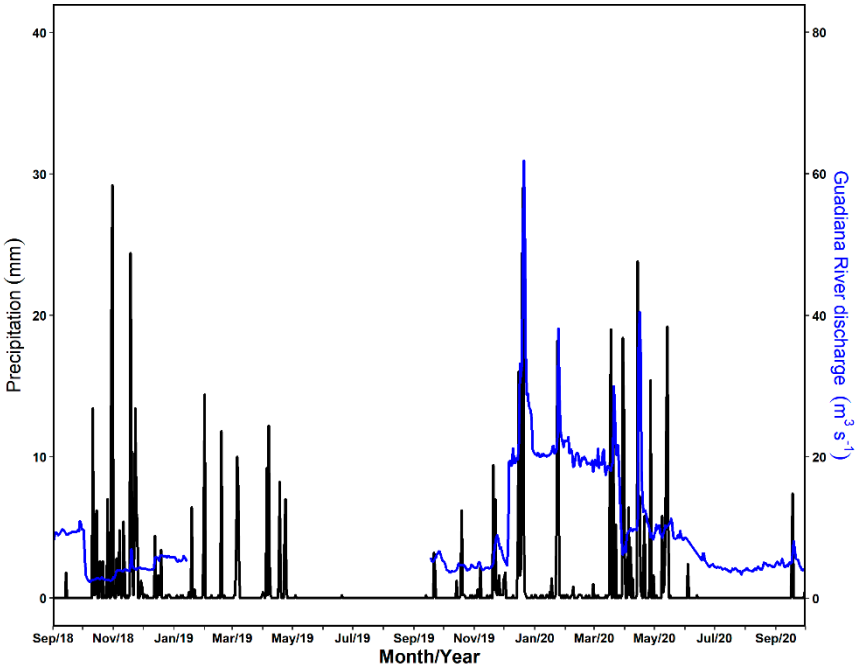
SUPPLEMENTARY MATERIAL

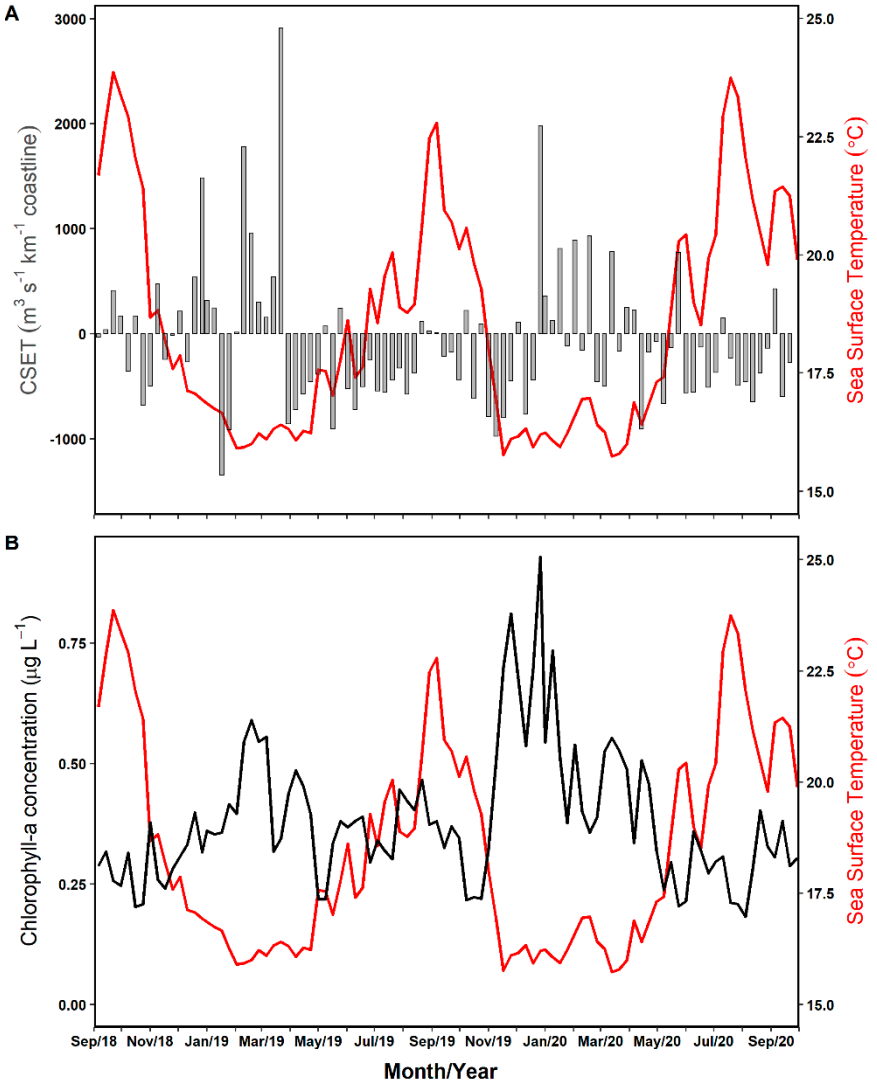
Patterns and Predictors of Phytoplankton Assemblage Structure in a Coastal Lagoon: Species-Specific Analysis Needed to Disentangle Anthropogenic Pressures from Ocean Processes

Maria João Lima, Ana B. Barbosa, Alexandra Cravo, Cátia Correia, André Matos

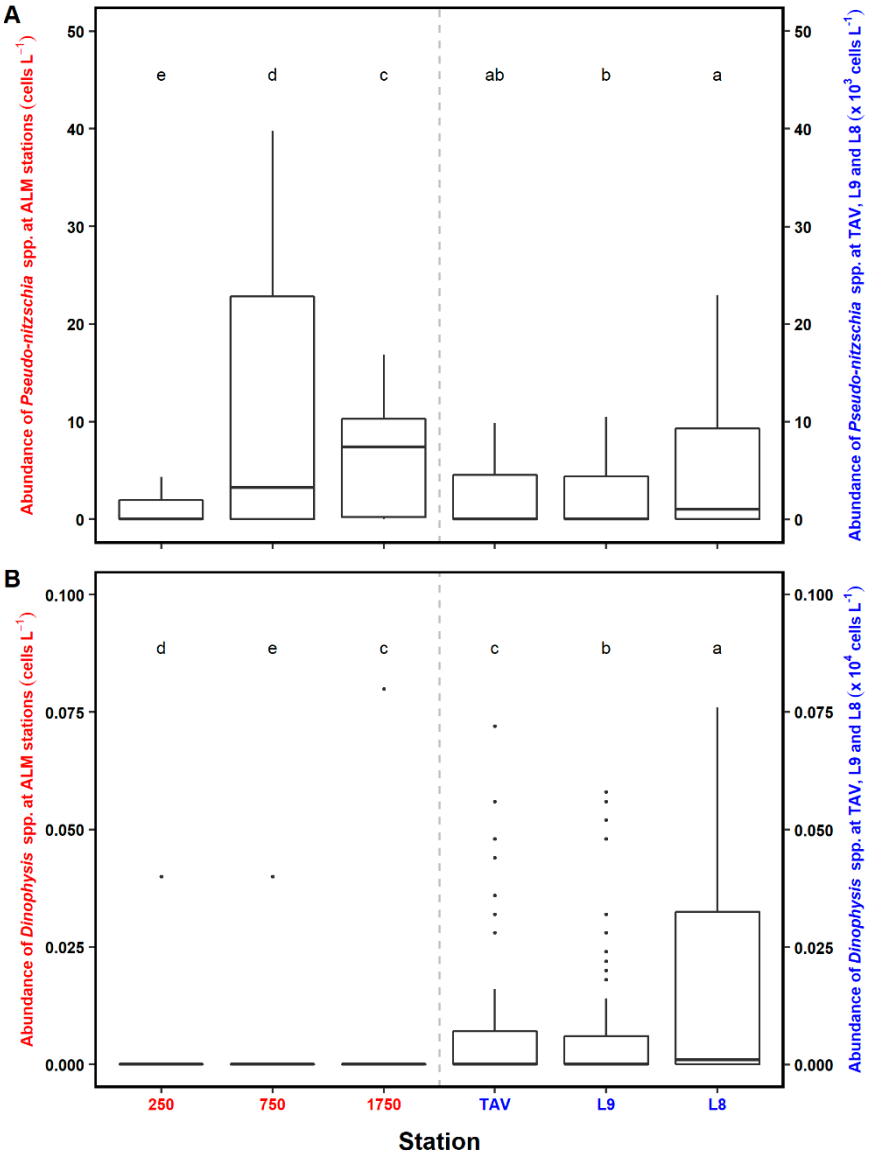
Centre for Marine and Environmental Research (CIMA), ARNET—Aquatic Research Network, Universidade do Algarve, Campus of Gambelas, 8005-139 Faro, Portugal.



