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PHYTOPLANKTON TAXONOMY AND DISTRIBUTION IN THE OFFSHORE SOUTHERN ADRIATIC

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This account of the taxonomic composition of phytoplankton (mainly microphytoplankton) in the offshore south-eastern Adriatic is a contribution to a check-list of Adriatic phytoplankton, which has not been prepared to date. The investigated area is influenced by warm, highly saline and extremely oligotrophic waters of the north-westerly, inflowing current from the eastern Mediterranean (Ionian Sea). Samples were collected by Niskin samplers and plankton net in the 0–100 m layer, in April, June and September 1993, and in February 1994. Seven additional cruises in 1979/80 and six cruises in the period from 1981 to 1990 gave data on rare taxa found in net samples only. Two hundred twenty nine taxa have been determined by light microscopy (2 chrysophytes, 12 prymnesiophytes, 95 diatoms, 119 dinoflagellates and 1 prasinophyte).

Keywords: Phytoplankton, taxonomy, distribution, Adriatic sea, Croatia

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Taksonomski sastav fitoplanktona (uglavnom mikrofitoplanktona) u otvorenom moru jugoistočnog dijela Jadrana, prilog je za izradu popisa Jadranskog fitoplanktona, koji do danas nije sastavljen. Istraživano područje se nalazi pod utjecajem tople, slane i ekstremno oligotrofne vode koju donosi sjeveroistočna ulazna struja iz istočnog Mediterana (Jonskog mora). Uzorci su sakupljeni Niskinovim crpcem i planktonskom mrežom u sloju od površine do 100 m dubine, u travnju, lipnju, rujnu 1993, te studenom 1994. godine. Također su dodani podaci o rijetkim vrstama, dobiveni analizom mrežnih uzoraka sa sedam krstarenja u 1979/80 i šest krstarenja u razdoblju od 1981 do 1990. godine. Svjetlosnim mikroskopom je određeno 229 svojiti (2 krizoficeje, 12 primnezioficeja (kokolitoforida), 95 dijatomeja, 119 dinoflagelata i 1 prasinoficeja).

Ključne riječi: Fitoplankton, taksonomija, distribucija, Jadransko more, Hrvatska

INTRODUCTION

Knowledge of the taxonomic composition of the phytoplankton in the Adriatic is scanty, because no check-list of phytoplankton has been completed to date. The only existing check-list of phytoplankton species relates to the northern Adriatic (REVELANTE 1986). There is also another check-list of taxa relating to the northern and partially to the central Adriatic, published as an internal document by the Marine Biology Station, Portorož, Slovenia (KERŽAN & ŠTIRN 1976). The southern Adriatic is an area influenced by warm, oligotrophic water from the Eastern Mediterranean, providing phytoplankton of high species diversity.

The scope of this paper is to describe the taxonomic composition of phytoplankton (mainly microphytoplankton) in the south-eastern Adriatic, near Dubrovnik, as a contribution to a check-list of Adriatic phytoplankton that still remains to be prepared. It describes microphytoplankton density and thermohaline conditions of the area.

STUDY AREA

The southern Adriatic is the deepest part of the Adriatic (Fig. 1). The investigated area is influenced by the NW inflowing current from the Eastern Mediterranean (ZORE-ARMANDA 1969, BARALE *et al.* 1984, ORLIĆ *et al.* 1992, LEDER *et al.* 1992, ARTEGANI *et al.* 1993) and the permanent Southern Adriatic cyclonic gyre (MALANOTTE-RIZZOLI & BERGAMASCO 1989).

Thermal stratification of the water column usually becomes evident in April, and culminates in August (VILIČIĆ *et al.* 1998). The mixing and inflowing current from the Ionian Sea predominate in the period from January to April, resulting in higher salinity. The Southern Adriatic contains extremely oligotrophic water, with $< 0.2 \text{ mol l}^{-1} \text{ PO}_4$ (most frequently about 0.1 mol l^{-1}) and $< 3 \text{ mol l}^{-1} \text{ NO}_3$ (most frequently about $1 \text{ mol l}^{-1} \text{ NO}_3$) (VILIČIĆ 1989, VILIČIĆ *et al.* 1998). Winter mixing and upwelling in the interior of the Southern Adriatic cyclonic gyre induces enrichment of the euphotic layer with nitrates (of up to 2.5 mol l^{-1}) and subsequent development and accumulation of phytoplankton (VILIČIĆ *et al.* 1989). In April 1987, a maximum cell density of $9 \cdot 10^5 \text{ cells l}^{-1}$ was recorded. Offshore phytoplankton exhausts nutrients and soon disappears. Nitrates are the limiting nutrients for phytoplankton growth in the southern Adriatic. In May, when the average temperature reaches $18 \text{ }^\circ\text{C}$, phytoplankton bloom exhausts nitrates to average concentrations lower than about 0.5 mol l^{-1} (VILIČIĆ *et al.* 1998). In this way microphytoplankton density remains low until next spring. Concentrations of orthophosphate decrease during spring to minimum values of $< 0.03 \text{ mol l}^{-1}$. Following May, slight peaks of phytoplankton could be recorded in the neritic waters.

