melosira* sp.	–	–	–	–	–	–	–	–	–	+	+
80	*Meuniera membranacea* (Cleve) P.C. Silva in Hasle et Syvertsen	+	–	–	–	–	–	–	–	–	–	+
81	*Navicula cf. carinifera* Grun. Grunow in Schmidt	–	+	–	–	–	–	–	–	–	–	–
82	*Navicula forcipata* Greville	–	–	–	–	–	–	–	–	–	–	+
83	*Navicula hasta* Pantocsek	–	–	–	–	–	–	–	–	–	–	+
84	*Navicula hennedyi* W.Smith	–	–	–	–	–	–	–	–	–	–	+
85	*Navicula humerosa* Brébisson ex W. Smith	–	–	–	–	–	–	–	–	–	–	+
86	*Navicula lanceolata* (C. Agardh) Kützing	–	–	–	–	–	–	–	–	–	–	+
87	*Navicula menaiana* Hendey	–	–	–	–	–	–	–	–	–	–	+
88	*Navicula smithii Navicula smithii* (Agardh) Van Heurck	–	–	–	–	–	–	–	–	–	–	+
89	*Navicula* spp.	–	+	+	–	+	+	–	–	+	–	+
90	*Navicula tuscula* (Ehrenberg) Grunow	–	+	–	–	–	–	–	–	–	–	–
91	*Cylindrotheca closterium* (Ehrenberg) Reimann et J.C.Lewin Kingston	–	+	+	+	+	+	+	–	+	+	+
92	*Nitzschia levidensis* (W. Smith) Grunow in Cleve et Grunow	–	–	–	–	–	–	–	–	–	–	+
93	*Nitzschia longissima* (Brébisson) Ralfs	+	+	+	+	+	+	+	+	+	+	+

Tab. 1. – continued

		Stations										
		1	2	3	4	5	6	7	8	9	10	11
94	*Nitzschia panduriformis* W. Gregory	–	–	–	–	–	–	–	–	–	–	+
95	*Nitzschia sigma* (Kützing) W. Smith	–	+	–	–	–	+	–	–	–	–	+
96	*Nitzschia* sp.	–	+	+	+	+	+	+	+	+	+	+
97	*Nitzschia ventricosa* Kitton	+	+	–	–	+	+	+	+	+	+	+
98	*Oestrupia musca* (Gregory) Hustedt	–	–	–	–	–	–	–	–	–	–	+
99	*Plagiotropis lepidoptera* (Greg.) Reimer Navarro	–	–	–	–	–	–	+	–	–	–	–
100	*Planctoniella sol* (Wallich) Schutt	–	–	–	–	–	–	–	–	–	–	+
101	*Pleurosigma elangatum* W. Smith	+	+	+	–	+	+	+	+	+	+	+
102	*Pleurosigma itium* Ricard	–	+	+	+	+	+	+	–	+	+	+
103	*Pleurosigma* spp.	+	–	+	+	–	–	–	–	–	–	+
104	*Podocystis adriatica* (Kützing) Ralfs	–	+	–	–	–	–	–	–	–	–	+
105	*Proboscia alata* (Brightwell) Sundström	–	–	–	–	–	–	–	–	–	–	+
106	*Pseudoguinardia recta* von Stosch	–	–	–	–	–	–	–	–	–	+	+
107	*Pseudo-nitzschia* spp.	+	+	+	+	+	+	+	+	+	+	+
108	*Rhizosolenia alata* Brightwell	–	–	–	–	–	–	–	–	–	–	+
109	*Rgizosolena setigera* Brightwell	–	+	–	+	+	–	–	+	–	+	–
110	*Rhizosolenea* sp.	–	–	–	+	–	–	–	–	–	–	–
111	*Rhizosolenia alata* forma *indica* (H. Peragallo) Gran	–	–	–	–	–	–	–	–	+	–	+
112	*Rhizosolenia setigera* Brightwell	+	+	+	+	+	+	–	+	+	+	+
113	*Rhizosolenia* sp.	–	–	–	–	–	–	–	–	–	–	+
114	*Rhizosolenia styliformis* Brightwell	–	–	–	–	+	+	–	–	–	+	+
115	*Rhoicosigma* sp.	–	–	–	–	–	–	–	–	–	–	+
116	*Skeletonema* sp.	–	+	+	+	+	+	+	+	+	+	+
117	*Stauroneis amphioxys* Gregory	–	–	–	–	–	–	–	–	–	–	+
118	*Stenopterobia intermedia* (Lewis) Brébisson ex Van Heurck	–	–	–	–	–	–	–	–	–	–	+
119	*Helicotheca tamesis* Ricard	–	–	–	+	–	–	–	–	–	–	–
120	*Striatella unipunctata* (Lyngbye) C. Agardh	+	+	+	+	–	–	+	–	–	–	+
121	*Surirella amoricana* H. Peragallo	–	–	–	–	–	–	–	–	–	–	+
122	*Surirella fastuosa* Ehrenberg	–	–	–	+	+	+	–	–	–	+	+
123	*Surirella gemma* (Ehrenberg) Kützing	–	+	+	+	–	+	+	–	–	–	–
124	*Surirella* sp.	–	–	–	–	–	–	–	–	–	–	+
125	*Synedra* sp.	+	–	–	–	–	–	–	–	–	–	–
126	*Thalassionema nitzschioides* (Grunow) Mereschkowsky	+	+	+	+	+	+	+	+	+	+	+
127	*Thalassiosira hyalina* (Grunow) Gran	–	–	–	–	–	–	–	–	–	–	+
128	*Thalassiosira* sp.	+	+	–	–	+	–	–	–	–	+	+

