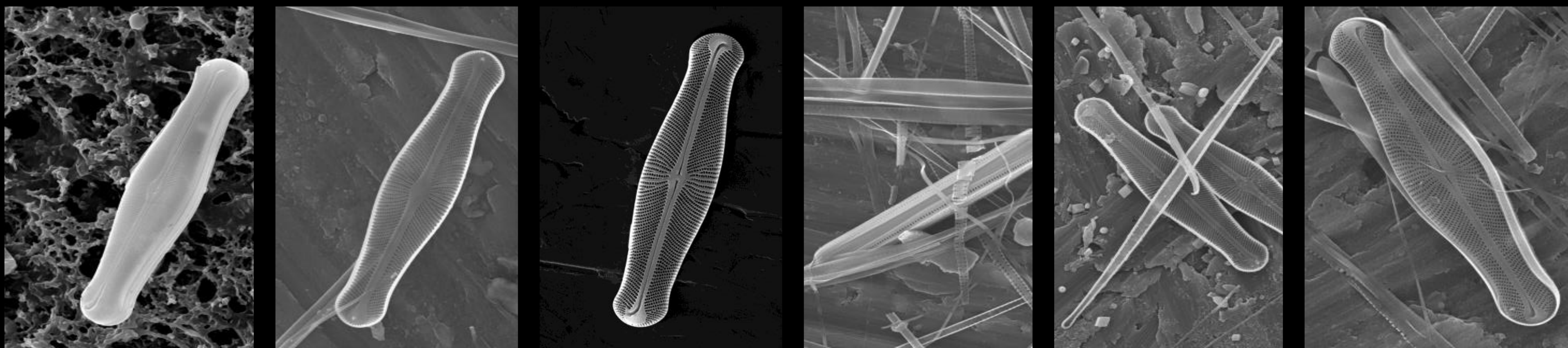
PRVI ZNANSTVENI SIMPOZIJ O BIOLOGIJI
SLATKIH VODA
20.VELJAČE 2015.
ZAGREB

FUNKCIONALNA KLASIFIKACIJA FITOPLANKTONA U SLATKOVODNIM SUSTAVIMA HRVATSKE

Marija Gligora Udovič



1° What

2° Why

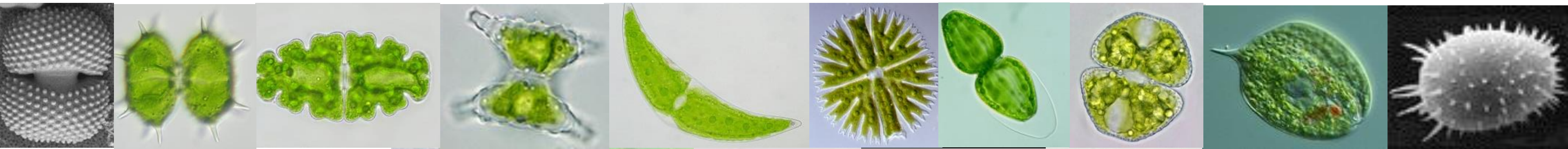
1° What

Investigations on freshwater ecosystems

biotic interactions in aquatic ecosystems

biodiversity

…understand how sensitive habitats might be affected by natural changes throughout the years, by human impacts or by climate changes.



1° What

Phytoplankton

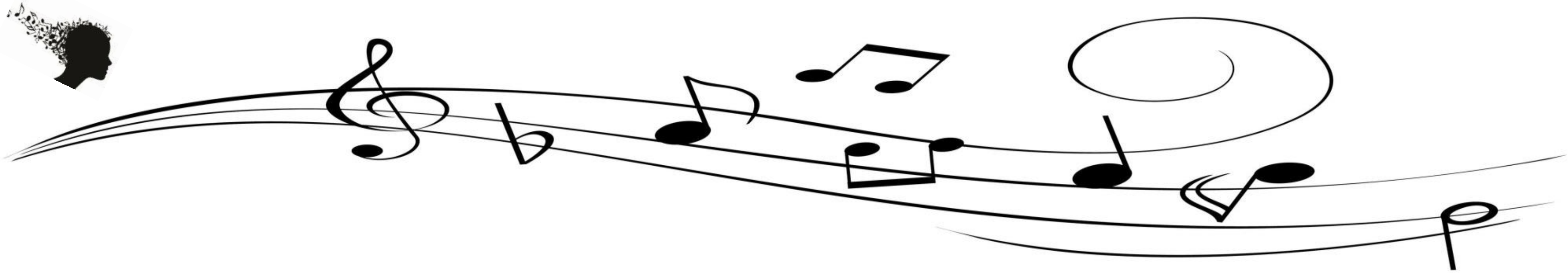
„The phytoplankton is an extremely diverse, polyphyletic group of photosynthetic protists and cyanobacteria, which fuel food webs and drive biogeochemical cycling" (Rousseaux & Gregg, 2014).

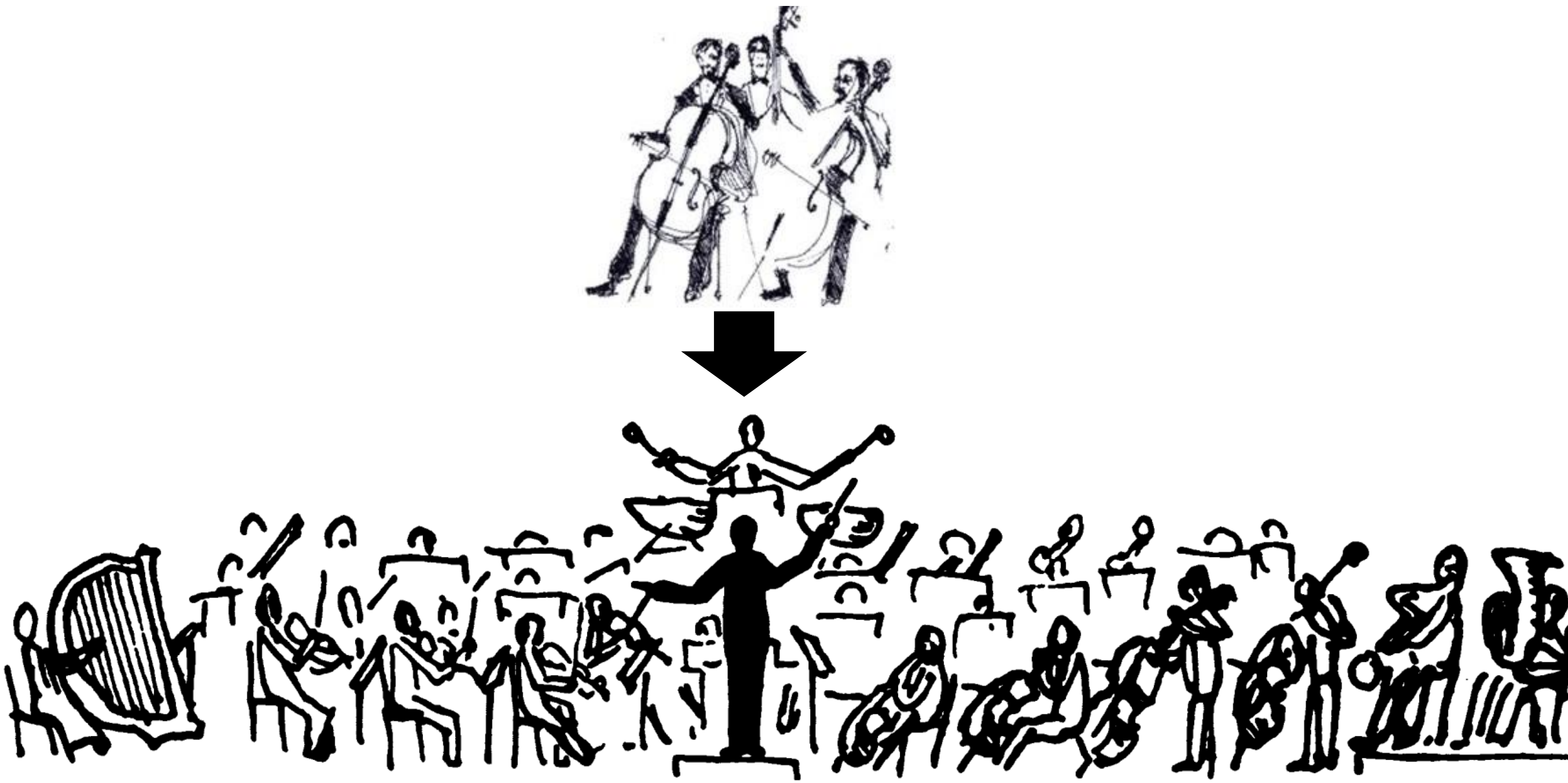
Phytoplankton funtional groups

1° What

„Phytoplankton trait-based approaches are designed to group species with similar morphological and functional properties, thus indicating the optimal ecological strategies for certain habitat conditions”. (Žutinić et al. 2014)

Phytoplankton functional classification





‘**Ecology is evolution in action**’ (Krebs, 2009)….

„…thus, from an evolutionary perspective, functional criteria should comprise the biological processes and characters implicated in adaptation. The criteria used to define functional groups in phytoplankton include morphology, physiological features and, where appropriate, taxonomy. Besides biological and taxonomic traits, other criteria include ecological features, such as phenology, implicitly acknowledging that species showing similar seasonality respond similarly to a set of particular environmental conditions. In this respect, phytoplankton functional groups are arbitrary assemblages” (Salmaso et al. 2015) .