MATERIALS AND METHODS

Water samples for the analyses of phytoplankton were collected from eight stations located over the isobaths of 100, 150, 200, 300 and 1000 m, along two transects crossing the NW edge of the Southern Adriatic Pit, near Dubrovnik (Fig. 1), using 5-litre Niskin bottles. At each station sampling was performed at five depths in the 0–100 m layer, during four cruises of the R.V. »Bios« (April 1993, June 1993, September 1993, and February 1994). Samples were preserved in a 2% (final concentration) neutralised formaldehyde solution. The cell counts were obtained by the inverted microscope method (UTERMÖHL 1958). Subsamples of 50 or 100 ml were analysed microscopically, after a sedimentation time of 48 h, within 2 months of the end of the cruise. Cells were counted at a magnification of 400 (1 to 2 transects) and 100 (transects along the rest of the counting chamber base plate). The precision of the counting method was $\pm 10\%$. Plankton closing net (53 μ m pore-size) samples, taken from two layers (50 to 0, 100 to 50 m) were useful for detection of rare microphytoplankton species. Determination of species (mostly microphytoplankton, i.e. cells longer than 20 μ m) were done using phase contrast and interference-phase contrast, and a magnification of 400. Each species was attributed by frequency of findings (see Tab. 2) resulted from the analyses of both bottle and net samples.

Salinity and temperature were determined simultaneously, at the same stations, using a conductivity, temperature and depth multisonde (SEA Bird Electronics Inc., USA).

RESULTS AND DISCUSSION

Several studies on phytoplankton in the southern Adriatic have referred to ecology (PUCHER-PETKOVIĆ & ZORE-ARMANDA 1973, REVELANTE & GILMARTIN 1977, VILIČIĆ 1985, 1989, VILIČIĆ *et al.* 1989, 1994, 1995, 1997). A check-list of phytoplankton species in the southern Adriatic will provide a basic taxonomic document. The next step is the preparation of a check-list for the Adriatic as a whole, using existing data from the northern and central Adriatic.

General hydrographic conditions, as well as the distribution of microphytoplankton density in the area of investigation, are presented in Table 1 and Figure 2. During five case studies, relatively stable temperature (12.4–23.5 °C) and salinity (37.12–38.70) values were recorded in the south-eastern Adriatic, near Dubrovnik (Tab. 1). Oligotrophic conditions in the southern Adriatic Sea have been already detected (VILIČIĆ *et al.* 1989); these result in a low microphytoplankton cell density (maximum value 49200 cells l^{-1}) (Tab. 1). The winter values in February 1994 were extremely low, with mostly less than 2000 cells l^{-1} (Fig. 2). In April 1993, an offshore accumulation of microphytoplankton was observed in the southern Adriatic cyclonic gyre interior. Later on (in June 1993), phytoplankton cell density increased in the area nearer to the coast. Phytoplankton abundance values were similar to those observed in the Otranto strait (VILIČIĆ *et al.* 1995), Ionian

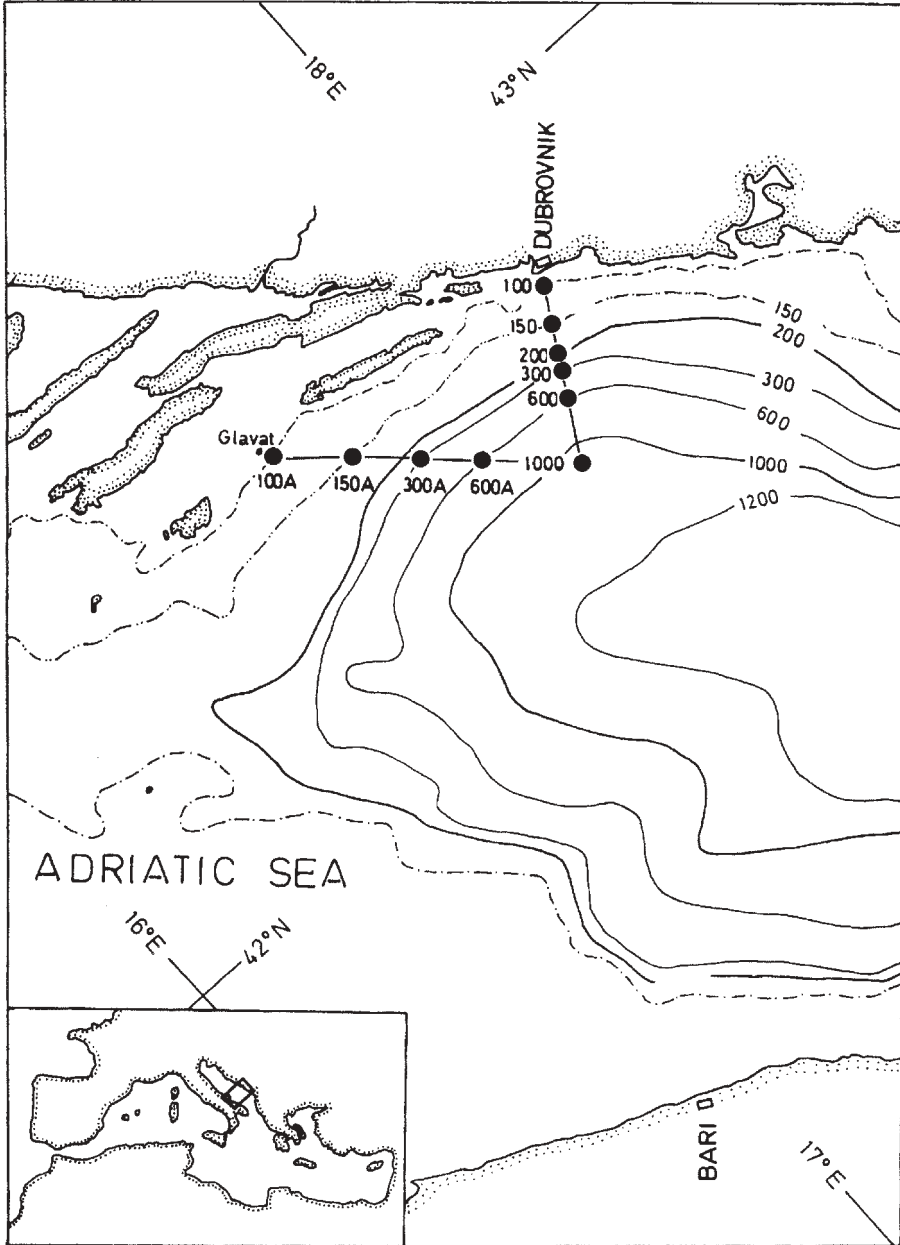


Fig. 1. Location of stations along two transects through the north-western edge of the Southern Adriatic Pit, near Dubrovnik. At stations 600A, 600 and 200, only hydrographic measurements were performed.

