Poročilo o delu Inštituta za vode Republike Slovenije za leto 2012

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PROJEKT: **I/1/2 EKOLOŠKO STANJE**

NALOGA: I/1/2/5 Sodelovanje v procesu interkalibracije
Interkalibracija metod vrednotenja ekološkega stanja - fitobentos

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PROGRAM:	Program dela IzVRS za leto 2012
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NASLOV NALOGE:	Interkalibracija metod vrednotenja ekološkega stanja - fitobentos
ŠIFRA NALOGE:	I/1/2/5
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KAZALO

KAZALO SLIK

KAZALO PREGLEDNIC

POVZETEK

Interkalibracija metod vrednotenja ekološkega stanja z biološkimi elementi kakovosti je obligacija vsake države članice Evrospke unije v skladu z Vodno direktivo. V letu 2012 se je zaključila druga faza ineterkalibracije. Glede na preliminarne rezultate interkalibracije in komentarje »peer-review« smo dopolnili mejne vrednosti za vrednotenje ekološkega stanja velikih rek na podlagi fitobentosa in podali obrazložitev, zakaj je Trofični indeks primeren tudi za vrednotenje ekološkega stanja jezer na podlagi fitobentosa, čeprav je bil razvit za vrednotenja ekološkega stanja rek. Ker smo poročila oz. znastvene obrazložitve pripravili za Evropsko komisijo, so pripravljena v angleščini.

1 PYHTOBENTHOS-BASED ASSESSMENT OF THE ECOLOGICAL STATUS OF LARGE RIVERS IN SLOVENIA

1.1 Introduction

Large rivers in Slovenia are defined as rivers with a catchment area >2500 km^2 and/or mean annual discharge >50 m^3/s (Urbanič 2011). However, in the "large river" intercalibration group only data from very large rivers (water-bodies with a catchment area >10000 km^2) were considered.

1.2 Official name of the assessment method

Metodologija vrednotenja ekološkega stanja rek s fitobentosom in makrofiti v Sloveniji; fitobentos (Ecological status assessment system for rivers using phytobenthos and macrophytes in Slovenia; Phytobenthos)

1.3 Assessment system

Ecological status assessment system for rivers using phytobenthos and macrophytes in Slovenia consists of 2 modules:

- Organic pollution: Saprobic index (Zelinka & Marvan 1961, Rott et al. 1997) based on diatom data
- Eutrophication: Trophic index (Rott et al. 1999) based on diatom data and RMI (Kuhar et al. 2011) based on macrophytes (RMI is not always applicable)

Final classification of the water body is obtained using worst case approach of both modules (Fig. 1).

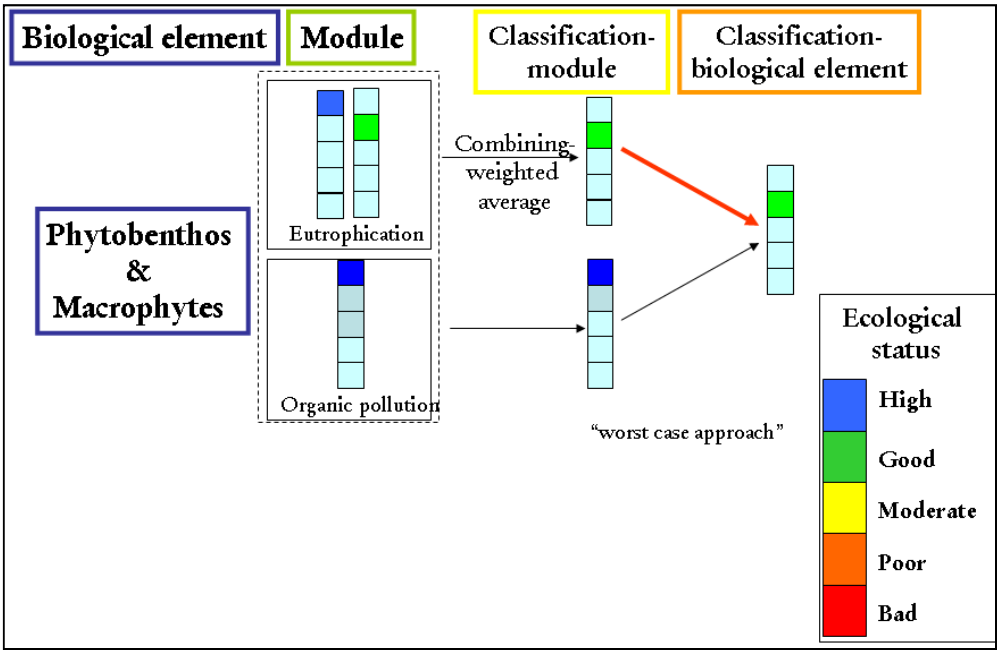

Figure 1. Phytobenthos and macrophytes-based classification of Slovenian rivers.

For the intercalibration purpose of phytobenthos-based assessment methods and ecological quality boundary values EQRs were defined not including a macrophyte metric (RMI index). Thus, EQR was obtained calculating minimum of transformed EQRs of Trophic index and Saprobic index (Tabs 2-4).

1.4 Reference conditions

Reference values of both indices (Trophic and Saprobic index) for large rivers were defined using regression equations between log total phosphorous values and indices. Reference values were calculated as index values at log TP = -2 (TP = 10 ug/L).

Ecological class boundary setting

Boundary setting

a) High/Good and Good/Moderate boundaries were derived from metric variability at stressor class 1.

b) Other boundaries (Moderate/Poor and Poor/Bad) by equidistant division.

Boundary description

a) High/Good boundary was defined as 10th percentile value of the pressure class 1 (out of three).
b) Good/Moderate boundary was defined as 50th percentile value of the pressure class 1 (out of three).
c) Other boundary values (Moderate/Poor and Poor/Bad) were defined using equidistant division of the remaining EQR gradient.
d) Lower anchor was defined as highest possible index value based on the Slovenian operational taxa list; it is not maximum index value.

Boundary community

Expressed by specific metric values (Trophic index and Saprobic index), no verbal description.

1.5 Ecological classification

Original boundary values of the Saprobic and Trophic Index describing ecological classes are given in the Table 1.

Table 1. Boundary values and normalised boundary values of the Saprobic index and Trophic index.