2° Why

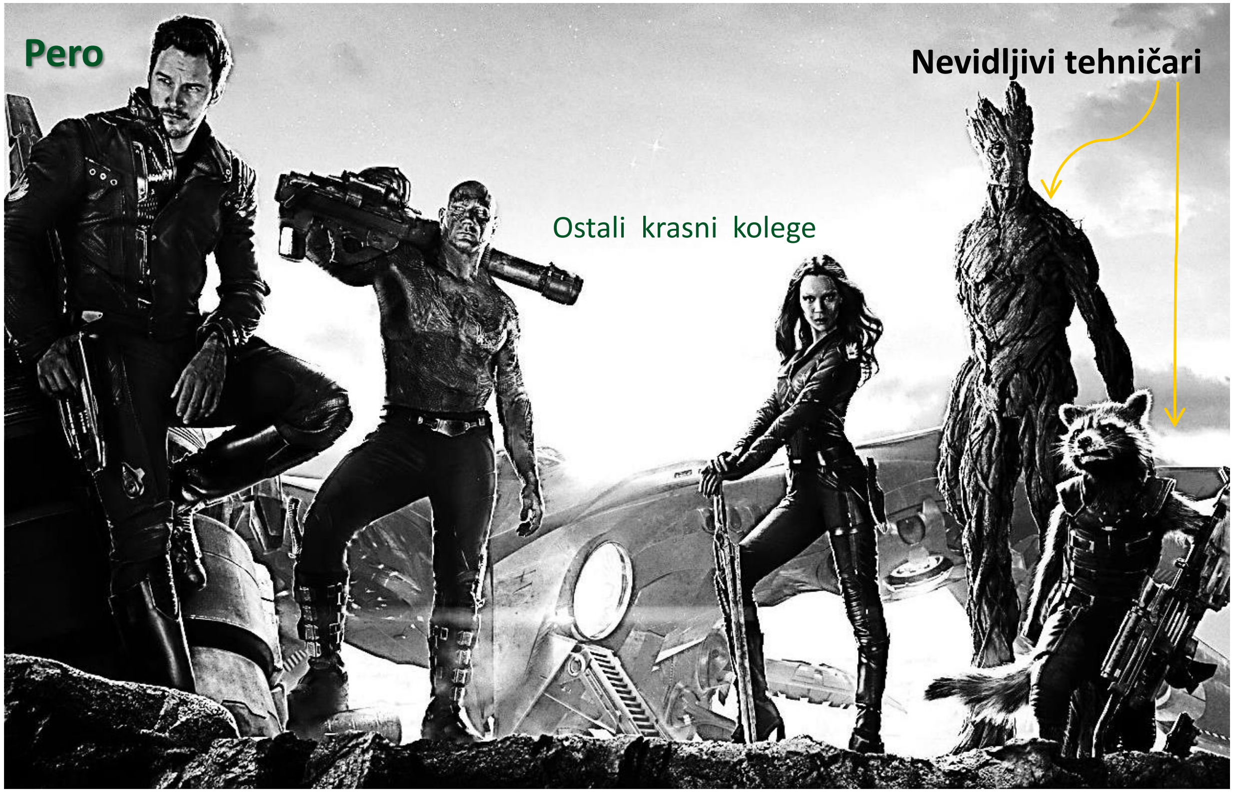
...

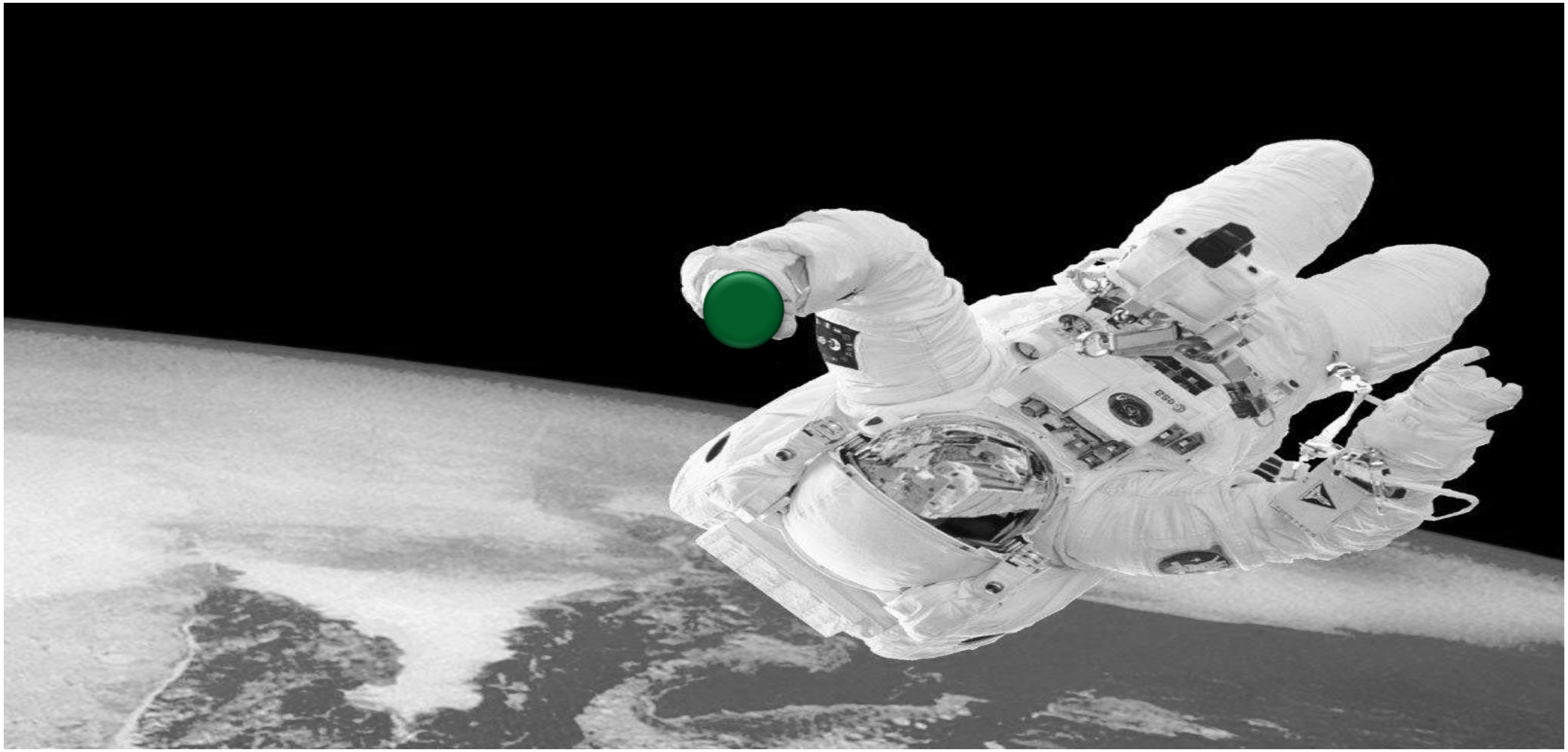
3°

…beyond the state of the art

Kora

Maja


Pero
Nevidljivi tehničari
Ostali krasni kolege



4° New

5° Usefull

4° New

?

Table. Phytoplankton functional classifications

Functional group	Acronym	Principal criteria	Main discriminant features	Reference (relevant to phytoplankton ecology)
r and K selection	*r/K*	Functional	Functional (growth) and morphometric attributes (see Pianka, 1970)	Margalef (1978); Reynolds (1988b)
Competitive, Stress-tolerant and Ruderal strategists	*CSR*	Functional	Functional (growth) and morphological/morphometric attributes (see Reynolds, 2006)	Reynolds (1988a)
Biomass size spectrum; Normalised Biomass Size spectrum	*BSS, NBS*	Morphometrical	Size distribution	Platt & Denman (1978); Kamenir *et al.* (2004)
Traditional Taxonomic Size Spectrum	*TTSS*	Morphometrical	Size distribution	Kamenir *et al.* (2006)
Phytoplankton Geometric Shapes	*PGS*	Morphological	Shapes	Stanca *et al.* (2013)
Morphologically Based Functional Groups	*MBFG*	Morphometrical Structural	V, S, S/V, MLD, mucilage, flagella, aerotopes, heterocytes and siliceous exoskeletal structures	Kruk *et al.* (2010)
Functional Groups	*FG*	Phenological Ecological Functional	Phenology and ecological/ functional attributes (tolerances to: low z_{mix}, light, temperature, SRP, DIN, Si, CO_2; high zooplankton grazing; see Table S1)	Reynolds (1980); Reynolds *et al.* (2002); Padisák *et al.* (2009)
Morpho-Functional Groups	*MFG*	Morphometrical Structural Functional Taxonomic	Structural, functional and taxonomic characters: flagella, mixotrophy, cellular organisation, aerotopes, dimensions, shapes, mucilage	Salmaso & Padisák (2007)

V, Volume; S, cell surface; MLD, maximum linear dimension; SRP, soluble reactive phosphorus; DIN, dissolved inorganic nitrogen; Si, reactive silica.

