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SEVENTH FRAMEWORK PROGRAMME

WISER

Water bodies in Europe: Integrative Systems to assess Ecological status and Recovery

DELIVERABLE

Deliverable D3.3-3: Development of tools for the assessment of European lakes using benthic invertebrates: A preliminary analysis

Lead contractor: **Uniroma1 and IGB**

Contributors: **Francesca Pilotto, Angelo G. Solimini (Uniroma1), Muriel Gevrey, Christine Argillier (Cemagref), Oliver Miler, Martin Pusch (IGB), Jürgen Böhmer (BIOFORUM GmbH)**

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PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Content

Non-technical summary

The Directive 2000/60/EC, commonly known as the Water Framework Directive (WFD), legally requires from the EU member states an ecological assessment of the functioning and structure of aquatic ecosystems. This includes several biological quality elements (BQEs), i.e. fish, phytoplankton, macrophytes, phytobenthos and benthic macroinvertebrates. Benthic invertebrates constitute important links between primary producers, detrital deposits and higher trophic levels in lake ecosystems and are an integral part within food chains as well as lake productivity, nutrient cycling and decomposition. Hence, benthic invertebrates do not only indicate eutrophication, for which mainly phytoplankton and macrophytes are used, but among other pressures also hydromorphological degradation.

The habitat of bottom-dwelling, benthic invertebrates in lakes can be divided into 3 major zones: eulittoral, sublittoral and profundal which harbour distinct macrozoobenthos communities. The uppermost eulittoral zone that is inundated at high water levels and falls dry at low water levels is especially sensible for wave action, water level changes and structural lake shore alterations that have been shown to have detrimental impacts on the littoral zone through the alteration and/or loss of littoral habitats. Anthropogenic water level fluctuations severely affect macroinvertebrates in reservoirs and regulated lakes since their low mobility restricts the ability of benthic organisms to follow the receding water. Ship-induced wave action often substantially exceeds the strength and impact of natural waves and affects the habitat characteristics of macroinvertebrate organisms by influencing sediment particle size distribution and the structure and composition of macrophyte patches. Shore line development (e.g. shore protection by rip-rap or vertical walls) has been shown to have detrimental impacts on the littoral zone through the alteration or loss of littoral mesohabitats such as stones, sand, macrophytes and woody debris. Such an anthropogenically caused hydromorphological degradation is reflected in the diversity and composition of eulittoral macrozoobenthos communities and shows macrozoobenthos organisms to be probably useful indicators for this. Furthermore, it has been shown that the trophic state influences the composition of eulittoral macroinvertebrate communities to a lesser extent than has been previously reported for profundal habitats and they are hence weak indicators of eutrophication.

Below the eulittoral zone the sublittoral zone starts and extends until depths, where macrophyte growth is not possible anymore and the profundal starts. Previous studies have shown the use of profundal macroinvertebrate communities to classify the trophic status of lakes. Furthermore, also macrozoobenthos organisms in the sublittoral zone can be used in principal to indicate eutrophication. However, separating effects of sublittoral habitat structure, including depth, from that of nutrients per se is difficult, since they are often interrelated. E. g. distinct macroinvertebrate communities are often associated with particular sediment types or macrophytes.

In order to obtain quality assessment of lakes, benthic macroinvertebrates, as one of the Biological Quality Elements (BQEs), must be analysed in terms of taxonomic and functional composition, abundance, disturbance sensitive taxa, diversity and absence of major taxonomic groups.

This can be achieved by means of metrics and multimetric indices. A metric is a measurable part or process of a biological system shown to change in value along a gradient of anthropogenic influence, while a multimetric index is a combination of standardized single metrics. Multimetric indices are often used in assessment systems because they synthesize information on different biological attributes into a single index value.

Here we show different approaches to the development of invertebrate based metrics suitable to indicate hydromorphological alterations in (sub-)Alpine and Central Baltic lakes. The first analysis by Pilotto et al. is focused on the sublittoral zone while the second (by Böhmer et al.) is focused on the eulittoral zone. The dataset on which this analysis is based comes from different sources and, unavoidably, has several drawbacks in terms of variance heterogeneity and statistical power.

This deliverable anticipates in a preliminary way some aspects that will further elaborated in Deliverable 3.3.4, which will be dedicated to the development of multimetric indices for hydromorphological degradation based on a more homogeneous eulittoral dataset that was collected within the Wiser WP3.3 field campaign (see D3.3.2 for details).

1. Multimetric index development for invertebrates in the sublittoral zone of subalpine lakes in response to morphological and eutrophication stressors

Francesca Pilotto, Muriel Gevrey, Christine Argillier, Angelo G. Solimini

1.1 Introduction

The Water Framework Directive 2000/60/ EC (WFD) requires the definition of the ecological status of European water bodies.

In order to obtain quality assessment of lakes, benthic macroinvertebrates, as one of the Biological Quality Elements (BQEs), must be analysed in terms of taxonomic and functional composition, abundance, disturbance sensitive taxa, diversity and absence of major taxonomic groups (Hering et al., 2010).

This can be achieved by means of metrics and multimetric indices. A metric is a measurable part or process of a biological system shown to change in value along a gradient of anthropogenic influence (Karr & Chu, 1999), while a multimetric index is a combination of standardized single metrics. Multimetric indices are often used in assessment systems because they synthesize information on different biological attributes into a single index value (Simon, 2000).

We focused our analysis on invertebrates sampled in the sublittoral zone of subalpine lakes, with the aims to develop a multimetric index, and to evaluate the suitability of the sublittoral zone for lake quality assessment.

We applied the Guidelines for Indicator Development given by WISER D.2.2.2 (Hering et al., 2010) and compared different stressor combinations and different ways of calculating the EQR that derive from slightly different interpretation of hindcasted anchor points.

1.2 Procedure

Dataset

The database we used has been developed within the subalpine GIG. Samples were collected between 1997 and 2010 in the sublittoral zone of 19 Austrian, 25 German, 21 France and 28 Italian subalpine lakes. 10 of those lakes were sampled in 2 different years while 1 lake was sampled in 3 different years, each lake-year combination has been considered as an indipendent sample unit. Invertebrates were indentifyed to the lower taxonomic level possible, mostly to genus/species level. Data gathered in more than one sampling site were aggregated to lake-year level.

Environmental variables

We considered climatic and morphological environmental variables (table 1): precipitation, mean annual temperature, difference between temperature in July and in January, lake surface area, lake mean depth and catchment area. The climatic data were gathered from the Climatic Research Unit (CRU) model (New et al. 2002; http://www.cru.uea.ac.uk/).

***Table 1:** Environmental variables ranges.*

	min	max
Mean annual Prec. (cm)	60.16	162.67
Mean annual Temp. (°C)	5.17	12.99
T(July)-T(January) (°C)	17.40	21.60
surface (km^2)	0.04	79.90
mean depth (m)	3.20	53.21
catchment (km^2)	1.01	4551.60

Stressors

We considered a set of 6 potential stressors (table 2): 3 morphological stressors (landuse at site level, landuse in the lake surround and percentage of shore alteration), mid-lake TP, and 2 synthetic stressors, calculated as a combination of the morphological stressors (Morph_stressor) and as a combination of morphological stressors and TP (Morph_stressor_TP). The stressors aggregation was proposed by GIG members.

***Table 2:** Stressors included in the analysis. The formula used, the number of lakes (here onwards intended as lake-year) and the minimum-maximum values recorded are reported.*

stressor	explanation	lakes	range		
landuse site	Landuse at site level: (4*urban%_site)+(2*agric%_site)	40	3.57	-	262.72
landuse surround	Landuse within 200 m from the lake: (4*urban%_surround)+(2*intens_agric%_surround)+ grass%_surround	80	0	-	375.89
shore alteration (%)	%perimeter affected by hard alteration	40	0	-	75.00
mid-lake TP (mg/l)	Mid-lake TP (mg/l)	40	0	-	0.23
Morph_stressor	Morphological stressor calculated as [(3*(landuse_site/4/25+1)+ (landuse_surround/4/25+1) + (shore_alteration%/25+1)]/5	40	1.13	-	3.47
Morph_stressor_TP	Morph_stressor+(TP_class/2)	40	2.13	-	4.47

Metric selection

Metric calculation

For each lake a list of 51 potential metrics have been calculated (table 3) according to the AQEM European stream assessment program tools (2002; http://www.aqem.de/).

Table 3: *Initial set of metrics. Metric types are shown (TFC: taxonomic and functional composition; TC: Taxa composition; A: abundance; DST: disturbance sensitive taxa; D: diversity).*

Metric	Metric type	
no_individuals	A	
Insecta_excl_Chir_HK	A	TC
Insecta_HK	A	TC
Chiro%	A	TC
Orthocladinae%	A	TC
Chironominae%	A	TC
orthoclad.chir%	A	TC
Tanypodinae%	A	TC
Prodiamesinae%	A	TC
Diamesini%	A	TC
Crust%	A	TFC
Gastropoda%	A	TFC
Coleoptera%	A	TFC
Pleco%	A	TFC
Tricho%	A	TFC
Insecta%	A	TFC
Odo%	A	TFC
Oligochaeta%	A	TFC
no_Taxa	D	TC
famrich	D	
DomFam%	D	
ShW	D	
FI_nat	DST	
ASPT	DST	
ASPT_IZ	DST	
BMWP_Score	DST	
EPT%	DST	TC/D
EPT_HK%	DST	TC/D
EPTCBO%	DST	TC/D
ETO_HK%	DST	
EPTCBO_	DST	A
ETO_	DST	A
EPT_	DST	A
Odo_HK	TFC	
rk_HK	TFC	
rk	TFC	
oligo_HK%	TFC	
Xeno%	TFC	
xeno_HK%	TFC	
Gather%	TFC	
Grazer%	TFC	
Shred%	TFC	
LIT_HK	TFC	

PEL%	TFC
PSA%	TFC
AKA%	TFC
AKA_HK%	TFC
lsw_HK	TFC
gather_HK	TFC
grazer_HK	TFC
xenoligo	TFC

Exclusion of numerically unsuitable metrics

We excluded from the analysis the numerically unsuitable metrics. We draw box-whisker plots (see examples in figure 1) in order to detect metrics characterized by a narrow range of values or with many outliers and extreme values (Hering et al., 2006).

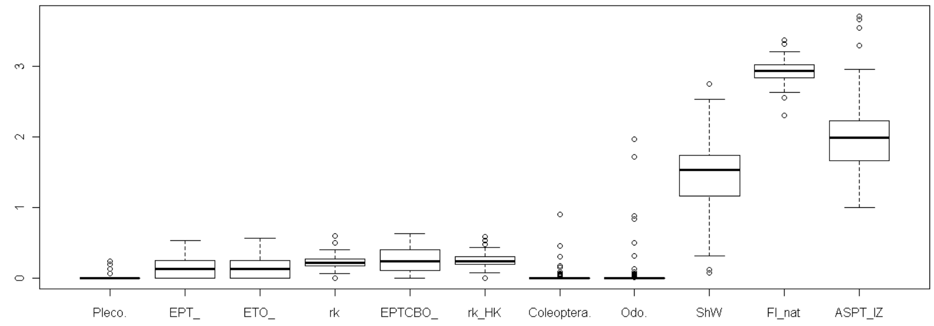

Figure 1: *11 example metrics box-whisker plots representing the metrics distribution values in order to detect the numerically unsuitable metric.*

After this step of the procedure 38 metrics were included in the analysis (table 4).

Table 4: *Numerically unsuitable metrics. A metric was considered as numerically unsuitable (yes) if the box-whisker revealed a narrow range of values or many outliers and extreme values.*

Metric	Numerically unsuitable metric	Metric	Numerically unsuitable metric
no_Taxa	No	Shred%	Yes
no_individuals	No	LIT_HK	No
FI_nat	No	PEL%	No
ASPT	No	PSA%	No
ASPT_IZ	No	AKA%	Yes
Odo_HK	Yes	AKA_HK%	No
famrich	No	Crust%	Yes
DomFam%	No	Gastropoda%	No
BMWP_Score	No	Coleoptera%	Yes
rk_HK	No	Pleco%	Yes
Insecta_excl_Chir_HK	No	EPT%	No
Insecta_HK	No	EPT_HK%	No
Chiro%	No	EPTCBO%	No
Orthocladinae%	Yes	Tricho%	No
Chironominae%	No	ETO_HK%	No
orthoclad.chir%	Yes	Insecta%	No
Tanypodinae%	No	Odo%	Yes
Prodiamesinae%	Yes	Isw_HK	No
Diamesini%	Yes	gather_HK	No
rk	No	grazer_HK	No
ShW	No	xenoligo	No
oligo_HK%	No	EPTCBO_	No
Xeno%	Yes	ETO_	No
xeno_HK%	Yes	EPT_	No
Gather%	No	Oligochaeta%	No
Grazer%	No		

Definition of a stressor gradient

Since some stressor data were not available for every lake (table 2), we run 2 main analysis: analysis 1, considering only landuse in the lake surround as stressor, and analysis 2 with landuse at site and surround level, TP and percentage of shore alteration as stressors. For analysis 1, stressor data were available for 80 lakes, while for analysis 2 the number of lakes was reduced to 40. Analysis 2 was further divided as shown in table 5.