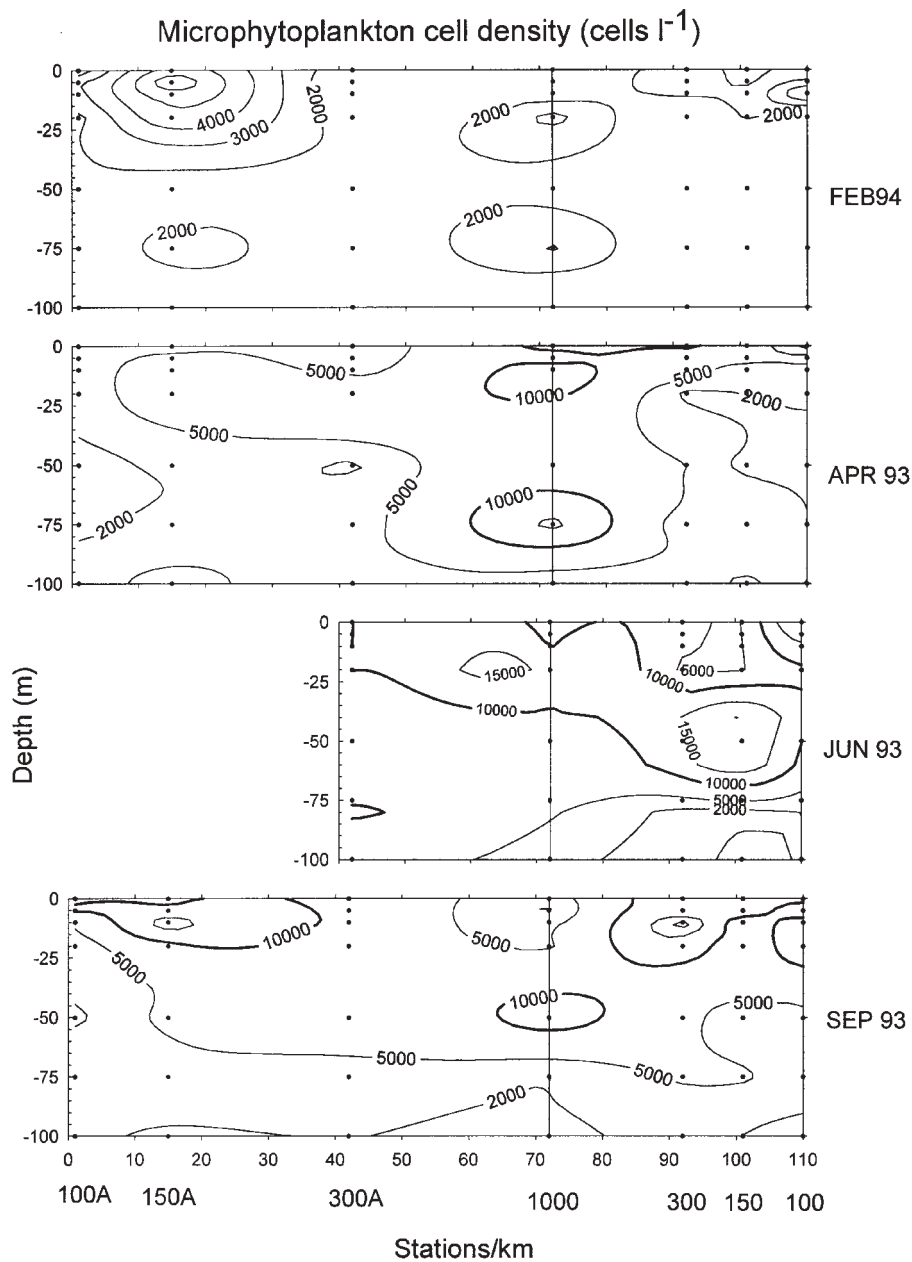


Fig. 2. Isopleth diagrams for microphytoplankton population density along the 100A-1000 and 1000-100 profiles, during the R/V »Bios« cruises in the south-eastern Adriatic.

Sea (RABITTI *et al.* 1994) and the Levantine Basin (KIMOR & WOOD 1975). Occasional offshore short peaks of phytoplankton have been reported in the southern Adriatic cyclonic gyre interior, with a density maximum of as many as $9 \cdot 10^5$ cells l^{-1} (VILIČIĆ *et al.* 1989). In the northern Adriatic phytoplankton blooms may induce much higher cell densities (REVELANTE & GILMARTIN 1976).

Table 1. Range of temperature, salinity and microphytoplankton density in the southern Adriatic («Bios research») in April, June and September 1993, and February 1994.

	Temperature (°C) min-max	Salinity min-max	Cell density (cells/l) min-max
APRIL 1993	12.5–23.5	37.81–38.64	600–16300
JUNE 1993	13.3–23.2	37.85–38.64	60–49200
SEPTEMBER 1993	13.4–23.5	37.86–38.70	330–20300
FEBRUARY 1994	12.4–13.9	37.12–38.68	100–7000

The oligotrophic conditions support a relatively rich phytoplankton flora, mainly microphytoplankton (Tab. 2). Two hundred twenty nine taxa are listed (2 chryso-phytes, 12 coccolithophorids, 95 diatoms, 119 dinoflagellates and 1 prasinophyte).

