Water Framework Directive Intercalibration Technical Report: Alpine Lake Macrophyte ecological assessment methods

K. Pall, Vincent Bertrin, F. Buzzi, Sébastien Boutry, Alain Dutartre, M. Germ, A. Oggioni, J. Schaumburg, G. Urbanic, Sandra Poikane

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Alpine Lake Macrophyte ecological assessment methods

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Introduction

The European Water Framework Directive (WFD) requires the national classifications of good ecological status to be harmonised through an intercalibration exercise. In this exercise, significant differences in status classification among Member States are harmonized by comparing and, if necessary, adjusting the good status boundaries of the national assessment methods.

Intercalibration is performed for rivers, lakes, coastal and transitional waters, focusing on selected types of water bodies (intercalibration types), anthropogenic pressures and Biological Quality Elements. Intercalibration exercises were carried out in Geographical Intercalibration Groups - larger geographical units including Member States with similar water body types - and followed the procedure described in the WFD Common Implementation Strategy Guidance document on the intercalibration process (European Commission, 2011).

In a first phase, the intercalibration exercise started in 2003 and extended until 2008. The results from this exercise were agreed on by Member States and then published in a Commission Decision, consequently becoming legally binding (EC, 2008). A second intercalibration phase extended from 2009 to 2012, and the results from this exercise were agreed on by Member States and laid down in a new Commission Decision (EC, 2013) repealing the previous decision. Member States should apply the results of the intercalibration exercise to their national classification systems in order to set the boundaries between high and good status and between good and moderate status for all their national types.

Annex 1 to this Decision sets out the results of the intercalibration exercise for which intercalibration is successfully achieved, within the limits of what is technically feasible at this point in time. The Technical report on the Water Framework Directive intercalibration describes in detail how the intercalibration exercise has been carried out for the water categories and biological quality elements included in that Annex.

The Technical report is organized in volumes according to the water category (rivers, lakes, coastal and transitional waters), Biological Quality Element and Geographical Intercalibration group. This volume addresses the intercalibration of the Lake Alpine Macrophyte ecological assessment methods.

Contents

1. Introduction 2
2. Description of national assessment methods 2
3. Results of WFD compliance checking 5
4. Results IC Feasibility checking 6
5. IC dataset collected 9
6. Common benchmarking 10
7. Comparison of methods and boundaries 12
8. Description of boundary setting procedure and biological communities ...15

Annexes

A. Description of member states assessment methods 22
B. Summary description of member states assessment methods 112

1. Introduction

In the Alpine Macrophyte Geographical Intercalibration Group:

- Five Member States (Austria, France, Germany, Italy and Slovenia) compared and harmonised their national lake macrophyte assessment systems;
- All methods address eutrophication and general degradation pressure and follow a similar assessment principle (including species composition and abundance indices);
- Intercalibration "Option 3" was used - direct comparison of assessment methods using a common dataset via application of all assessment methods to all the data available;
- The comparability analysis show that methods give a closely similar assessment (in agreement to comparability criteria defined in the IC Guidance), so only one boundary adjustment was needed (France where "good-moderate" boundary was adjusted from 0.69 to 0.72);
- The final results include EQRs of lake macrophyte assessment systems of Austria, France, Germany, Italy and Slovenia for two common types: LAL-3 and L-AL4.

2. Description of national assessment methods

Five Member States compared and harmonised their national lake macrophyte assessment systems (more detailed descriptions in Annex E.1, Annex E.2):

- Austria - AIM for Lakes (Austrian Index Macrophytes for lakes), a multimetric system including five metrics: overall macrophyte abundance, vegetation limit, vegetation zonation, trophic indication, species composition. In each case the deviation from reference condition is calculated.
- France - IBML (French Macrophyte Index for Lakes) includes only one metric based on abundance of indicator taxa and composition (trophic level indicating species and stenoecy coefficient).
- Germany - PHYLIB for Lakes (German Assessment system for Macrophytes & Phytobenthos for Lakes for implementation of the WFD). Multimetric system uses the arithmetic mean of a macrophyte species composition metric, supported by additional metrics (vegetation limit and mass stands of eutrophication indicating species) and a phytobenthos species composition metric combined with a phytobenthos trophic index is calculated.
- Italy– MacroIMMI (Macrophytic index for the evaluation of the ecological quality of the Italian lakes), a multimetric system including three metrics: vegetation limit (Z-cmax), trophic score (sk) and dissimilarity index. Other two metrics - percent frequencies of submerged species and of exotic species are used as limits of application of the index.

- Slovenia– SMILE (Slovenian macrophyte-based index for lake ecosystems) uses a multimetric system comprising three metrics - Macrophyte Index (MI) (Melzer et al., 1986); vegetation limit and Charophyte vegetation limit

2.1. Methods and required BQE parameters

All macrophyte assessment systems include (See Table 2.1):

- Taxonomic composition metrics, mostly expressed as species composition indices;
- Abundance metrics, mostly expressed as maximum colonization depth (see table below), except French method (they don't use vegetation limit, only abundance of indicator taxa).

Table 2.1 Overview of the metrics included in the national phytoplankton assessment methods. MP- macrophytes, Phb – phytobenthos.

Member State	Full BQE method	Taxonomic composition	Abundance	Combination rule of metrics
AT	only MP	Trophic index Reference species index	Vegetation limit Vegetation density Zonation	Average
FR	only MP	Species composition index	Abundance of indicator taxa	Combined in one metric
GE	MP and Phb*	MP: Species composition index Phb: Species composition index" trophic index	Abundance of indicator taxa (Kohler and %), vegetation limit, mass stands of selected taxa	Average
IT	only MP	Trophic score, Dissimilarity index, Percent frequency of exotic species	Vegetation limit	Average metric scores
SI	MP and Phb*	MP: Trophic index Phb: Trophic index	Vegetation limit Vegetation limit of charophytes	Weighted average

*Macrophytes and phytobenthos intercalibrated separately

Sampling and data processing

All countries use similar sampling strategies and data processing techniques (Table 2.2.)

Table 2.2 Overview of the sampling and data processing of the national phytoplankton assessment methods

Member State	Sampling device	Surveyed compartment/ Habitat/ecotope	Sample processing	How is abundance measured
AT	Diving equipment	Entire littoral of each transect down to the vegetation limit	Mapping of the vegetation of the entire transect. Single plants are taken for assurance of determination	PMI (according to Kohler, 1978)
FR	Rake or grapnel			
GE	Rake or diving equipment			
IT	Rake, underwater video			
SI	Rake			

National reference conditions

Table 2.3 summarizes the methodology used to derive the reference high status or the H/G boundary (in the case of Poland).