Table 5: *Analysis performed. The number of lakes and the stressors included in each analysis are reported.*

	Lakes	**Stressors**
Analysis 1	80	Landuse surround
Analysis 2a	40	Landuse site, landuse surround, percentage of shore alteration and TP
Analysis 2b	40	Morphological stressors and TP
Analysis 2c	40	Morphological stressor combined with class of TP

The following steps of the procedure were performed separately for each type of analysis.

Selection of candidate metrics

Multiple linear regressions (MLR) have been used to model each metric, by using environmental variables and stressors as predictor variables (Hawkins et al., 2010). The square of each environmental variable were also included to allow for possible non-linear relationships. The full model has the following formula:

Model=lm(metric~Precip+MeanAnnual_temperature+jul_jan+surface+mean_depth+catchment +I(Precip^2)+I(MeanAnnual_temperature^2)+I(jul_jan^2)+I(surface^2)+I(mean_depth^2)+I(catchment^2)+stressor_1+stressor_2+…+stressor_n)

Stepwise procedure has been applied in order to select the best explaining model for each metric; this analysis has been performed with the stepAIC function in the R MASS library (Venables and Ripley, 2002).

We analysed the adjusted R^2 of the selected model and checked the residuals for normality (Shapiro Wilk test). We deleted from the analysis those metrics for which the R^2 was <0.3 and/or the residuals were non-normally distributed.

The next steps of the procedure have been applied to the metric - stressor pairs resulted from the selected models.

We run Spearman rank correlation analysis to evaluate the biological consistency of the correlation of each metric-stressor pair.

Extrapolation of reference conditions

We applied the hindcasting technique with the aim to extrapolate the metric value at reference conditions. We predicted the value of each invertebrate metric by running the model selected by the stepwise procedure with the original environmental variables but with stressors set to 0 (Baker et al., 2005; Kilgour & Stanfiel, 2006).

EQR calculation and normalisation

This step of the procedure has the aim to convert the metric results in values between 0 and 1, decreasing with increasing stress.

We applied two different EQR calculation methods. The first method, more conservative, is based on the ratio between observed and expected metric values, it is appropriate if there is not certainty that among the sample sites there are sites at reference condition. The second method, assuming that there are near-pristine sites among the sample sites, is based on the difference between observed and expected values.

1. For the first calculation method we used the 95th and the 5th percentile of the metric predicted by the hindcasting procedure as the best expected value, in order to avoid anomalous outliers (Blocksom et a., 2002).

For metrics that decrease with increasing stress the EQR was calculated as:

$$EQR1 = \frac{\text{obs\_metric}}{\text{95percentile\_hind\_metric}}$$

For metrics that increase with increasing stress, it was calculated as:

$$EQR1 = \frac{(\max(\text{obs\_metric}) - \text{obs\_metric})}{(\max(\text{obs\_metric}) - \text{5percentile\_hind\_metric})}$$

2. For the second calculation method the EQR was calculated as:

$$EQR2 = \frac{(\text{obs\_metric} - \text{hind\_metric}) - \min(\text{obs\_metric} - \text{hind\_metric})}{\max(\text{obs\_metric} - \text{hind\_metric}) - \min(\text{obs\_metric} - \text{hind\_metric})}$$

for metrics that decrease with increasing stress.

For metrics that increase with increasing stress, it was calculated as:

$$EQR2 = 1 - \frac{(\text{obs\_metric} - \text{hind\_metric}) - \min(\text{obs\_metric} - \text{hind\_metric})}{\max(\text{obs\_metric} - \text{hind\_metric}) - \min(\text{obs\_metric} - \text{hind\_metric})}$$

Where obs_metric is the value of the observed metric and hind_metric is the metric predicted by the hindcasting procedure.

The Spearman rank correlation between the normalized EQR and the stressor has been calculated.

Selection of core metrics

We run Spearman rank correlation analysis among the remaining metrics and considered as redundant those metrics with Spearman's r > 0.8 (Hering et al., 2010). We select as core metrics one metric per each redundant metrics group and excluded the others from the analysis.

Distribution of metrics within the metric types

In case a multimetric index is targeted, it should preferably contain at least one metric from each type (table 3).

Generation of a multimetric index

Aggregations of core metrics EQRs have been done using a simple average, and then the final EQR, (the multimetric index) has been correlated to the stressors. Comparison of these values is necessary to select the best index.

1.3 Results

Analysis 1. Landuse surround as unique stressor

We analysed the 80 lakes, with landuse surround as unique stressor.

EQR1:

We deleted the metrics for which the selected linear model had adjusted R2 <0.3 and/or non-normally distributed residuals. 8 metrics were retained after this step of the procedure (table 6), all of them had the expected sign of the correlation coefficient with the stressor. 5 metrics were redundant. The metrics selected as core metrics were: no_EPTCBO and ASPT_IZ.

The Spearman's rank correlation between the stressor and the index, calculated as the mean value of the core metrics EQRs, was -0.147.

Table 6: *Analysis 1: metric selection results. Metric - stressor correlation was consistent (yes) if the sign of the correlation was as expected. Spearman rank correlation between the EQR, calculated using the formula EQR1, and the stressor is reported. A metric was redundant (redundancy=yes) if correlated (r>0.8) with other metrics. The final metric selection is reported in the core metric column (yes).*

Candidate metrics	Consistency of metric-stressor correlation	Spearman rank correlation EQR-stressor (landuse_surround)	Redundancy	Core metric
no_EPTCBO	Yes	-0.198	No	Yes
no_EPT	Yes	-0.191	Yes	No
EPT%	Yes	-0.184	Yes	No
EPT_HK%	Yes	-0.22	Yes	No
no_Taxa	Yes	-0.142	Yes	No
ASPT_IZ	Yes	-0.239	No	Yes
famrich	Yes	-0.169	Yes	No
BMWP_Score	Yes	-0.181	Yes	No

Spearman correlation Index - stressor = -0.147

EQR2:

We deleted the metrics for which the selected linear model had adjusted R2 <0.3 and/or non-normally distributed residuals. 8 metrics were retained after this step of the procedure (table 7), all of them had the expected sign of the correlation coefficient with the stressor. 7 metrics were redundant. The metrics selected as core metrics were: EPT% and ASPT_IZ.

The Spearman's rank correlation between the stressor and the index, calculated as the mean value of the core metrics EQRs, was -0.349.

Table 7: *Analysis 1: metric selection results. Metric - stressor correlation was consistent (yes) if the sign of the correlation was as expected. Spearman rank correlation between the EQR, calculated using the formula EQR2, and the stressor is reported. A metric was redundant (redundancy=yes) if correlated (r>0.8) with other metrics. The final metric selection is reported in the core metric column (yes).*

Candidate metrics	**Consistency of metric stressor correlation**	**Spearman rank correlation EQR-stressor**	**Redundancy**	**Core metric**
Landuse_surround				
no_EPTCBO	Yes	-0.329	Yes	No
no_EPT	Yes	-0.350	Yes	No
EPT%	Yes	**-0.377**	**Yes**	**Yes**
EPT_HK%	Yes	-0.239	Yes	No
no_Taxa	Yes	-0.273	Yes	No
ASPT_IZ	Yes	-0.322	No	**Yes**
famrich	Yes	-0.202	Yes	No
BMWP_Score	Yes	-0.203	Yes	No
Spearman correlation index-stressor = -0.349				

Analysis 2a. Landuse site, landuse surround, percentage of shore alteration and TP

EQR1

The results of the analysis applied to the 40 lakes subset with landuse site, landuse surround, percentage of shore alteration and TP as stressors are reported in the table 7. For landuse at site level 4 metrics were selected as core metrics (EPTCBO%, EPT_HK%, Insecta% and rk), for landuse in the surrounding 5 metrics (Oligochaeta%, PSA%, AKA_HK%, Insecta% and ASPT_IZ). For percentage of shore alteration 4 metrics were selected as core metrics (Oligochaeta%, PSA%, Insecta%, insecta_HK), finally for TP 5 metrics (PEL%, Insecta%, ASPT, Insecta_HK and LIT_HK) were selected.

Table 8: *Analysis 2a: metric selection results. Metric - stressor correlation was consistent (yes) if the sign of the correlation was as expected. Spearman rank correlation between the EQR, calculated using the formula EQR1, and the stressor is reported. A metric was redundant (redundancy=yes) if correlated (r>0.8) with other metrics. The final metric selection is reported in the core metric column (yes).*

Candidate metrics	Consistency of metric-stressor correlation	Spearman rank correlation EQR-stressor	Redundancy	Core metric
landuse_site				
gather%	No	-0.33	-	No
Gastropoda%	No	-0.425	-	No
EPT%	Yes	-0.243	Yes	No
EPT_HK%	Yes	-0.247	No	Yes
EPTCBO%	Yes	-0.075	No	Yes
ETO_HK%	Yes	-0.199	Yes	No
Insecta%	Yes	-0.338	No	Yes
no_EPTCBO	Yes	-0.129	Yes	No
no_ETO	Yes	-0.082	Yes	No
no_EPT	Yes	-0.168	Yes	No
ASPT	Yes	-0.165	Yes	No
rk_HK	Yes	-0.323	Yes	No
rk	Yes	-0.372	No	Yes
Spearman correlation Index - stressor = -0.261				
landuse_surround				
Oligochaeta%	Yes	-0.507	No	Yes
DomFam%	No	-0.414	-	No
Gather%	No	-0.393	-	No
PSA%	Yes	-0.339	No	Yes
AKA_HK%	Yes	-0.051	No	Yes
Insecta%	Yes	-0.526	No	Yes
ASPT_IZ	Yes	-0.193	No	Yes
Spearman correlation Index - stressor = - 0.415				
shore_alteration%				
Oligochaeta%	Yes	-0.019	No	Yes
gather%	No	-0.034	-	No
PSA%	Yes	-0.095	No	Yes
AKA_HK%	No	-0.429	-	No
EPT%	No	-0.506	-	No
EPT_HK%	No	-0.394	-	No
EPTCBO%	No	-0.579	-	No
ETO_HK%	No	-0.376	-	No
Insecta%	Yes	-0.101	No	Yes
no_EPTCBO	No	-0.397	-	No
no_ETO	No	-0.412	-	No
no_EPT	No	-0.426	-	No
no_Taxa	No	-0.39	-	No
ASPT	No	-0.421	-	No
ASPT_IZ	No	-0.492	-	No
famrich	No	-0.39	-	No
BMWP_Score	No	-0.435	-	No
rk_HK	No	-0.371	-	No
Insecta_HK	Yes	-0.194	No	Yes
Spearman correlation Index - stressor = -0.074				
TP				

PEL%	Yes	-0.08	No	Yes
Gastropoda%	No	-0.163	-	No
EPT%	Yes	-0.389	Yes	No
EPT_HK%	Yes	-0.358	Yes	No
ETO_HK%	Yes	-0.314	Yes	No
Insecta%	Yes	-0.213	No	Yes
no_ETO	Yes	-0.249	Yes	No
no_EPT	Yes	-0.337	Yes	No
ASPT	Yes	-0.419	No	Yes
Insecta_HK	Yes	-0.223	No	Yes
LIT_HK	Yes	-0.260	No	Yes
Spearman correlation Index - stressor = -0.426				

EQR2

The results of the analysis applied to the 40 lakes subset with landuse site, landuse surround, percentage of shore alteration and TP as stressors are reported in the table 9.

The Spearman's rank correlation between the stressor and the index, calculated as the mean value of the core metrics EQRs, was -0.328 for landuse-site, -0.379 for landuse_surround, -0.543 for Shore-alteration and -0.776 for TP (see figure 2).