Among diatoms, centric diatoms were most common, while penatae diatoms contributed only 20 taxa. Fifteen taxa were most frequently found ($F > 20\%$): *Cerataulina pelagica*, *Chaetoceros curvisetus*, *Ch. danicus*, *Ch. decipiens*, *Guinardia flaccida*, *Hemiaulus hauckii*, *Leptocylindrus danicus*, *L. mediterraneus*, *Nitzschia longissima*, *Pseudonitzschia spp.*, *Rhizosolenia alata f. gracillima*, *Rh. imbricata*, *Rh. stouterfothii*, *Skeletonema costatum* and *Thalassionema nitzschioides*. Most frequent dinoflagellates were small undetermined gymnodinoid cells, small *Gyrodinium spp.* and *Gyrodinium fusiformis*. Three species of coccolithophorids (*Prymnesiophyceae*) were most frequently recorded: *Anaplosolenia brasiliensis*, *Rhabdosphaera tignifer* and *Syracosphaera pulchra*.

Diatoms such as *Chaetoceros* (26 taxa) and *Rhizosolenia* (11 taxa), provided representative species of the association characteristic of the eastern Mediterranean (KIMOR 1983, KIMOR *et al.* 1987). Among dinoflagellates, four genera provided a great number of taxa: *Ceratium* (27 taxa), *Dinophysis* (16 taxa), *Oxytoxum* and *Protoperidinium* (12 taxa). The phytoplankton community, including cells smaller than 20 μm , is dominated by small dinoflagellates and prymnesiophytes, as found in the Ionian Sea (RABITTI *et al.* 1994). This was the reason that coccolithophorids in the southern Adriatic samples contributed a relatively small number of taxa (12). Many microphytoplankton species were characteristic of offshore and warm waters, such as diatoms: *Chaetoceros vixvisibilis*, *Gossleriella tropica*, *Rhizosolenia castracanei*, dinoflagellates: *Brachidinium capitatum*, *Ceratium gravidum*, *Cladopyxis spp.*, *Dinophysis uracantha*, *Oxytoxum tessellatum*, *Tripodosolenia spp.* and coccolithophorids: *Thorosphaera elegans*.

Table 2. List of phytoplankton species in the south-eastern Adriatic near Dubrovnik, determined in 1993 (April, June, September) and 1994 (February) during the R/V »Bios« cruises.

F – denotes frequency of findings; *F* (%) – relative frequency of findings; *MAX* – maximum population density (cells l⁻¹); *AVG* – average population density, *STD* – standard deviation. Totally 214 samples were analyzed in the 0 to 100 m layer; 199 bottle samples (*n*₁) and 15 net samples (*n*₂). Species found in net samples only are denoted by * and *N*, where *MAX* < 10 cells l⁻¹. ** – denotes rare species found in net samples during sampling performed along the 1000–100 profile, in the period from 1979 to 1990. N. rec. – new record for the Adriatic; species not recorded in the existed catalogs for the northern and middle Adriatic (KERŽAN & ŠTIRN 1976, REVELANTE 1986).

Taxa	<i>n</i> ₁ = 199,	<i>n</i> ₂ = 15	<i>F</i>	<i>F</i> (%)	(cells l ⁻¹)			N. rec.
					<i>MAX</i>	<i>AVG</i>	<i>STD</i>	
CHRYSTOPHYCEAE								
<i>Dictyocha fibula</i> Ehrenb.			49	24.6	10000	49.3	132.0	
<i>Dictyocha speculum</i> Ehrenb.			22	11.1	3664	26.2	260.6	
PRYMNESIOPHYCEAE								
<i>Anoplosolenia brasiliensis</i> (Lohm.) Gerl.			41	20.6	2010	21.5	145.6	
<i>Calciosolenia murrayii</i> Gran			16	8.0	2010	19.5	149.9	
<i>Calyptrosphaera oblonga</i> Lohm.			21	10.6	22500	188.3	893.4	
<i>Discosphaera thomsonii</i> Ostenf. **					< 10	(N)	(N)	+
<i>Halopappus adriaticus</i> Schiller			5	2.5	105	0.8	7.6	
<i>Ophiaster hydroideus</i> (Gran)			5	2.5	2000	12.3	142.8	+
<i>Ophiaster formosus</i> Gran			11	5.5	310	5.5	33.2	
<i>Rhabdosphaera clavigera</i> Murray et Black.			2	1.0	2000	10.2	141.4	
<i>Rhabdosphaera tignifer</i> Schiller			50	25.1	10500	687.9	1826.0	
<i>Scyphosphaera apsteinii</i> Lohm.			1	0.5	10	> 0.0	0.7	
<i>Syracosphaera pulchra</i> Lohm.			52	26.1	7500	242.4	732.3	
<i>Thorosphaera elegans</i> Ostenf. **					< 10	(N)	(N)	+
BACILLARIOPHYCEAE								
<i>Actynocyclus ehrenbergii</i> Ralfs **					< 10	(N)	(N)	
<i>Amphiprora sulcata</i> O'Meara			1	0.5	10	> 0.0	0.7	
<i>Amphora ostreararia</i> Breb.*			1	0.4	< 10	(N)	(N)	
<i>Asterionella bleakeleyii</i> W. Sm.			7	3.5	840	3.9	27.2	+
<i>Asterionella glacialis</i> Castr.			22	11.1	2100	20.8	81.9	
<i>Asterionella notata</i> Grun.**					< 10	(N)	(N)	
<i>Asterolampra marylandica</i> Ehrenb.**					< 10	(N)	(N)	