Table 2.3 Overview of the methodologies used to derive the reference conditions for the national macrophyte assessment methods

MS	Austria	France	Germany	Italy	Slovenia
Key source to derive RC	Historical information, existing reference transects and expert judgement	Existing list of least disturbed condition sites according to national circular	Historical information, paleolimnological data, existing reference transects and expert judgement	Expert knowledge, historical data (no reference site in Italy available) Use of the reference sites of the IC database	Existing reference transects
Geographical scope	Alpine region	Alpine region	Alpine region	Alpine region	Alpine region
Number of ref sites	5 transects from 3 lakes	12 observation units (transects) from 3 lakes	4 transects from 1 lake	Use of all reference transects of the Alp-GIG database	2 transects from 1 lake*
Location of ref sites	Attersee, Fuschlsee, Weißensee	Barterand, Grand Maclu, Etival	Alpsee	Attersee, Fuschlsee, Weißensee, Barterand, Grand Maclu, Etival, Alpsee, Lake Bohinj	Lake Bohinj
Time period	August 2005	July 2008	Juli 2004	August 2005 to July 2009	July 2009

*Slovenia has only 2 lakes

National boundary setting

Table 2.4 summarizes the methodology used to derive ecological boundaries.

Table 2.4 Overview of the methodology used to derive ecological class boundaries

MS	Austria	France	Germany	Italy	Slovenia
Pressure assessed	Eutrophicatio n and general degradation	Eutrophication and general degradation	Eutrophication and general degradation	Eutrophication and general degradation	Eutrophication and general degradation
Rationale of quality class boundary setting	Use of discontinuities and equidistant division of continuum in different metrics	Use of percentiles and equidistant division of continuum	Use of change of species composition and abundance along a gradient of degradation in different metrics	Use of percentiles and equidistant division of continuum on a log scale	Use of percentiles and equidistant division of continuum
H/G boundary	Use of discontinuities in different metrics	75th percentile of reference sites	Use of change of species composition and abundance along a gradient of degradation in different metrics	95th percentile of common ALP-GIG database reference sites	25th percentile of pressure class 1
G/M boundary	Use of discontinuities in different metrics	Equidistant division of continuum	Use of change of species composition and abundance along a gradient of degradation in different metrics	Equidistant class widths on a log scale	25th percentile of pressure class 2
M/P boundary	Equidistant division of continuum	Equidistant division of continuum	Use of change of species composition / abundance along a gradient of degradation in different metrics	Equidistant class widths on a log scale	Equidistant division of continuum

3. Results of WFD compliance checking

All MS methods are considered WFD compliant. The table below lists the criteria from the IC guidance and compliance checking conclusions.

General conclusion of the compliance checking:

- Design and concept of national assessment methods were extensively discussed and evaluated among experts at the meetings in Vienna. The WFD compliance criteria stated in the IC Guidance are met by all countries;
- All methods are WFD compliant.

Table 3.1 List of the WFD compliance criteria and the WFD compliance checking process and results

Compliance criteria	Compliance checking conclusions
Ecological status is classified by one of five classes (high, good, moderate, poor and bad).	All MS: Yes
High, good and moderate ecological status are set in line with the WFD's normative definitions (Boundary setting procedure)	All MS: Yes For details see Chapter 8
All relevant parameters indicative of the biological quality element are covered (see Table 1 in the IC Guidance). A combination rule to combine parameter assessment into BQE assessment has to be defined. If parameters are missing, Member States need to demonstrate that the method is sufficiently indicative of the status of the QE as a whole.	All MS consider taxonomic composition and abundance of macrophytes and have defined a combination rule for these two parameters; GERMANY in addition has a combination rule for two Phytobenthos-metrics. Even SLOVENIA has a Phytobenthos assessment system. Both countries have a rule for calculating an entire BQE – EQR (Germany on transect level, Slovenia an lake level).
Assessment is adapted to intercalibration common types that are defined in line with the typological requirements of the WFD and approved by WG ECOSTAT	All MS: Yes All systems are appropriate for L-AL3 and L-AL4 lakes
The water body is assessed against type-specific near-natural reference conditions	All MS: Yes For Details see Chapter 6.
Assessment results are expressed as EQRs	All MS: Yes
Sampling procedure allows for representative information about water body quality/ ecological status in space and time	All MS: Yes Details see Annex II, Table 1
All data relevant for assessing the biological parameters specified in the WFD's normative definitions are covered by the sampling procedure	All MS: Yes Sampling includes species composition and abundance parameters, AUSTRIA, FRANCE, ITALY: only macrophytes are considered. GERMANY: Macrophytes and Phytobenthos are considered. SLOVENIA: Phytobenthos is handled separately
Selected taxonomic level achieves adequate confidence and precision in classification	All MS: Yes Work on species level.

4. Results IC Feasibility checking

Typology

Intercalibration feasible in terms of typology (Table 4.1) - all assessment methods are appropriate for the common types.

Table 4.1 Evaluation if IC feasibility regarding common IC types

Common IC type	Type characteristics	MS sharing IC common type
L-AL3	Altitude 50 – 800 m Mean depth: >15 m Alkalinity > 1 meq/l	All MS: Yes
L-AL4	Altitude: 200 – 800 m Mean depth: 3 – 15 m Alkalinity > 1 meq/l	AUSTRIA, FRANCE, GERMANY, ITALY: Yes Not in SLOVENIA

Pressures addressed

Intercalibration is feasible in terms of pressures addressed by the methods – eutrophication and general degradation (Table 4.2).

Table 4.2 Evaluation if IC feasibility regarding common IC types

Member State	Pressure or combination of pressures	Pressure indicators /Strength of relationship
Austria	Eutrophication and general degradation	TP*: r^2 = 0.27 Secchi*: r^2 = 0.36 Chl a*: r^2 = 0.20 (*GIG-database)
France	Eutrophication and general degradation	Significant Pearson correlation -0.57 for the riparian type (FR data) TP*: r^2 = 0.33 Secchi*: r^2 = 0.50 Chl a*: r^2 = 0.29 (*GIG-database)
Germany	Eutrophication and general degradation	TP*: r^2 = 0.50 Secchi*: r^2 = 0.41 Chl a*: r^2 = 0.37 (*GIG-database)
Italy	Eutrophication and general degradation	Regression EQR – LogTP R^2 = 0,4595 (IT data) TP*: r^2 = 0.30 Secchi*: r^2 = 0.37 Chl a*: r^2 = 0.37 (*GIG-database)
Slovenia	Eutrophication and general degradation	Combined pressure gradient index was built including mean annual total phosphorous concentration, land use in 200 m site-belt and lakeshore modification class (SI data). TP*: r^2 = 0.31 Secchi*: r^2 = 0.53 Chl a*: r^2 = 0.28

(*GIG-database)

Assessment concept

All national methods follow a similar assessment concept (see table below)

Table 4.3 Evaluation if IC feasibility regarding assessment concept

Method	Assessment concept	Remarks
Austria	Submersed macrophytes in the entire littoral of investigated transects from all habitats. Species composition indexes (reference species and trophic indication) Additional: Overall macrophyte abundance Vegetation limit Type-specific zonation	Data from emergent macrophytes are available, but don't enter the assessment. No Phytobenthos data available, but other short-term reacting components as e.g. vegetation limit can substitute them
France	Submersed macrophytes in the entire littoral of investigated transects from all habitats. Species composition and abundance index. Trophic level indicating taxa and stenoecy coefficient (300 indicating taxa) Additional: Emergent macrophytes and macroalgae. But: The assessment is possible only with submersed macrophytes, too.	Phytobenthos: under development
Germany	Submersed macrophytes in the entire littoral of investigated transects from all habitats. Macrophytes: Species composition index Additional: Vegetation limit mass stands of eutrophication indicating species Phytobenthos: Species composition index, trophic index EQRs are calculated for macrophytes and for phytobenthos separately. Combination rule for entire BQE Macrophytes & Phytobenthos: One ecological status index (EQR) But: The assessment is possible only with submersed macrophytes, too.	Data from emergent macrophytes are available, but don't enter the assessment.
Italy	Submersed macrophytes in the entire littoral are investigated using transects from all habitats. Species composition indexes (reference species and trophic indication) Additional: Vegetation limit	For phytobenthos a new metric (species composition index and trophic index), proposed in the phytobenthos IC group will be testet: a mean between German and French phytobenthos approach.
Slovenia	Submersed macrophytes in the entire littoral of investigated transects from all habitats. Species composition index (trophic indication) Additional: Vegetation limit Vegetation limit of Charophytes	Data from emergent macrophytes are available, but don't enter the assessment. Phytobenthos assessment method is developed, however, separated from macrophytes.