Supplementary Figure S1 – Daily time series of rainfall precipitation (left y-axis), measured at Tavira land-based meteorological station (Source: Direção Regional de Agricultura e Pescas do Algarve, https://www.drapalg.min-agricultura.pt/), and Guadiana River discharge (right y-axis), measured at the hydrometric station Pulo do Lobo (Source: Portuguese Environmental Agency, http://snirh.apambiente.pt/), during the period September 2018 - September 2020.



Supplementary Figure S2 – Weekly (8-day) mean time series of selected oceanographic variables in the coastal region adjacent to the Tavira inlet, for the period September 2018 - September 2020. **(A)** Cross-shore Ekman transport (CSET; left y-axis), a wind-based upwelling index, and sea surface temperature (SST; right y-axis); and **(B)** Chlorophyll-a concentration (Chl-a; left y-axis) and SST (right y-axis). Negative and positive CSET values represent upwelling-favourable, and downwelling-favourable conditions, respectively. See Figure 1 for the location of the site used to derive CSET, and the coastal area used to extract Chl-a and SST data.



Supplementary Figure S3 – Distribution of the abundance of **(A)** *Pseudo-nitzschia* spp. and **(B)** *Dinophysis* spp. in different sampling stations in the Ria Formosa lagoon, and in classified lagoonal (TAV) and coastal (L8, L9) shellfish production areas, during the period September 2018 - September 2020. Lagoon stations are located at 250 m (ALM 250), 750 m (ALM 750), and 1750 m (ALM 1750) from the discharge point of the Almargem wastewater treatment plant (WWTP). Median values are identified by the central line within the box, the bottom and top edges of the box indicate the 25th and 75th percentiles, respectively, and the whiskers represent non-outlier limits. For each phytoplankton group, different uppercase letters above the bars denote significant differences between stations/areas ($p < 0.05$), with abundances decreasing (higher - lower) in alphabetical order (a - e). Note differences in scale for lagoon stations (red left y-axis) and shellfish production areas (blue right y-axis). See Fig. 1 for the location of sampling stations in the Ria Formosa lagoon and adjacent coastal area.

Supplementary Table S1 – General statistical information, including mean, standard deviation (SD), minimum (Min) and maximum (Max) values, and number of samples (N), for meteorological, hydrological, and oceanographic variables, during the period September 2018 - September 2020. Information on the effluents discharged by the Almargem wastewater treatment plant, including monthly average effluent discharge rate, and total nitrogen and phosphorus loads, was provided by Águas do Algarve (AdA), the water supply company. * Data only available after July 2019.

Variable	Mean ± SD	Min - Max	N
Rainfall precipitation (mm d^{-1})	0.9 ± 3.3	0.0 – 29.2	761
Almargem Stream discharge (m^3 s^{-1})*	0.000249 ± 0.00339	0.0 – 0.05	441
Guadiana River discharge (m^3 s^{-1})	9.7 ± 8.1	2.3 – 61.9	496
Effluent discharge rate (m^3 d^{-1})	4092.6 ± 862.0	2512.6 – 6374.5	25
Effluent total nitrogen load (kg N d^{-1})	33.10 ± 26.95	10.98 – 127.46	25
Effluent total phosphorus load (kg P d^{-1})	15.38 ± 10.47	2.66 – 46.98	25
Sea surface temperature (ºC)	18.5 ± 2.3	15.7 – 23.9	95
Cross-shore Ekman Transport (m^3 s^{-1} km^{-1} coastline)	-96.6 ± 662.5	-1346.6 – 2907.9	96

Supplementary Table S2 – General statistical information, including mean, standard deviation (SD), minimum (Min) and maximum (Max) values, and number of samples (N) for different water physical-chemical variables evaluated in three sampling stations in the Ria Formosa lagoon, during the period September 2018 - September 2020. Stations are located at 250 m (ALM 250), 750 m (ALM 750), and 1750 m (ALM 1750) from the discharge point of the Almargem wastewater treatment plant. Significant differences between ALM stations ($p<0.05$), tested by Durbin's rank test, followed by post-hoc pairwise comparisons, are also included.

Variable	Station	Mean ± SD	Min - Max	N	Differences between (ALM) stations
Temperature (°C)	250	22.8 ± 4.8	14.4 – 30.6	20	
	750	22.3 ± 4.6	13.9 – 29.5	19	250 > 750 > 1750
	1750	20.8 ± 4.1	13.2 – 27.9	19	
Salinity	250	28.0 ± 5.1	9.3 – 32.2	20	
	750	32.0 ± 3.3	19.4 – 34.8	19	250 < 750 < 1750
	1750	36.3 ± 0.7	34.6 – 37.4	19	
pH	250	8.0 ± 0.3	7.7 – 9.0	20	
	750	8.1 ± 0.2	7.7 – 8.8	19	250 < 1750
	1750	8.1 ± 0.1	7.8 – 8.2	19	
Dissolved Oxygen (mg L^{-1})	250	10.3 ± 3.6	6.0 – 23.3	20	250 > 750 and 1750
	750	9.6 ± 3.1	4.5 – 19.5	19	
	1750	8.4 ± 0.7	6.4 – 9.6	19	
Dissolved Oxygen (% sat.)	250	143.3 ± 62.2	79.1 – 363.9	20	250 > 750 and 1750
	750	135.3 ± 50.9	67.8 – 302.0	19	
	1750	117.0 ± 11.2	89.8 – 135.4	19	
Total Suspended Solids (mg L^{-1})	250	12.3 ± 5.3	2.7 – 20.2	20	250 and 750 > 1750
	750	13.8 ± 11.3	1.9 – 53.3	19	
	1750	6.5 ± 3.9	0.7 – 17.6	19	
Ammonium (µM)	250	25.1 ± 34.5	0.7 – 124.6	20	
	750	9.7 ± 12.4	0.1 – 42.2	19	250 > 750 > 1750
	1750	0.7 ± 0.7	0.1 – 2.7	19	
Nitrate (µM)	250	10.0 ± 5.7	0.9 – 22.5	20	
	750	6.1 ± 3.8	0.5 – 14.7	19	250 > 750 > 1750
	1750	0.7 ± 0.9	0.04 – 4.2	19	
Nitrite (µM)	250	3.4 ± 2.4	0.8 – 9.0	20	250 > 750 > 1750