Boundary value	SI	SI_EQR	TI	TI_EQR
Reference value	1.74	1	1.96	1
High/Good	1.87	0.94	2.39	0.78
Good/Moderate	2.02	0.86	2.94	0.49
Moderate/Poor	2.61	0.58	3.26	0.33
Poor/Bad	3.21	0.29	3.58	0.16
Lower anchor	3.80	0	3.90	0

In order to combine EQR values in the final BQE based EQR and to compare EQR values with other Biological quality elements EQR values, all values were pieceweise lineary transformed and five equidistant classes were obtained (Tables 2-4).

Table 2. Piecewise linear transformation equations for Saprobic Index (SI).

SI_EQR	SI_EQR_transformed
>0.94	0.8+0.2*(SI_EQR-0.95)/(0.05)
0.94-0.86	0.6+0.2*(SI_EQR-0.86)/(0.08)
0.85-0.58	0.4+0.2*(SI_EQR-0.58)/(0.27)
0.57-0.29	0.2+0.2*(SI_EQR-0.29)/(0.28)
<0.29	0.2*(SI_EQR)/(0.28)

Table 3. Piecewise linear transformation equations for Trophic Index (TI).

TI_EQR	TI_EQR_transformed
>0.78	0.8+0.2*(TI_EQR-0.79)/(0.21)
0.78-0.49	0.6+0.2*(TI_EQR-0.49)/(0.29)
0.48-0.33	0.4+0.2*(TI_EQR-0.33)/(0.15)
0.32-0.16	0.2+0.2*(TI_EQR-0.16)/(0.16)
<0.16	0.2*(TI_EQR)/(0.15)

Table 4. Transformed boundary values between five ecological status classes of the Ecological status assessment system for rivers using phytobenthos and macrophytes in Slovenia; phytobenthos (PhB_transformed).

Boundary	PhB_transforme
High/Good	0,8
Good /Moderate	0,6
Moderate/Poor	0,4
Poor /Bad	0,2

1.6 Pressure-impact relationships – phytobenthos

Based on very large river data, there was a significant relationship between logarithmic value of the total phosphorous and EQR values of the Ecological status assessment system for rivers using phytobenthos and macrophytes in Slovenia with phytobenthos data (Fig. 2).

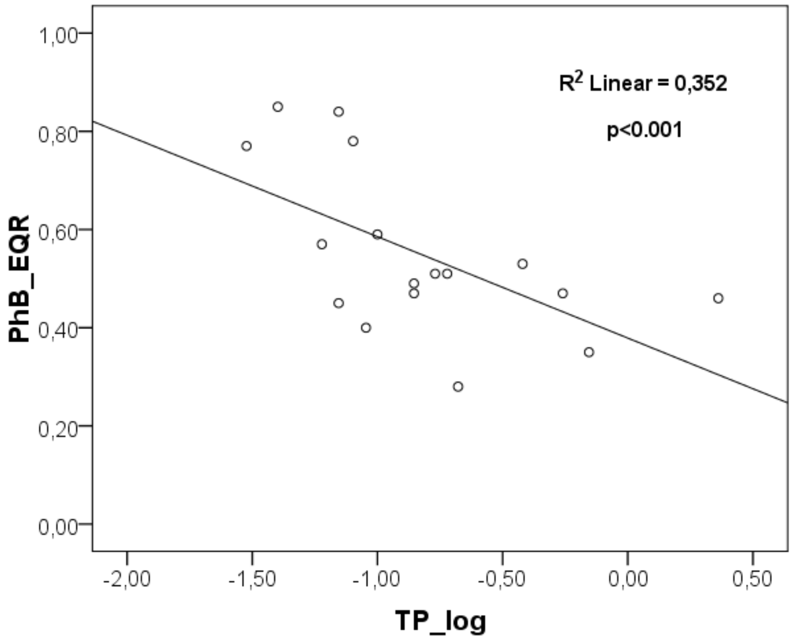

Figure 2. Regression plot of total phosphorous (log transformed data – TP_log) against phytobenthos-based Slovenian national EQR values (PhB_EQR) in large rivers of Slovenia.

1.7 **References**

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2 USING (RIVER) TROPHIC INDEX FOR ASSESSMENT OF THE LAKE TROPHIC STATUS IN SLOVENIA

2.1 Introduction

Phytobenthos and macrophytes are one biological element under the Water Framework Directive (Directive 2000/60/ES). In Slovenian lake ecological classification system both sub-elements are used together as one element. Phytobenthos assessment system consists of one metric - Trophic Index (Rott et al. 1998). Trophic Index is calculated as weighted average of the diatom taxa trophic values (TW), where taxa abundance (H), and taxa indicative weights (G) are weighting factors. Individual trophic values (TW) and indicative weights (G) were defined according to the occurrence of the diatom taxa along the eutrophication gradient in rivers (Rott et al. 1998).
The aim of our work is to show that (River) Trophic Index (Rott et al. 1998) can provide a reliable assessment of the trophic status of lakes using lake littoral diatoms.

2.2 Study area

Altogether, 13 lakes were investigated and 96 diatom samples were taken between 2005 and 2011 (Tabs. 1-2).

Table 5. The main characteristics of the studied lakes.

Lake	Ecoregion (Urbanič 2008)	Elevation (m a.s.l.)	Surface area (km^2)	Volume (Mio m^3)	Depth - maximum (m)	Average depth (m)
Blejsko jezero	Alps	475	1.43	26.6	31	19
Bohinjsko jezero	Alps	526	3.28	92.4	45	28
Družmirsko jezero	Alps	360	0.70	25.0	87	24
Velenjsko jezero	Alps	367	1.35	25.0	55	19
Klivnik	Dinaric western Balkan	460	0.36	4.3	20	9
Mola	Dinaric western Balkan	450	0.68	4.3	12	6
Gajševsko jezero	Pannonian lowland	206	0.77	2.6	10	~3
Ledavsko jezero	Pannonian lowland	225	2.18	5.7	5	~3
Pernica 1	Pannonian lowland	245	0.57	1.2	4	3
Pernica 2	Pannonian lowland	245	0.66	2.1	4	3
Slivniško jezero	Pannonian lowland	292	0.84	4.0	14	5
Šmartinsko jezero	Pannonian lowland	265	1.07	6.5	12	6
Vogeršček	Po lowland	101	0.82	8.5	20	10

Table 6. Number of sampling sites for each lake and year of sampling.