5. IC dataset collected

Huge dataset was collected within the Alpine GIG (Table 5.1 to Table 5.3.).

Table 5.1 Overview of the Alpine GIG macrophyte IC dataset

Size of common dataset: total number of sites	219 transects LAL3, 109 transects LAL4
Number of Member States	5
Repackage/disaggregation of samples/WB results?	Use of transect data (no disaggregation of lake data)
Gradient of ecological quality	High to poor
Coverage per ecological quality class	High: 19% of sites Good: 35% of sites Moderate: 39% of sites Poor: 7% of sites Bad: -

Table 5.2 Description of data collection within the GIG per MS

Member State	Number of lake-transects		
	Biological data	Physico- chemical data	Pressure data
L-AL3			
Austria	43	7 lakes	7 lakes
France	5	1 lake	1 lake
Germany	64	13 lakes	13 lakes
Italy	92	5 lakes	5 lakes
Slovenia	15	2 lakes	2 lakes
L-AL4			
Austria	30	3 lakes	3 lakes
France	15	4 lakes	4 lakes
Germany	21	4 lakes	4 lakes
Italy	42	9 lakes	9 lakes
Slovenia	1	1 lake	1 lake

Table 5.3 List of the data acceptance criteria used for the data quality control and the data acceptance checking

Data acceptance criteria	Data acceptance checking
Data requirements (obligatory for ALL MS)	Macrophyte data must be available for single lake-transects Macrophyte abundances must be given in a five level scale
The sampling and analytical methodology (ALL MS)	Macrophyte data must be sampled from different depth zones Information on the vegetation limit must be available for each transect
Level of taxonomic precision required and taxalists with codes (ALL MS)	Species level is required WISER-CODES are used
The minimum number of sites / samples per intercalibration type	No minimum number (For AUSTRIA, GERMANY and ITALY at minimum data from 20 transects per IC type exist, FRANCE and SLOVENIA contributed data from a lower number of transects [FRANCE just started the investigations, SLOVENIA has only two WFD-relevant lakes])
Sufficient covering of all relevant quality classes per type	MS were asked to provide data which should as far as possible cover the whole EQR range.

6. Common benchmarking

Reference conditions were defined using reference transects. The approach to define reference sites of Alpine lakes, prepared by the Phytoplankton group of the Alpine GIG, was considered (See Annex A.2, Alpine Phytoplankton GIG). Furthermore, the additional criteria were used (Table 6.1)

Table 6.1 Overview of the Alpine GIG macrophyte GIG reference criteria

Criteria	Requirement
Lake	
Trophic state	No deviation of the actual from the natural trophic state
pH, salinity	No deviation from reference conditions
Hydrology	Artificial water level fluctuations not larger than the range between the natural mean low water level (MNW) and the natural mean high water level (MHW)
Transect	(at least 100 m shore length)
Surrounding	No intensive agriculture or settlements in the near surrounding
Nutrient input	No direct local nutrient input near the transect
Hydrology	No tributary near the transect
Morphology	No (or insignificant) artificial modifications of the shore line at the transect
Other pressures	No recreation area near the transect

Additionally, the biological data have been screened using expert judgement for impacts caused by pressures not regarded in the reference criteria within the GIG.

Following reference sites were selected for each Member State in each common IC type.

- Austria: AT-Fus03, AT-FU04, AT-Wes04, AT-Wes05, AT-Att-08;
- Germany: GE-Alp01, GE-Alp02, GE-Alp03, GE-Alp07;
- Italy: All Alpine GIG reference sites were used;
- France: All transects of Lac de Barterand, Grand Lac Etival, Lac du Grand Maclu;
- Slovenia: SI-Boh02, SI-Boh03.

The approaches for setting reference conditions were very similar in all MS:

- Austria, Germany and Slovenia selected reference transects according to the ALP-GIG reference criteria;
- Only France had whole lakes as reference sites (they have been selected following a national standard). The sites have been rechecked according to GIG criteria and could be accepted;
- Italy had no own reference sites. For defining reference conditions they used the data of the ALP-GIG database;
- All MS calculated as "reference condition" the median of parameters used in the single metrics from reference transects or sites respectively;
- Due to the very similar approaches the reference conditions set in the single MS could directly be used for the intercalibration exercise. All reference sites have been rechecked according to GIG criteria.

The high ecological status in Alpine lakes in general is characterised by deep vegetation limit (mean vegetation limit about 10 m in reference transects of the Alpine-GIG database) according to high Secchi depth / low phytoplankton density. The macrophyte community usually builds more or less dense stands dominated by sensitive taxa, above all Charophytes. The figure below shows the Relative Plant Mass (RPM = relative share of the plant mass of single species on the overall plant mass; Pall & Janauer, 1995) in the reference transects of the Alpine-GIG database.

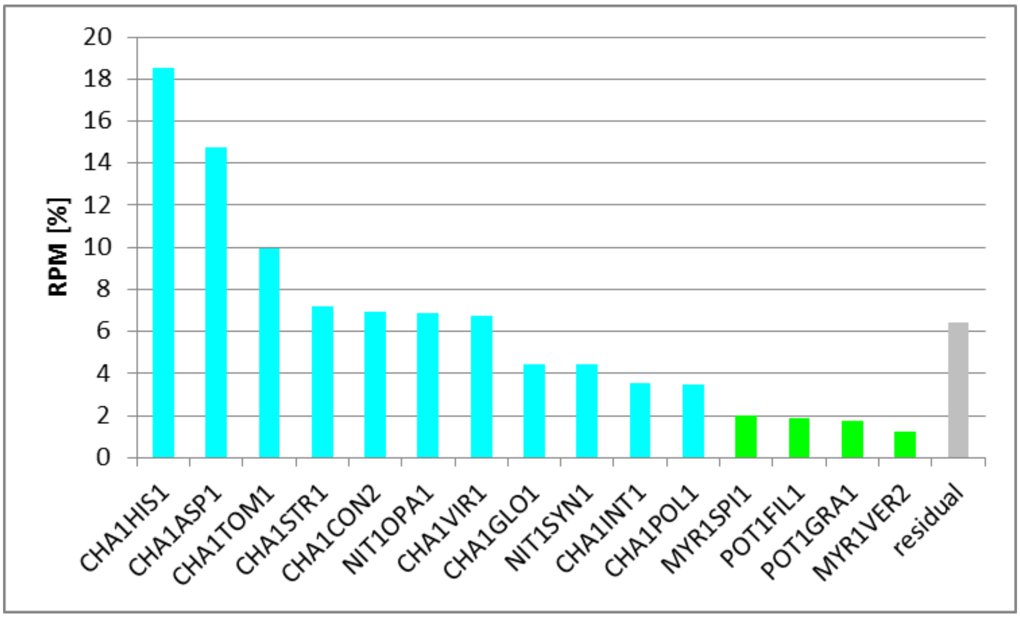

Figure 6.1 Relative share of plant mass of single species (WISER codes) on the overall plant mass as RPM. RPM = relative share of the plant mass of single species on the overall plant mass; Pall & Janauer, 1995)

Due to the high similarity of species composition in reference transects and the high similarity of sampling procedures it was not necessary to apply benchmark standardization.