Tab. 1. – continued

		Stations										
		1	2	3	4	5	6	7	8	9	10	11
129	*Thalassiothrix froenfeldeii* Grunow	+	+	+	–	+	–	+	–	+	–	+
130	*Thalassiothrix* spp.	+	+	+	+	+	+	+	+	+	+	+
131	*Toxonidea* sp.	–	–	–	–	–	–	–	–	–	–	+
132	*Triceratium alternans* J. W. Bailey	–	–	–	–	–	–	–	–	+	–	+
133	*Trichotoxon reinboldii* (Van Heurck) Reid et Round	–	+	–	–	–	–	–	–	–	+	–
	Dinoflagellates											
1	*Achradina pulchra* Lohmann	+	+	–	–	–	+	+	–	–	–	–
2	*Alexandrium catenella* (Whedon et Kofoid) Balech	–	–	+	+	–	–	–	–	–	–	+
3	*Alexandrium margalefi* Balech	–	–	–	–	–	–	–	–	–	+	+
4	*Alexandrium minutum* Halim	+	+	+	+	+	+	+	+	+	+	+
5	*Alexandrium pseudogonyaulax* (Biecheler) Horiguchi ex Yuki et Fukuyo	–	+	+	–	–	+	–	+	+	+	+
6	*Alexandrium* sp.	–	–	–	–	–	–	–	–	+	–	+
7	*Alexandrium tamarense* (Lebour) E.Balech	–	–	–	–	–	–	+	–	–	–	–
8	*Amphidinium* sp.	–	–	–	+	+	–	–	–	–	–	–
9	*Amphidoma caudata* Halldal	+	+	+	+	+	+	+	+	+	+	+
10	*Amylax* sp.	–	–	–	+	–	–	–	–	–	–	–
11	*Archaeperidinium* sp.	–	–	–	–	–	–	–	–	–	–	+
12	*Coolia monotis* Meunier	+	+	+	–	–	–	+	+	–	+	+
13	*Cyst Alexandrium minutum*	–	–	–	+	+	+	–	+	+	+	–
14	Cyst of dinoflagellates	+	+	+	–	–	+	+	+	+	+	+
15	*Dinophysis caudata* Saville–Kent	–	+	–	–	–	–	+	+	+	+	+
16	*Dinophysis contracta* (Kofoid et Skogsberg) Balech	–	–	–	–	–	–	–	–	–	–	+
17	*Dinophysis diegensis* Kofoid	–	–	–	–	–	–	–	–	–	–	+
18	*Dinophysis exigua* Kofoid and Skogsberg	–	–	+	–	–	–	–	–	+	+	+
19	*Dinophysis rapa* (Stein) Balech	–	–	–	–	–	–	–	–	–	–	+
20	*Dinophysis rotundata* Claparède et Lachmann	–	–	–	–	–	–	–	–	–	–	+
21	*Dinophysis sacculus* Stein	+	+	+	+	+	+	+	+	+	+	+
22	*Dinophysis* sp.	–	–	–	–	–	–	–	–	–	–	+
23	*Diplopelta asymetrica* (Mangin) Lindermann	–	–	–	–	+	–	–	+	–	–	–
24	*Diplopelta steinii* (T. H. Abé) E. Balech	–	–	–	–	–	–	–	–	–	–	+
25	*Diplopeltopsis minor* Pavillard	–	+	–	–	–	–	–	–	–	–	+
26	*Diplopeltopsis* sp.	–	+	–	–	–	–	–	–	–	–	–
27	*Diplopsalis* sp.	+	+	+	–	+	+	+	+	+	+	+
28	*Diplopsalopsis bomba* (Stein ex Jörgensen) J. D. Dodge et S. Toriumi	–	–	–	–	–	–	–	–	+	–	–

