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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 svojti (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, ARTEGIANI *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 mol l^{-1} PO_4 (most frequently about 0.1 mol l^{-1}) and < 3 mol l^{-1} NO_3 (most frequently about 1 mol l^{-1} 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 10^5 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 °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 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 transacts) and 100 (transacts along the rest of the counting chamber base plate). The precision of the counting method was ±10%. Plankton closing net (53 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 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 multisond (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

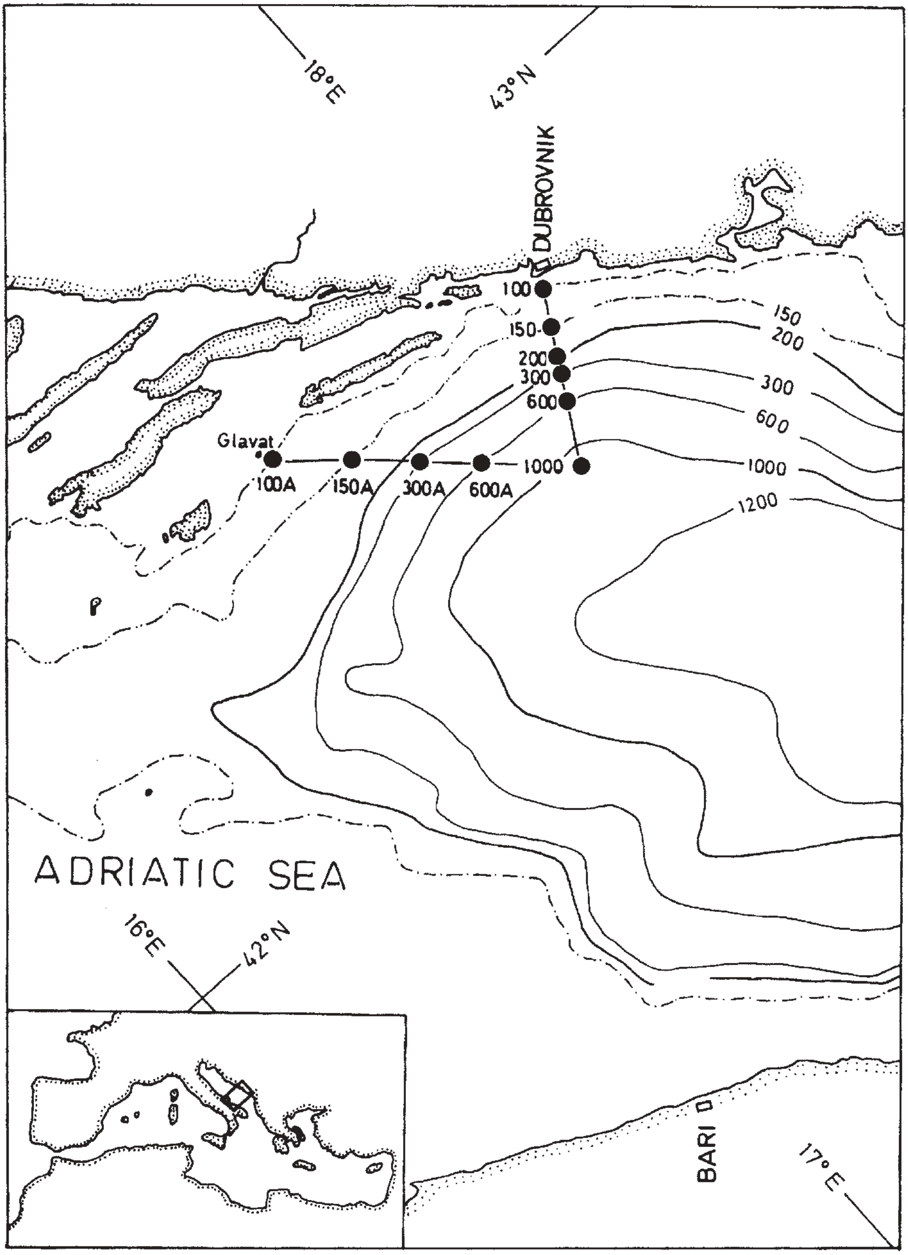

Fig. 1. Location of stations along two transects through the north-western edge of the Southern Adriatic Pit, near Dubrovnik. At stations 600A, 600 and 200, only hydrographic measurements were performed.