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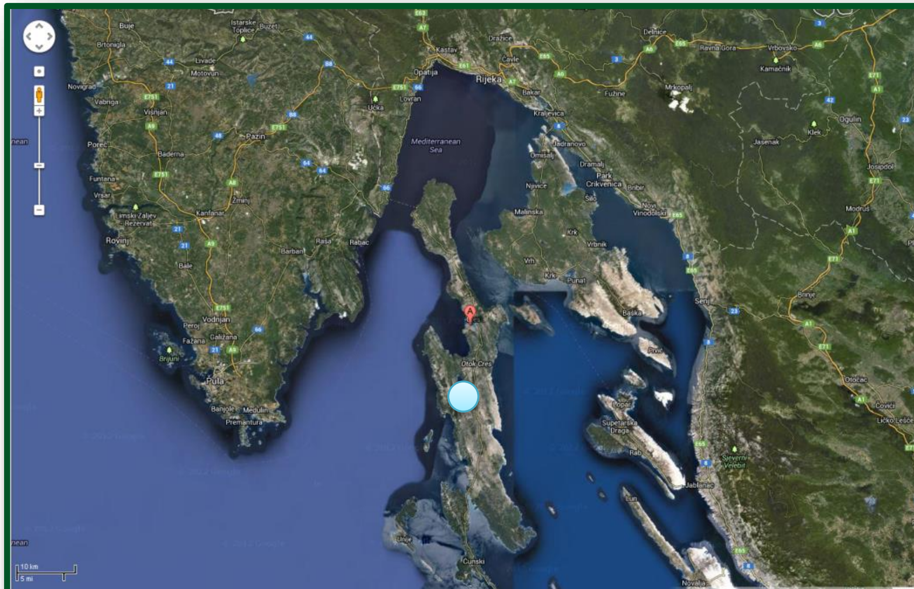


Vranско lake Cres

Phytoplankton classes present in Vransko Lake from April to September 2010 were Chrysophyta (12), Chlorophyta (7 species), Cyanobacteria (4) and Dinophyta (4). A total of 27 species was detected in the investigated samples. The dominant species were *Dinobryon sociale, Cyclotella* spp.*, Ceratium hirundinella* and *Peridinium* spp.

The average biomass ranged from 0.10 mg l^{-1} to 0.87 mg l^{-1}.

Cyclotella

Dinobryon

Ceratium

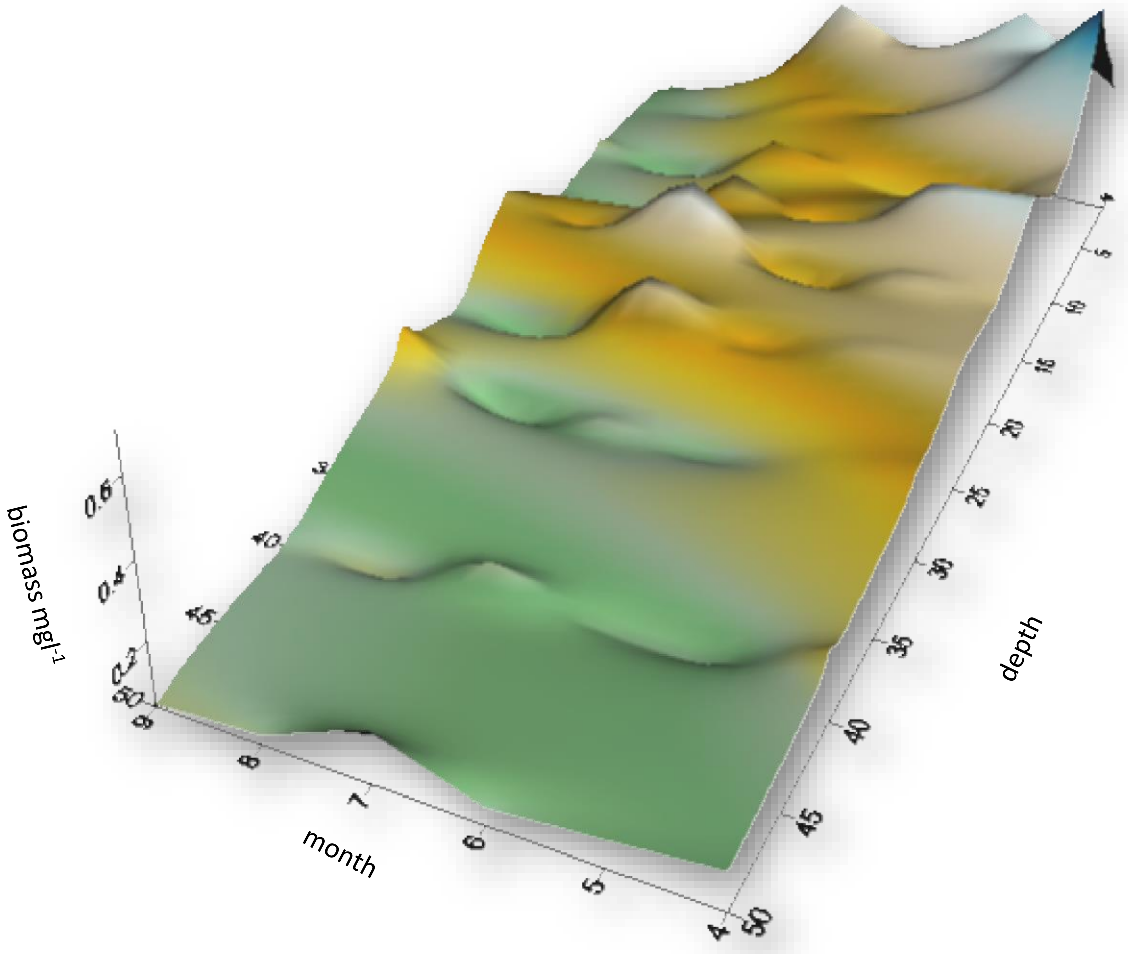


Fig Spatial and temporal destitution of phytoplankton total biomass in Vransko Lake in period from April to September 2010 (tree-dimensional)

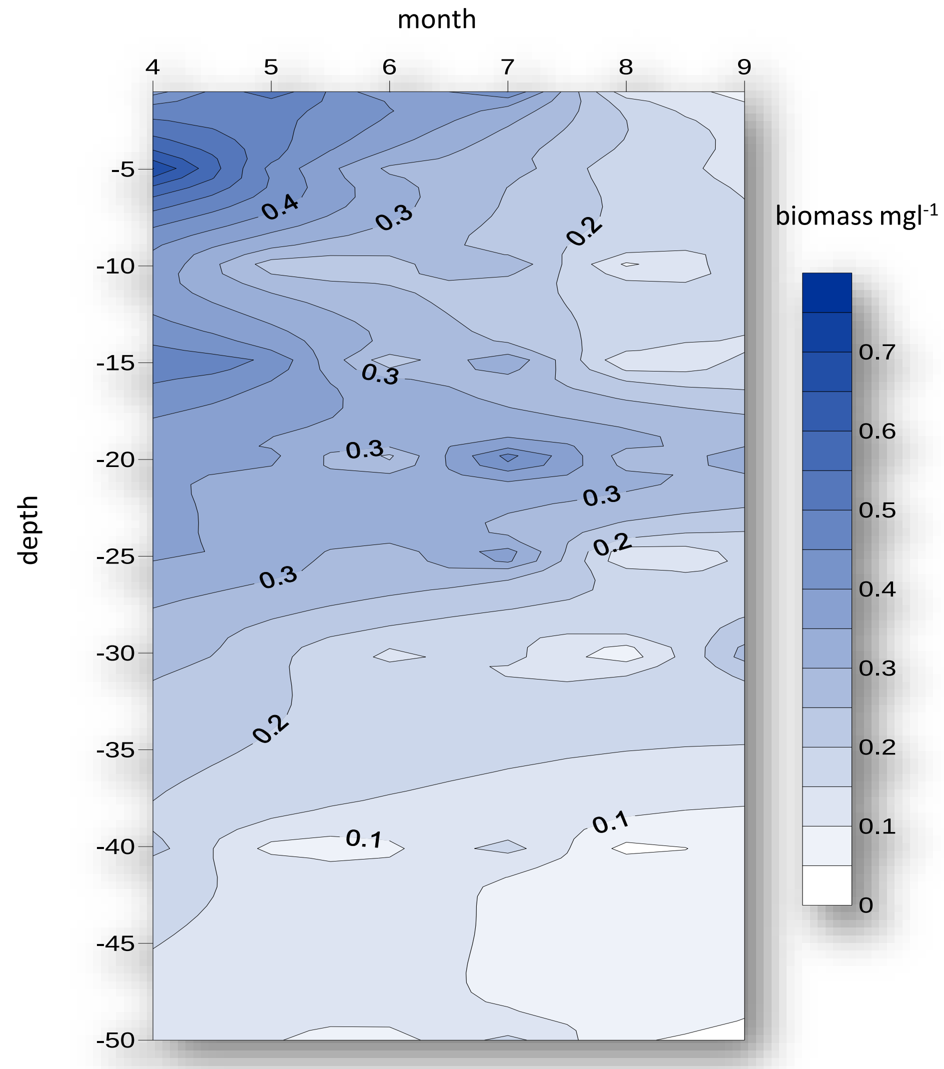


Fig Spatial and temporal destitution of phytoplankton total biomass in Vransko Lake in period from April to September 2010 (two dimensional)

Taxonomic phytoplankton assemblages are usually used as a good descriptor of waterbodies but they do not always reflect the perceived ecological functions. A taxonomic unit may be composed of species possessing different structural and functional properties.