Tab. 1. – continued

		Stations										
		1	2	3	4	5	6	7	8	9	10	11
29	*Diplopsalopsis* sp.	–	–	–	–	–	–	–	–	–	+	–
30	*Ensciculifera* sp.	+	+	+	+	–	+	+	+	+	–	+
31	*Ensiculifera angulata* E. Balech	–	–	–	–	–	–	–	–	–	+	–
32	*Ensiculifera angulata* E. Balech	–	–	–	–	–	–	–	–	–	–	+
33	*Gambierdiscus toxicus* Adachi and Fukuyo	+	–	–	–	–	–	–	–	–	–	–
34	*Goniodoma polyedricum* (Pouchet) Jörgensen	–	–	+	–	–	–	–	–	–	+	+
35	*Gonyaulax dicantha* (Meunier) Schiller	–	–	+	+	+	+	+	+	+	–	+
36	*Gonyaulax digitale* (Pouchet) Kofoid	+	–	–	+	–	+	+	+	–	+	+
37	*Gonyaulax grindleyi* Reinecke	–	–	–	–	–	–	–	+	–	–	+
38	*Gonyaulax polygramma* Stein	–	–	–	–	–	+	–	–	+	+	+
39	*Gonyaulax sousae* Balech	+	+	+	+	+	+	+	+	+	+	+
40	*Gonyaulax spinifera* (Claparède et Lachmann) Diesing	+	+	+	+	+	+	+	+	+	+	+
41	*Gonyaulax striata* Mangin	–	–	–	–	–	–	–	–	–	–	+
42	*Gonyaulax turbynei* Murray et Whitting	–	–	–	–	–	–	–	–	–	+	+
43	*Gonyaulax unicornis* Lebour	+	+	–	+	+	–	+	+	+	–	+
44	*Gonyaulax veriore* Sournia	–	–	–	–	–	–	–	+	+	–	–
45	*Gotoius mutsuensis* Abé	–	–	–	–	–	–	–	–	–	+	–
46	*Gymnodinium catenatum* Graham	–	+	–	+	–	–	–	–	–	–	–
47	*Gymnodinium sanguineum* K. Hirasaka	+	+	+	+	+	+	+	+	+	+	+
48	*Gymnodinium* sp.	–	+	–	–	–	–	+	+	–	+	+
49	*Gyrodinium* sp.	–	–	+	+	–	–	–	+	–	–	+
50	*Gyrodinium spirale* (Bergh) Kofoid et Swezy	–	+	+	+	–	+	+	+	+	+	–
51	*Heterocapsa circularisquama* Horiguchi	–	–	–	–	–	–	–	–	–	+	–
52	*Heterocapsa niei* (Loeblich) Morrill et Loeblich III	–	–	–	+	–	–	–	+	+	+	–
53	*Heterocapsa rotundata* (Lohmann) G. Hansen	–	–	–	–	–	–	–	+	+	+	–
54	Heterocapsa triquetra (Ehrenberg) F. Stein	–	–	+	–	–	–	–	–	–	–	–
55	*Katodinium* sp.	–	+	–	–	–	+	+	–	–	+	+
56	*Lingulodinium polyedrum* (Stein) Dodge	+	+	+	+	+	+	+	+	+	+	+
57	*Neoceratium azoricum* (Cleve) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	–	–	+
58	*Neoceratium candelabrum* (Ehrenberg) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	–	–	+
59	*Neoceratium contrarium* (Gourret) F. Gómez, D. Moreira et P. López-García	–	+	–	–	–	–	–	–	–	+	+
60	*Neoceratium declinatum* f. *declinatum* (Sournia) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	–	+	–

Tab. 1. – continued

		Stations										
		1	2	3	4	5	6	7	8	9	10	11
61	*Neoceratium declinatum* f. *majus* (Jörgensen) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	–	+	–
62	*Neoceratium deflexum* (Kofoid) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	–	–	+
63	*Neoceratium extensum* (Gourret) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	–	–	+
64	*Neoceratium furca* (Ehrenberg) F. Gómez, D. Moreira et P. López-García	+	+	+	+	+	+	+	+	+	+	+
65	*Neoceratium fusus* (Ehrenberg) F. Gómez, D. Moreira et P. López-García	–	+	+	+	–	–	–	–	+	+	+
66	*Neoceratium karstenii* (Pavillard) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	–	–	+
67	*Neoceratium lineatum* (Ehrenberg) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	–	–	+
68	*Neoceratium longipes* (Bailey) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	–	–	+
69	*Neoceratium macroceros* (Ehrenberg) F. Gómez, D. Moreira et P. López-García	–	+	–	–	–	–	–	–	–	+	–
70	*Neoceratium massiliens* (Gourret) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	–	+	+
71	*Neoceratium massiliens armatum* (Karsten) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	–	–	+
72	*Neoceratium pentagonum* var. *tenerum* (Jörgensen) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	–	–	+
73	*Neoceratium teres* (Kofoid) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	+	–	–
74	*Neoceratium trichoceros* (Ehrenberg) F. Gómez, D. Moreira et P. López-García	–	+	+	–	–	–	–	+	–	+	+
75	*Neoceratium tripos* (O. F. Müller) F. Gómez, D. Moreira et P. López-García	–	–	+	–	–	–	–	–	+	–	–
76	*Neoceratium tripos* f. *tripodoides* (Jörgensen) F. Gómez, D. Moreira et P. López-García	–	–	–	–	–	–	–	–	–	–	+
77	*Noctiluca scintillans* (Macartney) Kofoid et Swezy	–	+	+	+	+	+	–	+	+	+	+
78	*Oblea baculifera* Balech ex Loeblich Jr. et Loeblich III	+	–	+	+	+	+	+	+	+	+	+
79	*Ornithocercus magnificus* Stein	–	–	–	–	–	–	–	–	–	–	+
80	*Ostreopsis ovata* Fukuyo	–	–	+	–	–	–	–	–	–	–	+
81	*Palaeophalacroma unicinctum* Schiller	–	–	–	–	–	–	–	–	–	–	+
82	*Pentapharsodinium* sp.	–	–	+	–	–	–	–	–	–	+	–