Table 9: *Analysis 2a: metric selection results. Metric - stressor correlation was consistent (yes) if the sign of the correlation was as expected. Spearman rank correlation between the EQR, calculated using the formula EQR2, and the stressor is reported. A metric was redundant (redundancy=yes) if correlated (r>0.8) with other metrics. The final metric selection is reported in the core metric column (yes).*

Candidate metrics	**Consistency of metric stressor correlation**	**Spearman rank correlation EQR-stressor**	**Redundancy**	**Core metric**
Landuse_site				
gather%	No	-0.271	-	No
Gastropoda%	No	-0.442	-	No
EPT%	Yes	-0.158	Yes	No
EPT_HK%	Yes	**-0.220**	**Yes**	**Yes**
EPTCBO%	Yes	-0.088	**No**	**Yes**
ETO_HK%	Yes	-0.175	Yes	No
insecta%	Yes	-0.266	**No**	**Yes**
no_EPTCBO	Yes	-0.082	Yes	No
no_ETO	Yes	-0.097	Yes	No
ASPT	Yes	-0.111	Yes	No
rk_HK	Yes	-0.384	Yes	No
rk	Yes	**-0.396**	**Yes**	**Yes**
Insecta_HK	Yes	-0.236	**No**	**Yes**
Spearman correlation index-stressor = -0.328				
Landuse_surround				
Oligochaeta%	Yes	-0.677	**No**	**Yes**
DomFam%	No	-0.434	-	No
gather%	No	-0.178	-	No
PSA%	Yes	-0.355	**No**	**Yes**
AKA_HK%	Yes	-0.092	**No**	**Yes**
insecta%	Yes	-0.253	**No**	**Yes**
ASPT_IZ	Yes	-0.222	**No**	**Yes**
Spearman correlation index-stressor = -0.379				
Shore_alteration%				
oligochaeta%	Yes	-0.107	**No**	**Yes**
gather%	No	-0.383	-	No
PSA%	Yes	-0.132	**No**	**Yes**
AKA_HK%	No	-0.547	-	No
EPT%	No	-0.654	-	No
EPT_HK%	No	-0.664	-	No
EPTCBO%	No	-0.621	-	No
ETO_HK%	No	-0.636	-	No
insecta%	Yes	-0.489	**No**	**Yes**
no_EPTCBO	No	-0.516	-	No
no_ETO	No	-0.582	-	No
no_EPT	No	-0.608	-	No
no_Taxa	No	-0.438	-	No
ASPT	No	-0.651	-	No
ASPT_IZ	No	-0.446	-	No
famrich	No	-0.511	-	No
BMWP_Score	No	-0.609	-	No
rk_HK	No	-0.403	-	No
Insecta_HK	Yes	-0.449	**No**	**Yes**
Spearman correlation index-stressor = -0.543				
TP				
PEL%	Yes	-0.457	**No**	**Yes**
gastropoda%	No	-0.355	-	-
EPT%	Yes	-0.599	Yes	No
EPT_HK%	Yes	-0.595	Yes	No
ETO_HK%	Yes	-0.581	Yes	No
insecta%	Yes	-0.686	**No**	**Yes**
no_ETO	Yes	**-0.601**	**Yes**	**Yes**
no_EPT	Yes	-0.499	Yes	No
ASPT	Yes	-0.531	Yes	No
Insecta_HK	Yes	-0.722	**No**	**Yes**
LIT_HK	Yes	-0.380	**No**	**Yes**
no_EPTCBO	Yes	-0.504	Yes	No
Spearman correlation index-stressor = -0.776				

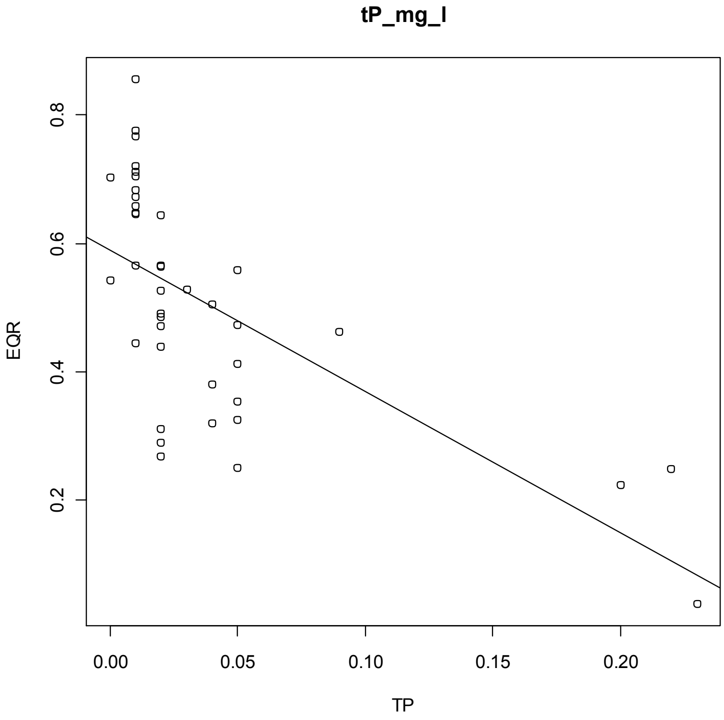

Figure 2: *relationship between the multi-metric index EQR (made of %PEL, %insecta, no_ETO, INSECTA_HK and LITH_HK) and the stressor TP (r=0.776).*

Analysis 2b. Morphological stressors and TP

The analysis has been performed for the 40 lakes subset with TP and morphological stressor as stressors, the results are reported in table 10 and 11 respectively for EQR1 and EQR2.

EQR1

For TP, 3 metrics were retained as candidate metrics after the analysis of the best explaining model. 2 of them were selected as core metrics: PEL% and LIT_HK. The Spearman's rank correlation between the stressor and the index, calculated as the mean value of the core metrics EQRs, was -0.143.

For the morphological stressor, 4 metrics were retained as candidate metrics after the analysis of the best explaining model, but only EPT _HK% was selected as core metric. The Spearman's rank correlation between the stressor and the index, calculated as the mean value of the core metrics EQRs, was -0.027.

Table 10: *Analysis 2b: metric selection results. Metric - stressor correlation was consistent (yes) if the sign of the correlation was as expected. Spearman rank correlation between the EQR, calculated using the formula EQR1, and the stressor is reported. A metric was redundant (redundancy=yes) if correlated (r>0.8) with other metrics. The final metric selection is reported in the core metric column (yes).*

Candidate metrics	Consistency of metric-stressor correlation	Spearman rank correlation EQR-stressor	Redundancy	Core metric
TP				
PEL%	Yes	-0.08	No	Yes
Gastropoda%	No	-0.169	-	No
LIT_HK	Yes	-0.085	No	Yes
Spearman correlation Index - stressor = -0.143				
Morph_stressor				
Chiro%	No	-0.385	-	No
Gather%	No	-0.365	-	No
Gastropoda%	No	-0.472	-	No
EPT_HK%	Yes	-0.143	No	Yes
Spearman correlation Index - stressor = -0.027				

EQR2

The analysis has been performed for the 40 lakes subset with TP and morphological stressor as stressors, the results are reported in table 11.

The Spearman's rank correlation between the stressor and the index, calculated as the mean value of the core metrics EQRs, was -0.457 for TP and -0.295 for Morph_stressor

Table 11: *Analysis 2c: metric selection results. Metric - stressor correlation was consistent (yes) if the sign of the correlation was as expected. Spearman rank correlation between the EQR, calculated using the formula EQR2, and the stressor is reported. A metric was redundant (redundancy=yes) if correlated (r>0.8) with other metrics. The final metric selection is reported in the core metric column (yes).*

Candidate metrics	**Consistency of metric stressor correlation**	**Spearman rank correlation EQR-stressor**	**Redundancy**	**Core metric**
TP				
PEL%	Yes	-0.457	**No**	**Yes**
gastropoda%	No	-0.286	-	No
LIT_HK	Yes	-0.380	**No**	**Yes**
Spearman correlation index-stressor = -0.457				
Morph_stressor				
chiro%	No	-0.298	-	No
gather%	No	-0.281	-	No
gastropoda%	No	-0.490	-	No
EPT_HK%	Yes	**-0.295**	**No**	**Yes**
Spearman correlation index-stressor = -0.295				

Analysis 2c. Morphological stressor combined with class of TP

EQR1

When analysing the unique synthetic morphological stressor combined with TP class (morph_stressor_TP), 5 metrics were retained as candidate metrics after the analysis of the best explaining model. 3 of them were selected as core metrics: Oligochaeta%, EPT_HK% and Insecta_HK (table 16).

Table 12: *Analysis 2c: metric selection results. Metric - stressor correlation was consistent (yes) if the sign of the correlation was as expected. Spearman rank correlation between the EQR, calculated using the formula EQR1, and the stressor is reported. A metric was redundant (redundancy=yes) if correlated (r>0.8) with other metrics. The final metric selection is reported in the core metric column (yes).*

Candidate metric	Consistency of metric-stressor correlation	Spearman rank correlation EQR-stressor	Redundancy	Core metric
Morph_stressor_TP				
Oligochaeta%	Yes	-0.215	No	Yes
Chiro%	No	-0.385	No	No
Gastropoda%	No	-0.239	No	No
EPT_HK%	Yes	-0.143	No	Yes
Insecta_HK	Yes	-0.331	No	Yes
Spearman correlation Index - stressor = -0.147				

EQR2

When analysing the unique synthetic morphological stressor combined with class of TP (morph_stressor_TP), 5 metrics were retained as candidate metrics after the analysis of the best explaining model. 3 of them were selected as core metrics: Oligochaeta%, EPT_HK% and Insecta_HK (table 13).

The Spearman's rank correlation between the stressor and the index, calculated as the mean value of the core metrics EQRs, was -0.495 for Morph_stressor_TP.

Table 13: *Analysis 2e: metric selection results. Metric - stressor correlation was consistent (yes) if the sign of the correlation was as expected. Spearman rank correlation between the EQR, calculated using the formula EQR2, and the stressor is reported. A metric was redundant (redundancy=yes) if correlated (r>0.8) with other metrics. The final metric selection is reported in the core metric column (yes).*

Candidate metrics	**Consistency of metric stressor correlation**	**Spearman rank correlation EQR-stressor**	**Redundancy**	**Core metric**
Morph_stressor_TP				
oligochaeta%	Yes	-0.596	**No**	**Yes**
chiro%	No	-0.300	-	No
gastropoda%	No	-0.528	-	No
EPT_HK%	Yes	-0.296	**No**	**Yes**
Insecta_HK	Yes	-0.280	**No**	**Yes**
Spearman correlation index-stressor = -0.495				

1.4 Discussion and recommendations

The best correlations among multimetric indices and stressors were obtained for landuse within a 200 m stretch from the lake shore (Spearman's rank correlation=-0.415), and total phosphorus (Spearman's rank correlation =-0.426) for the EQR1 calculation method (table 8). The best correlations were with total phosphorus (Spearman's rank correlation =-0.776) and percentage of shore alteration (Spearman's rank correlation =-0.543) for the EQR2 calculation method (table 9). These results show that the sublittoral zone is still affected by the influence of eutrophication, which is well known to mostly affect the profundal zone (Rasmussen & Kalff, 1987; Bazzanti et al., 1994; Solimini et al., 2006). The correlations among the indices and the morphological stressors were generally low, indicating the high variability of the sublittoral zone.

Thus, the sublittoral macrozoobenthos assemblage can be used to indicate the composite effect of eutrophication and hydromorphological pressures. The pure effect of hydromorphological degradation on sublittoral macrozoobenthos could not be demonstrated clearly as it could not be disentangled from the co-variation of eutrophication. Hence, sublittoral macrozoobenthos did not appear to be an efficient bioindication tool for hydromorphological alterations. For that purpose, the eulittoral zone is expected to be more appropriated (Solimini et al., 2006).

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2. Common metrics for invertebrates in the eulittoral zone of Alpine and Central Baltic GIG lakes in response to hydromorphological stressors

Jürgen Böhmer, Oliver Miler, Martin Pusch

In the previous chapter Pilotto et al. showed that sublittoral macrozoobenthos assemblages respond to the combined effects of eutrophication and hydromorpholo¬gical pressures. The pure effect of hydromorphological degradation on sublittoral macrozoobenthos could not be demonstrated clearly as it could not be disentangled from the co-variation of eutrophication. Hence, sublittoral macrozoobenthos did not appear to be an efficient bioindication tool for hydromorphological alterations.

Hence in this chapter we show how the two multimetric indices “Alpine Intercalibration Common Metric” (ALP-ICM) and “Central/Baltic Intercalibration Common Metric” (CB-ICM), that are based on eulittoral macrozoobenthos communities, were developed in cooperation with the lake macroinvertebrate intercalibration groups as a first approach to develop a multimetric index describing the hydromorphological degradation of lake shores. The dataset on which this analysis is based comes from different sources and, unavoidably, has several drawbacks in terms of variance heterogeneity and statistical power. This work anticipates in many aspects Deliverable 3.3.4 that will target the development of multimetric indices for hydromorphological degradation based on a more homogeneous eulittoral dataset collected within the Wiser WP3.3 field campaign (see D3.3.2 for details).

2.1 Dataset

Dataset description

The data basis was compiled within the lake macroinvertebrate groups of the AL- and CB-GIG. 7 countries with existing assessment systems for eulittoral macroinvertebrates and 4 additional countries contributed data. 9 countries are represented in the CB-GIG (table 1) and 3 in the AL-GIG (table 2).