	750	1.8 ± 1.2	0.05 – 4.1	19	
	1750	0.1 ± 0.1	0.01 – 0.3	19	
Phosphate (µM)	250	13.1 ± 8.7	1.8 – 33.7	20	
	750	6.8 ± 4.3	1.6 – 15.7	19	250 > 750 > 1750
	1750	0.3 ± 0.2	0 – 0.6	19	
Silicate (µM)	250	37.6 ± 19.2	0.5 – 97.1	20	
	750	24.7 ± 12.5	0.4 – 62.0	19	250 > 750 > 1750
	1750	3.3 ± 1.5	0.4 – 5.9	19	

Supplementary Table S3 – List of phytoplankton operational taxonomic units (OTUs), identified to the lowest possible taxonomic level, detected in the Ria Formosa lagoon, during the period September 2018 - September 2020. Sampling stations are located at 250 m (ALM 250), 750 m (ALM 750), and 1750 m (ALM 1750) from the discharge point of the Almargem wastewater treatment plant. OTUs are organized alphabetically, within each phylum and class. Taxonomic and nomenclatural information according with AlgaeBase, accessed on 2023-11-02 [92]. Black circle symbol denotes OTUs present in more than 5% of samples. 'B' and 'FW' after selected OTUs represent benthic/tychoplanktonic and freshwater habitats, respectively. Potentially harmful species and harmful effects are also included, as follows: (a) potentially harmful but not toxigenic; (b) toxic to aquatic biota (including marine living resources); and (c) toxic to humans. Taxa not identified to the species level may also include potentially toxigenic genera (Cyanophyceae: *Oscillatoria*/*Planktothrix*; *Phormidium*; Dinophyceae: *Alexandrium*, *Amphidinium*, *Cochlodinium*, *Gonyaulax*, *Heterocapsa*, *Karenia*, *Margalefidinium*, *Ostreopsis*, *Scripsiella*). Information sources for HAB effects: [5,93].

Operational Taxonomic Unit	HAB Effects	ALM Stations		
		250	750	1750
PHYLUM CHAROPHYTA				
Class Zygnematophyceae				
Closterium sp. Nitzsch ex Ralfs, 1848• FW		x	x	
PHYLUM CHLOROPHYTA				
Class Chlorophyceae				
Golenkinia sp. Chodat, 1894 FW			x	x
Hafniomonas sp. Ettl & Moestrup, 1980 FW		x		x
Monoraphidium sp. Komárková-Legnerová, 1969• FW		x	x	x
Pediastrum spp. Meyen, 1829 FW		x		
Scenedesmus spp. Meyen, 1829 FW		x		
Unidentified forms•		x	x	x
Class Trebouxiophyceae				
Closteriopsis Lemmermann, 1899 FW		x		
Unidentified Chlorophytes				
Morphotype 1•		x	x	x
Morphotype 2		x		
Class Pyramimonadophyceae				
Pterosperma sp. Pouchet, 1893				x
PHYLUM CRYPTISTA				
Class Cryptophyceae				
Unidentified forms < 10 µm•		x	x	x
Unidentified forms > 10 µm•		x	x	x
PHYLUM CYANOBACTERIOTA				

Class Cyanophyceae				
Arthrospira sp. Sitzenberger ex Gomont, 1892 / *Spirulina* sp. Turpin ex Gomont, 1892		x	x	
Komvophoron sp. K.Anagnostidis & J.Komárek, 1988 B FW		x		
Merismopedia spp. Meyen, 1839•		x	x	x
Oscillatoria spp. Vaucher ex Gomont, 1892 / *Planktothrix* spp. Anagnostidis & Komárek, 1988•		x	x	
Phormidium spp. Kützing ex Gomont, 1892 B FW	b, c	x	x	
Unidentified forms of the order Oscillatoriales•		x	x	x
Unidentified forms•		x	x	x
PHYLUM DINOFLAGELLATA				
Class Dinophyceae				
Akashiwo cf. *sanguinea* (K.Hirasaka) Gert Hansen & Moestrup 2000•	b	x	x	x
Alexandrium cf. *minutum* Halim, 1960	b, c			x
Alexandrium spp. Halim, 1960			x	x
Amphidinium crassum Lohmann, 1908				x
Amphidinium sp. Claperède & Lachmann, 1859				x
Ceratium hirundinella (O.F.Müller) Dujardin, 1841				x
Cochlodinium spp. F.Schütt, 1896		x		
Dinophysis acuminata complex Claparède & Lachmann, 1859•	b, c			x
Dinophysis caudata Kent, 1881				x
Dinophysis odiosa (Pavillard) Tai & Skogsberg, 1934				x
Dinophysis ovum F.Schütt, 1895		x		
Dinophysis sp. Ehrenberg, 1839•		x	x	x
Gonyaulax digitalis (Pouchet) Kofoid, 1911•		x	x	x
Gonyaulax spp. Diesing, 1866•		x		x
Gonyaulax verior Sournia, 1973				x
Gymnodinium cf. *catenatum* H.W.Graham 1943	b, c			x
Gymnodinium sp. F.Stein, 1878		x	x	x
Heterocapsa cf. *minima* A.J.Pomroy 1989				x
Heterocapsa pygmaea Lobelich III, R.J.Schmidt & Sherley, 1981		x		x
Heterocapsa spp. F.Stein, 1883, nom. et typ. cons.•		x	x	x
Heterocapsa rotundata (Lohmann) Gert Hansen, 1995•		x	x	x
Karenia spp. Hansen & Moestrup, 2000		x	x	
Karlodinium spp. J.Larsen, 2000•		x	x	x
Katodinium sp. Fott, 1957				x
Kryptoperidinium foliaceum (F.Stein) Lindemann, 1924•	a	x	x	x
Lingulodinium polyedra (F.Stein) J.D.Dodge, 1989•	b, c		x	x
cf. *Margalefidinium polykrikoides* (Margalef) F.Gómez, Richlen & D.M.Anderson, 2017•		x	x	x
cf. *Ostreopsis* sp. Johs.Schmidt, 1901			x	
Oxytoxum sp. Stein, 1883			x	
Polykrikos sp. Bütschli, 1873				x
Prorocentrum cordatum (Ostenfeld) J.D.Dodge, 1976•	b, c	x		x
Prorocentrum dentatum F. Stein, 1883 / *Prorocentrum shikokuense* Y. Hada, 1975				x
Prorocentrum mexicanum Osorio-Tafall, 1942 / *Prorocentrum rhathymum* Loeblich III, Sherley & Schmidt, 1979 B				x