Functional classification

Table. Monthly changes of dominant phytoplankton groups according to the three classifications used for to the studied deep karstic Vransko Lake Cres from April to September 2010. (***MFG***-Morpho-functional groups according to Kruk *et al.*, 2010; ***FG*** -Functional groups according to Reynolds *et al.*, 2002 revised by Padisak *et al.*, 2009)

	TAXA	*MFG*	*FG*
IV	***Dinobryon* spp.** *Peridinium* spp. *Cyclotella* spp.	**II**, V, VI	**E**, Lo, A
V	***Dinobryon* spp.** *Peridinium* spp. *Cyclotella* spp.	**II**, V, VI	**E**, Lo, A
VI	***Peridinium* spp.** *Dinobryon* spp. *Ceratium* sp. *Cyclotella* spp.	**V**, II, VI	**Lo**, E, A
VII	***Peridinium* spp.** *Dinobryon* spp. *Cyclotella* spp.	**V**, II, VI	**Lo**, E, A
VIII	***Cyclotella* spp.** *Dinobryon* spp. *Peridinium* spp.	**VI**, II, V	**A, E, Lo**
IX	***Dinobryon* spp.** *Cyclotella* spp.	**II**, VI	**E**, A

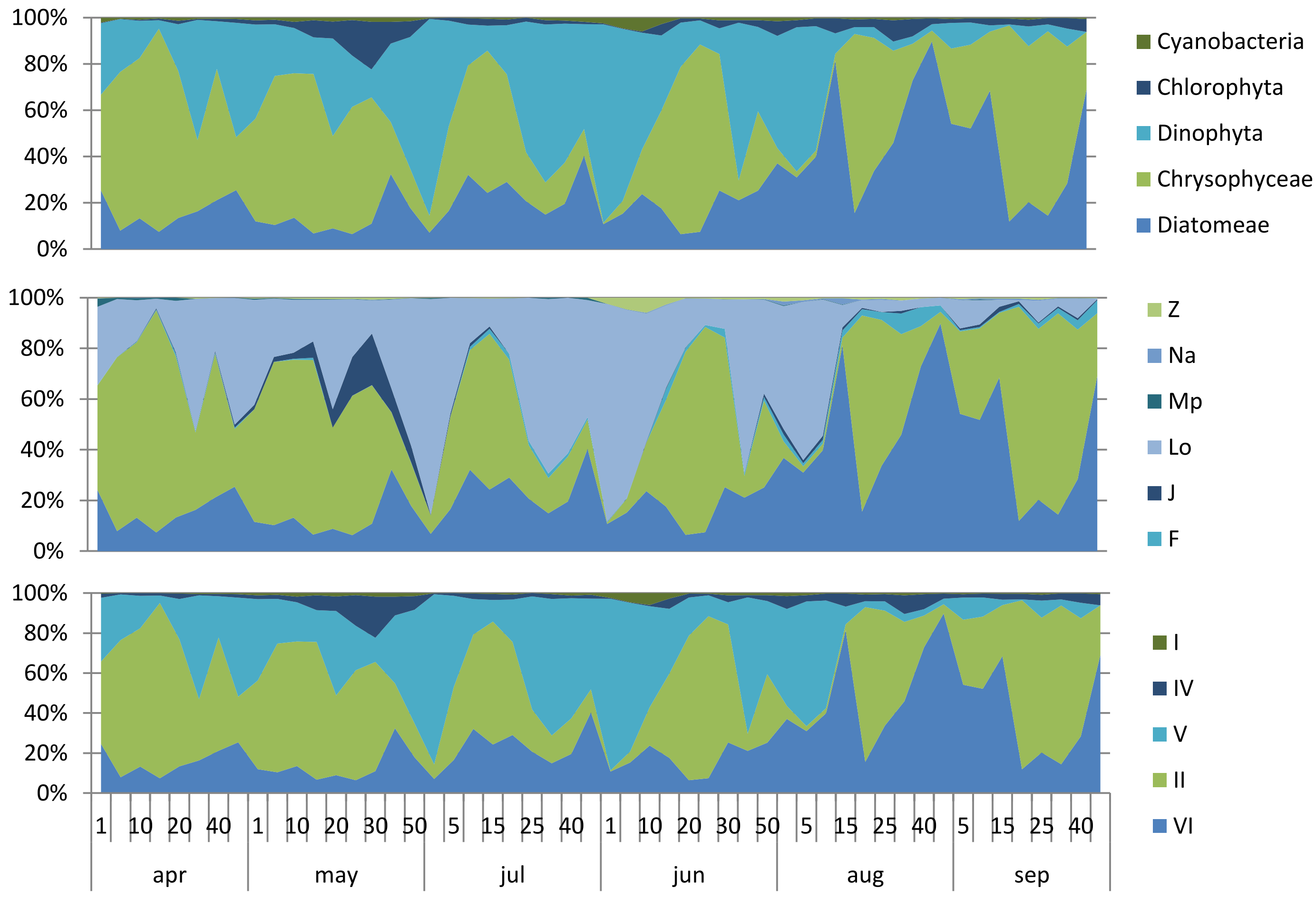


Fig Variation of relative proportion of the different algal, functional and morfo- functional groups in Vransko Lake 2010.

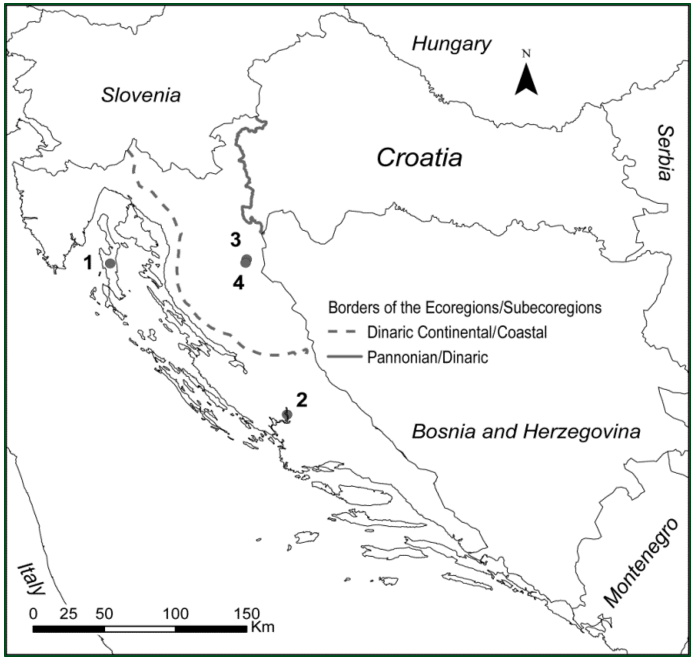


Fig. Map of the investigated lakes: Vransko (1), Visovačko (2), Kozjak (3) and Prošće (4).

Table. Physical properties of the investigated lakes.

Lake (no. on the map)	Elevation (a.s.l.) (m)	Surface area (km²)	Volume (m³)	Max depth (m)	Geographic coordinates	Dinaric ecoregion
Lake Vransko (1)	13	5.75	220.3×10^6	74.5	44° 51´ 13˝N, 14° 23´ 23˝E	Coastal subregion
Lake Visovačko (2)	47 (Skradinski buk)	5.72	103×10^6	30.0	43° 51´ 33˝N, 15° 58´ 37˝E	Coastal subregion
Kozjak (3)	535	0.82	12.71×10^6	48.0	44° 53´ 27˝N, 15° 36´ 16˝E	Continental subregion
Prošće (4)	636	0.70	7.67×10^6	38.5	44° 52´ 06˝N, 15° 35´ 51˝E	Continental subregion

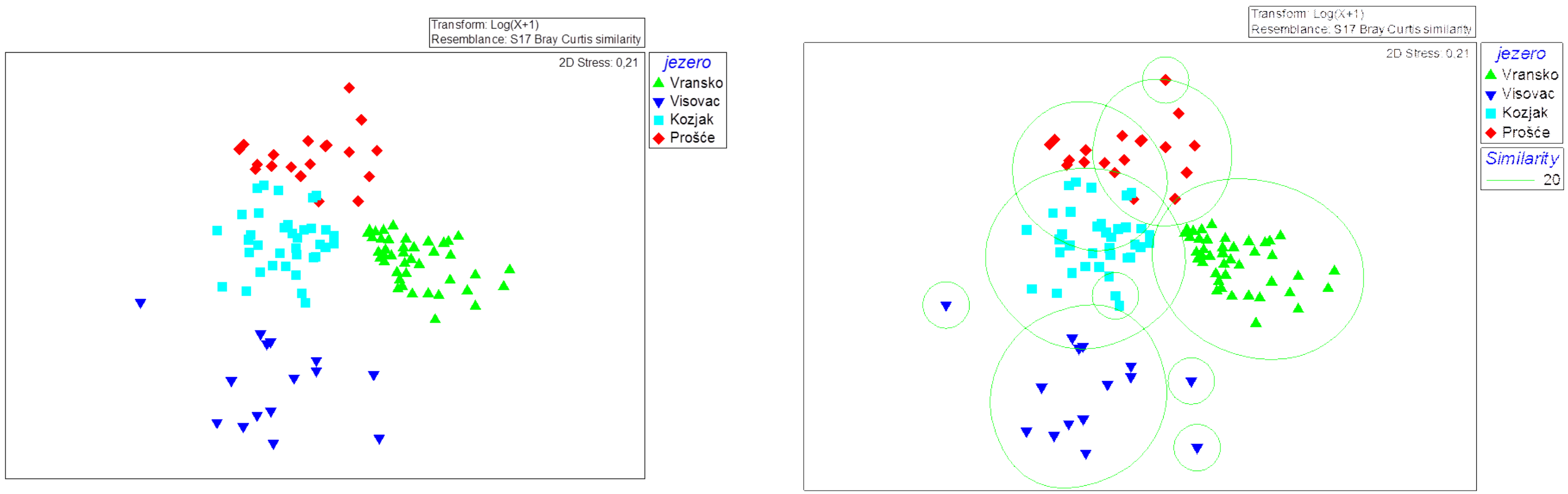


Fig. NMDS ordinations of phytoplankton species with cluster overlap at 20% similarity.