Table 1: *Number of lakes, sites and samples used for the development of eulittoral MMIs for the Central/Baltic GIG*

Member State	**Method**	**N lakes**	**N sites**	**N samples**
Belgium/Flanders (BE/FL)	Multimetric Macroinvertebrate Index Flanders (MMIF)	12	55	119
Germany (DE)	German Macroinvertebrate Lake Assessment (AESHNA)	54	410	410
Denmark (DK)	No method yet	17	79	79
Estonia (EE)	Estimation of Freshwater Quality Using Macroinvertebrates	20	20	20
United Kingdom (UK)	Chironomid Pupal Exuviae Technique (CPET)	26	26	26
Latvia (LV)	No method yet	23	23	25
Lithuania (LT)	Lithuanian Lake Macroinvertebrate Index	26	29	56
The Netherlands (NL)	WFD-Metrics for Natural Watertypes	32	113	149
Poland (PL)	No method yet	6	21	21

Table 2: *Number of lakes, sites and samples used for the development of eulittoral MMIs for the Alpine GIG*

Member State	**Method**	**N lakes**	**N sites**	**N samples**
Austria (AT)	No method yet	5	14	14
Germany (DE)	German Macroinvertebrate Lake Assessment (AESHNA)	12	131	131
Slovenia (SI)	Slovenian ecological status assessment system for lakes using littoral benthic invertebrates	2	28	28

Environmental variables

A variety of environmental data was collected within the GIG groups to characterise the lakes and to check for typological differences. The basic parameters were ecoregion, intercalibration type, national type, coordinates, lake area, catchment size, altitude above sea level, mean depth and conductivity.

Stressors

Stressor parameters were compiled within the GIG groups in dependence of their importance for intercalibrating the assessment systems and their availability. Different parameters were collected within the AL- and the CB-GIG. Both GIGs started with whole lake parameters, since the WFD assessment was done on water body level. Due to the low number of data for alpine lakes the AL-GIG decided to work on sampling site level and to collect sampling site specific data in addition.

Since the focus of most assessment methods was clearly on hydromorphological pressure (table 3) morphological stressor parameters dominated (tables 4 and 5).

Table 3: *Pressures indicated by the MMIs of member states (pressures in brackets are minor pressures indicated by the respective MMI)*

Member State	**Method**	**Pressure**
Belgium/Flanders (BE/FL)	Multimetric Macroinvertebrate Index Flanders (MMIF)	hydromorphology, eutrophication
Germany (DE)	German Macroinvertebrate Lake Assessment (AESHNA)	hydromorphology, (eutrophication)
Estonia (EE)	Estimation of Freshwater Quality Using Macroinvertebrates	hydromorphology, eutrophication
United Kingdom (UK)	Chironomid Pupal Exuviae Technique (CPET)	eutrophication
Lithuania (LT)	Lithuanian Lake Macroinvertebrate Index	eutrophication, (hydromorphology)
The Netherlands (NL)	WFD-Metrics for Natural Watertypes	hydromorphology, (eutrophication)
Slovenia	Slovenian ecological status assessment system for lakes using littoral benthic invertebrates	hydromorphology

The stressor parameters used for the development of the Intercalibration Common Metrics comprise different variables describing landuse and alteration of shore structure (see tables 4 and 5 for more details).

Table 4: *Stressor Variables for the development of the AL-ICM*

Variable	**Explanation**
Shore alteration%	% altered shore length of total shore length
Landuse_surround	Land-use index from the % of land uses in the 100 m belt around the whole lake (1 * % extensive agriculture + 2 * % intensive agriculture + 4 * % urban areas)
Landuse_catchment	Land-use index from the % of land uses in the lake catchment (1 * % extensive agriculture + 2 * % intensive agriculture + 4 * % urban areas)
Naturalness_site_national	National naturalness classification by expert judgement, based on morphology and landuse of the shoreline and adjacent areas at the sampling sites (5 classes)
Urban_agr%_site	% of non-natural[#] landuses (mainly urban and agricultural areas) directly adjacent to the site (15 m belt at 100 m shore length)
Urban_agr%_site100	% of non-natural[#] landuses (mainly urban and agricultural areas) directly adjacent to the site (100 m belt at 100 m shore length)
Morpho_AT_DE_SI_all	Combined stressor index[##] consisting of 2* Naturalness_site_national, Urban_agr%_site, Urban_agr%_site100, Landuse_surround and Shore alteration%
Morpho_AT_DE_SI_TP	Combined parameters[##] of 2* Morpho_AT_DE_SI_all and TP
TP	Total Phosphorous concentration in mg P/l

[#] all anthropogenically altered areas, except woodlands, successional areas (e.g. scrublands) and natural marshes

[##] All combined indices are weighted averages of standardised single parameters; for standardisation the parameters were transformed into a range from 1.0 to 5.0

Table 5: *Stressor Variables for the development of the CB-ICM*

Variable	**Explanation**
Shore_alteration	% altered shore length of total shore length
Landuse_surround	Land-use index from the % of land uses in the 100 m belt around the whole lake (1 * % extensive agriculture + 2 * % intensive agriculture + 4 * % urban areas)
Landuse_catchment	Land-use index from the % of land uses in the lake catchment (1 * % extensive agriculture + 2 * % intensive agriculture + 4 * % urban areas)
Landuse_shore	Lnduse in the 15m belt around the whole lake (4* [%artificial] + 1.5* [%agriculture])
Morphoindex	Combined stressor index[##] consisting of shore_alteration, landuse_surround, 2* landuse_shore
Morpho_TP	Combined stressor index[##] consisting of 2* morphoindex and TP

[#] all anthropogenically altered areas, except woodlands, successional areas (e.g. scrublands) and natural marshes

[##] All combined indices are weighted averages of standardised single parameters; for standardisation the parameters were transformed into a range from 1.0 to 5.0

2.2 Metric selection

Metric calculation

Metric results will be dependent on the taxonomic resolution of the taxa list. The differences in determination level between the countries were analysed and harmonised within the GIGs. In the AL-GIG the taxonomic level was maintained on mostly species level for all taxa with the exception of Chironomidae and Oligochaeta, which were transformed to family level. In the CB-GIG Oligochaeta were also transformed to family level, Chironomidae to subfamily/tribe and most other taxa were left unchanged on mostly species level. For both GIGs, all meio- or microfauna, as well as Acari and parasites were excluded.

Using the harmonised taxa lists, over 120 biological indices were calculated within the Access-databases of the GIG groups. The algorithms and ecological informations were identical to the current Asterics software (version 3.1), developed by the EU projects AQEM and EUROLIMPACS. Some additional indices for lakes were created on the basis of that information (e.g. “no_ETO”= number of Ephemeroptera + Trichoptera + Odonata taxa). Only the Alpine Faunaindex was based on a different indicator list, which was derived during the development of the German assessment system AESHNA.

From these indices many were excluded, i.e. those for which there was no rationale why a metric is supposed to increase or decrease with the degradation of a water body. For example some stream indices were considered as unsuitable for lakes. Finally 71 indices were tested.

More details on these can be found in the appendix.

Selection of candidate metrics

To ensure a successful intercalibration, the metrics have to be well correlated with the national assessment systems of all countries (i.e. with the national multimetric indices, normalized as

EQR values (EQRs = Ecological Quality Ratios) from 0 to 1). At the same time it is desirable to have a good correlation with the stressor parameters.

Since the pressure situation differs between countries, the biological indices were analysed for the whole dataset as well as for each country separately. The data of some countries however, do not cover a wide range of the pressure gradient. This leads to weaker correlations for these countries.

The criteria for the selection of candidate metrics were in descending order:

- overall correlation with the national Ecological Quality Ratios (EQR values),
- correlation with the national EQRs for each country separately,
- overall correlation with the stressor variables and
- correlation with the stressor variables for each country separately

To judge the strength and quality of the correlation, Spearman's and Pearson's R were calculated and scatter plots were inspected for separation quality near the presumable good-moderate boundary. The focus was laid on the combined morphological indices which yielded the highest R^2 values.

Within the Alpine GIG only 2 countries had a method and 3 countries supplied data. R^2 values > 0,5 between the national EQR and metrics for all data together could only be obtained for the Faunaindex (FI_AL, figure 1), while all other metrics had much weaker correlations. For single countries, especially Slovenia, there were metrics with stronger correlations, but these metrics did not work that well in other countries.

The reason for these differences is to be attributed most likely to differences in sampling design, because metric responses were very similar between the countries with a similar sampling design (Austria and Slovenia with multihabitat sampling, Germany with habitat specific sampling).

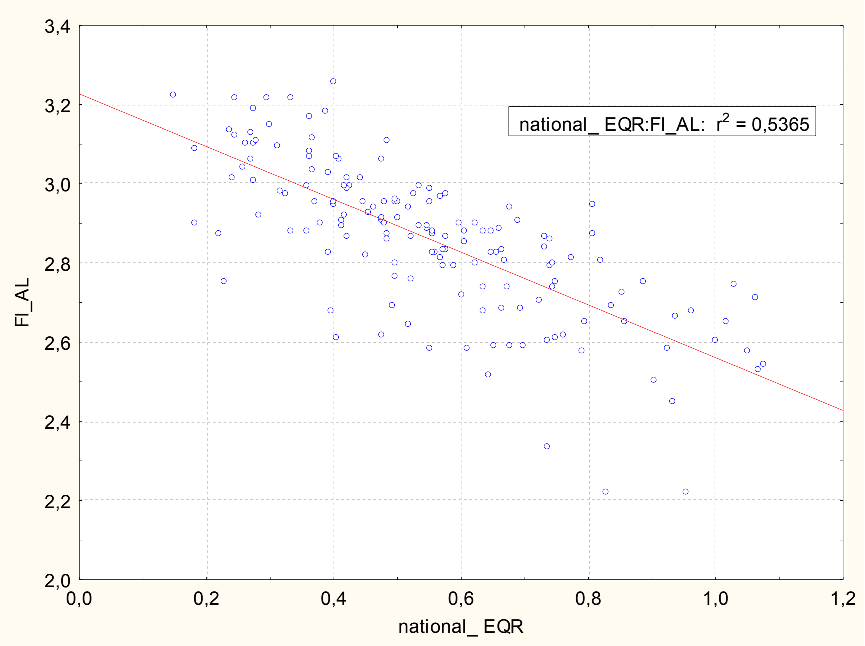

Figure 1: *Correlation between national assessment result (national_EQR) and the Faunaindex FI_AL.*

Based on all results the following metrics were selected for the alpine lakes as candidates for combination into multimetric indices:

- Faunaindex FI_AL
- % Odonata (% in relation to abundance classes)
- % ETO (% in relation to taxa number)
- Shannon-Wiener diversity
- number of taxa
- % feeding type gatherer (% in relation to abundance classes)
- rk (reproduction strategy r / k)
- % indifferent taxa (% in relation to abundance classes).

For Central Baltic lakes the candidate metrics were:

- number of EPTCBO-taxa
- number of ETO-taxa
- ASPT
- % Odonata (% in relation to abundance classes)
- % ETO (% in relation to abundance class)
- Reproduction strategy: r-/k-strategists
- % ETO (% in relation to abundance class)
- % indifferent taxa (% in relation to abundance class)

Metric standardisation and normalisation

Metric values need to be standardised to account for biogeographical and/or methodological differences. Also type-specific differences have to be considered, if necessary.

The evaluation of scatter plots revealed no differences for the intercalibration types CB1 and CB2 for Central/Baltic lakes and AL3 and AL4 for alpine lakes. However within the alpine lakes the differences between the smaller (< 5 km^2) and larger lakes (> 5 km^2) according to the German national macroinvertebrate assessment method AESHNA had to be taken into account. This was only relevant for the German data, because only one of the Austrian lakes and no Slovenian lake were larger than 5 km^2.

As long as sufficient data which cover the whole stressor gradient are available for each data group to be normalised the normalisation can be performed using upper and lower anchor points. Hereby the upper anchor corresponds to the upper limit of the metric's value under reference conditions, and to the lower limit of the metric's value under the worst attainable conditions.

Since reference lakes were scarce in most countries and several countries covered only a small part of the stressor gradient, this approach could not be satisfactorily applied to many countries and an alternative approach was applied to standardise the metrics in a first step, before normalising the data. This approach uses the full dose response curve of a metric to adjust for country differences in metric responses. The procedure will be described in detail within the final intercalibration report of the CB-macroinvertebrate group. Instead of using only parts of the metric responses to the stressor (benchmarks or references) it uses the full regression curve to calculate the differences between the countries. This is done with linear mixed models. We used the R statistics package lme4 with Morpho_AT_DE_SI_all as a stressor gradient and the offset as random factor. Table 6 gives the resulting offsets for the AL-lakes and table 7 for the CB-lakes.