Tab. 1. – continued

		Stations										
		1	2	3	4	5	6	7	8	9	10	11
83	*Peridiniella* sp.	+	+	+	+	–	–	–	–	–	–	–
84	*Periperidinium* sp.	–	–	+	–	+	+	–	–	–	+	–
85	*Podolampas palmipes* Stein	–	–	–	–	–	–	–	–	–	+	–
86	*Polykrikos schwarzii* Bütschli	–	+	–	–	+	+	+	+	+	+	+
87	*Prorocentrum balticum* (Lohmann, 1908) Loeblich	–	–	–	–	–	–	–	–	–	–	+
88	*Prorocentrum compressum* (Bailey) Abé ex Dodge	–	–	–	–	–	–	–	–	–	–	+
89	*Prorocentrum lima* (Ehrenberg) Dodge	+	–	–	–	–	–	–	–	–	+	+
90	*Prorocentrum mexicanum* Tafall	+	+	+	+	+	+	+	+	–	+	+
91	*Prorocentrum micans* Ehrenberg	+	+	+	+	+	+	+	+	+	+	+
92	*Prorocentrum minimum* (Pavillard) Schiller	+	+	–	+	+	+	–	+	+	+	–
93	*Prorocentrum ruetzlerianum* Faust	+	–	–	–	–	–	–	–	–	–	–
94	*Prorocentrum sigmoide* Bohm	+	+	–	+	+	+	+	–	+	+	–
95	*Prorocentrum* sp.	–	–	–	–	–	–	–	–	+	–	+
96	*Prorocentrum triestinum* Schiller	+	+	+	+	+	+	+	+	–	+	+
97	*Protoceratium reticulatum* (Claparède et Lachmann) Butschli	–	–	–	–	–	–	–	+	–	–	+
98	*Protoceratium* sp.	–	–	–	–	–	–	–	–	–	+	+
99	*Protoperidinium acanthophorum* (Balech) Balech	+	–	–	–	–	–	–	–	–	–	–
100	*Protoperidinium bipes* (Paulsen) Balech	+	+	+	+	+	+	+	+	+	+	+
101	*Protoperidinium bispinum* (Schiller)Balech	+	+	+	+	+	+	+	+	+	+	+
102	*Protoperidinium brevipes* (Paulsen) Balech	+	+	–	–	+	+	–	–	+	–	+
103	*Protoperidinium capurroi* (Balech) Balech	+	–	+	–	–	–	–	–	–	–	–
104	*Protoperidinium cf. avellana* (Meunier) Balech	+	–	–	–	–	–	–	–	–	–	–
105	*Protoperidinium cf. capurroi subpellucidum* (E. Balech) E. Balech	–	–	–	–	–	–	–	–	–	–	+
106	*Protoperidinium cf. nanum* (Balech) Balech	–	–	–	–	–	–	–	–	–	–	+
107	*Protoperidinium cf.* obtusum (Karsten) Parke et Dodge	–	–	–	–	–	–	–	–	–	+	–
108	*Protoperidinium claudicans* (Paulsen) Balech	–	–	–	–	–	–	–	–	–	+	+
109	*Protoperidinium conicoides* (Paulsen) Balech	+	+	–	–	–	–	+	–	+	+	+
110	*Protoperidinium conicum* (Gran) Balech	–	+	–	+	–	–	–	+	+	+	+
111	*Protoperidinium conicum* (Gran) Balech avr. *conicum* in Balech	–	–	+	+	–	–	–	–	–	–	–
112	*Protoperidinium conicum* (Gran) Balech var. *concavum* Matzenauer	–	–	–	–	–	–	–	–	–	–	+
113	*Protoperidinium cruciferum* (Balech) Balech	–	–	–	–	–	–	–	–	+	–	–
114	*Protoperidinium curtipes* (Jörgensen) Balech	–	–	–	–	–	–	–	+	+	–	–