Lake/year	2005	2006	2007	2008	2009	2010	2011	Sum
Blejsko jezero	3		7		7	3		**20**
Bohinjsko jezero	3		7		7	3		**20**
Družmirsko jezero							3	**3**
Velenjsko jezero					3		3	**6**
Klivnik				3				**3**
Mola				3				**3**
Gajševsko jezero		3					3	**6**
Ledavsko jezero		3					3	**6**
Pernica 1		3						**3**
Pernica 2		3					3	**6**
Slivniško jezero					3		3	**6**
Šmartinsko jezero		5					3	**8**
Vogerščček		3		3				**6**
Sum	**6**	**20**	**14**	**9**	**20**	**6**	**21**	**96**

Physico-chemical parameters and chlorophyll *a* were measured 4 times a year in a vegetation period. Water samples were taken at the deepest part of the lake (Table 3).

Table 7. Minimum and maximum values of measured parameters of the whole dataset and used in the development and validation dataset for Lake Littoral Trophic Index.

	Dataset	Whole		Development		Validation	
Parameter	**Code**	min	max	min	max	min	max
Total Phosphorous – mean (μg/L)	TP-log	3,6	224,0	4,0	224,0	3,6	101,0
Total Nitrogen – mean (μg/L)	TN-log	296	1693	299	1693	296	1534
Secchi depth – mean (m)	Secchi depth	0,3	9,7	0,3	9,0	0,3	9,7
Chlorophyll *a* – mean (μg/L)	Chlorophyll	1,0	37,6	1,0	36,4	1,0	37,6

2.3 **Trophic Index (TI)**

Trophic Index (Rott et al. 1998) is calculated according to the equation:

$$TI = \frac{\sum_{i=1}^{n} TWi * Gi * Hi}{\sum_{i=1}^{n} Gi * Hi}$$

where

TI = Trophic index

TWi = Trophic value of the taxon »i«

Gi = Indicative weight of the taxon »i«

Hi = Abundance of the taxon »i«

Trophic index shows a response to eutrophication. In lakes of Slovenia we have found a good relationship between mean annual total phosphorous concentrations in lakes and the Trophic Index (Fig. 6).

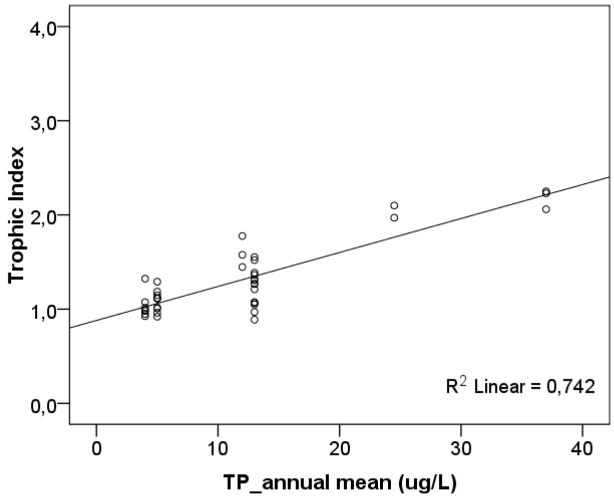

Figure 3. Regression plots of the mean annual Total phosphorous vs. Trophic Index using diatom data from alpine lakes (Slovenian intercalibration dataset).

Comparison of reference and non-reference sites in alpine lakes revealed significant differences in the Trophic Index (Fig. 7).

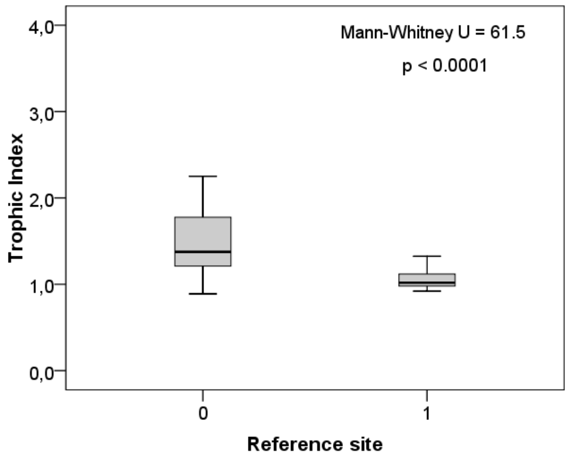

Figure 4. Distribution of Trophic index values between reference (1) and impaired (0) sites of the alpine lakes (Slovenian intercalibration dataset) with the results of the Mann-Whitney U-test.

On average slightly more than 33 diatoma taxa were present in lake littoral samples (Fig. 8). The number of taxa ranged from 10 to 56, whereas in alpine lakes from 25 to 49 (Figs. 9-10). Number of indicator taxa used for the calculation of the Trophic Index ranged from 8 to almost 50, whereas in alpine lakes from 20 to 42 (Figs. 10-11). Percentage of Trophic Index indicator taxa in the diatom sample was always relatively high and on average exceeds 80 % of the present diatom taxa. Only in one diatom sample indicator taxa represent <60% (Fig. 12). In the alpine lake littoral samples percentage of indicator diatom taxa was never below 70% whereas the mean percentage was even slightly higher in comparison to all considered samples (Fig. 13).

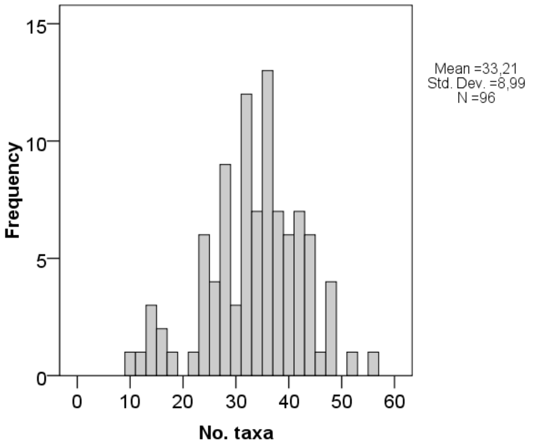

Figure 5. Frequency distribution of number of taxa in lake littoral diatom samples.