Table 2 -continued	F	F (%)	MAX	AVG	STD	N. rec.
<i>Asterolampra grevillei</i> (Walich) Greville **			< 10	(N)	(N)	
<i>Asteromphalus flabellatus</i> (Breb.) Greville **			< 10	(N)	(N)	
<i>Asteromphalus heptactis</i> (Breb.) Ralfs.	3	1.5	105	0.2	1.7	
<i>Bacillaria paxillifer</i> (Muell.) Hendey			< 10	(N)	(N)	
<i>Bacteriastrum biconicum</i> Pav.**			< 10	(N)	(N)	
<i>Bacteriastrum delicatulum</i> Cleve	39	19.6	3980	45.0	167.9	
<i>Bacteriastrum elegans</i> Pav.	3	1.5	890	8.2	74.4	+
<i>Bacteriastrum elongatum</i> Cleve	6	3.0	630	7.2	51.4	
<i>Bacteriastrum mediterraneum</i> Pav.	7	3.5	1680	14.7	126.5	
<i>Biddulphia bidulphiana</i> (Sm.) Boyer **			< 10	(N)	(N)	
<i>Bidulphia titiana</i> Grun.**			< 10	(N)	(N)	
<i>Cerataulina pelagica</i> (Cleve) Hendey	53	26.6	1780	54.3	205.9	
<i>Chaetoceros affinis</i> Lauder.	36	18.1	18000	34.5	113.0	
<i>Chaetoceros anastomosans</i> Grun.	8	4.0	1680	17.6	142.2	
<i>Chaetoceros atlanticus</i> Cleve	2	1.0	420	1.7	22.0	
<i>Chaetoceros brevis</i> Schutt	11	5.5	3665	40.8	337.8	
<i>Chaetoceros coarctatus</i> Lauder *	1	0.4	< 10	(N)	(N)	
<i>Chaetoceros compressus</i> Lauder	28	14.1	22000	118.6	813.2	
<i>Chaetoceros convolutus</i> Castr.	19	9.5	210	3.7	18.4	+
<i>Chaetoceros curvisetus</i> Cleve	41	20.6	13000	43.3	187.2	
<i>Chaetoceros dadayi</i> Pav.	3	1.5	210	1.5	12.9	
<i>Chaetoceros danicus</i> Cleve	53	26.6	1780	52.4	198.0	
<i>Chaetoceros decipiens</i> Cleve	61	30.7	3979	68.9	317.5	
<i>Chaetoceros delicatulum</i> Ostenfeld *	2	0.9	< 10	(N)	(N)	
<i>Chaetoceros densus</i> (Cleve) Cleve	1	0.5	40	0.2	2.8	
<i>Chaetoceros didymus</i> Ehrenb.	4	2.0	3500	1.4	10.5	
<i>Chaetoceros diversus</i> Cleve	3	1.5	520	0.9	9.0	
<i>Chaetoceros lauderi</i> Ralfs	4	2.0	520	5.8	52.2	
<i>Chaetoceros lorenzianus</i> Grun *	1	0.4	< 10	(N)	(N)	
<i>Chaetoceros messanensis</i> Castr.	1	0.5	630	0.4	4.9	
<i>Chaetoceros peruvianus</i> Brightw.	7	3.5	104	0.9	7.7	
<i>Chaetoceros rostratus</i> Lauder	2	1.0	210	2.1	20.9	
<i>Chaetoceros simplex</i> Ostenf.	6	3.0	1890	2.7	30.0	
<i>Chaetoceros socialis</i> Lauder. *	1	0.4	< 10	(N)	(N)	
<i>Chaetoceros tetrastichon</i> Cleve	3	1.5	160	0.7	6.2	

Table 2 -continued	F	F (%)	MAX	AVG	STD	N. rec.
<i>Chaetoceros tortissimus</i> Gran	1	0.5	940	4.7	66.5	
<i>Chaetoceros vixovisibilis</i> Schiller	31	15.6	28200	208.3	1000.3	
<i>Chaetoceros wighamii</i> Brightw.	2	1.0	520	0.4	5.7	
<i>Corethron hystrix</i> Cleve	2	1.0	105	0.6	7.5	
<i>Coscinodiscus centralis</i> Ehrenb. **			< 10	(N)	(N)	
<i>Coscinodiscus perforatus</i> Ehrenb.	11	5.5	105	1.1	5.9	
<i>Coscinodiscus stellaris</i> Roper	6	3.0	10	> 0.0	0.7	+
<i>Detonula pumila</i> (Castr.) Schuett	21	10.6	1780	28.0	155.0	
<i>Diploneis</i> spp.	29	14.6	110	7.1	21.1	
<i>Ditylum brightwellii</i> (West) Grun. **			< 10	(N)	(N)	
<i>Eucampia cornuta</i> (Cleve) Grun.	13	6.5	140	2.9	14.5	+
<i>Gossleriella tropica</i> Schuett *	2	0.9	< 10	(N)	(N)	+
<i>Grammatophora</i> spp.	15	7.5	320	7.7	35.9	
<i>Guinardia blavyana</i> Perag **			< 10	(N)	(N)	
<i>Guinardia flaccida</i> (Castr.) Perag.	48	24.1	950	27.9	99.3	
<i>Hemiaulus hauckii</i> Grun.	40	20.1	2020	39.4	178.7	
<i>Hemiaulus sinensis</i> Grev.	11	5.5	2500	8.8	53.8	
<i>Lauderia annulata</i> Cleve	13	6.5	310	4.3	19.5	
<i>Leptocylindrus adriaticus</i> Schroeder **			< 10	(N)	(N)	
<i>Leptocylindrus danicus</i> Cleve	73	36.7	246000	129.2	308.2	
<i>Leptocylindrus mediterraneus</i> (Perag.) Hasle	60	30.2	2090	53.9	149.1	
<i>Leptocylindrus minimus</i> Gran	8	4.0	320	7.1	40.3	
<i>Melosira sulcata</i> (Ehrenb.) Kutz.	6	3.0	180	1.4	14.5	
<i>Navicula distans</i> (Sm.) Cleve *	1	0.4	< 10	(N)	(N)	
<i>Nitzschia incerta</i> Grun.	3	1.5	50	0.5	4.6	
<i>Nitzschia longissima</i> (Breb.) Ralfs.	124	62.3	730	84.2	116.7	
<i>Nitzschia sicula</i> (Castr.) Hust.	31	15.6	630	30.6	95.2	+
<i>Planktoniella sol</i> (Wall.) Schuett *	3	1.3	< 10	(N)	(N)	
<i>Pleurosigma angulatum</i> (Quekett) W.Sm.	27	13.6	420	6.8	33.1	
<i>Pleurosigma elongatum</i> W. Sm.	1	0.5	10	> 0.0	0.7	
<i>Pseudonitzschia</i> spp.	147	73.9	44220	779.4	3292.9	
<i>Rhizosolenia acuminata</i> (H. Per.) Gran *	2	0.9	< 10	(N)	(N)	+
<i>Rhizosolenia alata f. gracillima</i> (Cleve) Grun.	91	45.7	2510	55.9	108.7	
<i>Rhizosolenia alata f. indica</i> (H.Perag.) Ostenf.	7	3.0	105	1.0	8.4	
<i>Rhizosolenia calcar-avis</i> Schultze	14	7.0	70	1.8	8.8	