Tab. 1. – continued

		Stations										
		1	2	3	4	5	6	7	8	9	10	11
115	*Protoperidinium decipiens* (Jörgensen) Parke et Dodge (Jörgensen) Parke et Dodge	–	–	+	–	–	–	–	–	–	–	–
116	*Protoperidinium depressum* (Bailey) Balech	–	+	–	–	–	–	–	–	–	–	+
117	*Protoperidinium diabolus* (Karsten) Balech	–	+	+	+	+	+	+	+	+	+	+
118	*Protoperidinium divaricatum* (Meunier) Balech	–	–	–	–	–	–	+	–	+	–	–
119	*Protoperidinium divergens* (Ehrenberg) Balech (Ehrenberg) Balech	+	+	–	–	–	+	+	+	+	+	+
120	*Protoperidinium excentricum* (Paulsen) Balech	–	–	–	–	–	–	–	–	–	–	+
121	*Protoperidinium fartum* Balech	–	–	–	–	–	–	–	–	–	–	+
122	*Protoperidinium gibbosum* (Matzenauer) Balech	–	–	–	–	–	+	–	–	–	–	–
123	*Protoperidinium granii* (Ostenfield) Balech (Ostenfield) Balech	–	–	–	–	–	+	–	–	–	–	–
124	*Protoperidinium hirobis* Abè	+	+	+	+	+	+	–	+	+	+	+
125	*Protoperidinium* hirobis Abè	–	–	–	–	–	–	–	–	–	+	–
126	*Protoperidinium* incognitum (Balech) Balech	–	–	–	–	–	–	–	+	–	–	–
127	*Protoperidinium latispinum* (Mangin) Balech	–	–	–	–	–	–	–	–	–	–	+
128	*Protoperidinium leonis* (Pavillard) Balech	–	–	–	–	–	–	+	+	+	–	+
129	*Protoperidinium mastophorum* (Balech) Balech	–	–	+	+	–	–	–	+	–	+	+
130	*Protoperidinium metananum* (Balech) Balech	–	–	+	+	–	–	–	+	–	–	–
131	*Protoperidinium minutum* (Kofoid) Loeblich III	–	–	–	–	+	–	–	–	–	–	+
132	*Protoperidinium mite* (Pavillard) Balech	–	+	+	–	+	–	–	+	–	+	+
133	*Protoperidinium nanum* (Balech) Balech	–	–	+	–	–	–	–	–	–	–	–
134	*Protoperidinium nudum* (Meunier) Balech	–	–	–	–	–	–	–	+	–	+	–
135	*Protoperidinium oblongum* (Aurivillius) Parke et Dodge	+	+	+	+	+	+	+	+	+	+	+
136	*Protoperidinium obtusum* (Karsten) Parke et Dodge	–	–	–	–	–	–	–	+	+	–	–
137	*Protoperidinium ovatum* subsp. *asymmetricum* Pouchet	+	+	+	–	–	–	–	–	+	–	–
138	*Protoperidinium oviforme* (Dangeard) Balech	–	+	–	–	–	–	–	–	–	–	+
139	*Protoperidinium ovum* (Schiller) Balech	–	–	–	–	–	–	–	+	–	–	+
140	*Protoperidinium pallidum* (Ostenfeld) Balech	–	–	+	–	–	–	–	–	–	–	–
141	*Protoperidinium parapyriforme* (Hermosilla) Balech	–	–	–	+	+	–	–	–	–	+	+
142	*Protoperidinium parcum* (Balech) Balech	–	–	–	–	–	–	–	–	+	–	–
143	*Protoperidinium parviventer* Balech	–	–	–	–	–	–	–	–	+	–	–
144	*Protoperidinium paulseni* Pavillard	–	–	–	–	–	–	–	–	+	–	–
145	*Protoperidinium punctulatum* (Paulsen) Balech	+	+	+	+	+	+	+	+	+	+	+