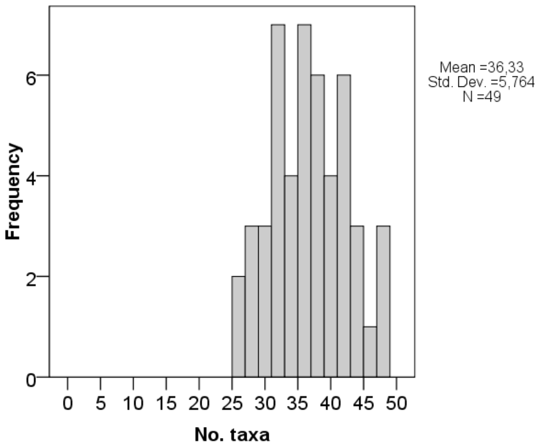

Figure 6. Frequency distribution of number of taxa in alpine lake littoral diatom samples.

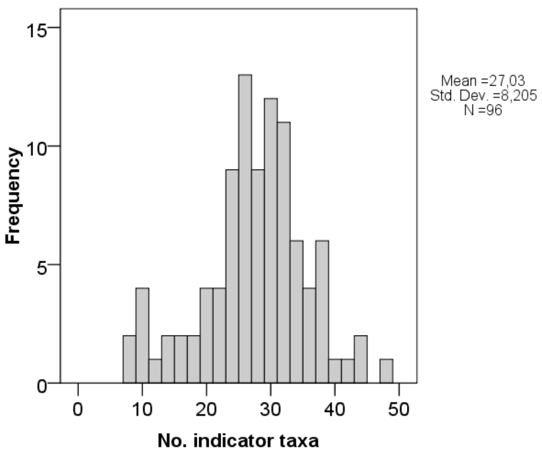

Figure 7. Frequency distribution of number of Trophic Index indicator taxa in lake littoral diatom samples.

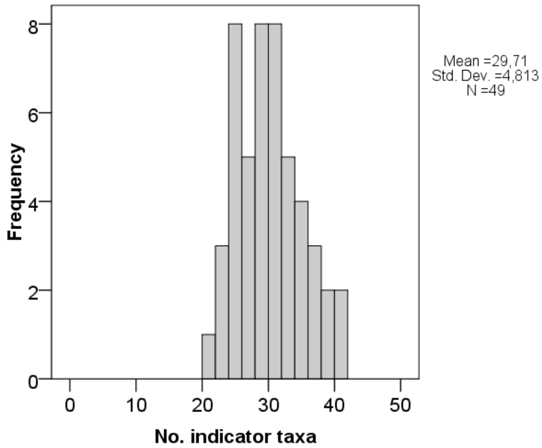

Figure 8. Frequency distribution of number of Trophic Index indicator taxa in alpine lake littoral diatom samples.

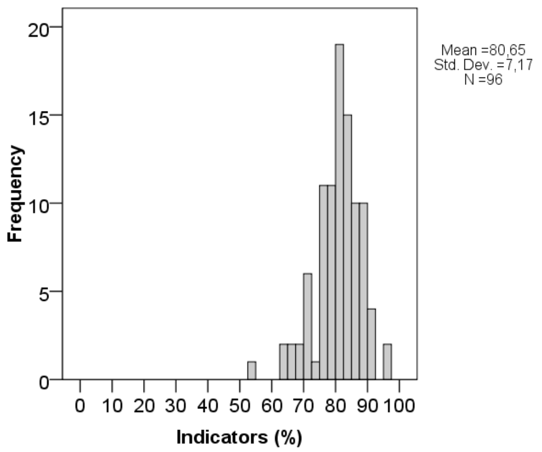

Figure 9. Frequency distribution of percentage of Trophic Index indicator taxa in lake littoral diatom samples.

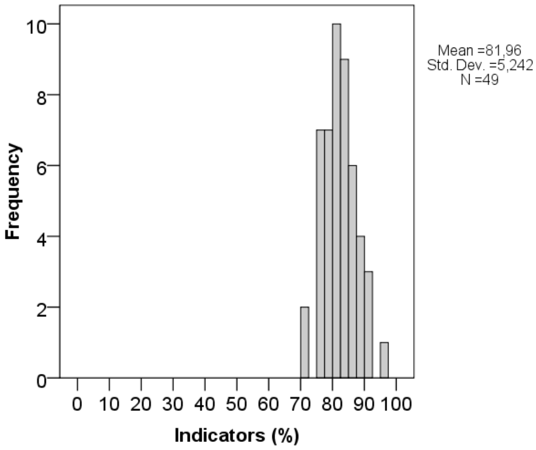

Figure 10. Frequency distribution of percentage of Trophic Index indicator taxa in alpine lake littoral diatom samples.

2.4 **Lake Littoral Trophic Index (LLTI)**

A whole dataset was divided in a development dataset (62 sites) and a validation dataset (34 sites). A Lake Littoral Trophic Index was developed using a development dataset. A canonical correspondence analysis (CCA) was performed with 185 diatom taxa (Appendix 1) and four environmental parameters (Tables 3-4, Fig. 1).

Table 8. Marginal (Lambda 1) and conditional (Lambda A) effects of the environmental parameters, P-value and F-value.

Variable-code	**Lambda 1**	**Lambda A**	**P**	**F**
Chlorophyll	0.45	0.45	0.001	6.76
TP-log	0.44	0.24	0.001	3.86
Secchi depth	0.37	0.15	0.001	2.45
TN-log	0.29	0.22	0.001	3.45