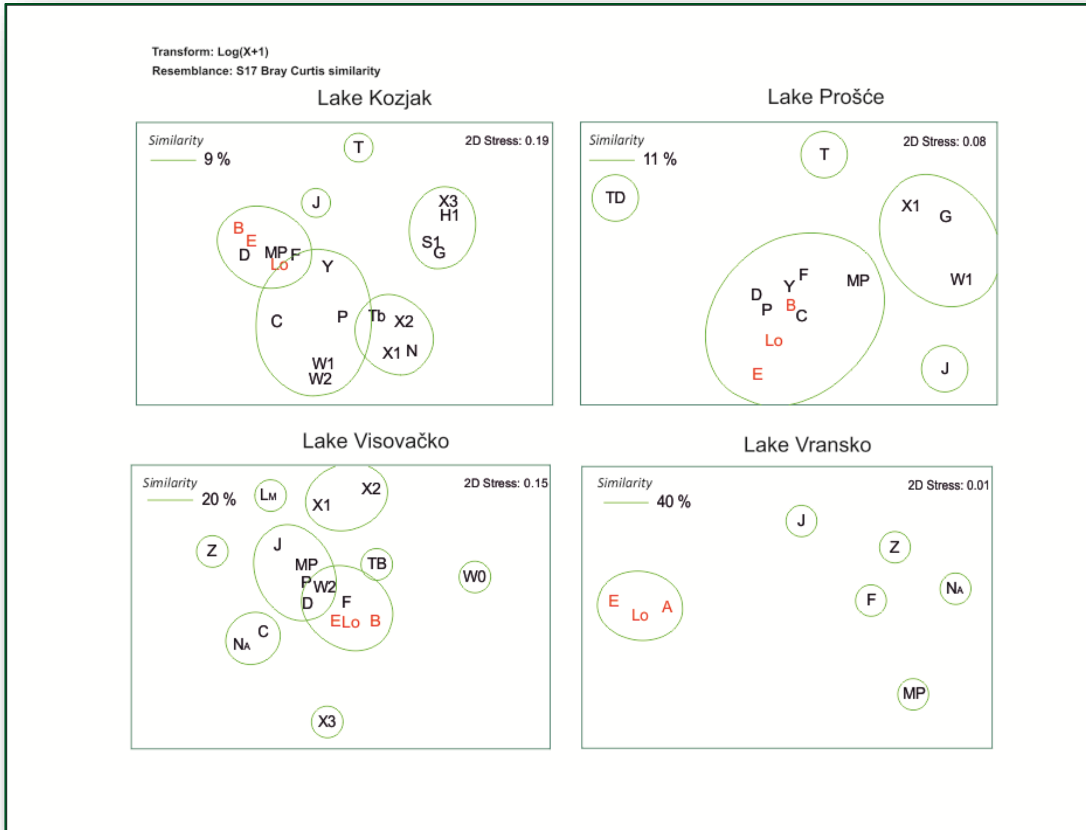
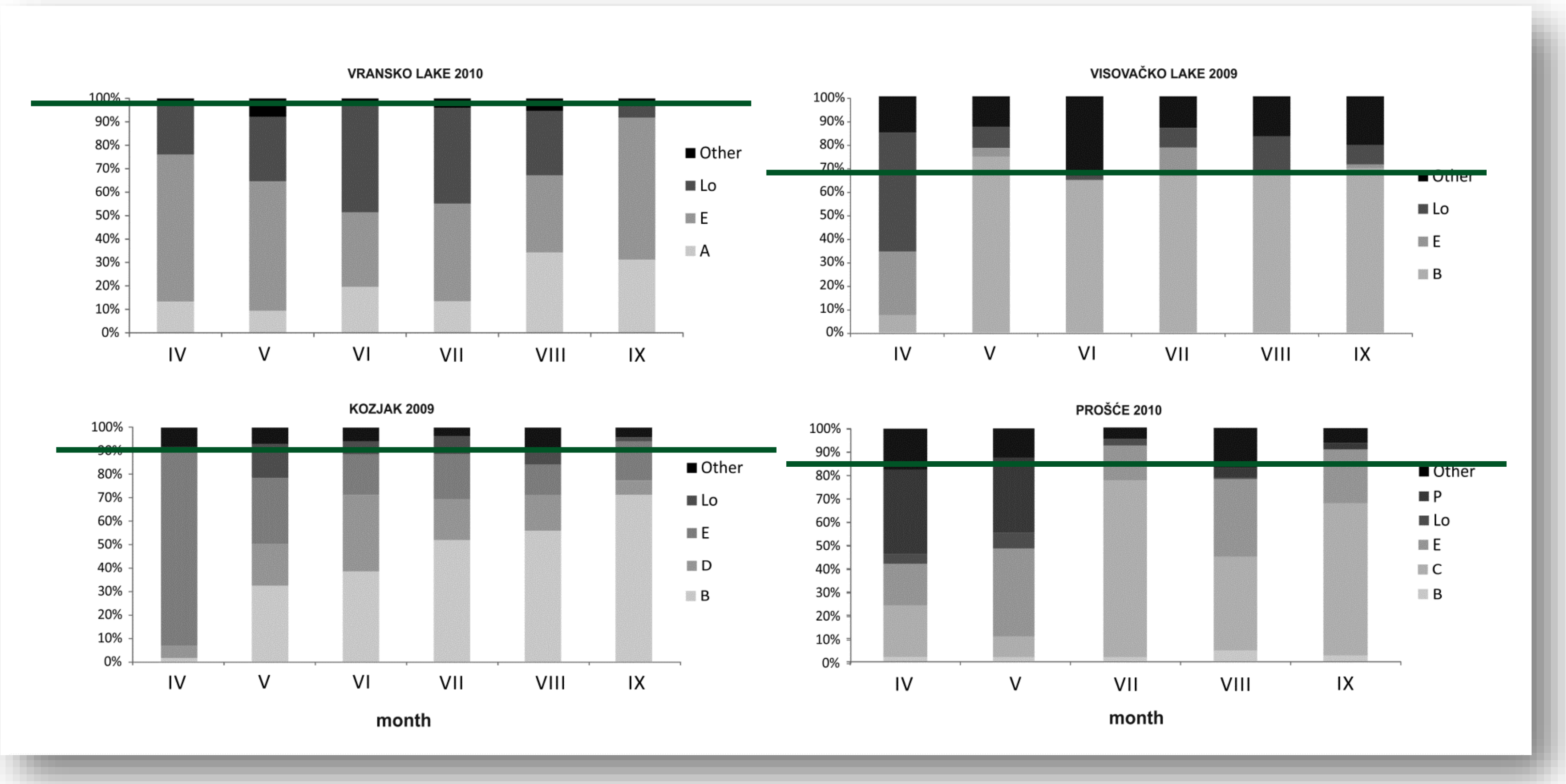


Fig. NMDS ordinations of phytoplankton FG in karstic lakes

Table 3 Monthly changes of dominant phytoplankton functional groups (FGs) in the investigated lakes from April to September.

Lake	Vransko	Visovačko	Kozjak	Prošće
IV	E	L_O, E	E	P, C, E, D
V	E	B	B, E	E, P
VI	L_O	B	B, D	-
VII	E, L_O	B	B	C
VIII	A, E, L_O	B	B	C, E
IX	E	B	B	C