Prorocentrum micans Ehrenberg, 1834•		x	x	x
Prorocentrum cf. *scutellum* B.Schröder, 1900•		x		x
Prorocentrum spp. Ehrenberg, 1834•		x		x
Prorocentrum triestinum J.Schiller, 1918•			x	x
Scrippsiella trochoidea (F.Stein) A.R.Loeblich III, 1976				x
Scrippsiella spp. Balech, 1965•		x	x	x
Torodinium robustum Kofoid & Swezy, 1921				x
Torodinium sp. Kofoid & Swezy, 1921				x
Tripos furca (Ehrenberg) F.Gómez, 2013•	a		x	x
Tripos fusus (Ehrenberg) F.Gómez, 2013•	a	x		x
Tripos lineatus (Ehrenberg) F.Gómez, 2021				x
Tripos spp. Bory, 1823				x
Unidentified forms of the order Amphidomataceae/*Heterocapsa* sp.•		x	x	x
Unidentified forms of the order Gymnodiniales < 20 µm•		x	x	x
Unidentified forms of the order Gymnodiniales > 20 µm•		x	x	x
Other unidentified thecate dinoflagellates < 20 µm•		x	x	x
Other unidentified thecate dinoflagellates > 20 µm•		x	x	x
Unidentified dinoflagellates < 20 µm•		x	x	x
Unidentified dinoflagellates > 20 µm•		x		x
PHYLUM EUGLENOPHYTA				
Class Euglenophyceae				
Eutreptiella spp. A.M.da Cunha, 1914•		x	x	x
Lepocinclis acus (O.F.Müller) B.Marin & Melkonian, 2003• FW		x	x	x
Unidentified forms•		x	x	x
PHYLUM HAPTOPHYTA				
Class Coccolithophyceae				
Unidentified Coccolithophores•		x	x	x
PHYLUM HETEROKONTOPHYTA				
Class Bacillariophyceae				
Achnanthes sp. Bory, 1822 B			x	
Asterionellopsis glacialis (Castracane) Round, 1990				x
Bacillaria sp. Gmelin, 1791 B		x		
Cocconeis sp. Ehrenberg, 1836• B		x	x	x
Cylindrotheca closterium (Ehrenberg) Reimann & J.C.Lewin, 1964• B		x	x	x
Cymbella sp./ *Amphora* sp. Ehrenberg ex Kützing, 1844 B			x	x
Diploneis sp. Ehrenberg ex Cleve, 1894• B		x	x	x
Entomoneis paludosa (W.Smith) Reimer 1975 B		x	x	
Entomoneis sp. Ehrenberg, 1845• B		x	x	
Gomphonema sp. Ehrenberg, 1832 B		x		
Gyrosigma fasciola (Ehrenberg) J.W.Griffith & Henfrey, 1856 B		x		
Haslea wawrikae (Husedt) Simonsen, 1974 B			x	x
Licmophora sp. C. Agardh, 1827, nom. et typ. cons.• B		x		x
Lioloma sp. Hasle, 1996• B		x	x	x
Mastogloia sp. Thwaites ex W.Smith, 1856 B		x		x
Navicula spp. Bory, 1822• B		x	x	x

Nitzschia acicularis (Kützing) W.Smith, 1853 B FW			x	x
Nitzschia longissima (Brébisson) Ralfs, 1861		x	x	
Nitzschia reversa W.Smith 1853• B		x	x	x
Nitzschia sigma (Kützing) W.Smith, 1853 B		x		x
Nitzschia spp. Hassal, 1845•		x	x	x
Pleurosigma spp. W.Smith, 1852 / *Gyrosigma* spp. Hassall, 1845• B		x	x	x
Pseudo-nitzschia delicatissima group (Cleve) Heiden 1928•	b, c	x	x	x
Pseudo-nitzschia seriata group (Cleve) H. Peragallo 1899•	b, c	x	x	x
Surirella sp. Turpin, 1828• B		x	x	
Thalassionema nitzschioides (Grunow) Mereschkowsky, 1902• B		x		x
Thalassionema spp. Grunow ex Mereschkowsky, 1902• B		x	x	x
Unidentified forms of the order Pennales < 10 µm• B		x	x	x
Unidentified forms of the order Pennales > 10 µm• B		x	x	x
Class Coscinodiscophyceae				
Actinocyclus sp. Ehrenberg, 1837*			x	
Coscinodiscus sp. Ehrenberg, 1839*		x		x
Dactyliosolen fragilissimus (Bergon) Hasle, 1996		x	x	x
Dactyliosolen phuketensis (B.G.Sundström) G.R.Hasle, 1996				x
Guinardia delicatula (Cleve) Hasle, 1997•		x	x	x
Guinardia flaccida (Castracane) H.Peragallo, 1892•			x	x
Guinardia spp. Peragallo, 1892•		x		x
Guinardia striata (Stolterfoth) Hasle, 1996•		x	x	x
Melosira sp. C.Agardh, 1824•		x	x	
Proboscia alata (Brightwell) Sundström, 1986•			x	x
Proboscia cf. *indica* (H.Peragallo) Hernández-Becerril, 1995				x
Proboscia sp. Sundström, 1986•			x	x
Rhizosolenia sp. Brightwell, 1858				x
Sundstroemia setigera Brightwell 1858 / *S. pungens* (Cl.-Euler) Medlin, Lundholm, Boonprakob, Moestrup 2021•		x	x	x
Unidentified centric forms•		x	x	x
Class Dictyophyceae				
Dictyocha sp. Ehrenberg, 1837•			x	x
Class Mediophyceae				
Bacteriastrum hyalinum Lauder, 1864				x
Bacteriastrum sp. Shadbolt, 1854			x	
Cerataulina bergonii (H.Peragallo) F.Schütt, 1896				x
Chaetoceros concavicornis Mangin, 1917				x
Chaetoceros curvisetus Cleve, 1889			x	
Chaetoceros danicus Cleve, 1889•			x	x
Chaetoceros debilis Cleve, 1894			x	
Chaetoceros peruvianus Brightwell, 1856				x
Chaetoceros spp. Ehrenberg, 1844•		x	x	x
Chaetoceros tenuissimus Meunier, 1913•		x	x	x
Cyclotella sp. (Kützing) Brébisson, 1838•		x	x	x
Detonula pumila (Castracane) Gran, 1900				x

Ditylum brightwellii (T.West) Grunow, 1885			x	x
Eucampia cornuta (Cleve) Grunow, 1883				x
Hemiaulus hauckii Grunow ex Van Heurck, 1882		x		x
Hemiaulus sinensis Greville, 1865		x		x
Hemiaulus sp. Heiberg, 1863•			x	x
Leptocylindrus danicus Cleve, 1889•		x	x	x
Leptocylindrus minimus Gran, 1915•		x	x	x
Leptocylindrus sp. Cleve, 1889•			x	x
Skeletonema costatum (Greville) Cleve, 1873•		x	x	x
Skeletonema sp. Greville, 1865•		x	x	x
Thalassiosira sp. Cleve, 1873•		x	x	x
PHYLUM OCHROPHYTA				
Class Raphydophyceae				
cf. *Heterosigma akashiwo* (Y.Hada) Y.Hada ex Y.Hara & M.Chihara 1987•	b	x	x	x
Heterosigma sp. Y.Hada ex Y.Hara & M.Chihara, 1987				x
Unidentified forms•		x	x	x
TOTAL NUMBER OF OTUs		**93**	**90**	**120**

Supplementary Table S4 – General statistical information, including mean, standard deviation (SD), minimum (Min), maximum (Max) values, and number of observations (N), for different phytoplankton alpha diversity metrics, in the Ria Formosa lagoon, during the period September 2018 - September 2020. Significant differences between year seasons ($p<0.05$), tested by Kruskal-Wallis rank test, followed by post-hoc pairwise comparisons, are also included. Asterisk symbols *, ** indicate p-value <0.05, and <0.01, respectively. ns: not significant.