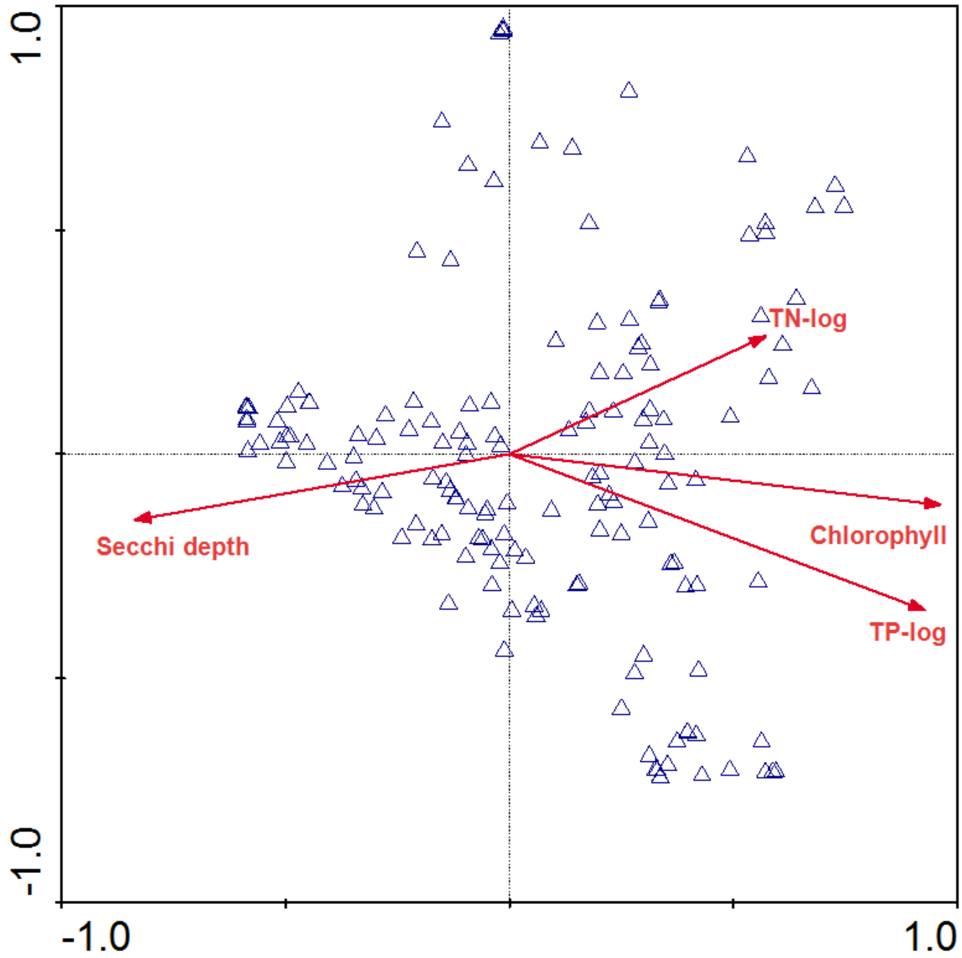

Figure 11. CCA ordination diagram with 185 diatom taxa (open triangles) and four environmental variables (arrows)

The LLTI was developed using trophic preferences (diatom trophic values - Dtv) and tolerance (trophic indicative weights - Tiw) of taxa along the first CCA axes. Diatom trophic values (Dtv) were then determined using CCA ordination axis 1 species scores (biplot scaling):

$$Dtv_i = \frac{SC\_CCA1_i}{SC\_CCA1_{max}} \quad ...(1)$$

where SC_CCA1i is the CCA ordination axis 1 species score (biplot scaling) of the i-th taxon and SC_CCA1max is the absolute maximum value of the CCA ordination axis 1 species score (biplot scaling). Trophic indicative weights (Tiw) were determined using the CCA ordination axis 1 species tolerance (root mean squared deviation for species) according to Table 5.

Table 9. Determination of the trophic indicative weight (Tiw) from the CCA axis 1 species tolerance (root mean squared deviation for species).

Tolerance (t_i)	Tiw
t_i <0.2	5
0.2< t_i <0.4	4
0.4< t_i <0.6	3
0.6< t_i <0.8	2
t_i >0.8	1

The LLTI was calculated according to the following equation:

$$LLTI_j = \frac{\sum_{i=1}^{n} a_i * Dtv_i * Tiw_i}{\sum_{i=1}^{n} a_i * Tiw_i} \qquad ...(2)$$

where a_i is the abundance of the i-th taxon, Dtv_i is the diatom trophic value of the i-th taxon, Tiw_i is the trophic indicative weight of the i-th taxon and n is the number of indicative taxa.

A good relationship was observed between annual mean total phosphorous concentration (log value) and LLTI using development (R^2 = 0.85) and validation dataset (R^2 = 0.70) (Figs. 2-3). Statistically significant differences were observed in LLTI values between reference sites and impaired sites using data from all lakes (Mann-Whitney U = 71, $p < 0.0001$) and from alpine lakes (Mann-Whitney U = 67, $p < 0.0001$) (Figs. 4-5).

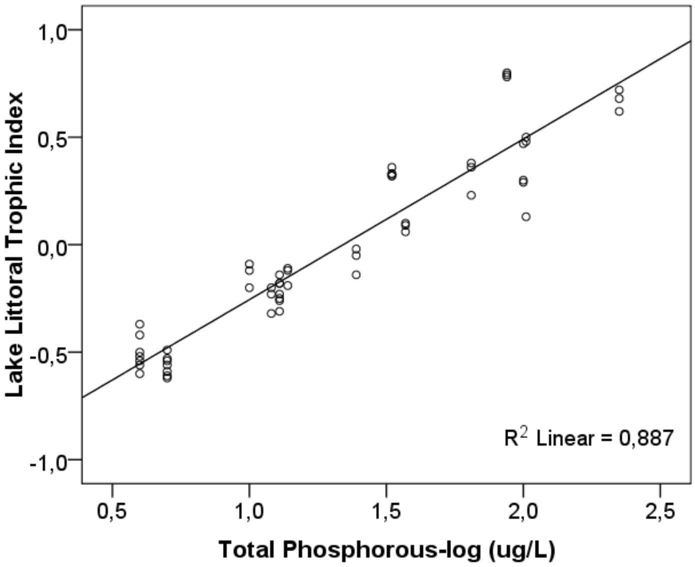

Figure 12. Regression plots of of the mean annual Total phosphorous (log value) vs. Lake Littoral Trophic Index using a diatom development dataset

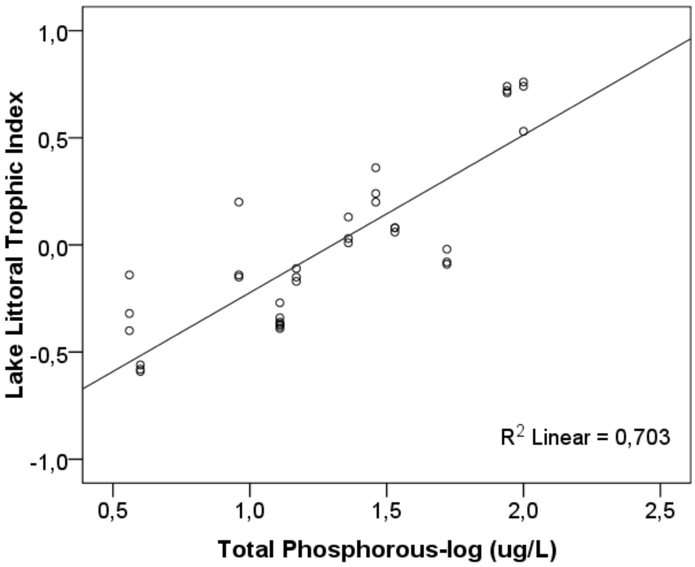

Figure 13. Regression plots of the mean annual Total phosphorous (log value) vs. Lake Littoral Trophic Index using a diatom validation dataset