Table 6: *Offsets for the alpine lake metric standardisation calculated with linear mixed models.*

Group (country_laketype)	**FI_AL**	**no_Taxa**	**gatherer**	**rk**
AT_small(<5)	0.057	-4.33	3.13	-0.0076
DE_large(>5)	0.090	10.66	-5.55	0.0119
DE_small(<5)	-0.052	1.25	-3.99	0.0046
SI_small(<5)	-0.096	-7.58	6.40	-0.0089

***Table 7:** Offsets for the central/baltic lake metric standardisation calculated with linear mixed models.*

country	no_EPTCBO	no_ETO	ASPT	Odo_HK	ETO_HK	rk	LIT_HK	IN_HK
BE	-1.48	-1.78	-0.44	-0.70	-9.07	0.0010	-3.00	8.62
DE	0.68	0.51	0.14	-2.69	-1.03	0.0196	2.19	8.40
EE	1.35	1.11	0.15	6.61	8.50	-0.0321	-1.91	-8.99
GB	-3.23	-3.13	-0.23	-2.97	-7.23	0.0039	-0.34	1.32
LT	0.62	2.50	0.55	1.07	18.00	-0.0486	1.25	-10.72
NL	2.07	0.79	-0.16	-1.32	-9.17	0.0563	1.81	1.36

After standardisation the data of all countries could be combined to derive anchor points. With these the metrics were then normalised to a scale from 0 to 1. This standard procedure is briefly characterised here. A detailed description is given in WISER deliverable 2.2-2:

The upper and lower anchors mark the indicative range of a metric, where the upper anchor represents the best value at reference condition (transformed to 1 for the normalised metric) to the worst attainable value (transformed to 0 for the normalised metric). Depending on the available data the anchors may be derived by references/heavily degraded sites, regression/modelling or percentiles.

***Table 8a:** Anchor points of the candidate metrics for alpine lakes.*

	small		large	
Metrics	**upper**	**lower**	**upper**	**lower**
ETO_Art%	55	20	55	35
FI_AL	2.95	2.6	3.2	2.75
Shannon-Wiener index	3.0	1.5	3.2	1.7
r/K	0.14	0.05	0.14	0.05
IN_HK	45	32	45	35
Odo_HK	3	0	0	0
Gather_HK	42	27	45	27
No_taxa	65	25	70	30

***Table 8b:** Anchor points of the candidate metrics for central/baltic lakes.*

Metrics	upper	lower
no_EPTCBO	20	0
no_ETO	15	0
ASPT	5.3	3
Odo_HK	10	0
ETO_HK	40	10
rk	0.3	0.04
rk_HK	0.35	0
LIT_HK	20	8
IN_HK	70	20

Using these anchors, the formula for normalisation is

$$\text{Value} = \frac{\text{Metric\_result} - \text{Lower\_Anchor}}{\text{Upper\_Anchor} - \text{Lower\_Anchor}}$$

for metrics decreasing with increasing impairment, and

$$\text{Value} = 1 + \frac{\text{Metric\_result} - \text{Lower\_Anchor}}{\text{Upper\_Anchor} - \text{Lower\_Anchor}}$$

for metrics increasing with increasing impairment.

Generation of Multimetric Indices

Normalised Metrics can be simply averaged to generate multimetric indices. Equal weight was given to all metrics. Only for alpine lakes the MMIs were calculated with both, single and double weighting of the Faunaindex, because the Faunaindex was the only metric correlating well with the national methods and the stressor parameters.

24 MMI-variants were tested for Central/Baltic and 2*17 for alpine lakes. These variants contained 3 to 6 Metrics, where at least one metric belonged to one of the three WFD-types required (sensitivity, taxonomic composition, diversity; tables 9 and 10).

Table 9: *24 Metric combinations tested for Common Multimetric Index development for the Central/Baltic lakes.*

Variant	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Sensitivity metrics																								
ASPT	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Taxonomic composition and functional groups																								
Odo_HK	x	x			x	x			x				x				x	x	x	x				
ETO_HK			x	x			x	x		x				x			x	x			x	x		
rk	x	x	x	x							x				x		x	x	x	x	x	x		
LIT_HK	x	x	x	x	x	x	x	x				x				x	x	x						
IN_HK																			x	x	x	x	x	x
Diversity																								
no_EPTCBO	x		x		x		x		x	x	x	x					x		x		x		x	
no_ETO		x		x		x		x					x	x	x	x		x		x		x		x

Table 10: *Metric combinations tested for Common Multimetric Index development for the alpine lakes. All variants were calculated with single and double weighting of the Faunaindex.*

Variant	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Sensitivity metrics																	
FI_AL	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Taxonomic composition and functional groups																	
Odon_HK	X	X	X	X	X	X	X	X	X	X				X	X	X	X
ETO_Art%	X	X	X	X					X		X						
gather_HK%	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X
rk		X		X		X		X			X	X	X		X		X
IN_HK			X	X			X	X								X	X
Diversity																	
Shannon-Wiener					X	X	X	X		X		X					
Taxazahl													X	X	X	X	X

All MMI-variants were correlated with the national methods and the stressor variables. Using the same criteria as for the single metrics the final common multimetric indices were selected.

The resulting Alpine Intercalibration Common Metric was variant 13 with double weighting of the Faunaindex:

ALP-ICM = (2*FI_AL+gather_HK+rk+no_taxa)/5

The resulting Central/Baltic Intercalibration Common Metric was variant 17:

CB-ICM = ASPT + no_EPTCBO + Odo_HK + ETO_HK + rk + LIT_HK)/6

Correlations of the ICM with the morphological stressors and especially with the national methods are stronger for the AL- than for the CB-lakes (table 11). This can be explained by the higher number and larger heterogeneity of the countries and lakes within the CB-GIG. Example graphs for the correlation between the ICM and the national methods as well as with the morphological stressor are given in figures 2, 3 and 4.

The correlations within the CB-GIG are higher for the individual countries which cover most of the pressure gradient (e.g. Pearson's R for CB-ICM with national EQR = 0.66 for NL and 0.68 for DE) and much worse for countries covering too small parts of the gradients.

Correlations with TP and other water chemistry parameters are not significant within the AL-GIG and very weak within the CB-GIG.

Table 11: *Correlation coefficients (Pearson's R / Spearman's R) of the developed Intercalibration Common Metrics.*

	CB-ICM		**ALP-ICM**	
	Pearson's R	Spearman's R	Pearson's R	Spearman's R
National methods	0.50	0.49	0.79	0.77
Morphology index	-0.46	-0.46	-0.42	-0.35
Naturalness_site			-0.49	-0.44
TP	-0.16	-0.31	0.11	0.17

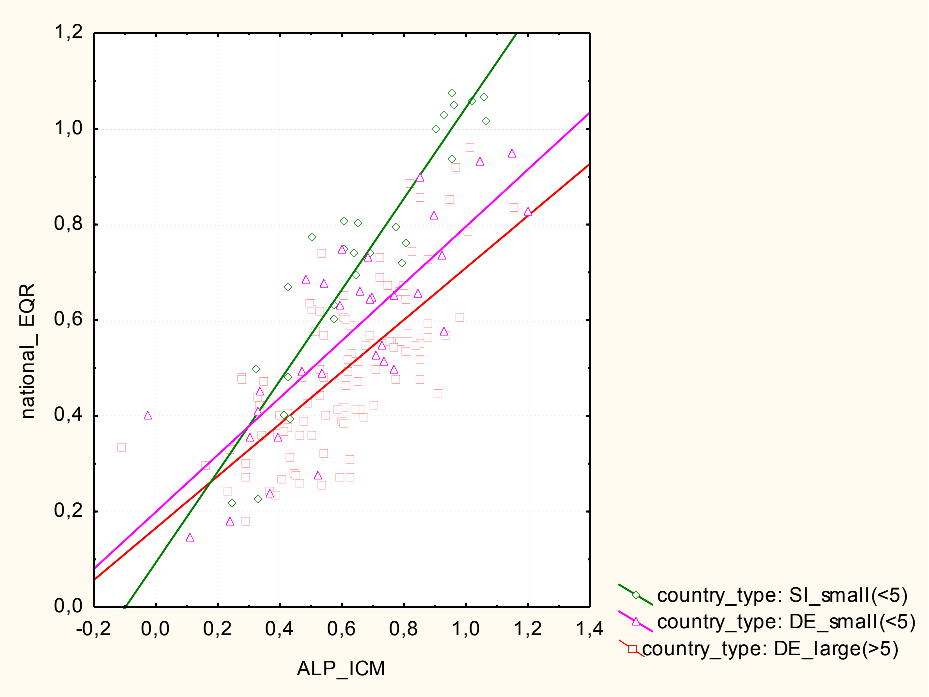

Figure 2: *Correlation between the selected ALP-ICM and the national assessment result (national_EQR).*

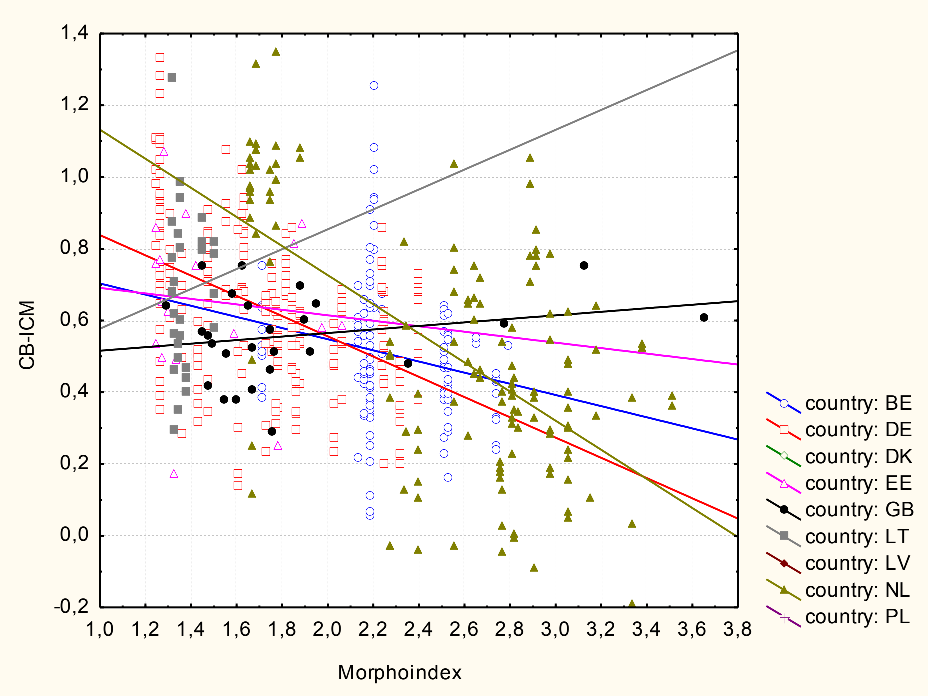

Figure 3: *Correlation between the combined morphological stressor (Morphoindex) and the selected CB-ICM. Note that some countries cover only very small parts of the stressor gradient. For LT this leads to a regression curve very much deviating from the others.*

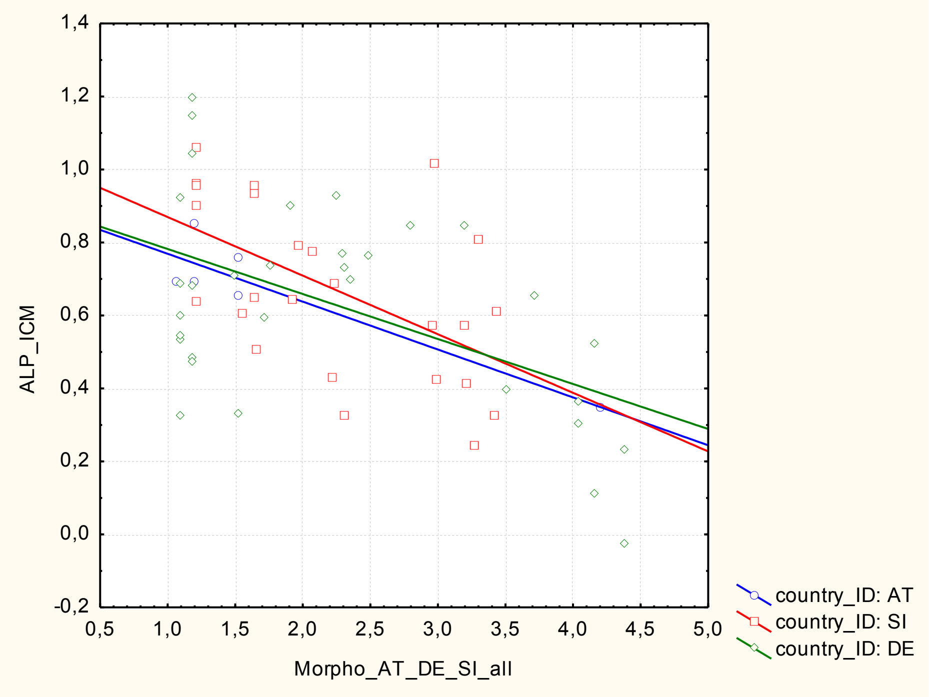

Figure 4: *Correlation between the combined morphological stressor (Morpho_AT_DE_SI_all) and the selected ALP-ICM for small lakes (< 5.0 km^2).*

2.3 References

Mathes, J., Plambeck, G., Schaumburg, J. (2002) Das Typisierungssystem für stehende Gewässer in Deutschland mit Wasserflächen ab 0,5 km² zur Umsetzung der Wasserrahmenrichtlinie. In: *Implementierung der EU-WRRL in Deutschland: Ausgewählte Bewertungsmethoden und Defizite*, 15-23, (Deneke, R. & Nixdorf, B., eds).