Tab. 1. – continued

		Stations										
		1	2	3	4	5	6	7	8	9	10	11
146	*Protoperidinium pyriforme* var. *pyriforme* (Paulsen) Balech	–	–	+	–	+	–	–	–	–	–	+
147	*Protoperidinium quarnerense* (Schröder) Balech	–	–	–	–	–	–	–	–	–	–	+
148	*Protoperidinium quinquecorne* (Abé) Balech	–	–	–	+	–	–	–	–	–	–	–
149	*Protoperidinium simulum* (Paulsen) Balech	–	–	–	–	–	–	–	+	–	–	–
150	*Protoperidinium* sp.	+	+	+	–	–	–	–	+	–	+	+
151	*Protoperidinium sphaeroideum* (Mangin) Balech	–	–	–	–	–	–	–	–	+	–	+
152	*Protoperidinium spinulosum* Schiller	–	–	+	+	+	+	+	–	+	–	+
153	*Protoperidinium steidingerae* Balech	–	–	–	–	–	–	–	–	–	–	–
154	*Protoperidinium steinii* (Jørgensen) Balech	+	–	–	–	–	–	–	–	–	+	+
155	*Protoperidinium subcrassipes* E. Balech	–	–	–	–	–	–	–	–	–	–	+
156	*Protoperidinium subpyriforme* (Dangeard) Balech	–	–	–	–	–	–	+	–	–	–	–
157	*Protoperidinium subsphaericum* (Broch) Balech	+	–	–	–	–	–	–	–	–	–	–
158	*Protoperidinium thorianum* (Paulsen) Balech	+	–	–	+	–	–	–	–	–	–	–
159	*Protoperidinium ventricum* (Abé) Balech	–	–	–	+	–	–	–	–	–	–	–
160	*Protoperidinium vulgare* Balech	–	–	+	–	–	–	–	–	–	–	–
161	*Pyrocystis noctiluca* Murray ex Haeckel Murray ex Haeckel	–	–	–	+	–	–	–	–	–	+	–
162	*Pyrophacus horologicum* Stein	+	+	+	+	+	+	+	+	+	+	+
163	*Pyrophacus* sp.	–	–	–	–	–	–	–	–	+	–	–
164	*Pyrophacus steinii* (Schiller) Wall et Dale	–	–	–	–	–	–	–	–	–	–	+
165	*Scrippsiella precaria* Montressor et Zingone	–	–	–	–	–	–	–	+	–	–	–
166	*Scrippsiella spinifera* G. Honsell et M. Cabrini	–	+	+	+	+	+	–	+	+	+	+
167	*Scrippsiella sweeneyae* Balech ex Loeblich III	+	–	+	+	–	+	–	+	+	+	+
168	*Scrippsiella trochoidea* (Stein) Loeblich III	+	+	+	+	+	+	+	+	+	+	+
169	*Spirilax jollifei* (Murray et Whitting) Kofoid	+	+	+	–	–	–	–	+	–	–	–

tium furca, *Gonyaulax souseae*, *Alexandrium minutum*, *Scrippsiella trochoidea*, *Prorocentrum triestinum and Achradina pulchra*. A maximum of 201 taxa were observed at station 11, the minimum of 72 species at station 7 (Fig. 5).

Abundance

The maximum phytoplankton abundance was found in August 2008 (Fig. 6), due to the bloom of *Nitzschia longissima* (1.7×10^7 cells L^{-1} at station 1, located in the N-W Beninsar area, and the bloom of *Skeletonema* (7.4×10^6 cells L^{-1}) observed at station 4. The minimum abundance was recorded in November 2007.

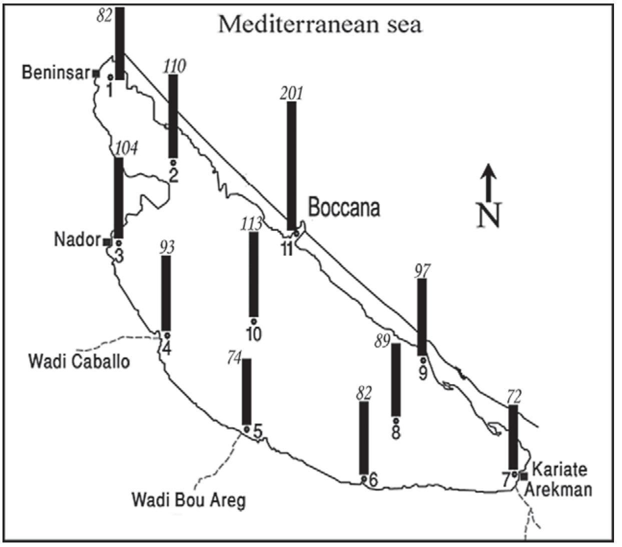

Fig. 5. Spatial distribution of the phytoplankton taxa numbers.

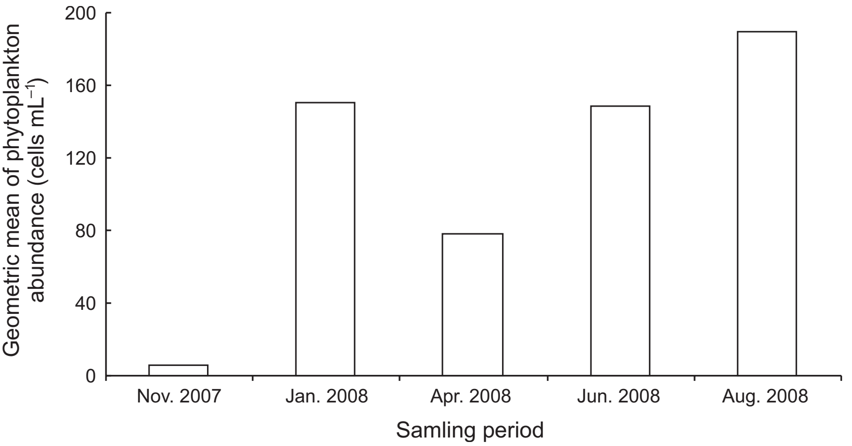

Fig. 6. Temporal variation of the geometric mean of phytoplanktonic abundance of the 11 stations.