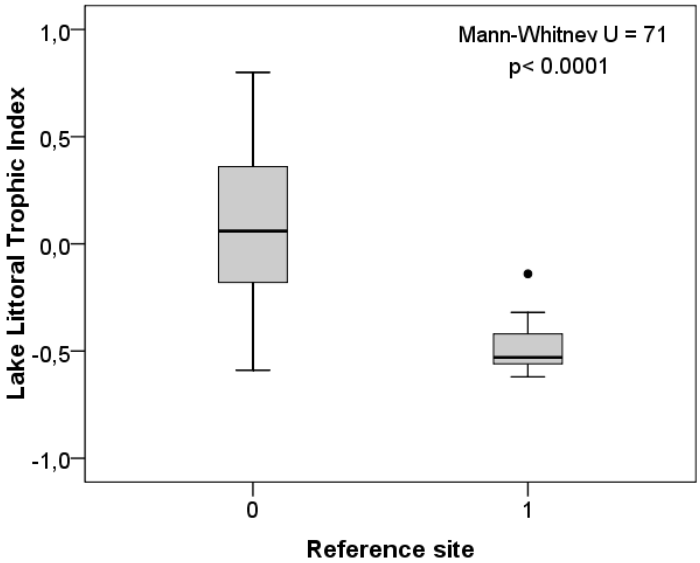

Figure 14. Boxplots of the Lake Littoral Trophic Index values recorded at reference (1) and impaired (0) sites with the results of the Mann-Whitney U-test

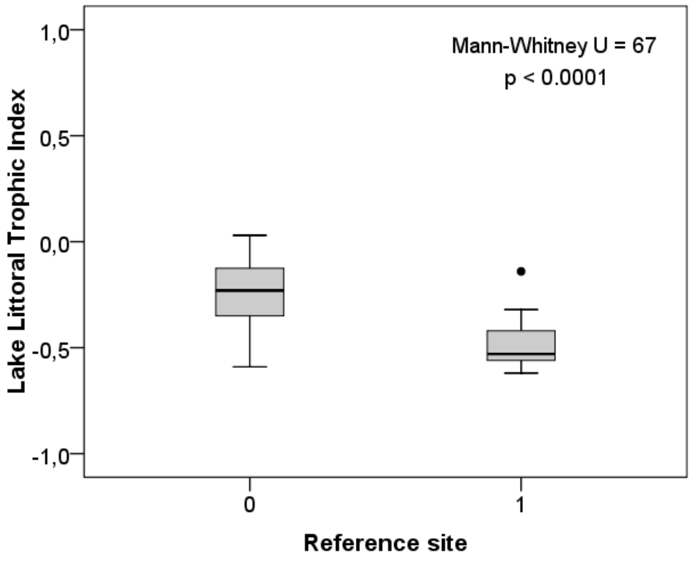

Figure 15. Boxplots of the Lake Littoral Trophic Index (LLTI) values recorded at reference (1) and impaired (0) sites of the alpine lakes with the results of the Mann-Whitney U-test

2.5 **Trophic Index (TI) vs. Lake Littoral Trophic Index (LLTI)**

A good relationship was observed between TI and LLTI using samples from all lakes (R^2 = 0.85) and alpine lakes (R^2 = 0.74) (Figs. 14-15).

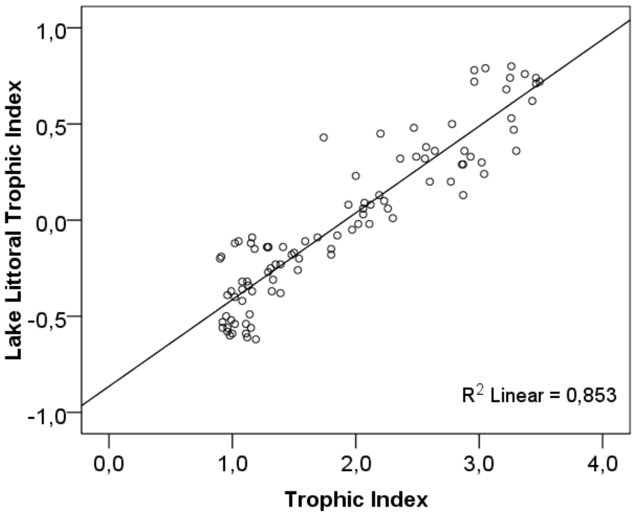

Figure 16. Regression plots of the Trophic Index vs. Lake Littoral Trophic Index using data from all lakes.

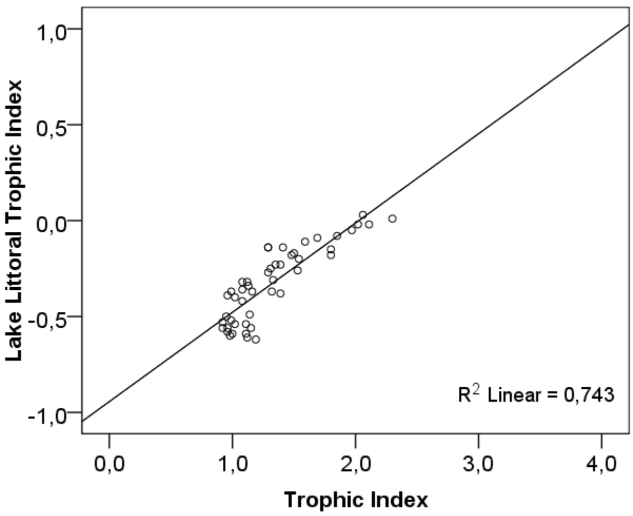

Figure 17. Regression plots of the Trophic Index vs. Lake Littoral Trophic Index using data from alpine lakes.