Table 2 -continued	F	F (%)	MAX	AVG	STD	N. rec.
<i>Rhizosolenia castracanei</i> Perag. *	3	1.3	< 10	(N)	(N)	
<i>Rhizosolenia delicatula</i> Cleve	36	18.1	1050	29.8	110.7	
<i>Rhizosolenia fragilissima</i> Bergh.	30	15.1	1260	12.7	41.8	
<i>Rhizosolenia hebetata</i> Bailey	31	15.6	310	9.8	32.2	+
<i>Rhizosolenia imbricata</i> Brightw.	54	27.1	240	10.6	26.5	
<i>Rhizosolenia robusta</i> Norm.	5	2.5	10	> 0.0	0.7	
<i>Rhizosolenia stolterfothii</i> Perag.	64	32.2	10000	56.5	142.3	
<i>Skeletonema costatum</i> (Grev.) Cleve	51	25.6	5300	200.6	678.5	
<i>Stauroneis quarnerensis</i> Grun.*	1	0.4	< 10	(N)	(N)	+
<i>Striatella interrupta</i> (Ehrenb.) Heib. **			< 10	(N)	(N)	
<i>Striatella unipunctata</i> (Lyngb.) Ag. *	2	0.9	< 10	(N)	(N)	
<i>Thalassionema nitzschioides</i> Grun.	131	65.8	10000	129.8	228.1	
<i>Thalassiosira eccentrica</i> (Ehrenb.) Cleve *	1	0.4	< 10	(N)	(N)	
<i>Thalassiosira decipiens</i> (Grun.) Joerg. *	3	1.3	< 10	(N)	(N)	
<i>Thalassiosira leptopus</i> (Grun.) Hasle et Fryxell *	2	0.9	< 10	(N)	(N)	
<i>Thalassiosira</i> sp.	23	11.6	2000	19.5	71.1	
<i>Thalassiothrix mediterranea</i> Pav.	2	1.0	730	1.1	14.8	
<i>Thalassiothrix longissima</i> Cleve et Grun.	22	11.1	310	7.3	30.0	
DINOPHYCEAE + DESMOPHYCEAE						
<i>Amphisolenia bidentata</i> Schroeder **			< 10	(N)	(N)	
<i>Amphisolenia globifera</i> Stein **			< 10	(N)	(N)	+
<i>Amphisolenia spinulosa</i> Kof. **			< 10	(N)	(N)	+
<i>Amphidinium acutissimum</i> Schiller *	1	0.4	< 10	(N)	(N)	
<i>Brachidinium capitatum</i> Taylor*	1	0.4	< 10	(N)	(N)	+
<i>Centrodinium eminens</i> Boehm. **			< 10	(N)	(N)	+
<i>Ceratium arietinum</i> Cleve *	4	1.8	< 10	(N)	(N)	
<i>Ceratium buceros</i> Zacharias	5	2.5	10	> 0.0	0.7	+
<i>Ceratium candelabrum</i> Ehrenb.	6	3.0	40	0.3	2.1	
<i>Ceratium carriense</i> Gourr. *	1	0.4	< 10	(N)	(N)	
<i>Ceratium concilians</i> Joerg. *	1	0.4	< 10	(N)	(N)	
<i>Ceratium contortum</i> (Gourret) Cleve **			< 10	(N)	(N)	
<i>Ceratium euarcuratum</i> Joerg. **			< 10	(N)	(N)	
<i>Ceratium extensum</i> (Gourr.) Cleve **			< 10	(N)	(N)	