The abundances in January and June differ due to the bloom of *Chaetoceros* observed in January at station 10, with abundance exceeding 2×10^6 cells L^{-1}.

November 2007 and January 2008: The community was dominated by the diatom *Chaetoceros* which contributed in 96.14% and 99.06% respectively in November and January.

In November, the maximum phytoplankton abundance was recorded at Station 2, with 4.4×10^4 cells L^{-1} (Fig. 7). The dominance of *Chaetoceros* was observed all over of the lagoon with the exception of stations 5 and 6 where *Neoceratium furca* dominated.

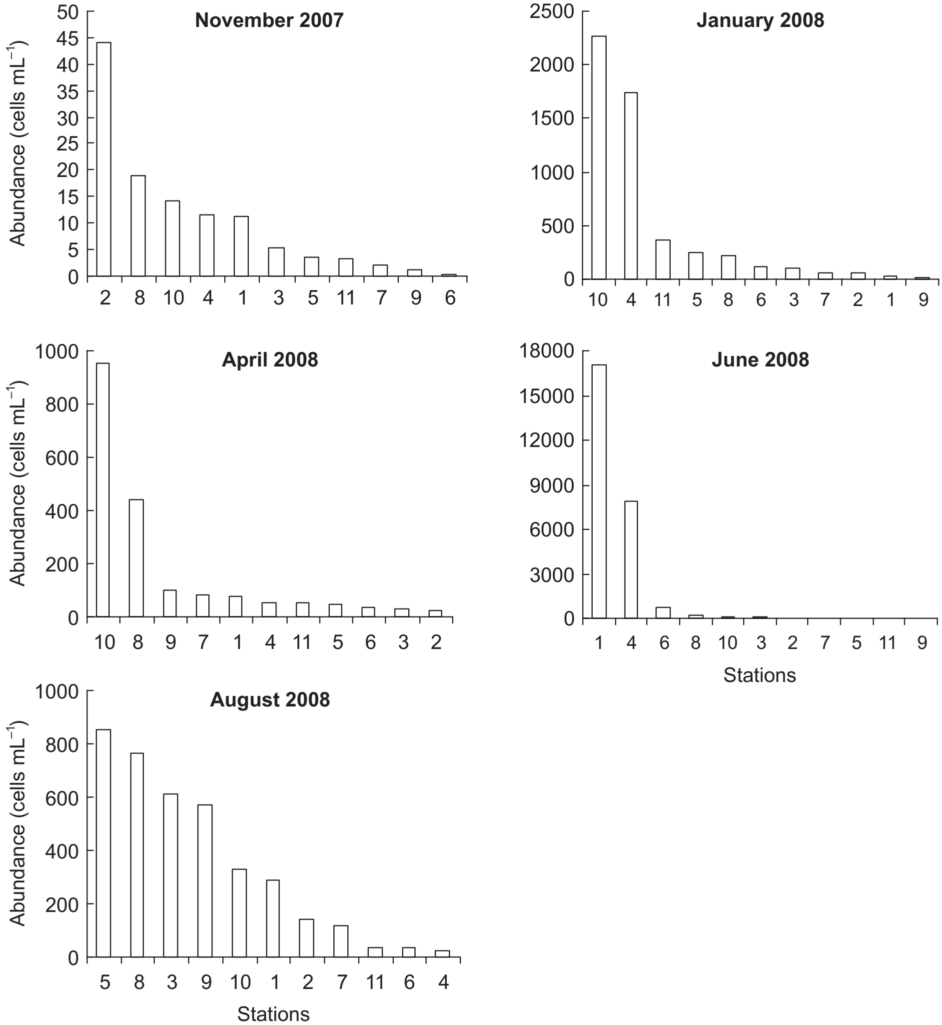

Fig. 7. Spatial variation of phytoplankton abundance during the investigated period.

In January 2008, beside the dominance of *Chaetoceros,* dinoflagellates such as *Gonyaulax souseae*, *Alexandrium minutum*, *Scrippsiella trochoidea* and *Prorocentrum triestinum* co-dominated at stations 1 and 2.

April 2008: High abundances were recorded at the station 10, with about 9.5×10^5 cells L^{-1} of *Pseudo-nitzschia,* which contributed 72.19% of the community abundance.

Jun 2008: The maximum abundance was recorded at the station 1, with 1.7×10^7 cells L^{-1} which was mostly contributed by *Nitzschia longissima* (99.9% of the community abundance).