Diversity metric	Season	Mean ± SD	Min - Max	N	Differences between seasons
Species diversity	Autumn	1.7 ± 0.3	1.2 - 2.5	14	ns
	Winter	1.8 ± 0.3	1.1 - 2.3	12	
	Spring	1.8 ± 0.4	0.8 - 2.5	15	
	Summer	1.4 ± 0.5	0.6 - 2.2	21	
Species evenness	Autumn	0.6 ± 0.1	0.4 - 0.7	14	Autumn*, Winter* and Spring* > Summer
	Winter	0.6 ± 0.1	0.5 - 0.8	12	
	Spring	0.6 ± 0.1	0.2 - 0.8	15	
	Summer	0.5 ± 0.1	0.2 - 0.6	21	
Species richness	Autumn	19.4 ± 7.9	8.0 - 34.0	14	ns
	Winter	20.0 ± 8.2	10.0 - 32.0	12	
	Spring	25.0 ± 7.2	15.0 - 41.0	15	
	Summer	24.5 ± 7.5	11.0 - 41.0	21	
Species dominance	Autumn	63.3 ± 11.1	39.4 - 81.5	14	ns
	Winter	63.9 ± 13.2	41.2 - 88.3	12	
	Spring	62.6 ± 14.7	37.3 - 90.3	15	
	Summer	72.5 ± 14.8	47.9 - 95.5	21	

Supplementary Table S5 – Summary of PERMANOVA (permutational multivariate analysis of variance) tests evaluating differences in the structure of phytoplankton assemblages in the Ria Formosa lagoon (period: September 2018 - September 2020), considering station and season as factors, and results of pairwise comparisons for each factor. Sampling stations are located at 250 m (ALM 250), 750 m (ALM 750) and 1750 m (ALM 1750) from the discharge point of the Almargem wastewater treatment plant. df: degrees of freedom; SS: sum of squares; partial R^2: partial coefficient of determination; Pseudo-F: pseudo-F ratio; P-val (perm): permutation P-value. Asterisk symbols *, **, *** indicate p-value <0.05, <0.01, and <0.001, respectively. ns: not significant.

Factor	df	SS	Partial R^2	Pseudo-F	P-val (perm)	Differences between ALM stations and seasons
Station	2	0.8	0.1	3.0	0.001	250 ≠ 1750*** and 750 ≠ 1750**
Season	3	2.4	0.2	6.3	0.001	Autumn ≠ Winter** and all other comparisons***
Station x Season	6	0.6	0.1	0.8	0.933	ns

Supplementary Table S6 – Summary of the results of the similarity percentage (SIMPER) analysis, applied to the dissimilarity in the structure of phytoplankton assemblages for two sampling stations in the Ria Formosa lagoon (ALM 250 and ALM 1750), during the period September 2018 - September 2020. Phytoplankton taxa are listed in descending order of importance and, for each taxa, the mean abundance for the two stations (log (cells L^{-1} + 1)), and the percentage contribution to the overall dissimilarity between stations (Contrib.) are provided. The cumulative percentage contribution (Cumulative contrib.), representing the sum of the individual contributions, shows how total dissimilarity is built up by the contributing species. Only the taxonomic entities that explained up to 70% of the cumulative dissimilarity are shown. Symbols next to each taxa represent different phytoplankton groups, including diatoms or specific phyla: $^{\Delta}$ – Diatoms; $^{\circ}$ – Dinoflagellata; $^{\square}$ – Cyanobacteriota; * – Chlorophyta; $^{+}$ - Cryptista; $^{\wedge}$ - Euglenophyta; $^{\bullet}$ - Haptophyta.

SIMPER overall average dissimilarity = 59.1 %				
Phytoplankton taxa	**Abundance ALM 250**	**Abundance ALM 1750**	**Contrib. (%)**	**Cumulative contrib. (%)**
Chaetoceros spp.$^{\Delta}$	2.4	4.1	5.0	5.0
Kryptoperidinium foliaceum$^{\circ}$	2.5	0.1	3.9	8.9
Unidentified Oscillatoriales$^{\square}$	2.4	0.6	3.7	12.7
Pseudo-nitzschia delicatissima group$^{\Delta}$	1.0	2.6	3.7	16.3
Unidentified Chlorophyte 1*	3.7	4.0	3.7	20.0
Unidentified Pennales < 10 µm$^{\Delta}$	2.5	1.5	3.5	23.5
Unidentified Cryptophyceae < 10 µm^{+}	5.9	5.3	3.4	26.9
Eutreptiella spp.$^{\wedge}$	2.3	1.5	3.2	30.1
Unidentified Pennales > 10 µm$^{\Delta}$	3.3	2.4	3.0	33.2
Thalassiosira sp.$^{\Delta}$	1.6	0.9	2.9	36.1
Unidentified Gymnodiniales < 20 µm$^{\circ}$	2.7	1.7	2.9	39.0
Unidentified Coccolithophores$^{\bullet}$	2.4	1.8	2.9	41.9
Cylindrotheca closterium$^{\Delta}$	2.0	2.2	2.7	44.5
Unidentified phytoplankton > 10 µm	1.6	0.9	2.6	47.2
Unidentified Cryptophyceae > 10 µm^{+}	4.3	4.1	2.6	49.8
Pseudo-nitzschia seriata group$^{\Delta}$	0.1	1.9	2.5	52.3
Skeletonema sp.$^{\Delta}$	0.4	1.4	2.3	54.6
Heterocapsa spp.$^{\circ}$	0.5	1.5	2.3	56.9
Unidentified centric forms$^{\Delta}$	0.6	1.4	2.2	59.0
Unidentified Gymnodiniales > 20 µm$^{\circ}$	1.2	0.4	2.0	61.1
Navicula spp.$^{\Delta}$	1.1	0.6	2.0	63.1
Sundstroemia setigera/S. pungens$^{\Delta}$	0.5	1.3	2.0	65.1
Leptocylindrus danicus$^{\Delta}$	0.5	1.2	1.9	66.9
Cyclotella sp.$^{\Delta}$	1.0	0.5	1.8	68.7
Skeletonema costatum$^{\Delta}$	0.4	0.7	1.7	70.5

Supplementary Table S7 – Summary of the results of the similarity percentage (SIMPER) analysis, applied to the dissimilarity in the structure of phytoplankton assemblages for two sampling stations in the Ria Formosa lagoon (ALM 750 and ALM 1750), during the period September 2018 - September 2020. For each phytoplankton taxa, the mean abundance for the two stations (log (cells L^{-1} + 1)), and the percentage contribution to the overall dissimilarity between stations (Contrib.) are provided. The cumulative percentage contribution (Cumulative contrib.), representing the sum of the individual contributions, shows how total dissimilarity is built up by the contributing species. Only the taxonomic entities that explained up to 70% of the cumulative dissimilarity are shown. Symbols next to each taxa represent different phytoplankton groups, including diatoms or specific phyla: $^{\Delta}$ – Diatoms; * – Chlorophyta; $^{+}$ – Cryptista; ° – Dinoflagellata; ˆ – Euglenophyta; • – Haptophyta; □ – Cyanobacteriota.