Michels, U., Böhmer, J. (2007) Bestandserfassung der benthischen wirbellosen Fauna in ausgewählten Seen des Landes Brandenburg im Jahr 2007. Projektbericht im Auftrag des Ministeriums für Ländliche Entwicklung, Umwelt und Verbraucherschutz des Landes Brandenburg, 1-105.

Appendices

3.1 Correlations between biological indices and stressor parameters for the Alpine GIG

Table A1: Example of a correlation table between biological indices and stressor parameters for the Alpine GIG; Spearman's R for all countries together.

biological index	National _ EQR	Naturalness_ site_ national	Morpho_ AT_DE_SI_ all_TP	Morpho_ AT_DE_ SI_all	urb_ agr% _site	urb_ agr100 _site	shore_ alteration%	landuse_ surround	landuse_ catchment	t-P_mg_l
afil%	-0.06	-0.07	0..06	0.05	-0.09	0.09	0.26	0.30	0.38	0.35
AKA%	-0.35	0.04	0.06	0.04	-0.09	-0.02	0.15	0.30	0.13	0.26
AKA_HK%	-0.25	-0.01	0.04	0.02	-0.12	-0.04	0.21	0.38	0.25	0.16
ASPT	-0.06	0.04	0.02	-0.01	-0.03	-0.02	0.12	0.19	0.18	0.17
ASPT_IZ	-0.15	0.03	0.16	0.14	-0.01	0.08	0.29	0.38	0.20	0.24
BMWP_Score	0.02	-0.04	0.08	0.08	-0.04	0.10	0.23	0.30	0.15	0.17
chiro%	-0.20	0.13	0.01	0.02	0.11	0.05	-0.13	-0.06	-0.05	-0.07
chiro_HK	-0.06	0.15	-0.05	-0.04	0.16	-0.04	-0.28	-0.35	-0.12	-0.19
Chironominae%	-0.06	0.10	-0.03	-0.02	0.08	0.03	-0.19	-0.12	-0.07	-0.04
Coleoptera%	-0.24	-0.04	-0.07	0.02	-0.08	-0.03	0.26	0.15	-0.16	-0.15
Crust%	0.06	-0.08	0.08	0.09	0.00	0.04	0.25	0.41	0.00	0.08
DomFam%	0.01	0.01	-0.07	-0.13	-0.05	-0.09	-0.18	-0.14	0.16	0.01
EPT%	-0.32	0.16	0.21	0.28	0.15	0.16	0.35	0.24	-0.03	0.00
EPT_HK%	-0.32	0.16	0.23	0.21	0.09	0.14	0.28	0.29	0.28	0.20
EPTCBO%	-0.22	0.02	0.15	0.17	-0.01	0.15	0.35	0.31	0.25	0.21
ETO_Art%	-0.13	0.13	0.14	0.08	0.02	0.08	0.12	0.18	0.28	0.30
ETO_HK%	-0.15	0.10	0.19	0.13	0.03	0.12	0.21	0.24	0.28	0.28
faf_fpf	-0.11	0.09	0.18	0.19	0.07	0.19	0.23	0.23	0.28	0.20
famrich	0.06	-0.07	0.06	0.08	-0.04	0.11	0.22	0.25	0.09	0.12
FI_AL	-0.76	0.41	0.43	0.45	0.35	0.37	0.23	0.35	0.11	0.21
FI_nat	-0.58	0.32	0.30	0.41	0.27	0.29	0.33	0.12	-0.07	-0.02
FI_nat_Ind	-0.15	0.20	0.13	0.28	0.23	0.16	0.19	0.02	-0.41	-0.29
Gastropoda%	0.44	-0.21	-0.08	-0.18	-0.16	-0.09	-0.29	-0.21	-0.04	0.25
gather%	-0.06	0.19	0.16	0.20	0.26	0.11	-0.11	-0.14	-0.15	-0.23
gather_HK	-0.09	0.16	0.03	0.15	0.18	-0.02	-0.03	-0.08	-0.21	-0.45
grazer%	-0.15	0.00	-0.06	0.02	-0.07	-0.03	0.17	0.11	-0.21	-0.23
grazer_HK	-0.05	-0.05	-0.06	0.01	-0.04	0.04	0.16	-0.03	-0.05	-0.22
IN%	0.12	-0.13	0.00	-0.04	-0.11	-0.05	0.14	0.19	0.37	0.14
Insecta%	-0.33	0.16	0.05	0.03	0.06	-0.01	-0.07	-0.01	-0.06	0.05
Lake%	0.43	-0.11	0.00	-0.08	-0.05	0.00	-0.08	-0.14	0.05	0.16
LB_HK%	-0.29	-0.01	0.00	0.01	-0.02	-0.01	0.02	0.06	-0.07	0.13
LIT_HK	-0.34	0.06	0.02	0.06	0.01	0.01	0.23	0.20	0.02	-0.10
littoral%	-0.08	0.18	0.13	0.11	0.16	0.10	-0.25	-0.19	-0.15	0.00
lse%	-0.14	0.00	0.16	0.12	0.00	0.12	0.28	0.35	0.44	0.28
lsw_HK	0.38	-0.06	-0.04	-0.05	-0.04	0.01	0.00	-0.13	-0.11	-0.05
no_C	-0.21	-0.06	0.05	0.07	-0.07	0.04	0.25	0.28	-0.04	0.06
no_E	-0.32	0.11	0.16	0.23	0.07	0.18	0.36	0.43	0.19	0.10
no_EPT	-0.25	0.09	0.26	0.21	0.02	0.20	0.31	0.47	0.34	0.40
no_EPTCBO	-0.24	0.06	0.27	0.20	-0.01	0.21	0.30	0.48	0.36	0.47
no_ETO	-0.15	0.07	0.26	0.18	-0.01	0.20	0.26	0.44	0.38	0.48
no_individuals	-0.21	0.01	0.15	0.10	-0.07	0.14	0.16	0.26	0.35	0.27
no_P	0.17	-0.03	-0.13	-0.10	0.02	-0.13	-0.13	-0.12	-0.28	-0.14
no_Taxa	-0.14	0.02	0.24	0.17	-0.01	0.20	0.27	0.45	0.33	0.40
no_Tricho	-0.19	0.08	0.27	0.17	0.01	0.20	0.25	0.41	0.38	0.47
Odo%	0.60	-0.27	-0.22	-0.30	-0.17	-0.15	-0.30	-0.24	-0.17	0.22

Odo_HK	0.63	-0.25	-0.17	-0.29	-0.17	-0.12	-0.31	-0.23	-0.09	0.28
oligo_HK%	-0.04	-0.10	-0.10	-0.07	-0.18	-0.02	0.20	0.21	0.16	0.03
orthoclad/chir%	-0.31	0.08	0.10	0.07	0.02	0.04	0.08	0.14	0.10	0.01
Orthocladinae%	-0.36	0.13	0.08	0.07	0.07	0.05	0.01	0.09	0.03	-0.03
PEL%	0.15	-0.01	-0.08	-0.04	-0.03	-0.04	-0.11	-0.31	-0.24	-0.12
pfil%	0.00	-0.09	-0.01	-0.09	-0.08	0.00	-0.05	0.05	0.10	0.24
PHY%	0.07	-0.10	-0.20	-0.15	-0.06	-0.15	-0.13	-0.20	-0.27	-0.25
Pleco%	0.17	-0.02	-0.13	-0.10	0.02	-0.12	-0.15	-0.14	-0.30	-0.15
POM%	0.23	-0.12	-0.05	-0.02	-0.06	-0.03	0.20	0.14	-0.03	-0.01
prodiamesinae%	-0.30	0.19	0.17	0.21	0.15	0.14	0.09	0.26	0.12	-0.07
PSA%	0.00	0.09	0.02	0.03	0.05	0.05	-0.13	-0.15	-0.02	-0.07
PTI	0.01	0.02	-0.01	0.00	0.11	0.08	-0.24	-0.26	-0.27	-0.14
rk	-0.53	0.16	0.25	0.19	0.08	0.19	0.13	0.08	0.24	0.31
rk_HK	-0.44	0.13	0.20	0.13	0.03	0.15	0.07	0.03	0.30	0.32
RTI	-0.07	0.01	-0.09	0.06	-0.01	-0.07	0.25	0.20	-0.29	-0.53
shred%	0.17	-0.06	0.06	0.03	0.00	0.00	0.10	0.21	-0.02	0.07
ShW	-0.24	0.02	0.06	0.10	0.02	0.06	0.24	0.29	-0.09	0.10
SI	0.26	-0.13	-0.01	-0.12	-0.02	0.00	-0.19	-0.20	0.07	0.29
sza%	0.25	-0.05	0.00	-0.06	0.03	-0.05	-0.18	-0.16	-0.23	-0.04
szo%	-0.10	-0.05	-0.02	0.01	-0.11	0.05	0.23	0.30	0.25	0.14
szp_HK	0.29	-0.13	-0.05	-0.08	0.00	-0.02	-0.09	-0.15	-0.06	-0.06
Tanypodinae%	0.09	-0.05	-0.09	-0.07	-0.06	-0.04	0.04	0.03	-0.16	-0.02
Tricho%	-0.12	-0.04	0.08	0.08	-0.01	0.02	0.38	0.32	0.17	0.05
xeno%	0.12	-0.09	-0.03	0.02	-0.02	0.05	0.13	0.06	0.08	-0.07
xeno_HK%	0.15	-0.09	-0.03	0.03	0.01	0.07	0.14	0.03	0.01	-0.14
xenoligo	-0.09	-0.05	-0.02	0.01	-0.10	0.06	0.22	0.30	0.25	0.13

CB-ICM-Metrics. standardised:

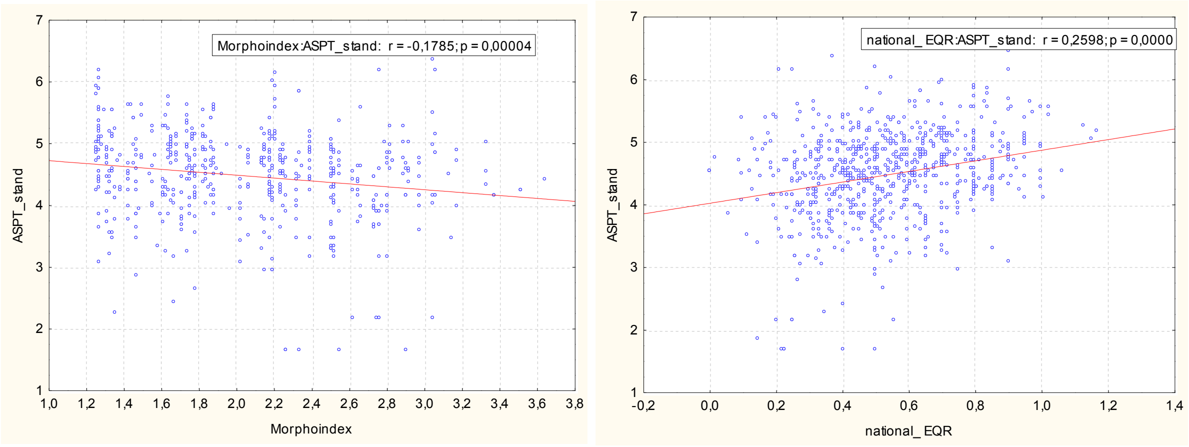

Figure A1: *Relation of standardised ASPT (CB-ICM core metric) with the combined morphological stressor (left) and the national assessment (right); Central/Baltic lakes.*

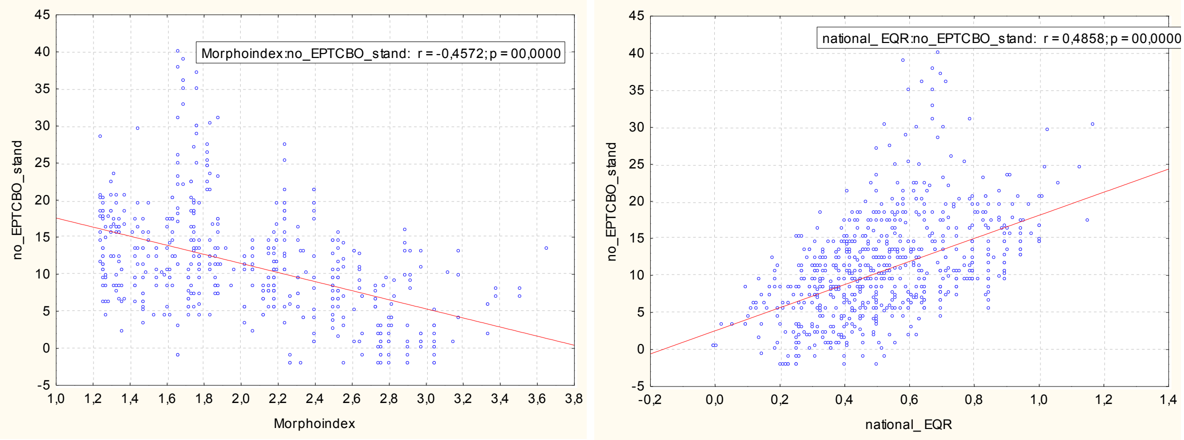

Figure A2: Relation of standardised no_EPTCBO (CB-ICM core metric) with the combined morphological stressor (left) and the national assessment (right); Central/Baltic lakes.