In order to test the difference of assessment systems, Kruskal-Wallis-Test was performed (for example, comparing the EQRs of AT assessment system applied to reference transects of all MS). In each case it turned out that there are no significant differences ($p>0.05$):

- AT method on all reference sites: p = 0.190;
- DE method on all reference sites: p = 0.282;
- FR method on all reference sites: p = 0.055;
- IT method on all reference sites: p = 0.0594;
- SI method on all reference sites: p = 0.246.

7. Comparison of methods and boundaries

IC Option and Common Metrics

IC Option 3 was used: due to similar sampling procedure, similar data structure of all national assessment methods can reasonably be applied to the data of other countries. For comparison of the MS assessments, a pseudo-common metric (PCM) - the global means of all the methods was used.

Results of the regression comparison

All methods have significant regressions to the pseudo-common metrics (see Table 7.1). The correlation coefficients (r) and the probability (p) for the correlation of each method with the common metric

Table 7.1 The correlation coefficients (r) and the probability (p) for the correlation of each method with the common metric (PCM)

Member State/Method	r	p	slope
Austria	0.74	< 0.001	0.648
France	0.83	< 0.001	0.689
Germany	0.86	< 0.001	0.713
Italy	0.74	< 0.001	0.756
Slovenia	0.83	< 0.001	0.716

The outcomes of the regression complied with the following characteristics according to the IC Guidance:

- All relationships were highly significant p<=0.001;
- Assumptions of normally distributed error and variance (homoscedasticity) of model residuals are met;
- Common metric must represented all methods (r2>0.5);
- Observed minimum r2 was > half of the observed maximum r2;
- Slope of the regression should lie between 0.5 and 1.5.

Evaluation of comparability criteria

Comparability criteria are acceptable according to the IC Guidance Annex V requirements (Table 7.2):

- All boundary biases for MS methods is <-0.250, except FR GM boundary which is adjusted (see Final results - Boundaries to be included in the EC Decision)
- Average class agreement equals to 0.45, for all MS methods class agreement is < 0.5 (only for FR – 0.51).

Table 7.2 Comparison of national boundaries of Alpine GIG macrophyte assessment systems, using comparability criteria

Member State	H/G boundary bias	G/M boundary bias	Class agreement
Requirement	**<-0.250**	**<-0.25**	**<1.0**
Austria	0.269	0.11	0.44
France	-0.169	-0.35 (-0.25*)	0.51
Germany	0.484	0.38	0.43
Italy	0.032	-0.15	0.42
Slovenia	-0.175	-0.05	0.42
Average	**0.23 ****	**0.21 (0.19**)**	**0.45**

*after adjustment of the national boundary value

**calculated from absolute values of boundary bias

Boundary adjustments

- Austria is to precautionary with its H/G boundary but doesn't intent to adapt boundary;
- Germany is to precautionary with its H/G boundary and with its G/M boundary but doesn't intent to adapt boundaries;
- France: adjustment of the G/M boundary is necessary (has to be more precautionary, so the boundary was adjusted from 0.69 to 0.72).

Table 7.3 Class boundaries of Alpine GIG macrophyte assessment systems to be included in the IC Decision

Member State	Classification	Ecological Quality Ratios	
	Method	High-good boundary	Good-moderate boundary
Austria	L-AL3 and L-AL4	0.80	0.60
France	L-AL3 and L-AL4	0.92	0.69 - 0.72*
Germany	L-AL3 and L-AL4	0.76	0.51
Italy	L-AL3 and L-AL4	0.80	0.60
Slovenia	L-AL3	0.80	0.60

*FR good-moderate boundary was moved from 0.69 to 0.72.

The IC-results of Phase 2 summarize the IC exercise of the separate modules of macrophytes and phytobenthos respectively, intercalibrated in two GIGs (Lake Alpine GIG for macrophytes and Cross-GIG Phytobenthos for Phytobenthos).

From Phase 1 one more IC result for the comparison of the combined BQE "macrophytes and phytobenthos" in one Alpine lake type L-AL4 is available and still valid, therefore was included in the final IC results (see Table 7.4).

Table 7.4 Final boundaries including German complete system for LAL4 type (Modules Macrophytes & Phytobenthos, in bold)

Member State	National classification systems intercalibrated		Ecological Quality Ratios	
			High-good boundary	Good-moderate boundary
Austria	AIM for Lakes (Austrian Index Macrophytes for lakes)	L-AL3+L-AL4	0.80	0.60
France	IBML (French Macrophyte Index for Lakes)	L-AL3+L-AL4	0.92	0.72
Germany	PHYLIB for Lakes (German Assessment system for Macrophytes & Phytobenthos for lakes for implementation of the WFD) : Module Macrophytes	L-AL3+L-AL4	0.76	0.51
Germany	PHYLIB for Lakes (German Assessment system for Macrophytes & Phytobenthos for lakes for implementation of the WFD): Modules Macrophytes & Phytobenthos	LAL4	**0.74**	**0.47**
Italy	MacroIMMI (Macrophytic index for the evaluation of the ecological quality of the Italian lakes)	L-AL3+L-AL4	0.80	0.60
Slovenia	SMILE (Slovenian macrophyte-based index for lake ecosystems)	L-AL3	0.80	0.60

8. Description of boundary setting procedure and biological communities

Ecological status classifications of national methods established individually by the Member States (see Table 2.4).Following biological quality element changes were detected along eutrophication gradient (see comparison with WFD Annex V normative definitions
Table 17-21):

- Decrease of reference species;
- Increase of tolerant species. decrease of sensitive species;
- Increase of disturbance indicating species;

- Decrease of vegetation limit;
- Specific vegetation zones (and communities) disappear;
- Change of vegetation density (both directions are possible).