SIMPER overall average dissimilarity = 58.0 %				
Phytoplankton taxa	**Abundance ALM 750**	**Abundance ALM 1750**	**Contrib. (%)**	**Cumulative contrib. (%)**
Chaetoceros spp.$^{\Delta}$	3.1	4.1	4.7	4.7
Unidentified Chlorophyte 1*	3.7	4.0	3.8	8.5
Pseudo-nitzschia delicatissima group$^{\Delta}$	1.7	2.6	3.8	12.3
Unidentified Cryptophyceae < 10 µm^{+}	5.5	5.3	3.7	16.0
Kryptoperidinium foliaceum°	2.4	0.1	3.6	19.6
Thalassiosira sp.$^{\Delta}$	2.1	0.9	3.6	23.2
Eutreptiella spp.ˆ	2.6	1.5	3.2	26.4
Unidentified Coccolithophores•	2.4	1.8	3.0	29.4
Unidentified Pennales < 10 µm$^{\Delta}$	1.9	1.5	2.9	32.4
Unidentified Pennales > 10 µm$^{\Delta}$	2.9	2.4	2.9	35.2
Unidentified Oscillatoriales□	1.8	0.6	2.8	38.1
Unidentified Gymnodiniales < 20 µm°	2.3	1.7	2.8	40.9
Unidentified phytoplankton > 10 µm	1.8	0.9	2.8	43.7
Pseudo-nitzschia seriata group$^{\Delta}$	0.6	1.9	2.7	46.3
Skeletonema sp.$^{\Delta}$	0.6	1.4	2.6	48.9
Cylindrotheca closterium$^{\Delta}$	2.1	2.2	2.5	51.4
Unidentified Cryptophyceae > 10 µm^{+}	4.5	4.1	2.5	53.9
Sundstroemia setigera/S. pungens$^{\Delta}$	0.9	1.3	2.3	56.2
Heterocapsa spp.°	0.3	1.5	2.2	58.5
Unidentified centric forms$^{\Delta}$	0.4	1.4	2.2	60.6
Leptocylindrus danicus$^{\Delta}$	0.8	1.2	2.1	62.8
Amphidomataceae/*Heterocapsa* sp.°	0.8	1.0	2.0	64.7
Unidentified Gymnodiniales > 20 µm°	1.1	0.4	1.9	66.6
Cyclotella sp.$^{\Delta}$	0.9	0.5	1.8	68.4
Guinardia delicatula$^{\Delta}$	0.4	0.9	1.8	70.2

Supplementary Table S8 – Summary of the results of the similarity percentage (SIMPER) analysis, applied to the dissimilarity in the structure of phytoplankton assemblages during two seasons in the Ria Formosa lagoon (Summer and Autumn), during the period September 2018 - September 2020. For each phytoplankton taxa, the mean abundance for the two seasons (log (cells L^{-1} + 1)), and the percentage contribution to the overall dissimilarity between stations (Contrib.) are provided. The cumulative percentage contribution (Cumulative contrib.), representing the sum of the individual contributions, shows how total dissimilarity is built up by the contributing species. Only the taxonomic entities that explained up to 70% of the cumulative dissimilarity are shown. Symbols next to each taxa represent different phytoplankton groups, including diatoms or specific phyla: $^{\Delta}$ – Diatoms; * – Chlorophyta; $^{+}$ - Cryptista; $^{\square}$ – Cyanobacteriota; $^{\wedge}$ - Euglenophyta; $^{\circ}$ – Dinoflagellata; $^{\bullet}$ - Haptophyta.

SIMPER overall average dissimilarity = 57.8 %				
Phytoplankton taxa	**Abundance Summer**	**Abundance Autumn**	**Contrib. (%)**	**Cumulative contrib. (%)**
Thalassiosira sp.$^{\Delta}$	3.9	0.1	6.1	6.1
Chaetoceros spp.$^{\Delta}$	4.9	1.5	6.1	12.1
Unidentified Pennales < 10 µm$^{\Delta}$	3.4	0.7	4.3	16.5
Pseudo-nitzschia delicatissima group$^{\Delta}$	3.3	1.5	4.3	20.7
Unidentified Chlorophyte 1*	5.8	3.3	4.2	25.0
Cylindrotheca closterium$^{\Delta}$	3.1	1.1	3.6	28.6
Sundstroemia setigera/S. pungens$^{\Delta}$	2.5	0.2	3.6	32.2
Cyclotella sp.$^{\Delta}$	2.4	0.0	3.5	35.7
Unidentified Cryptophyceae < 10 µm^{+}	6.7	4.9	3.5	39.2
Unidentified Oscillatoriales$^{\square}$	1.8	1.3	3.2	42.4
Unidentified Pennales > 10 µm$^{\Delta}$	3.4	1.6	3.2	45.6
Skeletonema sp.$^{\Delta}$	1.2	1.7	3.1	48.7
Unidentified Cryptophyceae > 10 µm^{+}	3.9	4.9	3.0	51.7
Unidentified phytoplankton > 10 µm	2.1	0.2	2.7	54.4
Eutreptiella spp.$^{\wedge}$	2.8	3.0	2.7	57.1
Unidentified Gymnodiniales < 20 µm$^{\circ}$	2.6	1.7	2.7	59.8
Unidentified Coccolithophores$^{\bullet}$	2.2	2.1	2.4	62.2
Unidentified Gymnodiniales > 20 µm$^{\circ}$	0.8	1.3	2.1	64.4
Pseudo-nitzschia seriata group$^{\Delta}$	1.1	0.7	1.9	66.3
Kryptoperidinium foliaceum$^{\circ}$	1.0	0.8	1.8	68.1
Guinardia delicatula$^{\Delta}$	0.1	1.1	1.7	69.8

Supplementary Table S9 – Summary of the results of the similarity percentage (SIMPER) analysis, applied to the dissimilarity in the structure of phytoplankton assemblages during two seasons in the Ria Formosa lagoon (Summer and Winter), during the period September 2018 - September 2020. For each phytoplankton taxa, the mean abundance for the two seasons (log (cells L^{-1} + 1)), and the percentage contribution to the overall dissimilarity between stations (Contrib.) are provided. The cumulative percentage contribution (Cumulative contrib.), representing the sum of the individual contributions, shows how total dissimilarity is built up by the contributing species. Only the taxonomic entities that explained up to 70% of the cumulative dissimilarity are shown. Symbols next to each taxa represent different phytoplankton groups, including diatoms or specific phyla: * – Chlorophyta; Δ – Diatoms; + – Cryptista; ˆ - Euglenophyta; □ – Cyanobacteriota; ° – Dinoflagellata; • - Haptophyta.