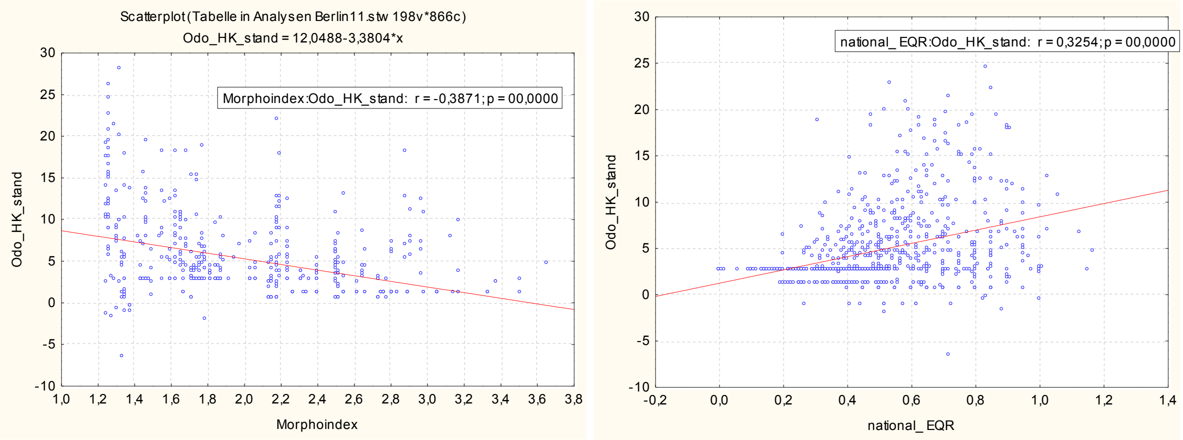

Figure A3: Relation of standardised Odo_HK (CB-ICM core metric) with the combined morphological stressor (left) and the national assessment (right); Central/Baltic lakes.

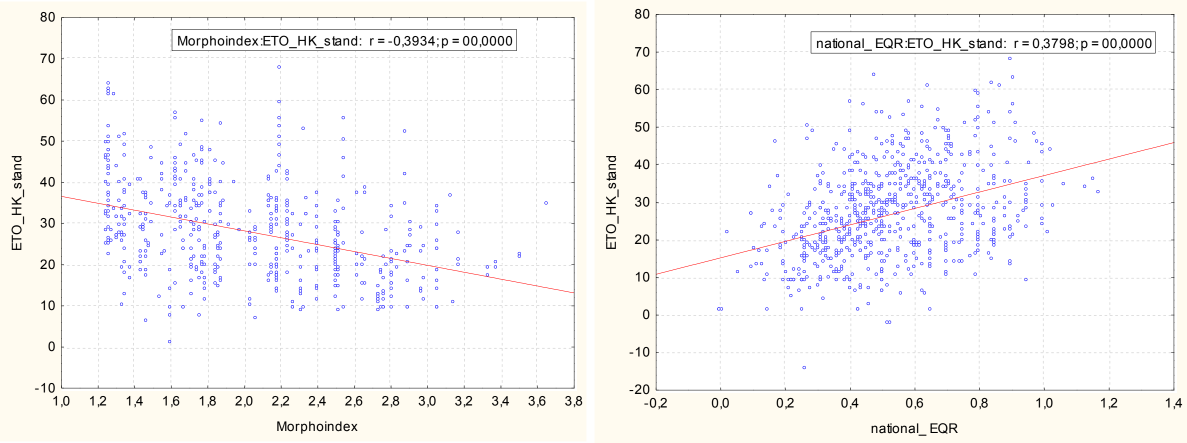

Figure A4: Relation of standardised ETO_HK (CB-ICM core metric) with the combined morphological stressor (left) and the national assessment (right); Central/Baltic lakes.

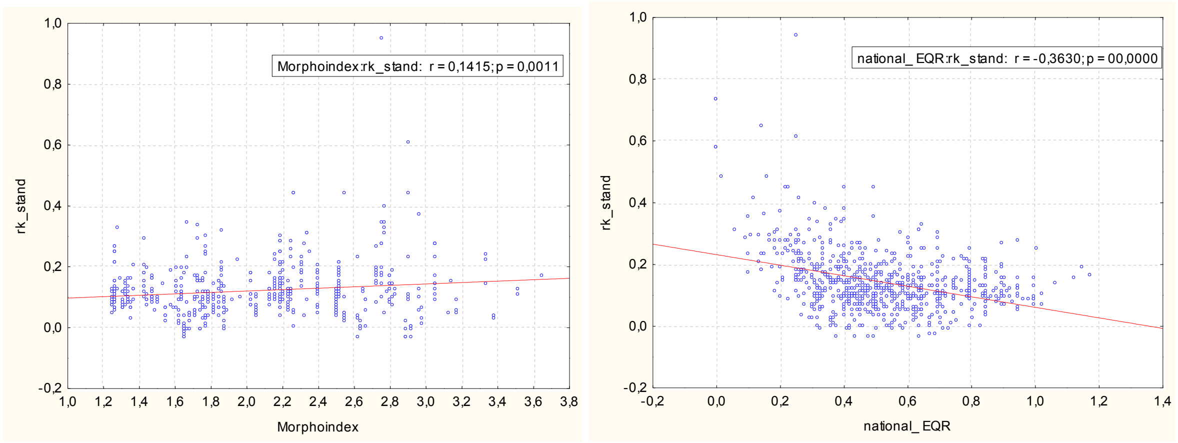

Figure A5: *Relation of standardised rk (CB-ICM core metric) with the combined morphological stressor (left) and the national assessment (right); Central/Baltic lakes.*

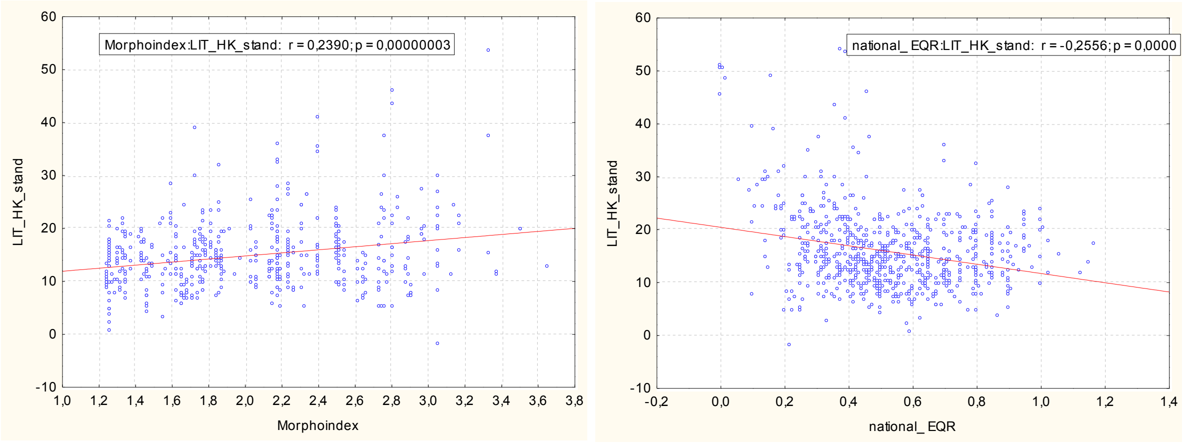

Figure A6: *Relation of standardised LIT_HK (CB-ICM core metric) with the combined morphological stressor (left) and the national assessment (right); Central/Baltic lakes.*

ALP-ICM-Metrics. standardised:

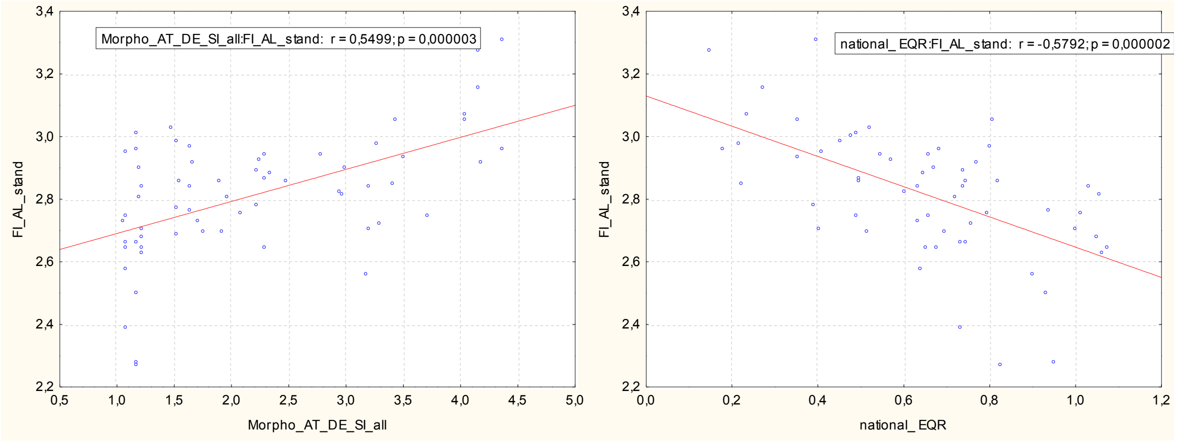

Figure A7: *Relation of standardised faunaindex (ALP-ICM core metric) with the combined morphological stressor (left) and the national assessment (right); alpine lakes. small lake data (<5.0 km^2).*

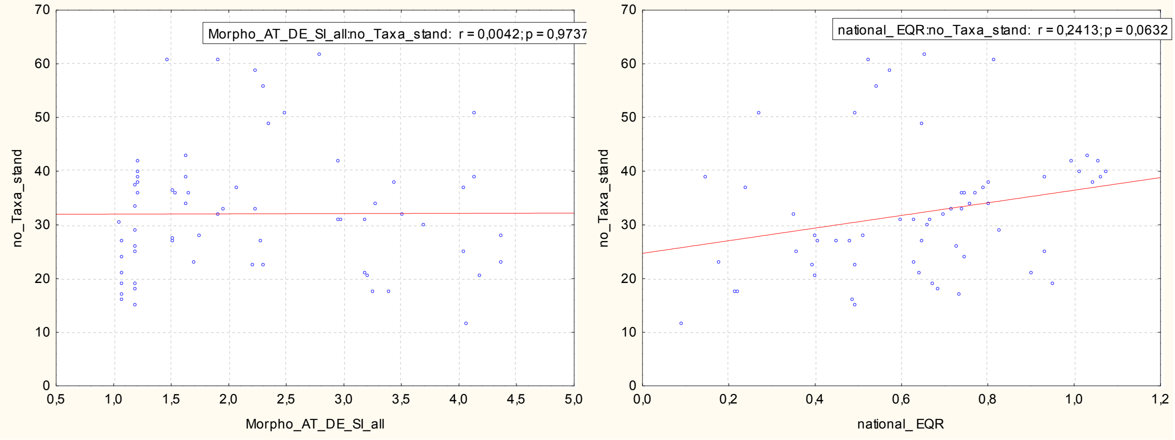

Figure A8: *Relation of standardised taxa number (ALP-ICM core metric) with the combined morphological stressor (left) and the national assessment (right); alpine lakes. small lake data (<5.0 km^2).*