Table 8.1 Comparisons with WFD Annex V normative definitions for Austrian macrophyte assessment system

Ecol status	Normative definition (WFD)	Interpretation	EQR
High	"The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic [...] abundance. [...]"	All metrics correspond totally or nearly totally to undisturbed conditions.	>0.8
Good	"There are slight changes in the composition and abundance of macrophytic [...] taxa compared to the type-specific communities. [...]"	All metrics differ slightly from undisturbed conditions. Or (in cases of re-oligotrophication): Vegetation density, position of the depth spread boundary and zoning correspond nearly totally to undisturbed conditions. Macrophyte Index differs slightly and the species composition differs remarkably (re-oligotrophication is completed only in the water body)	0.8–0.6
Moderate	"The composition of macrophytic [...] taxa differ moderately from the type-specific communities and are significantly more distorted than those observed at good quality. Moderate changes in the average macrophytic [...] abundance are evident. [...]"	All metrics differ moderately from undisturbed conditions. Or (in cases of re-oligotrophication): Vegetation density corresponds nearly totally to undisturbed conditions. Other metrics differ more than moderately (re-oligotrophication in progress).	0.6–0.4
Poor	Macrophyte "communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions".	All metrics deviate substantially from undisturbed conditions. Or (in cases of re-oligotrophication): Only the vegetation density corresponds more or less to undisturbed conditions. Other metrics differ remarkable (re-oligotrophication starting).	0.4–0.2
Bad	"Large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent".	Very low macrophyte abundances or lack of macrophytes without natural reasons.	≤0.2

Table 8.2 Comparisons with WFD Annex V normative definitions for French macrophyte assessment system

Ecol. status	Normative definition (WFD)	Interpretation	EQR
High	"The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic [...] abundance. [...]"	Vegetation density. IBML score and species composition correspond totally or nearly totally to undisturbed conditions	>0.91
Good	"There are slight changes in the composition and abundance of macrophytic [...] taxa compared to the type-specific communities. [...]"	Vegetation density. IBML score and species composition differ slightly from undisturbed conditions.	0.91–0.69
Moderate	"The composition of macrophytic [...] taxa differ moderately from the type-specific communities and are significantly more distorted than those observed at good quality. Moderate changes in the average macrophytic [...] abundance are evident. [...]"	Vegetation density. IBML score and species composition deviate moderately from undisturbed conditions.	0.69–0.50
Poor	Macrophyte "communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions".	Vegetation density. IBML score and species composition deviate substantially from undisturbed conditions.	0.50–0.461
Bad	"Large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent".	Very low macrophyte abundances or lack of macrophytes without natural reasons.	≤0.461

Table 8.3 Comparisons with WFD Annex V normative definitions for German macrophyte assessment system

ecol. status	Normative definition (WFD)	Interpretation	RI
High	"The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic [...] abundance. [...]"	RI values lie within the range of reference sites. Vegetation limit indicates undisturbed conditions	100 ... >55
Good	"There are slight changes in the composition and abundance of macrophytic [...] taxa compared to the type-specific communities. [...]"	RI values are slightly below high status and always positive (Taxa of species group A have higher abundances than species group C taxa).	55 ... >0
Moderate	"The composition of macrophytic [...] taxa differ moderately from the type-specific communities and are significantly more distorted than those observed at good quality. Moderate changes in the average macrophytic [...] abundance are evident. [...]"	RI values are around zero or negative (species group C taxa equal or slightly outweigh species group A taxa).	0 ... >-50
Poor	Macrophyte "communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions".	RI values are very low (species group A taxa are nearly replaced by species group C taxa).	-50 ... >-25
Bad	"Large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent".	Very low macrophyte abundances due to anthropogenic caused reasons.	<-25 or calculation of RI not possible

Table 8.4. Comparisons with WFD Annex V normative definitions for Italian macrophyte assessment system

ecol. status	Normative definition (WFD)	Interpretation	EQR
High	"The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic [...] abundance. [...]"	Dissimilarity index. maximum vegetation depth Zc and Sk correspond totally or nearly totally to undisturbed conditions.	>0.8
Good	"There are slight changes in the composition and abundance of macrophytic [...] taxa compared to the type-specific communities. [...]"	Dissimilarity index. maximum vegetation depth Zc and Sk differ slightly from undisturbed conditions.	0.8–0.6
Moderate	"The composition of macrophytic [...] taxa differ moderately from the type-specific communities and are significantly more distorted than those observed at good quality. Moderate changes in the average macrophytic [...] abundance are evident. [...]"	Dissimilarity indec. maximum vegetation depth Zc and Sk differ moderately from undisturbed conditions.	0.6–0.4
Poor	Macrophyte "communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions".	Dissimilarity index. maximum vegetation depth Zc and Sk deviate substantially from undisturbed conditions.	0.4–0.2
Bad	"Large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent".	Very low macrophyte abundance without natural reasons. Percent frequency of exotic species > 70%.	≤0.2

Table 8.5 Comparisons with WFD Annex V normative definitions for Slovenian macrophyte assessment system

ecol. status	Normative definition (WFD)	Interpretation	EQR
High	"The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic […] abundance. […]"	Position of the depth spread boundaries (Higher Plants and Charophytes) and Macrophyte Index correspond totally or nearly totally to undisturbed conditions.	>0.8
Good	"There are slight changes in the composition and abundance of macrophytic […] taxa compared to the type-specific communities. […]"	Position of the depth spread boundaries and Macrophyte Index differ slightly from undisturbed conditions.	0.8–0.6
Moderate	"The composition of macrophytic […] taxa differ moderately from the type-specific communities and are significantly more distorted than those observed at good quality. Moderate changes in the average macrophytic […] abundance are evident. […]"	Position of the depth spread boundaries and Macrophyte Index differ moderately from undisturbed conditions.	0.6–0.4
Poor	Macrophyte "communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions".	Position of the depth spread boundaries and Macrophyte Index deviate substantially from undisturbed conditions.	0.4–0.2
Bad	"Large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent".	Very low macrophyte abundances or lack of macrophytes without natural reasons.	≤0.2

8.1. Description of biological communities representing the "borderline" conditions between good and moderate ecological status

Biological communities at borderline between good and moderate ecological status are characterized by disappearance of reference species e.g. Charophytes and equal share of sensitive and disturbance indicating species.

The following graph shows the species composition (as Relative Plant Mass) of "good" and "moderate" sites of the Alpine-GIG database (Figure 8.1).