SIMPER overall average dissimilarity = 65.8 %				
Phytoplankton taxa	**Abundance Summer**	**Abundance Winter**	**Contrib. (%)**	**Cumulative contrib. (%)**
Unidentified Chlorophyte 1*	5.8	1.5	6.2	6.2
Chaetoceros spp.Δ	4.9	1.0	5.8	12.1
Thalassiosira sp.Δ	3.9	0.5	5.5	17.6
Unidentified Cryptophyceae < 10 µm+	6.7	3.5	5.2	22.8
Pseudo-nitzschia delicatissima groupΔ	3.3	0.3	4.5	27.3
Unidentified Pennales < 10 µmΔ	3.4	1.1	3.6	30.9
Eutreptiella spp.ˆ	2.8	0.6	3.4	34.3
*Sundstroemia setigera/S. pungens*Δ	2.5	0.0	3.3	37.6
Cyclotella sp.Δ	2.4	0.0	3.3	40.9
Unidentified phytoplankton > 10 µm	2.1	0.9	2.9	43.8
Unidentified Oscillatoriales□	1.8	1.1	2.9	46.7
Unidentified Gymnodiniales < 20 µm°	2.6	1.0	2.8	49.5
Unidentified Cryptophyceae > 10 µm+	3.9	4.3	2.8	52.3
*Cylindrotheca closterium*Δ	3.1	1.8	2.7	55.0
Unidentified Pennales > 10 µmΔ	3.4	2.2	2.6	57.6
Unidentified Coccolithophores•	2.2	1.7	2.6	60.2
Kryptoperidinium foliaceum°	1.0	1.4	2.3	62.5
*Skeletonema costatum*Δ	0.2	1.3	2.0	64.5
Skeletonema sp.Δ	1.2	0.0	1.8	66.3
Unidentified Chlorophyceae*	1.0	0.5	1.6	67.9
Navicula spp.Δ	0.7	0.8	1.6	69.5

Supplementary Table S10 – Summary of the results of the similarity percentage (SIMPER) analysis, applied to the dissimilarity in the structure of phytoplankton assemblages during two seasons in the Ria Formosa lagoon (Summer and Spring), during the period September 2018 - September 2020. For each phytoplankton taxa, the mean abundance for the two seasons (log (cells L^{-1} + 1)), and the percentage contribution to the overall dissimilarity between stations (Contrib.) are provided. The cumulative percentage contribution (Cumulative contrib.), representing the sum of the individual contributions, shows how total dissimilarity is built up by the contributing species. Only the taxonomic entities that explained up to 70% of the cumulative dissimilarity are shown. Symbols next to each taxa represent different phytoplankton groups, including diatoms or specific phyla: $^{\Delta}$ – Diatoms; $^{\circ}$ – Dinoflagellata; * – Chlorophyta; $^{\square}$ – Cyanobacteriotz; $^{\wedge}$ - Euglenophyta; $^{+}$ - Cryptista; $^{\bullet}$ - Haptophyta.

SIMPER overall average dissimilarity = 53.8 %				
Phytoplankton taxa	**Abundance Summer**	**Abundance Spring**	**Contrib. (%)**	**Cumulative contrib. (%)**
Thalassiosira sp.$^{\Delta}$	3.9	0.3	5.2	5.2
Kryptoperidinium foliaceum$^{\circ}$	1.0	3.6	4.4	9.6
Pseudo-nitzschia delicatissima group$^{\Delta}$	3.3	1.1	3.7	13.3
Unidentified phytoplankton > 10 µm	2.1	1.8	3.6	16.9
Unidentified Chlorophyte 1*	5.8	3.4	3.5	20.4
Chaetoceros spp.$^{\Delta}$	4.9	4.0	3.3	23.7
Unidentified Oscillatoriales$^{\square}$	1.8	1.8	3.2	26.9
Sundstroemia setigera/S. pungens$^{\Delta}$	2.5	0.0	3.2	30.1
Eutreptiella spp.$^{\wedge}$	2.8	1.8	3.2	33.3
Unidentified Pennales < 10 µm$^{\Delta}$	3.4	1.8	3.2	36.5
Cyclotella sp.$^{\Delta}$	2.4	0.0	3.1	39.6
Unidentified Cryptophyceae > 10 µm^{+}	3.9	4.2	2.9	42.5
Cylindrotheca closterium$^{\Delta}$	3.1	1.8	2.6	45.1
Leptocylindrus danicus$^{\Delta}$	1.3	1.2	2.5	47.6
Navicula spp.$^{\Delta}$	0.7	1.8	2.4	50.0
Unidentified Pennales > 10 µm$^{\Delta}$	3.4	3.9	2.3	52.3
Unidentified Coccolithophores$^{\bullet}$	2.2	2.7	2.3	54.6
Unidentified Cyanophyceae$^{\square}$	0.8	1.4	2.2	56.8
Unidentified Gymnodiniales < 20 µm$^{\circ}$	2.6	3.3	2.2	59.0
Pseudo-nitzschia seriata group$^{\Delta}$	1.1	1.2	2.2	61.2
Heterocapsa spp.$^{\circ}$	0.5	1.6	2.2	63.3
Unidentified Gymnodiniales > 20 µm$^{\circ}$	0.8	1.3	2.0	65.4
Unidentified Chlorophyceae*	1.0	1.0	1.9	67.2
Unidentified centric forms$^{\Delta}$	0.7	1.3	1.9	69.1

Supplementary Table S11 – Summary of the results of the similarity percentage (SIMPER) analysis, applied to the dissimilarity in the structure of phytoplankton assemblages during two seasons in the Ria Formosa lagoon (Autumn and Winter), during the period September 2018 - September 2020. For each phytoplankton taxa, the mean abundance for the two seasons (log (cells L^{-1} + 1)), and the percentage contribution to the overall dissimilarity between stations (Contrib.) are provided. The cumulative percentage contribution (Cumulative contrib.), representing the sum of the individual contributions, shows how total dissimilarity is built up by the contributing species. Only the taxonomic entities that explained up to 70% of the cumulative dissimilarity are shown. Symbols next to each taxa represent different phytoplankton groups, including diatoms or specific phyla: $^{+}$ – Cryptista; $^{\wedge}$ – Euglenophyta; * – Chlorophyta; $^{\bullet}$ – Haptophyta; $^{\square}$ – Cyanobacteriota; $^{\Delta}$ – Diatoms; $^{\circ}$ – Dinoflagellata.

SIMPER overall average dissimilarity = 58.9 %				
Phytoplankton taxa	**Abundance Autumn**	**Abundance Winter**	**Contrib. (%)**	**Cumulative contrib. (%)**
Unidentified Cryptophyceae < 10 µm^{+}	4.9	3.5	5.8	5.8
Eutreptiella spp.$^{\wedge}$	3.0	0.6	5.8	11.7
Unidentified Chlorophyte 1*	3.3	1.5	5.1	16.8
Unidentified Coccolithophores$^{\bullet}$	2.1	1.7	4.0	20.8
Unidentified Oscillatoriales$^{\square}$	1.3	1.1	3.8	24.6
Chaetoceros spp.$^{\Delta}$	1.5	1.0	3.7	28.3
Kryptoperidinium foliaceum$^{\circ}$	0.8	1.4	3.6	31.9
Skeletonema costatum$^{\Delta}$	0.6	1.3	3.5	35.4
Unidentified Pennales > 10 µm$^{\Delta}$	1.6	2.2	3.4	38.8
Skeletonema sp.$^{\Delta}$	1.7	0.0	3.3	42.2
Unidentified Gymnodiniales < 20 µm$^{\circ}$	1.7	1.0	3.3	45.5
Pseudo-nitzschia delicatissima group$^{\Delta}$	1.5	0.3	3.2	48.6
Cylindrotheca closterium$^{\Delta}$	1.1	1.8	2.9	51.6
Unidentified Gymnodiniales > 20 µm$^{\circ}$	1.3	0.2	2.9	54.5
Unidentified Pennales < 10 µm$^{\Delta}$	0.7	1.1	2.9	57.4
Guinardia delicatula$^{\Delta}$	1.1	0.3	2.7	60.1
Oscillatoria spp./*Planktothrix* spp.$^{\square}$	0.6	0.6	2.5	62.7
Unidentified Cryptophyceae > 10 µm^{+}	4.9	4.3	2.5	65.2
Unidentified phytoplankton > 10 µm	0.2	0.9	2.2	67.4
Navicula spp.$^{\Delta}$	0.3	0.8	2.2	69.6