2.6 **Summary**

1. (River) Trophic Index (TI) showed good relationship with lake total phosphorous concentrations.
2. Reference sites showed statistically significantly lower TI values than impaired sites.
3. High percentage of diatom taxa occurring in considered littoral samples have assigned trophic values (TW) according to Rott et al. (1998); on average >80% of recorded taxa. In alpine lakes >70% of diatom taxa recorded in each littoral sample were indicator taxa.
4. In the each littoral diatom sample at least eight TI indicator taxa were recorded, whereas on average >25. In samples of alpine lakes at least 20 indicative taxa occurred in the each sample.
5. A relationship between lake littoral diatom taxa and environmental variables representing eutrophication gradient in lakes was tested using Canonical correspondence analysis. Data were collected from varied lake types (lowland and alpine lakes).
6. A new Lake Littoral Trophic Index (LLTI) was developed using littoral diatom data and four environmental variables representing eutrophication gradient.
7. Lake Littoral Trophic Index (LLTI) showed good relationship with mean annual total phosphorous concentration (log data) using development (R^2 = 0.85) and validation dataset (R^2 = 0.70).
8. Reference sites showed statistically significantly lower LLTI values than impaired sites using all data and alpine data.
9. (River) Trophic Index showed a good relationship with new developed Lake Littoral Trophic Index (LLTI) using samples from all lakes (R^2 = 0.85) and alpine lakes (R^2 = 0.74).

2.7 **Conclusions**

(River) Trophic Index (TI) showed a good relationship with the eutrophication gradient. A statistically significant difference in TI was observed between reference and impaired sites and high percentage of recorded littoral diatom taxa was indicative according to TI in all samples. Moreover, a new developed littoral diatom-based trophic index (LLTI) was highly correlated with the (River) Trophic Index using all data and alpine data only. Thus, diatom-based (River) Trophic Index might considerable well address eutrophication pressure in lakes, although lake littoral diatom specific indices might be more applicable.

2.8 References

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Appendix 1. List of developed diatom trophic values (Dtv) and trophic indicative weights (Tiw) of diatom taxa for calculation of the Lake Littoral Trophic Index (LLTI).

Taxon	Omnidia code	Dtv	Tiw
Achnanthes helvetica	AHAL	-0,44	5
Achnanthes biasolletiana	ABIA	-0,28	5
Achnanthes bioretii	ABIO	-0,78	5
Achnanthes clevei	ACLE	0,49	1
Achnanthes exiqua	AEXG	0,49	1
Achnanthes flexella	AINF	-0,37	5
Achnanthes hungarica	AHUN	0,80	1
Achnanthes lanceolata	ALAN	0,25	3
Achnanthes minutissima v. gracillima	AMGR	-0,65	5
Achnanthes minutissima	AMIN	-0,04	5
Achnanthes oblongella	AOBG	0,09	5
Achnanthes sp.	ACHS	0,42	2
Achnanthes minutissima v.saprophila	AMSA	0,80	1
Amphora aequalis	AAEQ	-0,02	5
Amphora montana	AMMO	0,39	2
Amphora ovalis	AOVA	0,37	2
Amphora lybica	ALIB	0,34	3
Amphora pediculus	APED	0,13	4
Amphora sp.	AMPS	-0,79	5
Amphipleura pellucida	APEL	-0,12	5
Brachysira vitrea	BVIT	-0,66	5
Anomoeoneis sphaerophora	ASPH	0,45	2
Anomoeoneis vitrea	AVIT	-0,07	5
Asterionella formosa	AFOR	0,19	4
Caloneis alpestris	CAPS	-0,44	5
Caloneis amphisbaena	CAMP	-0,02	5
Caloneis bacillum	CBAC	-0,13	5
Caloneis silicula	CSIL	0,36	2
Fragilaria arcus	FARC	-0,02	5
Cocconeis pediculus	CPED	-0,13	5
Cocconeis placentula	CPLA	0,31	3
Cyclotella meneghiniana	CMEN	0,75	1
Cyclotella ocellata	COCE	0,45	2
Cyclotella sp.	CYLS	0,36	2
Cymatopleura elliptica	CELL	-0,05	5
Cymatopleura solea	CSOL	-0,20	5
Cymbella affinis	CAFF	-0,30	5
Cymbella amphycephala	CAPH	-0,05	5
Cymbella caespitosa	CCAE	0,02	5
Cymbella cesatii	CCES	-0,69	5
Cymbella cistula	CCIS	0,20	4

Appendix 1. continued

Taxon	Omnidia code	Dtv	Tiw
Cymbella delicatula	CDEL	-0,75	5
Cymbella ehrenbergii	CEHR	0,07	5
Cymbella falaisensis	CFAL	-0,18	5
Cymbella helvetica	CHEL	-0,60	5
Cymbella incerta	CINC	-0,19	5
Cymbella lanceolata	CLAN	-0,01	5
Cymbella microcephala	CMIC	-0,23	5
Cymbella minuta	CMIN	-0,38	5
Cymbella naviculiformis	CNAV	-0,79	5
Cymbella sp.	CYMS	0,78	1
Cymbella prostrata	CPRO	0,33	3
Cymbella silesiaca	CSLE	-0,29	5
Cymbella sinuata	CSIN	-0,61	5
Cymbella tumida	CTUM	0,53	1
Denticula kuetzingii	DKUE	-0,12	5
Denticula tenuis	DTEN	-0,68	5
Diatoma moniliformis	DMON	-0,08	5
Diatoma vulgaris	DVUL	-0,20	5
Diploneis elliptica	DELL	0,24	3
Diploneis oblongella	DOBL	-0,02	5
Diploneis ovalis	DOVA	-0,79	5
Diploneis subconstricta	DSCO	-0,79	5
Epithemia sorex	ESOR	-0,12	5
Epithemia adnata	EADN	-0,54	5
Eunotia arcus	EARC	-0,63	5
Eunotia bilunaris	EBIL	-0,28	5
Fragilaria capucina	FCAP	-0,05	5
Fragilaria capucina v. austriaca	FCAU	-0,47	5
Fragilaria capucina v. capucina	FCAP	-0,23	5
Fragilaria capucina v. distans	FCDI	-0,02	5
Fragilaria construens	FCON	-0,07	5
Fragilaria crotonensis	FCRO	0,26	3
Fragilaria leptostauron	FLEP	-0,78	5
Fragilaria pinnata	FPIN	-0,16	5
Fragilaria capucina v. vaucheriae	FCVA	-0,05	5
Frustulia vulgaris	FVUL	-0,13	5
Gomphonema angustatum	GANG	-0,79	5
Gomphonema augur	GAUG	0,49	1
Gomphonema clavatum	GCLA	-0,50	5
Gomphonema gracile	GGRA	0,31	3
Gomphonema micropus	GMIC	-0,32	5
Gomphonema minutum	GMIN	-0,23	5
Gomphonema pumilum	GPUM	-0,40	5
Gomphonema olivaceum	GOLI	0,21	4