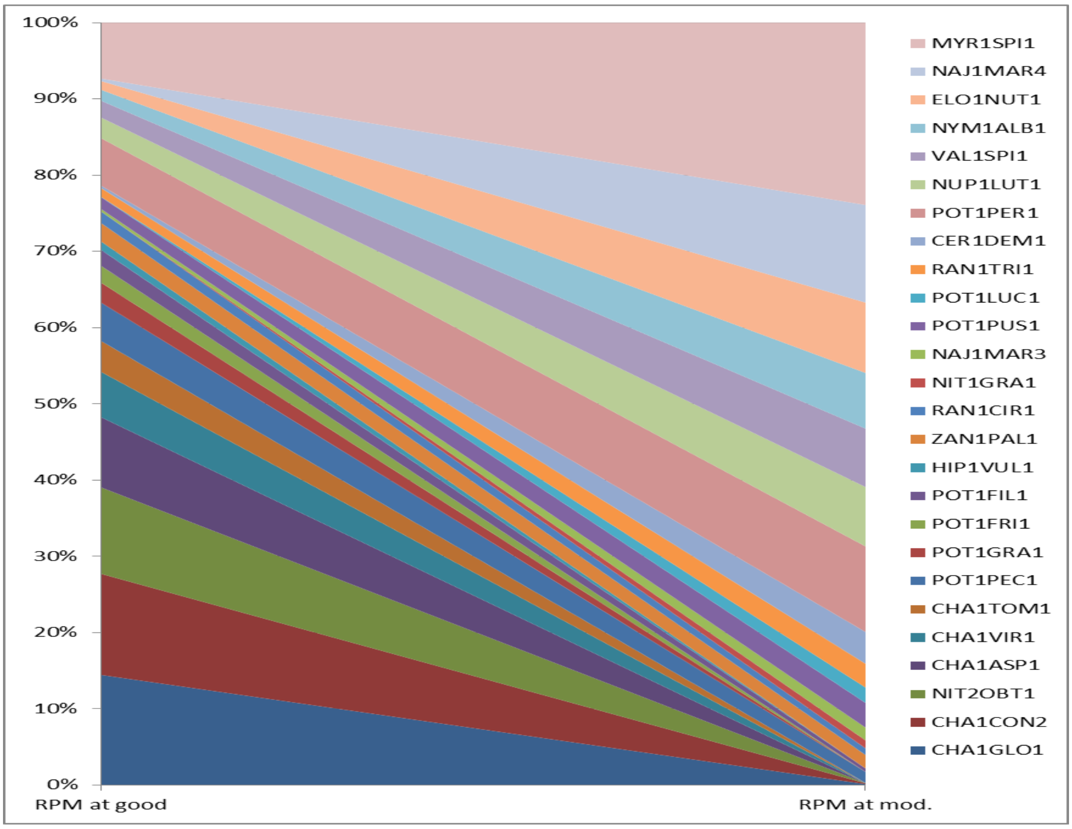

Figure 8.1 Relative share of plant mass (RPM) of single species (WISER codes) in good and in moderate status (Alpine-GIG database).

Annexes

A. Description of member states assessment methods

A.1 Austria: AIM for Lakes (Austrian Index Macrophytes for lakes)

Investigated lakes and used lake typology

In order to develop the assessment system, results from macrophyte investigations in 38 lakes out of all 45 lakes, relevant to the WFD in Austria, were used. For all investigated lakes data from an identical transect-mapping method exist (Pall, 2009). A total of 482 datasets (results from transects), mainly from the years 2002 and 2003, entered the analyses.

The assessment of the ecological state of lakes according to the WFD has to respect lake-type-specific aspects. Moog et al. (2004) established a system of "aquatic ecoregions" and "fluvial bioregions" in Austria on the basis of invertebrate communities. Starting from this, a macrophyte-based typology for Austrian lakes has been established on the basis of the results from the above mentioned macrophyte data (Pall et al., 2005). The 10 lake types found (Table A.1) are differentiated mainly according to ecological regions, geology, elevation above sea level and geographic position.

Table A.1 Macrophyte based typology for Austrian lakes (Pall et al., 2005)

Lake type	No. of lakes
Lakes of the Hungarian Lowlands	5
Lakes of the Central Highlands, perialpine region, calcareous	5
Lakes of the Northern Limestone Foothills <600m	5
Lakes of the Northern Limestone Foothills >600m	6
Lakes of the Northern Limestone Alps <1000m	9
Lakes of the Northern Limestone Alps >1000m	4
Lakes of the Southern Limestone Alps <600m	2
Lakes of the Southern Limestone Alps >600m	1
Lakes of the Central Crystalline Alps	2
Lakes of the Southern Inner-alpine Basins	5
Type not allocated yet	1

Mapping procedure

The mapping procedure applied here is in accordance to the Austrian and European normative standards (ÖNORM M6231 [ON, 2001]; ÖNORM EN 15460 [ON, 2006]; ÖNORM EN 14996 [ON, 2007]).

The best basis for an assessment of lakes with the help of the macrophyte vegetation is a whole lake investigation via scuba diving according to Melzer et al. (1986) and Pall (1999) respectively. For routine investigations according to the WFD such a comprehensive assessment would usually not be possible for cost reasons. Therefore, a new mapping method, particularly designed for the requirements of the WFD, was developed (Jäger et al., 2004). It combines a dGPS-supported echo-sounding (Dumfarth, 2003) of the entire littoral with a detailed mapping of selected transects by scuba diving (Pall, 2009). This guarantees a reliable statement for the whole lake, although some uncertainty may remain.

The echo-sounding of the littoral supplies a detailed picture of the spatial expansion and the structure of the macrophyte vegetation. By means of an appropriate evaluation, zones with structurally different macrophyte growth can be differentiated. Depending upon the variability of the vegetation structure, the length of these shoreline sections can vary between approximately 100 and more than 1000 m. One or more transects are positioned in these zones, depending upon their expansion. In any case the distance between the individual transects should not exceed 1500 m in WFD-relevant lakes.

The transects, 25 m wide and rectangular to the shoreline, reach from the long-term mean water level to the depth limit of vegetation. Along these transects the proper mapping procedure is carried out by scuba diving. According to Pall (2009) the different species, their abundance and growth height as well as further relevant parameters are recorded for defined depth zones, which depend on the type-specific zonation of the macrophyte vegetation (for example: reed zone, charophyte community of the shallow water, pondweed belt…). Helophytes, floating-leaved plants and the submerged vegetation are elements of this survey. Higher plants (Spermatophyta), aquatic ferns (Pteridophyta) and mosses (Bryophyta) as well as stoneworts (Charophyta) are determined to species level.

In each depth zone of a transect, the quantity of all the occurring species is estimated as "Plant Mass Index" (PMI) according to a five level scale (see Table A.2). Furthermore, for each depth zone the average growth height of the different species as well as sediment composition and slope are recorded. In addition for all transects other important abiotic information, such as the degree of shading, the type of the surrounding vegetation and the land use, is recorded.

Table A.2 Abundance classes referred to as PMI and explanation

PMI	Verbal description	Explanation
1	Very rare	Only single plants, up to about 5 specimens (individual plants)
2	Rare	About 6 to 10 specimens (individual plants), scattered over investigated section; up to 5 single plant stands
3	Common	Cannot be overlooked, but still not frequent or abundant; "can be found without searching for"
4	Abundant	Frequent, but not in masses; incomplete coverage with large gaps
5	Very abundant, in masses	Dominant, more or less overall; clearly more than 50% (ca. 75%) cover

Data Evaluation

The following indices are calculated:

1. Cumulative Plant Mass Index (CMI; Pall, 2009)

The mapping procedure described delivers abundance data (PMI, Table A.2) for all single species in the different depth zones. In order to derive the overall plant abundance in one depth zone the CMI_{raw} (Pall, 2009) has to be calculated:

$$CMI_{raw} = Min\left(\sqrt[3]{\sum_{i=1}^{n} PMI_i^3}, 5\right) \qquad \text{Eq. 1}$$

CMI_{raw} = Cumulative Plant Mass Index (raw = 2 decimal places included)

PMI = Plant Mass Index of different species

i = current index of different species

The average *CMI*, called CMI_{A}, of an entire transect consisting of different depth zones can be calculated using the Eq. 2 (Pall, 2009). For this assessment all depth zones, even those without macrophyte growth, must enter the calculation.

$$CMI_{A\,raw} = \sqrt[3]{\frac{\sum_{j=1}^{k} CMI_{raw\,j}^3 \cdot |lL_j - uL_j|}{\sum_{j=1}^{k} |lL_j - uL_j|}} \qquad \text{Eq. 2}$$

$CMI_{A\,raw}$ = Average Cumulative Plant Mass Index (raw = 2 decimal places included)

CMI_{raw} = Cumulative Plant Mass Index (raw = 2 decimal places included)

lL = lower limit of a depth zone in meter below surface

uL = upper limit or a depth zone in meter below surface

j = current index of (all!) different depth zones

Table A.3 gives the CMI-scale, the corresponding ranges of CMI_{raw} as well as a verbal description of the different CMI levels.