Supplementary Table S12 – Summary of the results of the similarity percentage (SIMPER) analysis, applied to the dissimilarity in the structure of phytoplankton assemblages during two seasons in the Ria Formosa lagoon (Autumn and Spring), during the period September 2018 - September 2020. For each phytoplankton taxa, the mean abundance for the two seasons (log (cells L^{-1} + 1)), and the percentage contribution to the overall dissimilarity between stations (Contrib.) are provided. The cumulative percentage contribution (Cumulative contrib.), representing the sum of the individual contributions, shows how total dissimilarity is built up by the contributing species. Only the taxonomic entities that explained up to 70% of the cumulative dissimilarity are shown. Symbols next to each taxa represent different phytoplankton groups, including diatoms or specific phyla: $^{\Delta}$ – Diatoms; $^{\circ}$ – Dinoflagellata; $^{\wedge}$ – Euglenophyta; $^{\square}$ – Cyanobacteriota; $^{+}$ - Cryptista; * – Chlorophyta; $^{\bullet}$ - Haptophyta.

SIMPER overall average dissimilarity = 56.4 %				
Phytoplankton taxa	**Abundance Autumn**	**Abundance Spring**	**Contrib. (%)**	**Cumulative contrib. (%)**
Chaetoceros spp.$^{\Delta}$	1.5	4.0	5.5	5.5
Kryptoperidinium foliaceum$^{\circ}$	0.8	3.6	5.4	10.9
Unidentified Pennales > 10 µm$^{\Delta}$	1.6	3.9	4.1	15.1
Eutreptiella spp.$^{\wedge}$	3.0	1.8	3.8	18.9
Unidentified Oscillatoriales$^{\square}$	1.3	1.8	3.7	22.6
Unidentified Gymnodiniales < 20 µm$^{\circ}$	1.7	3.3	3.3	25.9
Unidentified Cryptophyceae < 10 µm^{+}	4.9	6.3	3.3	29.2
Unidentified phytoplankton > 10 µm	0.2	1.8	3.3	32.5
Unidentified Pennales < 10 µm$^{\Delta}$	0.7	1.8	3.1	35.6
Unidentified Chlorophyte 1*	3.3	3.4	3.0	38.6
Unidentified Gymnodiniales > 20 µm$^{\circ}$	1.3	1.3	2.9	41.5
Pseudo-nitzschia delicatissima group$^{\Delta}$	1.5	1.1	2.9	44.4
Navicula spp.$^{\Delta}$	0.3	1.8	2.8	47.2
Heterocapsa spp.$^{\circ}$	0.3	1.6	2.7	49.9
Unidentified Coccolithophores$^{\bullet}$	2.1	2.7	2.7	52.6
Skeletonema sp.$^{\Delta}$	1.7	0.0	2.5	55.1
Guinardia delicatula$^{\Delta}$	1.1	0.8	2.4	57.5
Cylindrotheca closterium$^{\Delta}$	1.1	1.8	2.4	59.9
Pseudo-nitzschia seriata group$^{\Delta}$	0.7	1.2	2.4	62.3
Unidentified centric forms$^{\Delta}$	0.7	1.3	2.4	64.6
Unidentified Cryptophyceae > 10 µm^{+}	4.9	4.2	2.3	67.0
Amphidomataceae/*Heterocapsa* sp.$^{\circ}$	0.9	1.1	2.2	69.2

Supplementary Table S13 – Summary of the results of the similarity percentage (SIMPER) analysis, applied to the dissimilarity in the structure of phytoplankton assemblages during two seasons in the Ria Formosa lagoon (Winter and Spring), during the period September 2018 - September 2020. For each phytoplankton taxa, the mean abundance for the two seasons (log (cells L^{-1} + 1)), and the percentage contribution to the overall dissimilarity between stations (Contrib.) are provided. The cumulative percentage contribution (Cumulative contrib.), representing the sum of the individual contributions, shows how total dissimilarity is built up by the contributing species. Only the taxonomic entities that explained up to 70% of the cumulative dissimilarity are shown. Symbols next to each taxa represent different phytoplankton groups, including diatoms or specific phyla: $^{\Delta}$ – Diatoms; $^{+}$ – Cryptista; $^{\circ}$ – Dinoflagellata; * – Chlorophyta; $^{\square}$ – Cyanobacteriota; $^{\bullet}$ – Haptophyta; $^{\wedge}$ - Euglenophyta.

SIMPER overall average dissimilarity = 60.8 %				
Phytoplankton taxa	**Abundance Winter**	**Abundance Spring**	**Contrib. (%)**	**Cumulative contrib. (%)**
Chaetoceros spp.$^{\Delta}$	1.0	4.0	5.6	5.6
Unidentified Cryptophyceae < 10 µm^{+}	3.5	6.3	5.3	10.9
Kryptoperidinium foliaceum$^{\circ}$	1.4	3.6	5.2	16.1
Unidentified Chlorophyte 1*	1.5	3.4	4.0	20.1
Unidentified Gymnodiniales < 20 µm$^{\circ}$	1.0	3.3	4.0	24.1
Unidentified Oscillatoriales$^{\square}$	1.1	1.8	3.6	27.7
Unidentified Pennales > 10 µm$^{\Delta}$	2.2	3.9	3.3	31.1
Unidentified phytoplankton > 10 µm	0.9	1.8	3.3	34.3
Unidentified Coccolithophores$^{\bullet}$	1.7	2.7	3.2	37.5
Eutreptiella spp.$^{\wedge}$	0.6	1.8	3.0	40.5
Unidentified Pennales < 10 µm$^{\Delta}$	1.1	1.8	2.8	43.3
Navicula spp.$^{\Delta}$	0.8	1.8	2.7	46.1
Heterocapsa spp.$^{\circ}$	0.6	1.6	2.6	48.7
Unidentified Cryptophyceae > 10 µm^{+}	4.3	4.2	2.5	51.2
Unidentified Gymnodiniales > 20 µm$^{\circ}$	0.2	1.3	2.3	53.5
Unidentified Euglenophyceae$^{\wedge}$	0.5	1.2	2.3	55.8
Unidentified centric forms$^{\Delta}$	0.4	1.3	2.3	58.0
Leptocylindrus danicus$^{\Delta}$	0.2	1.2	2.2	60.2
Unidentified Chlorophyceae*	0.5	1.0	2.1	62.3
Unidentified Cyanophyceae$^{\square}$	0.0	1.4	2.1	64.5
Skeletonema costatum$^{\Delta}$	1.3	0.0	2.1	66.5
Cylindrotheca closterium$^{\Delta}$	1.8	1.8	2.0	68.6