Appendix 1. continued

Taxon	Omnidia code	Dtv	Tiw
Gomphonema parvulum	GPAR	0,46	1
Gomphonema sp.	GOMS	-0,09	5
Gomphonema truncatum	GTRU	0,37	2
Gyrosigma acuminatum	GYAC	0,71	1
Gyrosigma attenuatum	GYAT	0,56	1
Gyrosigma nodiferum	GNOD	0,47	1
Gyrosigma scalproides	GSCA	0,80	1
Gyrosigma spencerii	GSPE	0,77	1
Hantzschia amphioxys	HAMP	0,30	3
Aulacoseira granulata	AUGR	0,77	1
Melosira varians	MVAR	0,10	5
Navicula atomus	NATO	0,74	1
Navicula bacillum	NBAC	-0,79	5
Navicula bryophyla	NBRY	-0,78	5
Navicula cari	NCAR	0,08	5
Navicula capitata	NCAP	0,42	2
Navicula cincta	NCIN	0,46	1
Navicula citrus	NCIT	0,90	1
Navicula clementis	NCLE	0,24	3
Navicula contenta	NCON	-0,78	5
Navicula cryptocephala	NCRY	0,42	2
Navicula capitatoradiata	NCPR	0,26	3
Navicula veneta	NVEN	0,42	2
Navicula cuspidata	NCUS	0,50	1
Navicula elginensis	NELG	0,45	2
Navicula gallica	NGAL	-0,78	5
Navicula gallica v. perpusilla	NGPE	-0,78	5
Navicula halophila	NHAL	-0,13	5
Navicula goeppertiana	NGOE	0,86	1
Navicula gregaria	NGRE	0,53	1
Navicula lanceolata	NLAN	0,56	1
Navicula menisculus	NMEN	0,18	4
Navicula oblonga	NOBL	-0,02	5
Navicula protracta	NPRO	0,14	4
Navicula pupula	NPUP	0,27	3
Navicula pygmaea	NPYG	0,53	1
Navicula placentula	NPLA	-0,78	5
Navicula radiosa	NRAD	-0,15	5
Navicula cryptotenella	NCTE	-0,18	5
Navicula reichardtiana	NRCH	0,01	5
Navicula reinhardtii	NREI	0,45	2
Navicula rhynchocephala	NRHY	-0,78	5
Navicula schroeteri	NSHR	0,75	1

Appendix 1. continued

Taxon	Omnidia code	Dtv	Tiw
Navicula sp.	NASP	-0,03	5
Navicula splendicula	NSPD	0,45	2
Navicula subalpina	NSBN	-0,46	5
Navicula trivialis	NTRV	0,39	2
Navicula tripunctata	NTPT	0,56	1
Navicula tuscula	NTUS	-0,66	5
Navicula viridula	NVIR	0,91	1
Navicula viridula v. rostellata	NVRO	0,33	3
Neidium ampliatum	NEAM	0,47	1
Neidium binodis	NBID	-0,02	5
Neidium dubium	NEDU	0,27	3
Nitzschia acicularis	NACI	0,56	1
Nitzschia amphibia	NAMP	0,58	1
Nitzschia angustata	NIAN	-0,67	5
Nitzschia angustatula	NZAG	-0,03	5
Nitzschia constricta	NZCO	0,45	2
Nitzschia capitellata	NCPL	0,05	5
Nitzschia dissipata	NDIS	-0,03	5
Nitzschia dubia	NDUB	-0,13	5
Nitzschia fonticola	NFON	-0,40	5
Nitzschia frustulum	NIFR	0,66	1
Nitzschia gisela	NGIS	-0,78	5
Nitzschia heufleriana	NHEU	0,45	2
Nitzschia incospicua	NINC	0,49	1
Nitzschia levidensis	NLEV	0,79	1
Nitzschia linearis	NLIN	0,42	2
Nitzschia littoralis	NLIT	0,45	2
Nitzschia microcephala	NMIC	-0,20	5
Nitzschia palea	NPAL	0,40	2
Nitzschia paleacea	NPAE	0,76	1
Nitzschia recta	NREC	-0,18	5
Nitzschia sigmoidea	NSIO	0,48	1
Nitzschia sinuata	NSIN	0,27	3
Nitzschia sinuata v. delognei	NSDE	0,49	1
Nitzschia sp.	NZSS	0,23	4
Nitzschia umbonata	NUMB	0,45	2
Nitzschia tryblionella	NTRY	0,82	1
Pinnularia viridis	PVIR	-0,45	5
Rhiocosphenia abbreviata	RABB	0,40	2
Rhopalodia gibba v. minuta	RGMI	-0,79	5
Rhopalodia gibba	RGIB	0,45	2
Stauroneis anceps	STAN	-0,79	5
Stauroneis smithii	SSMI	-0,02	5

Appendix 1. continued

Taxon	Omnidia code	Dtv	Tiw
Stephanodiscus sp.	STSP	0,97	1
Surirella angusta	SANG	0,66	1
Surirella bifrons	SBIF	0,44	2
Surirella brebissonii	SBRE	0,45	2
Surirella biseriata	SBIS	-0,02	5
Surirella minuta	SUMI	0,44	2
Surirella ovalis	SOVI	-0,02	5
Surirella tenera	SUTE	1,00	1
Fragilaria ulna v. acus	FUAC	0,72	1
Fragilaria parasitica	FPAR	0,49	1
Fragilaria capucina v.rumpens	FCRP	-0,13	5
Fragilaria ulna	FULN	-0,16	5
Tabellaria flocculosa	TFLO	-0,60	5
Thalassiosira weisflogii	TWEI	0,45	2