Table A.3 Table 3 CMI scale (Pall, 2009)

CMI	CMI_{raw}, $CMI_{A\,raw}$	Verbal description
1	>0 – <2	Single plants, cover <1%
2	≥2 – <3	Single plant stands
3	≥3 – <4	Scattered plant growth, but low cover
4	≥4 – <5	Mostly dense vegetation, but with large gaps
5	5	Dense vegetation, clearly more than 50% (~ 75%) cover

2. Macrophyte Index (MI; Melzer, 1999)

In order to describe the trophic indication of the macrophyte vegetation the Macrophyte Index is used. The calculation is to be done with the help of the following formula:

$$MI = \frac{\sum_{j=1}^{k}\left(\sum_{i=1}^{n}\left(PMI_{ji}^{3} \cdot I_i\right)\right)}{\sum_{j=1}^{k}\left(\sum_{i=1}^{n} PMI_{ji}^{3}\right)} \qquad \text{Eq. 3}$$

MI = Macrophyte Index

PMI = Plant Mass Index

I = indicator value of the species (after Melzer et al, 1986; 1988, Melzer, 1999)

i = current index of the different species

j = current index of the different depth zones

According to Melzer (1988) the different index classes correspond to distinct trophic levels (see Table A.4).

Table A.4 Assignment of Macrophyte Index ranges to degree of nutrient enrichment (Melzer et al., 1988) and trophic classes according to Melzer (1988)

Index range	Degree of nutrient enrichment	Trophic state class
1.00 – 1.99	Very low	Ultraoligotrophic and oligotrophic
2.00 – 2.49	Low	Oligo-mesotrophic
2.50 – 2.99	Moderate	Mesotrophic
3.00 – 3.49	Considerable	Meso-eutrophic
3.50 – 3.99	Heavy	Eutrophic
4.00 – 5.00	Very heavy	Eu- and hypertrophic

Assessment system

The assessment system in its present form (AIM – Module 1) concentrates on the submerged vegetation and the floating-leaved plants and focuses on the assessment of “trophic state and general impairment”.

The assessment system presented is a multi-metric approach. The individual metrics deal with different features of the macrophyte vegetation with special regard to composition and abundance. Short time as well as long time reacting components are included. See

Table A.5 for the 5 defined metrics.

Table A.5 Metrics of AIM – Module 1 „trophic state and general impairment"

Metrics	Parameter
Vegetation density (Vd)	CMI (Pall, 2009)
Vegetation limit (Vl)	Depths [m]
Characteristic zonation (Z)	Type-specific zonation
Trophic indication (Ti)	Macrophyte Index (Melzer et al., 1986)
Species composition (Sc)	Bray Curtis (Beals, 1984; McCune & Beals, 1993)

Apart from the assessment of the trophic conditions, AIM – Module 1 allows a detection and evaluation of changes in the hydrology and hydrodynamics as well as of impairments of the shore structure, as far as these alterations affect the plant groups in question (submerged vegetation and floating-leaved plants).

For each individual metric the deviation from the reference condition has to be calculated. The final ecological quality class for one transect results from averaging the results of the single metrics. The ecological quality class of the entire lake results from averaging the results of the individual transects, weighted according to the length of the shoreline for which they are to be regarded as representative. If for this last step no results from echo-sounding are available, with some loss of accuracy, an averaging of the results of all investigated transects can be made.

Definition of reference conditions

Following the requirements of the WFD, the assessment has to reflect the degree of deviation of the current vegetation from the reference condition. This requires knowledge of the reference conditions. In fact, in Austria in most cases no data about whole lake macrophyte vegetation in reference condition exist. However, we found at least reference transects for the designated lake types in Austria. The following selection criteria for reference transects were used (Table A.6):

Table A.6 Criteria for the selection of reference transects

Criteria	Requirements
Lake	
Trophic state	The lake has to be in the trophic basic state (total Phosphorus, Chlorophyll a, Secchi-depth corresponding to the values defined for reference condition as fixed in Austrian law and agreed during intercalibration)
pH, salinity	No deviation from reference conditions (Cl^--concentration and ph corresponding to the values defined for reference condition or high status as fixed in Austrian law)
Hydrology	Artificial water level fluctuations must not be bigger than the natural range between the mean low water level and the mean high water level

	(comparison of long term gage-data before and after regulation [Wolfram, 2004])
Transect	**(surrounding area with a radius of at least 500 m)**
Surrounding	No intensive agriculture or settlements
Nutrient input	No direct local nutrient input or discharges
Hydrology	No tributary
Morphology	No (or insignificant) artificial modifications of the shore line
Other pressures	No recreation area, no other discernible pressures
Vegetation	Undisturbed macrophyte vegetation, based on expert judgement

In the investigated Austrian lakes altogether 51 reference sites (transects) could be found. At the moment a sufficient data basis of reference sites exists for 6 out of the 10 designated lake types. The aquatic vegetation of these sites forms the basis of the assessment system.

In order to define reference conditions for the single metrics we proceeded as follows:

- Vegetation density (Vd): Calculation of the median of the reference values (expressed as $CMI_{A\ raw}$) for each lake type;
- Vegetation limit (Vl): Calculation of the median of the reference values (in m water-depth) for each lake type;
- Characteristic zonation (Z): Definition of characteristic vegetation zones with characteristic species for each lake type out of the results from reference sites;
- Trophic indication (Ti): Level of "Macophyte Index" (Melzer, 1988) corresponding to the defined trophic state at reference condition;
- Species composition (Sc): We established a database for the macrophyte vegetation of the investigated reference sites. Historical information about macrophyte vegetation of some lakes (Schulz et al., 2003) as well as current results from other European lakes (e.g. results from lake monitoring in Germany) have also entered this database. Up to now not all Austrian lakes have been investigated in detail. Therefore this database will have to be completed with macrophyte data from possible new reference site assessments.

In Table A.7 the single reference values of the different metrics for all lake types described here are listed.

Table A.7 Reference values for the metrics of the different lake types

Lake type	Vd [CMI raw]	Vl[m]	Z	Ti [MI]	Sc
Lakes of the Central Highlands, perialpine region, calcareous	4.4	9.0	Cha_sw*) Cha_md & Spe_pw Cha_dw	2.00	type specific data base
Lakes of the Northern Limestone Foothills <600m	4.9	17.0	Cha_sw Cha_md Cha_dw	1.50	type specific data base
Lakes of the Northern Limestone Foothills >600m	4.5	15.1	Cha_sw Cha_md Cha_dw	1.25	type specific data base
Lakes of the Central Crystalline Alps	4.8	15.1	Cha_sw Cha_md Cha_dw	1.50	type specific data base
Lakes of the Southern Limestone Alps Limestone<600m	4.7	14.2	Cha_sw Cha_md Cha_dw	1.50	type specific data base
Lakes of the Southern Limestone Alps >600m	4.6	16.6	Cha_sw Cha_md Cha_dw	1.25	type specific data base

Boundary setting and calculation of the single metrics

The class boundaries for each metric were defined according to the normative definitions and interpretations of the Water Framework Directive. Whereas the database of reference sites gave a sound basis to define reference conditions, there were not enough data to calculate percentiles to define the boundaries for the other classes. In case of "only few data from sites available" the REFCOND-Guidance (CIS, 2003) proposes to apply Tool 3, Option B. Following this, we first established tentative EQR-scales for all metrics, we applied them on numerous real and virtual data sets and we adjusted them to the normative definitions of ecological status as given in Appendix V, 1.2 of the Directive.