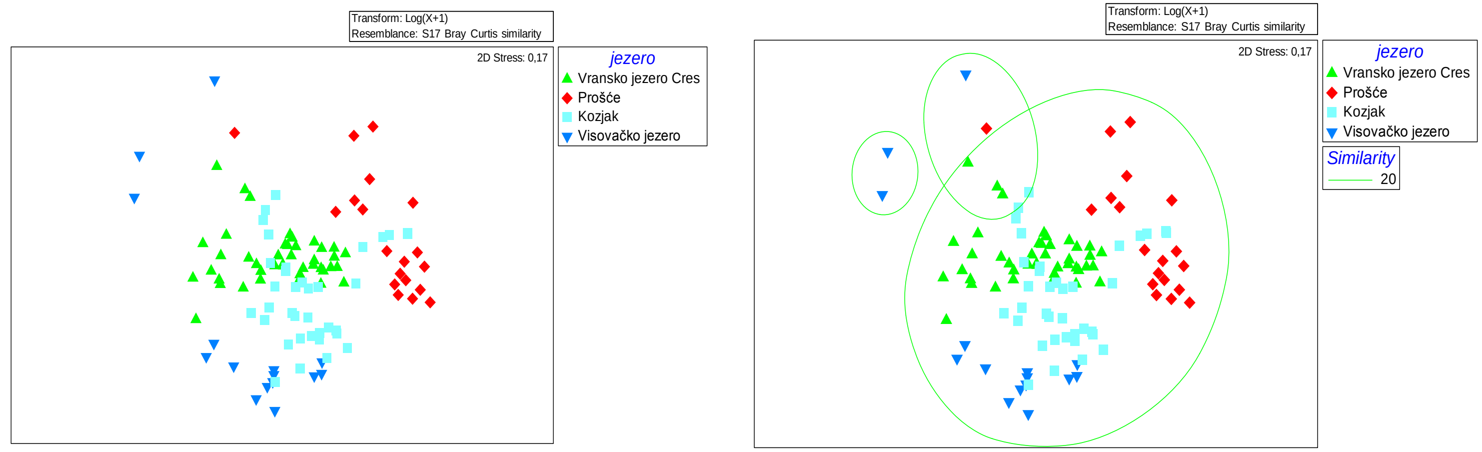
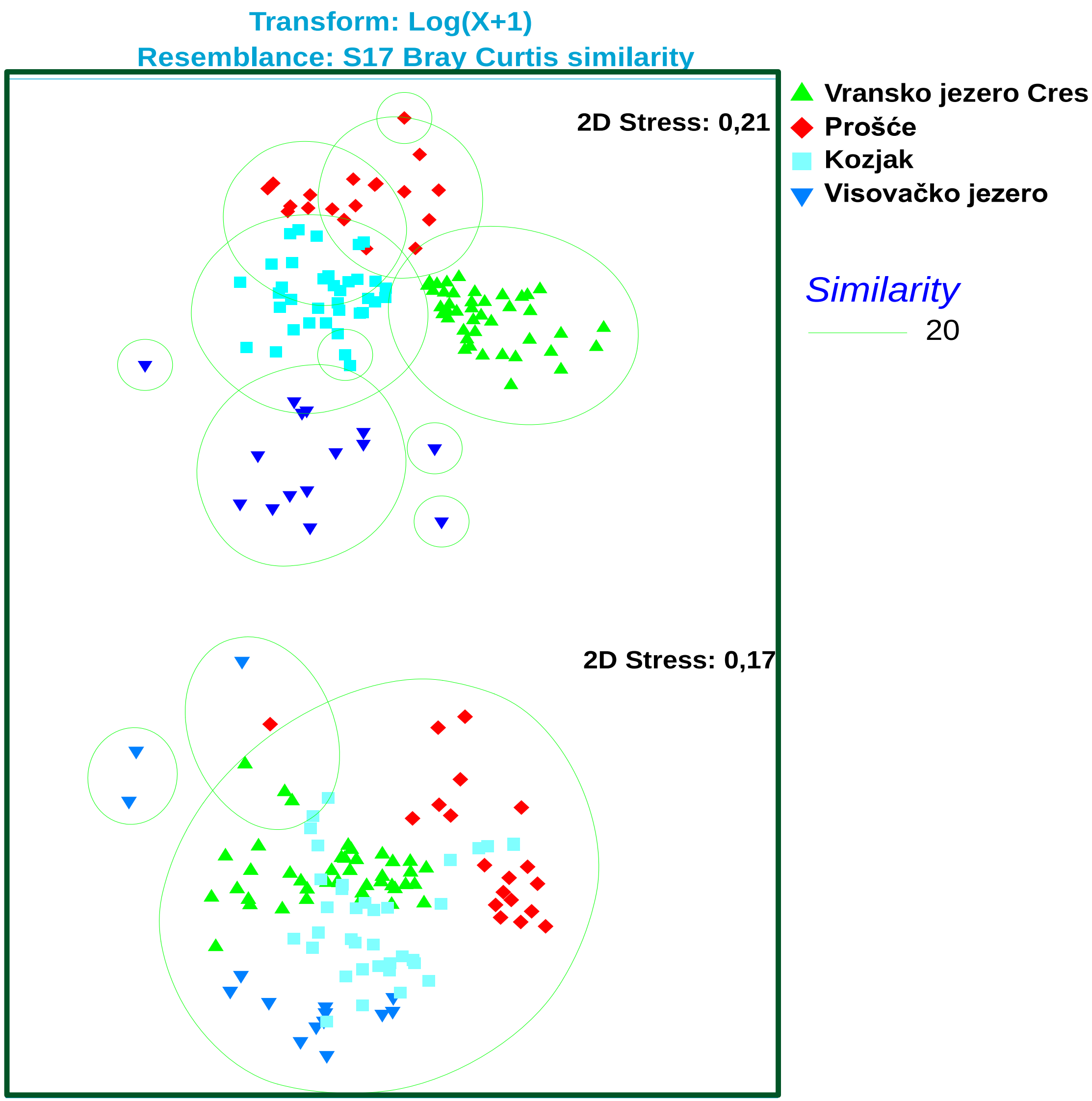


Fig. NMDS ordinations of: phytoplankton functional groups (FGs) with cluster overlap at 20% similarity.


Transform: Log(X+1)
Resemblance: S17 Bray Curtis similarity
2D Stress: 0,21
2D Stress: 0,17
Vransko jezero Cres
Prošće
Kozjak
Visovačko jezero
Similarity
20

Diversification of functional groups creates more coprehensive available empirical information for lakes and therefore increases the possibility of building a simple uniform pattern which successfully describes a variety of species in karstic deep lakes.

Deep stratified near-pristine or high-to-good status karstic lakes are attributed with the early spring (April) stratification forming, low total phytoplankton biomass, and with the maximum phytoplankton biomass accumulating in July. The co-occurrence of functional groups in those lakes is evident but typically distinct according to different biomass proportions. By linking several functional groups in four lakes across the Croatian karst we demonstrated regional distribution of phytoplankton in relation to the environment and showed possible uniform typifying pattern which was not evident in purely taxonomic observations of the lake assemblages.

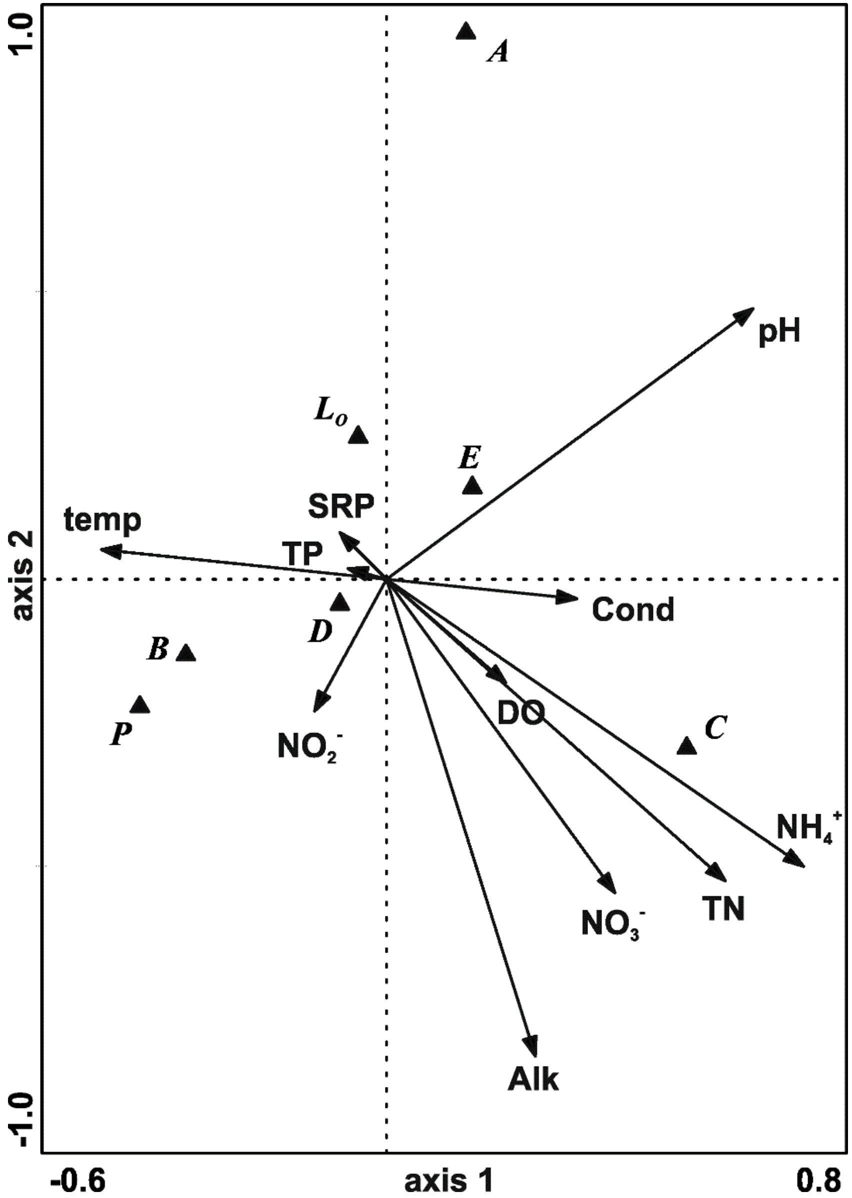


Fig. Biplots of the CCA based on the biomass of the functional groups (FGs).