Table 2 -continued	F	F (%)	MAX	AVG	STD	N. rec.
<i>Ceratium falcatum</i> (Kof.) Joerg. **			< 10	(N)	(N)	
<i>Ceratium furca</i> (Ehrenb.) Clap. et Lachm.	24	12.1	160	3.7	14.8	
<i>Ceratium fusus</i> (Ehrenb.) Dujardin.	26	13.1	105	2.7	10.0	
<i>Ceratium gibberum</i> Gourr. *	2	0.9	< 10	(N)	(N)	
<i>Ceratium gravidum</i> Gourr. *	1	0.4	< 10	(N)	(N)	
<i>Ceratium hexacanthum</i> Gourr.	2	1.0	20	0.1	1.4	
<i>Ceratium karstenii</i> Pav. *	1	0.4	< 10	(N)	(N)	
<i>Ceratium kofoidii</i> Joerg.**			< 10	(N)	(N)	
<i>Ceratium macroceros</i> (Ehrenb.) Cleve	4	2.0	20	0.1	1.4	
<i>Ceratium massiliense</i> (Gourr.) Karsten	3	1.5	210	1.3	15.1	
<i>Ceratium pavillardii</i> Joerg. *	2	0.9	< 10	(N)	(N)	
<i>Ceratium pentagonum</i> Gourr.	19	9.5	160	2.7	11.1	
<i>Ceratium platycorne</i> Daday *	3	1.3	< 10	(N)	(N)	
<i>Ceratium ranipes</i> Cleve **			< 10	(N)	(N)	
<i>Ceratium setaceum</i> Joerg.	1	0.5	50	0.3	3.5	
<i>Ceratium symmetricum</i> Pav.	8	4.0	10	0.2	1.2	
<i>Ceratium trichoceros</i> (Ehrenb.) Kof.	9	4.0	50	0.5	4.0	
<i>Ceratium vultur</i> Cleve *	1	0.4	< 10	(N)	(N)	+
<i>Ceratium tripos</i> (Muell.) Nitzsch.	12	6.0	20	0.5	2.8	
<i>Ceratocorys armata</i> (Schuett) Kof. **			< 10	(N)	(N)	
<i>Ceratocorys gouretti</i> Paulsen *	3	1.3	< 10	(N)	(N)	
<i>Ceratocorys horrida</i> Stein **			< 10	(N)	(N)	
<i>Cladopyxis brachiolata</i> Stein **			< 10	(N)	(N)	+
<i>Cladopyxis caryophyllum</i> (Kof.) Pav. **			< 10	(N)	(N)	+
<i>Dinophysis acuta</i> Ehrenb. *	1	0.4	< 10	(N)	(N)	+
<i>Dinophysis acutoides</i> Bal. *	1	0.4	< 10	(N)	(N)	
<i>Dinophysis alata</i> (Wood) Balech **			< 10	(N)	(N)	
<i>Dinophysis argus</i> (Stein) Abe vel Balech **			< 10	(N)	(N)	
<i>Dinophysis caudata</i> Seville-Kent	4	2.0	20	0.2	1.6	
<i>Dinophysis circumscuta</i> (Karsten) Balech **			< 10	(N)	(N)	+
<i>Dinophysis hastata</i> Stein **			< 10	(N)	(N)	
<i>Dinophysis mitra</i> (Schuett) Abe vel Balech **			< 10	(N)	(N)	
<i>Dinophysis parvula</i> (Schuett) Joerg. Bal.	2	1.0	20	0.2	1.6	
<i>Dinophysis reticulata</i> (Kof.) Balech **			< 10	(N)	(N)	+
<i>Dinophysis schroederi</i> Pav.**			< 10	(N)	(N)	

Table 2 -continued	F	F (%)	MAX	AVG	STD	N. rec.
<i>Dinophysis schuettii</i> Murray et Whitt. **			< 10	(N)	(N)	
<i>Dinophysis sphaerica</i> Stein **			< 10	(N)	(N)	+
<i>Dinophysis striata</i> (Kof.) Bal. **			< 10	(N)	(N)	+
<i>Dinophysis tripos</i> Gourr.	1	0.5	20	0.1	1.4	
<i>Dinophysis uracantha</i> Stein *	1	0.4	< 10	(N)	(N)	+
<i>Diplopsalis</i> group *	5	2.5	50	0.6	4.7	
<i>Diplopsalis lenticula</i> (Bergh.) Schiller (syn. = <i>Glenodinium lenticula</i>) *	2	0.9	< 10	(N)	(N)	
<i>Dissodinium elegans</i> Pav. *	2	0.9	< 10	(N)	(N)	+
<i>Dissodinium fusiforme</i> (Thom. ex Murray) Matz. *	1	0.9	< 10	(N)	(N)	+
<i>Dissodinium lunula</i> (Schuett) Pascher	1	0.9	< 10	(N)	(N)	
<i>Dissodinium obtusum</i> (Pav.) Matz. (syn. = <i>Pyrocystis obtusa</i>) **			< 10	(N)	(N)	+
<i>Gonyaulax birostris</i> Stein **			< 10	(N)	(N)	+
<i>Gonyaulax hyalina</i> Ostenf. et Schm. *	2	0.9	< 10	(N)	(N)	+
<i>Gonyaulax kofoidii</i> Pav. **			< 10	(N)	(N)	
<i>Gonyaulax polygramma</i> Stein *	1	0.4	< 10	(N)	(N)	
<i>Gymnodinium cucumis</i> Schuett **			< 10	(N)	(N)	+
Gymnodinoid cells	130	65.3	42050	365.3	2982.0	
<i>Gyrodinium fusiforme</i> Kof. et Sw.	44	22.1	310	12.7	43.2	+
<i>Gyrodinium</i> spp.	53	26.6	2500	40.7	125.4	
<i>Histioneis joergenseni</i> Schiller **			< 10	(N)	(N)	
<i>Kofoidinium velloides</i> Pav.	10	5.0	40	1.0	4.7	+
<i>Mesoporos perforatus</i> (Gran) Marg. (syn. = <i>Porella perforata</i>) **			< 10	(N)	(N)	
<i>Noctiluca scintillans</i> (Macartney) Ehrenb.	3	1.5	10	0.1	1.0	
<i>Ornithocercus carolinae</i> Kof. **			< 10	(N)	(N)	+
<i>Ornithocercus heteroporus</i> Kof. **			< 10	(N)	(N)	+
<i>Ornithocercus magnificus</i> Stein *	1	0.4	< 10	(N)	(N)	
<i>Ornithocercus quadratus</i> Schuett *	1	0.4	< 10	(N)	(N)	
<i>Ornithocercus steinii</i> Schuett **			< 10	(N)	(N)	
<i>Oxytoxum adriaticum</i> Schiller	1	0.5	100	0.5	7.1	+
<i>Oxytoxum caudatum</i> Schiller	5	2.5	105	0.9	8.3	+
<i>Oxytoxum constrictum</i> (Stein) Buetschli *	1	0.4	< 10	(N)	(N)	
<i>Oxytoxum coronatum</i> Schiller	2	1.0	40	0.4	4.0	+