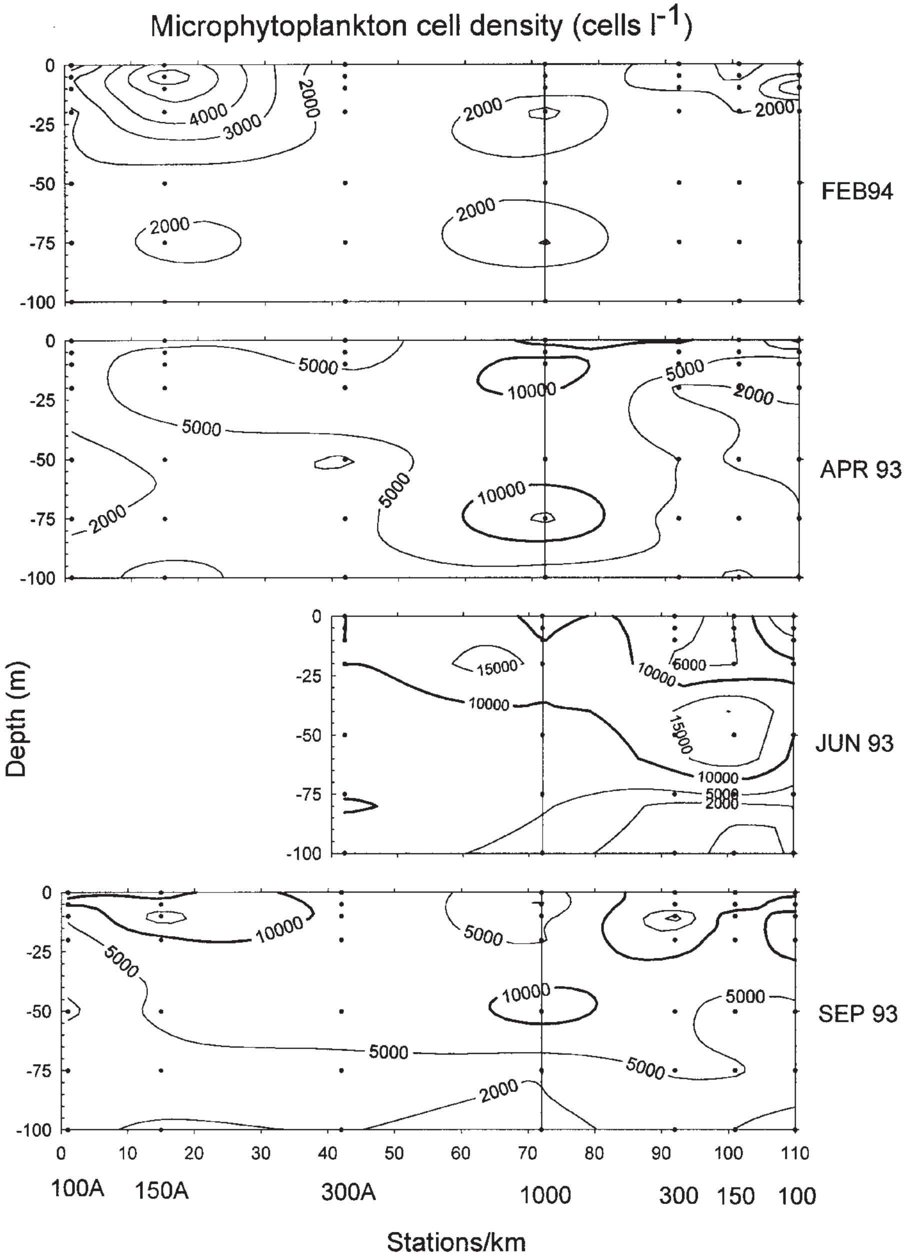

Fig. 2. Isopleth diagrams for microphytoplankton population density along the 100A–1000 and 1000–100 profiles, during the R/V »Bios« cruises in the south-eastern Adriatic.

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 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 chrysophytes, 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. stolterfothii, 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 prymnesiophites, 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 tesselatum, Triposolenia 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. Totaly 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 katalogs for the northern and middle Adriatic (KERŽAN & ŠTIRN 1976, REVELANTE 1986).

Taxa $n_1 = 199$, $n_2 = 15$	*F*	*F(%)*	(cells l^{-1})			N. rec.
			MAX	*AVG*	*STD*	
CHRYSOPHYCEAE						
Dictyocha fibula Ehrenb.	49	24.6	10000	49.3	132.0	
Dictyocha speculum Ehrenb.	22	11.1	3664	26.2	260.6	
PRYMNESIOPHYCEAE						
Anoplosolenia brasiliensis (Lohm.) Gerl.	41	20.6	2010	21.5	145.6	
Calciosolenia murrayii Gran	16	8.0	2010	19.5	149.9	
Calyptrosphaera oblonga Lohm.	21	10.6	22500	188.3	893.4	
Discosphaera thomsonii Ostenf. **			< 10	*(N)*	*(N)*	+
Halopappus adriaticus Schiller	5	2.5	105	0.8	7.6	
Ophiaster hydroideus (Gran)	5	2.5	2000	12.3	142.8	+
Ophiaster formosus Gran	11	5.5	310	5.5	33.2	
Rhabdosphaera clavigera Murray et Black.	2	1.0	2000	10.2	141.4	
Rhabdosphaera tignifer Schiller	50	25.1	10500	687.9	1826.0	
Scyphosphaera apsteinii Lohm.	1	0.5	10	> 0.0	0.7	
Syracosphaera pulchra Lohm.	52	26.1	7500	242.4	732.3	
Thorosphaera elegans Ostenf. **			< 10	*(N)*	*(N)*	+
BACILLARIOPHYCEAE						
Actynocyclus ehrenbergii Ralfs **			< 10	*(N)*	*(N)*	
Amphiprora sulcata O'Meara	1	0.5	10	> 0.0	0.7	
Amphora ostrearia Breb.*	1	0.4	< 10	*(N)*	*(N)*	
Asterionella bleakeleyii W. Sm.	7	3.5	840	3.9	27.2	+
Asterionella glacialis Castr.	22	11.1	2100	20.8	81.9	
Asterionella notata Grun.**			< 10	*(N)*	*(N)*	
Asterolampra marylandica Ehrenb.**			< 10	*(N)*	*(N)*	

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

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

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

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

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

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

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

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