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5°

Usefull

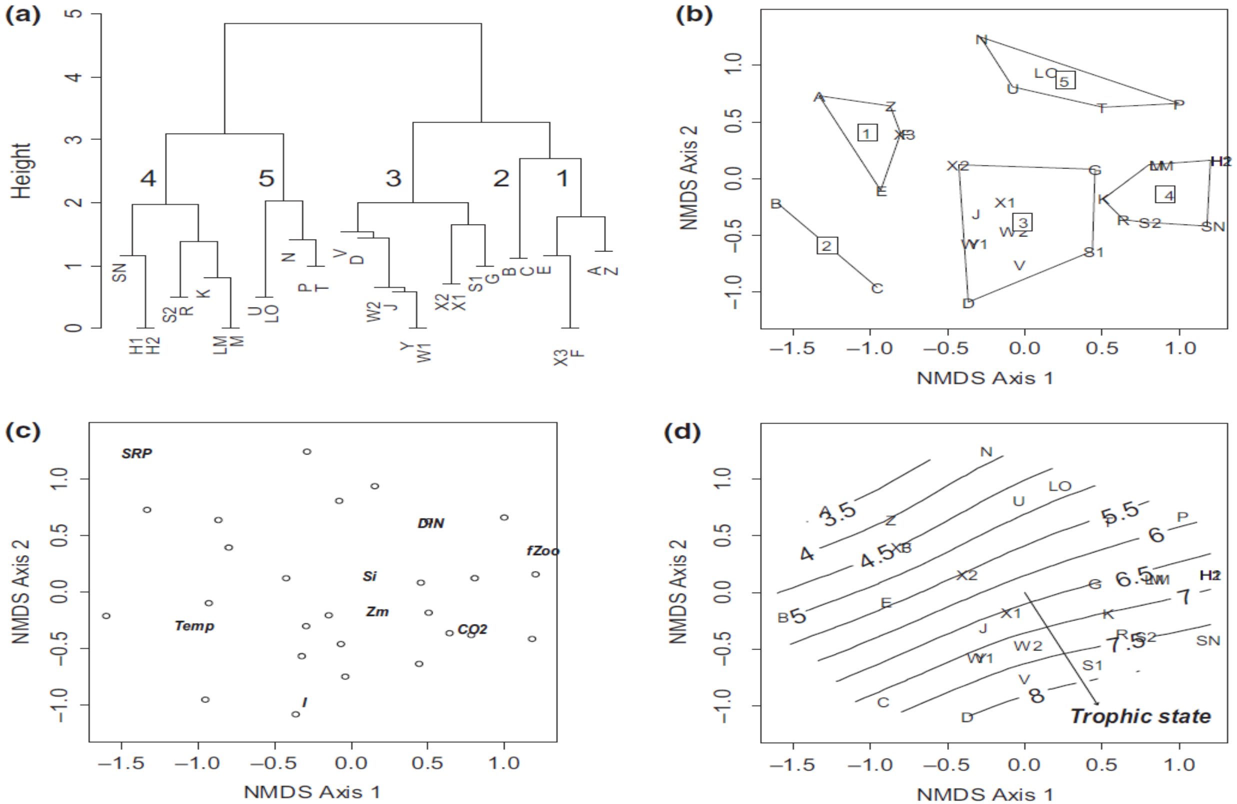

Fig. Classification (a) and NMDS ordination (b) of the *Functional Groups* (*FG*) defined by Reynolds *et al*. (2002). The numbers 1–5 divide the main *FG*. The analyses were carried out taking into account the environmental tolerance, that is, depth of the surface mixed layer (zm); mean daily irradiance (*I*); water temperature (*Temp*); soluble reactive phosphorus (*SRP*); dissolved inorganic nitrogen (*DIN*); soluble reactive silicon (*Si*); dissolved carbon dioxide (*CO2*); zooplankton grazing (*fZoo*). (c) Ordination of tolerances as weighted averages of *FG* scores. (d) Vector and surface fitting of trophic state coded numerically from 1 (ultraoligotrophy) to 9 (hypereutrophy).

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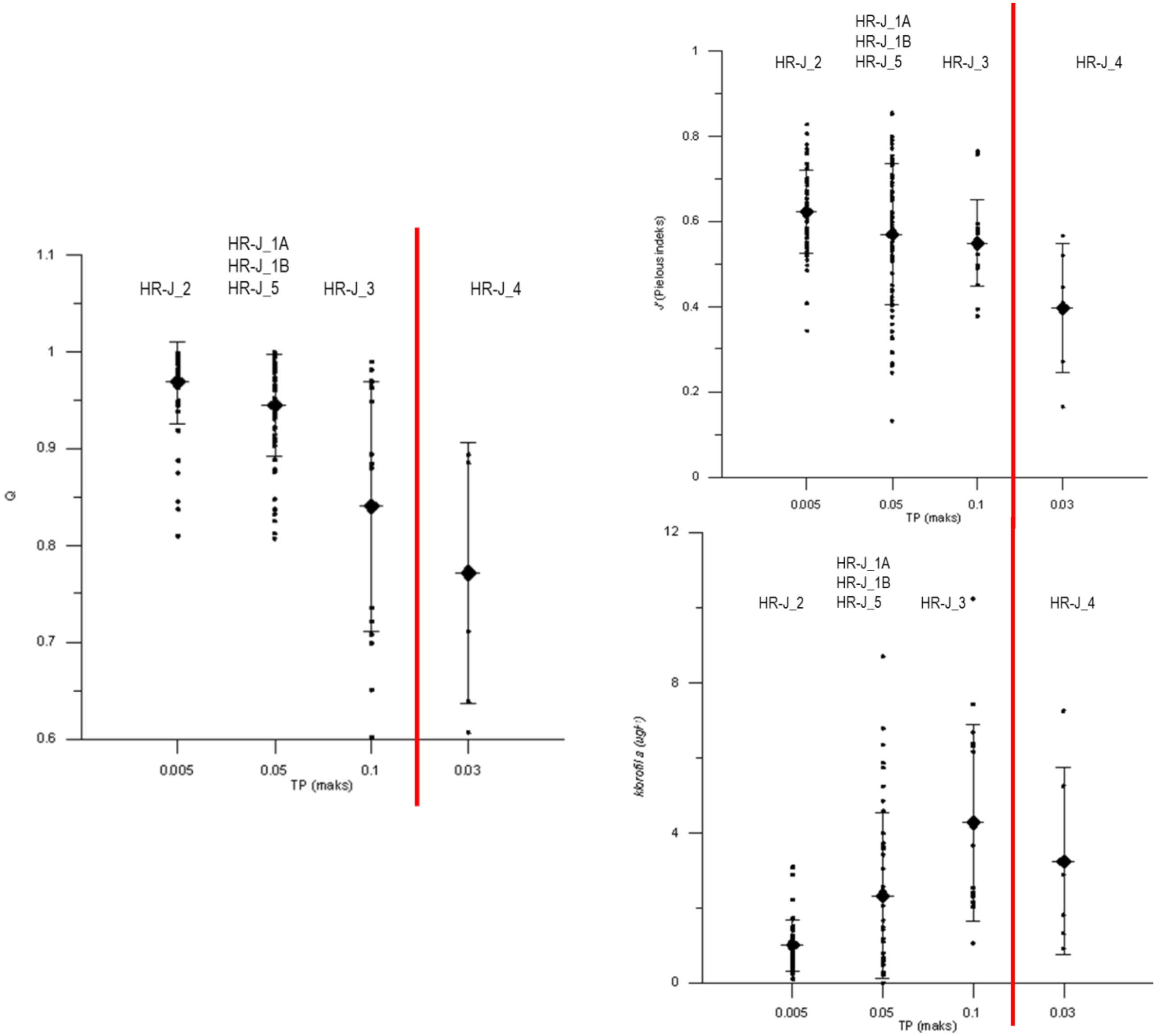

Fig Simulation and expertise on the water quality categorization of the lake based on the estimated maximum concentration of phosphorus.

PHYTOPLANKTON AS A FUNDAMENTALLY IMPORTANT PREDICTOR OF ENVIRONMENTAL CHANGES IN AQUATIC ECOSYSTEMS

PHYTOPLANKTON IS A FUNDAMENTALLY IMPORTANT PREDICTOR OF ENVIRONMENTAL CHANGES IN AQUATIC ECOSYSTEMS

Oligotrophic systems, are extremely sensitive to human impact. In the investigation of 600 lakes in Europe only 18% represented reference lakes with oligotrophic characteristics.

Phytoplankton approach presented in this study is a step forward to important conservation of such sensitive systems.

Freshwater Biology

Freshwater Biology (2014) doi:10.1111/fwb.12520

SPECIAL REVIEW

Functional classifications and their application in phytoplankton ecology

NICO SALMASO*, LUIGI NASELLI-FLORES† AND JUDIT PADISÁK‡

Table. Summary of analyses comparing different phytoplankton functional classifications

Origin/site	Data set	Functional classifications compared	Statistical methods	Reference
Large floodplain rivers: (Mura, Drava, Danube and Sava) (Croatia)	Spatial and temporal, 24 samples	*FG, MBFG*	Canonical Correspondence Analysis (CCA), Self-organising Maps (SOM)	Stanković *et al.* (2012)
87 Andalusian lakes and ponds (S-Spain)	Spatial, 87 samples	*FG, MBFG*	Pearson correlations, Generalised Linear Models (GLM)	Gallego *et al.* (2012)
Three Pampa lakes, three sites per lake (Argentina)	Spatial and temporal, 72 samples	*FG, MFG, MBFG*	Redundancy Analysis (RDA), Detrended Correspondence Analysis (DCA)	Izaguirre *et al.* (2012)
Three small reservoirs (S-China)	Spatial and temporal, 18 samples	*FG, MFG, MBFG*	CCA	Hu *et al.* (2013)
River Loire (France)	Spatial and temporal, 170 samples	*FG, MFG, MBFG*	SOM	Abonyi *et al.* (2014)
A lateral channel of the Upper Paraná floodplain (Brazil)	Temporal, 49 samples	*FG, MBFG*	PCA, CCA, Indicator Value Analysis (IndVal)	Bortolini *et al.* (2014)
Two deep karstic lakes (Plitvice NP, Croatia)	Temporal, 384 samples	*FG, MFG, MBFG*	Principal Components Analysis (PCA), CCA	Žutinić *et al.* (2014)

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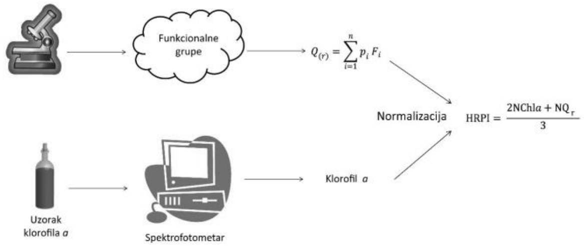


Ekološko stanje	HRPI
Dobro	>0,8
Vrlo dobro	0,8-0,6
Umjereno dobro	0,6-0,4
Loše	0,4-0,2
Vrlo loše	<0,2

$$Q = \sum_{i=1}^{n} p_i F_i$$

Stanković, Igor; Vlahović, Tatjana; Gligora Udovič, Marija; Várbíró, Gábor; Borics, Gábor (2012) Phytoplankton functional and morpho-functional approach in large floodplain rivers. Hydrobiologia, 698 (2012); 217-231.