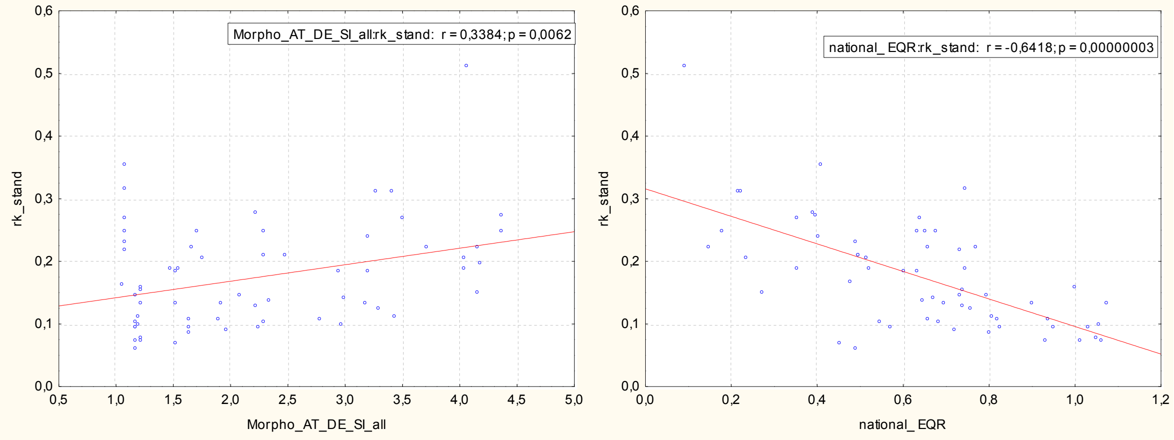

Figure A9: *Relation of standardised reproduction trait r/k (ALP-ICM core metric) with the combined morphological stressor (left) and the national assessment (right); alpine lakes. small lake data (<5.0 km^2).*

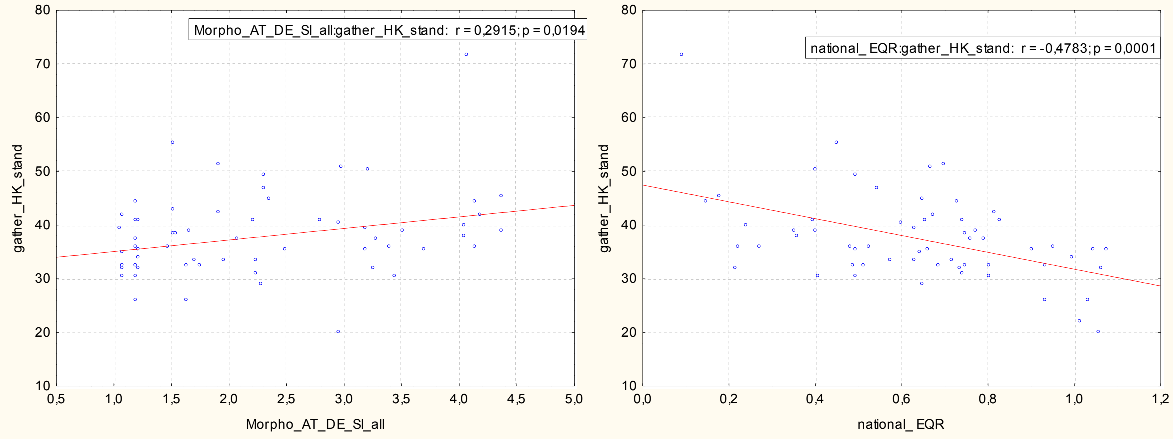

Figure A10: *Relation of standardised feeding type gatherer (ALP-ICM core metric) with the combined morphological stressor (left) and the national assessment (right); alpine lakes. small lake data (<5.0 km^2).*

3.2 Documentation of used indices

The table below lists all the index names used for common metric development.

Percentage Metrics were calculated in three different ways:

1. % of individuals (all individuals of taxa with an indicator value equal 100%)
2. % of abundance classes (the sum of the abundance classes of all taxa with an indicator value equals 100%)
3. % of taxa (the number of all taxa with an indicator value equals 100%)

A characterisation of the metrics can be found in the AQEM Manual 1.0 (AQEM consortium 2003: Manual for the application of the AQEM system, http://www.aqem.de/mains/products.php).

Table A2: *List of indices analysed for common metric development. Index shortname = name in database, graphs and tables; index name = full index name; Column in indicator list = name of column heading in the indicator list of the asterics software; % Ind. = percentage in relation to counts of individuals; % abundance classes = percentage in relation to the sum of abundance classes*

Index shortname	Index name	Column in indicator list
famrich	number of families	-
no_Taxa	Number of taxa	-
Margalef	Margalef diversity	-
ShW	Shannon Wiener diversity	-
no_E	number of Ephemeroptera taxa (E)	-
no_P	number of Plecoptera taxa (P)	-
no_Tricho	number of Trichoptera taxa (T)	-
no_C	number of Coleoptera taxa (C)	-
no_B	number of Bivalvia taxa (B)	-
no_O	number of Odonata taxa (O)	-
no_EPT	number of EPT taxa	-
no_EPTCBO	number of EPTCBO taxa	-
no_ETO	number of ETO taxa	-
EPT%	Percentage of EPT (% Indiv.)	-
DomFam%	Percentage of dominant family (% Indiv.)	-
Insecta%	Percentage of Insecta (% Indiv.)	-
Insecta_excl_Chir_HK	Percentage of Insecta without Chironomidae (% abundance classes)	-
Insecta_HK	Percentage of Insecta (% abundance classes)	-
chiro%	Percentage of Chironomidae (% Indiv.)	-
chiro_HK	Percentage of Chironomidae (% abundance classes)	-
Chironominae%	Percentage of Chironominae (% Indiv.)	-
prodiamesinae%	Percentage of Prodiamesinae (% Indiv.)	-
Tanypodinae%	Percentage of Tanypodinae (% Indiv.)	-
Orthocladinae%	Percentage of Orthocladinae (% Indiv.)	-
orthoclad/chir%	Percentage of Orthocladinae in relation to all Chironomidae (% Indiv.)	-
Diamesini%	Percentage of Diamesini (% Indiv.)	-
Pleco%	Percentage of Plecoptera (% Indiv.)	-
Pleco_HK	Percentage of Plecoptera (% abundance classes)	-
Tricho%	Percentage of Trichoptera (% Indiv.)	-

Index shortname	**Index name**	**Column in indicator list**
Odo%	Percentage of Odonata (% Indiv.)	-
Odo_HK	Percentage of Odonata (% abundance classes)	-
Crust%	Percentage of Crustacea (% Indiv.)	-
Crust_HK	Percentage of Crustacea (% abundance classes)	-
Gastropoda%	Percentage of Gastropoda (% Indiv.)	-
Gastropoda_HK	Percentage of Gastropoda (% abundance classes)	-
Coleoptera%	Percentage of Coleoptera (% Indiv.)	-
Coleoptera_HK	Percentage of Coleoptera (% abundance classes)	-
EPT_HK%	Percentage of EPT (% abundance classes)	-
EPTCBO%	Percentage of EPTCBO (% Indiv.)	-
ETO%	Percentage of ETO (% Indiv.)	-
ETO_HK%	Percentage of ETO (% abundance classes)	-
ETO_Art%	Percentage of ETO (% of taxa number)	-
szo%	oligo saprobic (% Ind.)	szo
oligo_HK%	oligo saprobic (% abundance classes)	szo
xeno%	xeno saprobic (% Ind.)	szx
xeno_HK%	xeno saprobic (% abundance classes)	szx
xenoligo	xeno + oligo saprobic (% Ind.)	szx, szo
sza%	alpha-meso saprobic (% Ind.)	sza
szb%	beta-meso saprobic (% Ind.)	szb
szp%	poly saprobic (% Ind.)	szp
szp_HK	poly saprobic (% abundance classes)	szp
Acidity	acidity class	acidclass new
ASPT	ASPT (Average Score Per Taxon)	bmwp
ASPT_IZ	ASPT (Average Score Per Taxon, Ind.)	bmwp
BMWP_Score	BMWP (Biological Monitoring Working Party)	bmwp
FI…	Fauna Index for type…	FI…
PTI	PTI (Potamo-Typie-Index)	ECO_P
RTI	RTI (Rhithron-Typie-Index)	RTI
SI	saprobic index	sin, sgn
afil%	Feeding type Active filter feeders (% Ind.)	faf
pfil%	Feeding type Passive filter feeders (% Ind.)	fpf
gather%	Feeding type Gatherers/Collectors (% Ind.)	fga

Index shortname	**Index name**	**Column in indicator list**
gather_HK	Feeding type Gatherers/Collectors (% abundance classes)	fga
grazer%	Feeding type Grazer and scrapers (% Ind.)	fgr
grazer_HK	Feeding type Grazer and scrapers (% abundance classes)	fgr
shred%	Feeding type Shredders (% Ind.)	fsh
fpa	Feeding type Parasites (% Ind.)	fpa
fmi	Feeding type Miners (% Ind.)	fmi
fpr	Feeding type Predators (% Ind.)	fpr
R_Art	Feeding type Predators (south German list, % taxa)	R
fot	Other Feeding Types (% Ind.)	fot
faf_fpf	Aktive Filterers / Passive Filterers	faf and fpf
zfs	feeding type index: Shredders/(Filterers + Gatherers)	fsh, zaf, zpf, zga
RETI	feeding type index RETI (Rhithron-feeding type index)	faf … fxy
har%	Preference for microhabitat Argyllal (% Ind.)	har
AKA%	Preference for microhabitat Akal (% Ind.)	hak
AKA_HK%	Preference for microhabitat Akal (% abundance classes)	hak
LIT%	Preference for microhabitat Lithal (% Ind.)	hli
LIT_HK	Preference for microhabitat Lithal (% abundance classes)	hli
PEL%	Preference for microhabitat Pelal % Ind.)	hpe
PHY%	Preference for microhabitat Phytal % Ind.)	hph
POM%	Preference for microhabitat POM (% Ind.)	hpo
PSA%	Preference for microhabitat Psammal (% Ind.)	hps
OTH%	Preference for other microhabitats (% Ind.)	hot
AHT1%	Preference for habitat type1 (coarse substrate/strong current, % Ind.)	AHT1
AHT1_HK%	Preference for habitat type1 (coarse substrate/strong current, % abundance classes)	AHT1
eukrenal%	Preference for eucrenal (spring, % Ind.)	zeu
hypokr%	Preference for hypocrenal (spring-brook, % Ind.)	zhy
krenal_ges%	Preference for crenal (% Ind.)	zhy, zeu
ER%	Preference for epirhithral (upper-trout region, % Ind.)	zer
MR%	Preference for metarhithral (lower-trout region, % Ind.)	zmr
HR%	Preference for hyporhithral (greyling region, % Ind.)	zhr
rhithral_ges%	Preference for rhithral (% Ind.)	zer, zmr
EP%	Preference for epipotamal (barbel region, % Ind.)	zep

Index shortname	**Index name**	**Column in indicator list**
MP%	Preference for metapotamal (brass region, % Ind.)	zmp
HP%	Preference for hypopotamal (brackish water, % Ind.)	zhp
potamal_ges%	Preference for potamal (% Ind.)	zpo
litoral%	Preference for Littoral (% Ind.)	hli
profundal%	Preference for Profundal (% Ind.)	zpr
Lake%	Preference for lakes (% Ind.)	zli, zpr
lse%	Locomotion type: (semi)sessil (% Ind.)	lse
lse_HK	Locomotion type: (semi)sessil (% abundance classes)	lse
lss%	Locomotion type: swimming/scating (% Ind.)	lss
lbb%	Locomotion type: burrowing/boring (% Ind.)	lbb
lsw_HK	Locomotion type: sprawling/waking (% abundance classes)	lsw
lot%	Locomotion type: other (% Ind.)	lot
rk	Reproduction strategy: R strategists / K strategists (Ind.)	rk
rk_HK	Reproduction strategy: R strategists / K strategists (abund. classes)	rk
LB%	Type LB (limnobiont, occurring only in standing waters) (Ind.)	cup
LB_HK%	Type LB (limnobiont, occurring only in standing waters) (abundance classes)	cup
LP%	Type LP (limnophil, preferably occurring in standing waters; avoids current; rarely found in slowly flowing streams) (Ind.)	cup
LP_HK%	Type LP (limnophil, preferably occurring in standing waters; avoids current; rarely found in slowly flowing streams) (abundance classes)	cup
LR_HK	Type LR (limno- to rheophil, preferably occurring in standing waters but regularly occurring in slowly flowing streams) (abundance classes)	cup
RL_HK	Type RL (rheo- to limnophil, usually found in streams; prefers slowly flowing streams and lentic zones; also found in standing waters) (abundance classes)	cup
RP%	Type RP (rheophil, occurring in streams; prefers zones with moderate to high current) (Ind.)	cup
RP_HK%	Type RP (rheophil, occurring in streams; prefers zones with moderate to high current) (abundance classes)	cup
RB%	Type RB (rheobiont, occurring in streams; bound to zones with high current) (Ind.)	cup
RB_HK%	Type RB (rheobiont, occurring in streams; bound to zones with high current) (abundance classes)	cup
IN%	Type IN (indifferent, no preference for a certain current velocity)	cup

Index shortname	**Index name**	**Column in indicator list**
	(Ind.)	
IN_HK%	Type IN (indifferent, no preference for a certain current velocity) (abundance classes)	cup
rheo_HK	Rheoindex according to Banning	RIB
rheo_IZ	Rheoindex according to Banning	RIB