August 2008: The maximum abundance was recorded at station 5, with 8.5×10^5 cells L^{-1} of unidentified rounded cells, 17 to 20 µm in diameter (dinoflagellates or rhaphidophycean flagellatres), contributing 95.7% of the community abundance. We also found abundant dinoflagellate *Achradina pulchra* (5.9×10^5 cells L^{-1}) at station 8, and *Nitzschia longissima* (4×10^5 cells L^{-1}) at station 3.

The dominant species (with abundance greater than 10^4 cells L^{-1}) for each sampling cruise are summarized in table 2. Generally, diatoms dominated the phytoplankton community, with the occasional dominance of unidentified flagellates and dinoflagellates in August 2008.

Tab. 2. Seasonality of dominant and accompanying species in the Nador Lagoon.

sampling campaign	Dominants species	Accompanying species (Density > 10^4)
November 2007	*Chaetoceros* spp.	*Neoceratium furca* (Ehrenberg) F. Gómez, D. Moreira et P. López-García, *Pseudo-nitzschia* spp.
January 2008	*Chaetoceros* spp.	*Prorocentrum triestinum* Schiller Small dinoflagellates (*) *Skeletonema* sp. *Pseudo-nitzschia* spp. Divers Bacillariophyceae pennates *Nitzschia longissima* (Brébisson) Ralfs
April 2008	*Pseudonitzschia* spp.	*Leptocylindrus minimus* Gran *Thalassionema nitzschioides* (Grunow) Mereschkowsky *Nitzscha longissima,* (Brébisson) Ralfs Small dinoflagellates (*) *Chaetoceros* spp. *Eutreptia* sp. *Prorocentrum triestinum* Schiller

(*): *Alexandrium minutum, Gonyaulax verrior, G. sousea, G. dicantha Scrippsiella* spp, *Protoperidinium* bipes, *P. quinquecorne, P. hirobis,* and others similar forms.

Discussion

In the present study, diatoms were generally dominant. The maximum number of taxa was observed at station 11, situated in Boccana channel, with a greater exchange of water between the lagoon and the open sea. The minimum number of taxa was found at station 7 located in the confined Kariat Arekman area as found in the period 1982–1993 (Lefebvre et al 1996). The difference in diversity between these two areas shows that more than half of the phytoplankton population comes from the open sea. The highly eutrophic conditions in the lagoon cannot maintain populations. In addition, Gilabert (2001a) explains the low diversity in the lagoon by strong physical perturbations. Anyway, more than 114 species are adapted to the lagoon's ecological conditions. About 44 phytoplankton species are common in most sampling stations (those found in at least 6 sampling stations).

The number of diatoms and dinoflagellates identified in different parts of the Mediterranean Sea mostly varies between 107 and 183 of diatoms, and 107 to 205 dinoflagellates (Viličić et al. 2002). In the Nador lagoon, we found 133 diatoms and 169 dinoflagellates.

In the Nador lagoon we recorded a high abundance of *Nitzschia longissima* (1.7×10^7 cells L^{-1}) in June at station 1. This station is situated in the confined area in the north-west part of the Mar Chica that receives wastewater from Beninsar City. An increasing abundance of phytoplankton, especially diatoms to 5×10^6 cells L^{-1}, usually reveals an area of anthropogenic influence (VILIČIĆ 1989).

Nador lagoon is slightly eutrophicated in October, with an tendency to increase with the approach of summer, due to the increasing temperature, light intensity and input of nutrients into the lagoon (fig. 4, 7). The eutrophication of the lagoon is manifested by the reduction of the water clarity, which is the direct result of the phytoplankton blooms, corresponding to the diatoms *Chaetoceros, Pseudo-nitzschia, Nitzschia longissima* etc. In summer, chlorophyll concentrations range from below 5 $\mu g\ L^{-1}$ to 20 $\mu g\ L^{-1}$, and oxygen decrease to anoxic conditions at stations 1 and 4. Strong eutrophic conditions were observed in the last decade. The blooms cause a green, brown or yellowish-brown discoloration of water. The bloom degradation results in increasing oxygen demand and degradation of water quality. Seasonal variations of primary production are the result of external physical chemical environmental variables and the shallowness of the lagoon (GILABERT 2001a, b).

During several years, we have observed that summer phytoplankton blooms are accompanied by appearance of abundant jellyfish *Rhyzostoma pulmo*. Occurrences were reported in the Mar Menor, where these organisms may play an important role in controlling eutrophication by feeding on diatoms and zooplankton (PÉREZ-RUZAFA et al. (2002).

The qualitative and quantitative results lead us to conclude that, in general, the Nador lagoon seem to be highly affected by eutrophication. A new channel (300 m wide) is going to be opened to increase the lagoon water exchange with the open sea, with an expected reduction of the residence time of water in the lagoon. This action is expected to have a great impact on the water quality by reducing the present eutrophication level, which will be accompanied by the modification of current phytoplankton population structure.

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