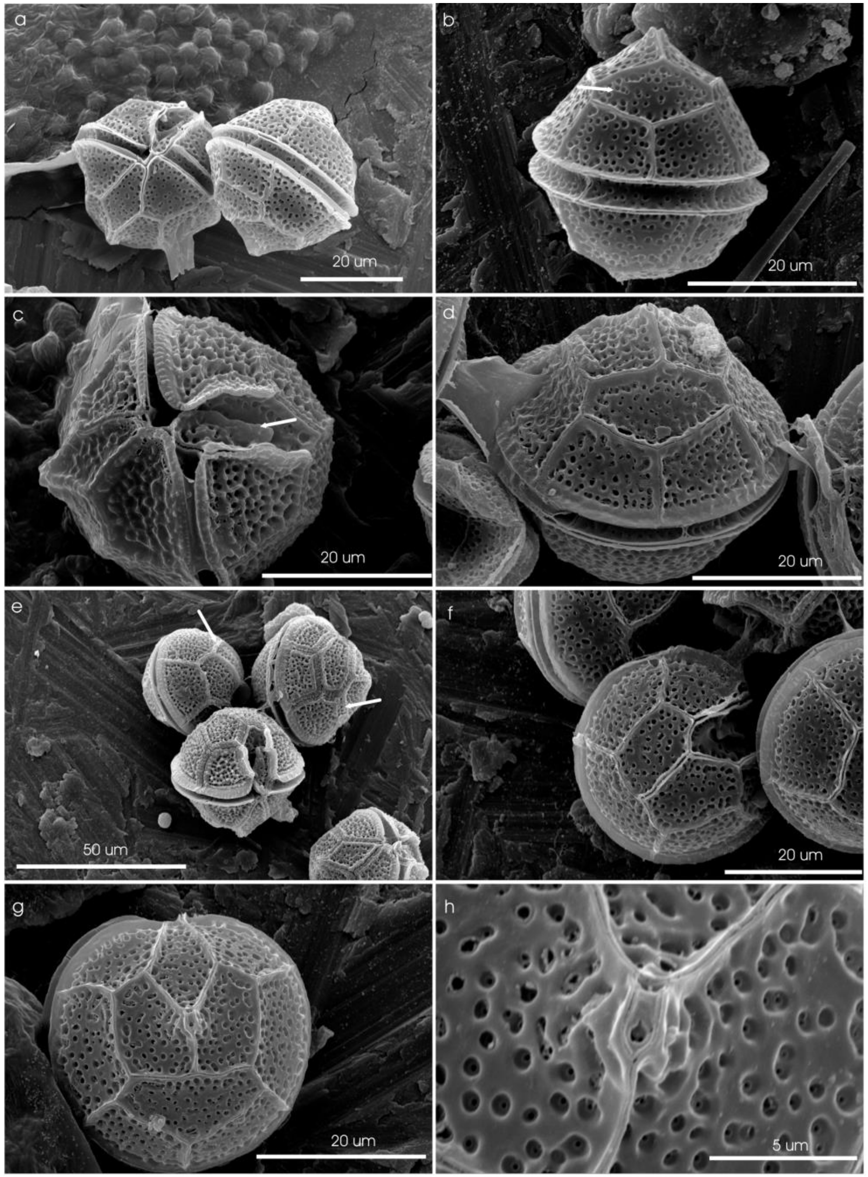
Mihaljević, M., Stević, F., Špoljarić, D., Žuna Pfeiffer, T., 2014. Spatial pattern of phytoplankton based on the morphology-based functional approach along a river-floodplain gradient. River Research and Applications, DOI: 10.1002/rra.2739.

Mihaljević, M., Špoljarić, D., Stević, F., Žuna Pfeiffer, T., 2013. Assessment of flood-induced changes of phytoplankton along a river–floodplain system using the morpho-functional approach. Environmental Monitoring and Assessment, 185: 8601-8619.

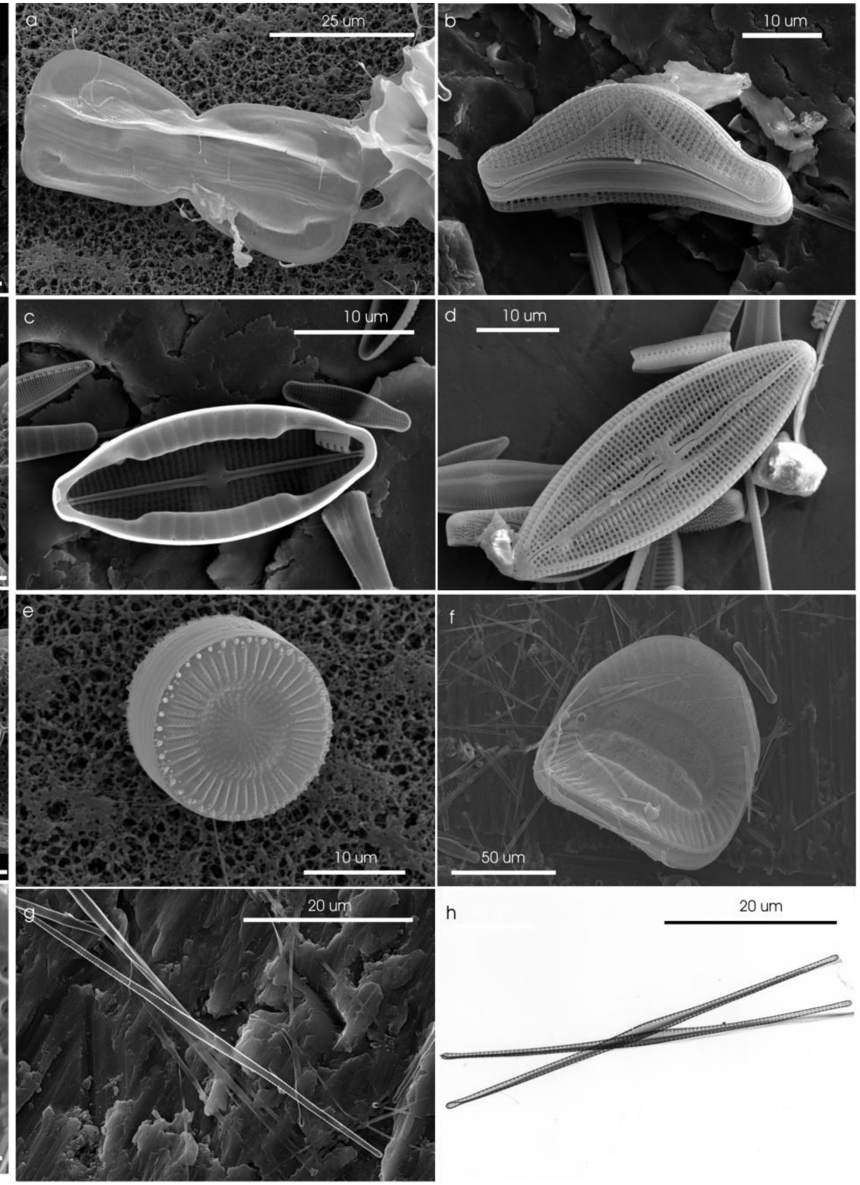
Stević, F., Mihaljević, M., Špoljarić, D., 2013. Changes of phytoplankton functional groups in a floodplain lake associated with hydrological perturbations. Hydrobiologia, 709: 143-158.

Žutinić P, Gligora Udovič M, Kralj Borojević K, Plenković-Moraj A, Padisák J (2014) Morpho-functional classifications of phytoplankton assemblages of two deep karstic lakes. Hydrobiologia. 740; 147-166.

Species specific adaptations to particular environmental conditions



PIV) *Peridiniopsis borgei* Lemmermann 3' 1a 6'' 7''' 2'''' - Vransko jezero
a) ventralna i dorzalna strana, b) dorzalna strana - interkalarna ploča, c) ventralna strana-vidljiv je sulkus, sulkalne ploče i pora, d) epiteka - vidljive su dvije od tri apikalne ploče, interkalarna i četiri od šest precingularnih ploča, e) hipoteka tri stanice različite starosti - vidljivo po različitoj debljini sutura, f) hipoteka 7''' 2'''' - sedam postcingularnih i dvije antapikalne ploče, g) epiteka 3' 1a 6''- tri apikalne ploče, jedna interkalarna i šest precingularnih ploča, h) apikalna pora.



PVIII) a) *Entomoneis alata* (Ehrenberg) Ehrenberg, b) *Epithemia sorex* Kützing, c) *Mastogloia* sp. Thwaites ex W. Smith (unutrašnja strana frustule), d) *Mastogloia* sp. (vanjska, valvalna strana frustule) Thwaites ex W. Smith, e) *Cyclotella meneghiniana* Kützing, f) *Campylodiscus clypeus* Ehrenberg, g) *Synedra* sp. Ehrenberg (SEM), h) *Synedra* sp. Ehrenberg (TEM)- Vransko jezero.

„Nije bitno koliko ste mali, bitno je da imate velike oči, bistar um i nekog pouzdanog uz sebe"

Hvala vam SVIMA na pažnji