Table 2 -continued	F	F (%)	MAX	AVG	STD	N. rec.
<i>Oxytoxum gladiolus</i> Stein **			< 10	(N)	(N)	+
<i>Oxytoxum milneri</i> Murr. et Whitt.	7	3.5	210	1.0	8.3	
<i>Oxytoxum reticulatum</i> (Stein) Schuett **			< 10	(N)	(N)	+
<i>Oxytoxum sceptrum</i> (Stein) Schroeder (syn. = <i>Ox. longiceps</i>)	7	3.5	40	0.6	3.8	
<i>Oxytoxum scolopax</i> Stein	8	4.0	100	1.2	6.8	
<i>Oxytoxum sphaeroideum</i> Stein	4	2.0	210	1.4	15.3	
<i>Oxytoxum tessellatum</i> (Stein) Schuett	1	0.5	10	> 0.0	0.7	
<i>Oxytoxum variabile</i> Schiller	1	0.5	105	0.5	7.4	
<i>Podolampas elegans</i> Schuett	5	2.5	10	0.3	1.6	
<i>Podolampas palmipes</i> Stein	5	2.5	20	0.4	2.3	
<i>Protoperidinium brochi</i> Kof. et Sw. *	2	0.9	< 10	(N)	(N)	
<i>Protoperidinium conicum</i> (Gran) Ost. et Schm. (Bal.)*	3	1.3	< 10	(N)	(N)	
<i>Protoperidinium crassipes</i> (Kof.) Bal.	6	3.0	20	0.2	1.7	
<i>Protoperidinium depressum</i> (Bailey) Bal.	2	1.0	20	0.1	1.4	
<i>Protoperidinium diabolus</i> (Cleve) Bal.	1	0.5	10	> 0.0	0.7	
<i>Protoperidinium divergens</i> (Ehrenb.) Bal.	8	4.0	20	0.3	1.7	
<i>Protoperidinium globulus</i> (Stein) Bal.	11	5.0	105	0.5	3.3	
<i>Protoperidinium leonis</i> (Pav.) Bal.	2	1.0	10	> 0.0	0.7	
<i>Protoperidinium oceanicum</i> (Vanhoeffen) Bal.	4	2.0	20	0.2	1.6	
<i>Protoperidinium pellucidum</i> Bergh	1	0.5	20	0.1	1.4	
<i>Protoperidinium steinii</i> (Joerg.) Bal.	6	3.0	50	0.6	4.0	
<i>Protoperidinium tubum</i> (Schiller) Bal.	5	2.5	420	2.5	29.8	+
<i>Prorocentrum compressum</i> (Bailey) Abe	6	3.0	105	0.9	8.0	
<i>Prorocentrum micans</i> Ehrenb.	34	17.1	210	6.5	18.5	
<i>Prorocentrum minimum</i> (Pav.) Schiller	3	1.5	210	0.8	8.0	
<i>Prorocentrum triestinum</i> Schiller	10	5.0	210	3.9	21.3	
<i>Pselodinium vaubanii</i> Sournia **			< 10	(N)	(N)	
<i>Pyrocystis noctyluca</i> Murr. ex Schuett (syn = <i>P. pseudonoctyluca</i>) **			< 10	(N)	(N)	
<i>Pyrophacus horologicum</i> Stein **			< 10	(N)	(N)	
<i>Pyrocystis noctyluca</i> Murr. ex Schuett (syn = <i>P. pseudonoctyluca</i>) **			< 10	(N)	(N)	
<i>Pyrocystis obtusa</i> Pav. **			< 10	(N)	(N)	+
<i>Pyrocystis robusta</i> Kof. **			< 10	(N)	(N)	+

Table 2 -continued	F	F (%)	MAX	AVG	STD	N. rec.
<i>Scrippsiella</i> sp.	26	13.1	5000	26.6	215.4	
<i>Spatulodinium pseudonociluca</i> (Pouchet) Cachon et Cachon **			< 10	(N)	(N)	+
<i>Spiraulax jollifei</i> (Murr. et Whitt.) Kof. (syn. = <i>S. kofoidi</i>) **			< 10	(N)	(N)	
<i>Triadinium polyedricum</i> (Pouchet) Joerg.	13	6.5	50	0.8	4.5	
<i>Triposolenia bicornis</i> Kof. **			< 10	(N)	(N)	+
<i>Triposolenia truncata</i> Kof. *	1	0.4	< 10	(N)	(N)	+
PRASINOPHYCEAE						
<i>Halosphaera viridis</i> Schm.	12	6.0	105	1.1	8.2	+

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