1. EQRVd (Vegetation density)

The vegetation density is the result of different pressures, such as alteration of the shoreline, artificial water level fluctuations, artificial wave action, and the trophic state. While the first impacts listed above, lead in most cases to a lower vegetation density compared with undisturbed conditions (Schutten et al. 2004) nutrient enrichment can influence the vegetation density in both directions (Ellenberg, 1996). For this reason, both, a lower as well as a higher vegetation density than the respective reference condition, have to be judged negatively. In order to achieve this, the absolute value of deviation has to be taken into account.

The vegetation density of a transect is expressed *as* $CMI_{A\ raw}$ (Pall, 2009). In order to derive EQR_{Vd} the deviation of the $CMI_{A\ raw\ Tr}$ from $CMI_{A\ raw\ Ref}$ has to be calculated.

The calculation algorithm is given in a way, that a deviation of $CMI_{A\ raw}$ of 1,00 (plus or minus) lowers the ecological state by one class. A deviation of $CMI_{A\ raw}$ of 2,00 leads to a lowering of the ecological state by two classes, respectively.

$$EQR_{Vd} = 1 - \left| CMI_{A\ raw\ Ref} - CMI_{A\ raw\ Tr} \right| \cdot 0{,}2 \qquad \text{Eq. 4}$$

EQR_{Vd} = EQR metric Vegetation density

$CMI_{A\ raw\ Ref}$ = Average CMI raw of reference condition

$CMI_{A\ raw\ Tr}$ = Average CMI raw of current transect

Table A.8 gives the definitions of the different status classes and the corresponding values of CMI- deviation and EQR_{Vd}. (For explanation of CMI-values see Table A.2.)

Table A.8 Boundary setting for the metric Vegetation density

Status	Definitions and interpretation	Deviation $CMI_{A\ raw}$	Range EQR_{Vl}
High	There are no detectable changes in the average macrophytic abundance. The macrophyte vegetation is within the expected abundance value of the reference conditions.	<1	>0.8 – 1.0
Good	The macrophyte abundance differs only slightly from that normally associated with the lake type under undisturbed conditions.	1 – <2	>0.6 – 0.8
Moderate	Moderate changes in the average macrophytic abundance are evident.	2 – <3	>0.4 – 0.6
Poor	The macrophyte abundance deviates substantially from the one normally associated with the lake type under undisturbed conditions.	3 – <4	>0.2 – 0.4
Bad	Large portions of the macrophyte community normally associated with the lake type under undisturbed conditions are absent. Very low abundances.	≥4	≤0.2

2. EQRVl (Vegetation limit)

The vegetation limit in lakes without any marsh or melting water influence is mainly regulated by the trophic state. In Austria as well as in the Alpine GIG it was agreed, that a deterioration of a whole trophic class (e.g. from the oligotrophic to a mesotrophic state or from an oligo-mesotrophic to a meso-eutrophic state) should lead to “call for action”.

Therefore this change should lead to a deterioration of two ecological classes in the assessment systems. A deterioration of a half trophic class (e.g. from the oligotrophic state to the oligo-mesotrophic state) results in a deterioration of one ecological class.

In order to derive the EQR_{Vl} a relationship between trophic state and vegetation limit had to be evaluated first. For this analysis a regression between the depth limits of the lakes in question and trophic half classes was calculated. The resulting equation was used to derive a, with regard to the trophic conditions, linear scale for the vegetation limit (Vl_{lin}).

$$Vl_{lin} = 2.151\ln(Vl) + 0.8257 \qquad \text{Eq. 5}$$

Vl_{lin} = linearised vegetation limit

Vl = vegetation limit [m below water surface (with one decimal place)]

For calculation of the EQR_{Vl} in a second step the deviation of the $Vl_{lin\ Tr}$ to the $Vl_{lin\ Ref}$ has to be calculated. Hereby, in contrast to the metric "vegetation density", only a shallower vegetation limit than the respective reference condition leads to a deterioration of the ecological status class.

$$EQR_{Vl} = Max\left(Min\left(1 - \left(Vl_{lin\,Ref} - VL_{lin\,Tr}\right) \cdot 0.2, 1\right), 0\right) \qquad \text{Eq. 6}$$

EQR_{Vl} = EQR, metric Vegetation Limit

$Vl_{lin\ Ref}$ = vegetation limit of reference transect

$Vl_{lin\ Tr}$ = vegetation limit of current transect

Table A.9 gives the used definitions and interpretations of the different status classes and the corresponding deviation of trophic level and EQR_{Vl} values.

Table A.9 Boundary setting for the metric Vegetation limit (Vl)

Status	Definitions and interpretation	Deviation Vl_{lin}	Range EQR_{Vl}
High	The total vegetated area will be within the range expected at reference conditions. The observed Vl corresponds to the expected one at reference conditions.	<1	>0.8 – 1.0
Good	The observed Vl and with it the total vegetated area deviate only slightly from that normally associated with the lake type under undisturbed conditions.	1 – <2	>0.6 – 0.8
Moderate	The observed Vl and with it the total vegetated area deviate moderately from that normally associated with the lake type under undisturbed conditions.	2 – <3	>0.4 – 0.6
Poor	The observed Vl and with it the total vegetated area deviate substantially from that normally associated with the lake type under undisturbed conditions.	3 – <4	>0.2 – 0.4
Bad	Absence of large portions of the macrophyte community normally associated with the lake type under undisturbedconditions. The macrophyte vegetation reaches only very minor depths.	≥4	≤0.2

3. EQRZ (Characteristic zonation)

This metric helps to check, if all type specific vegetation zones (only submerged vegetation and floating-leaved plants) are present. The following vegetation zones for the up to now regarded lake types (Table A.7) where defined.

Table A.10 gives the used definitions and interpretations of the different status classes and the corresponding deviation of vegetation zones and EQRZ values.

Table A.10 Boundary setting for the metric Characteristic zonation

Status	Definitions and interpretation	Reduction value (rv)	Range EQR_Z
High	The taxonomic composition and abundance corresponds totally or nearly totally to undisturbed conditions. All plant groups corresponding to the defined vegetation zones are present in sufficient abundance (CMI ≥3). or The abundance of not more than one of the defined plant groups differs slightly from reference conditions (CMI <3)	0 -0.1	>0.8 – 1.0
Good	There are slight changes in the composition and abundance of macrophytic taxa compared to the type-specific community. One of the defined vegetation zones is not represented by the plant group expected for this lake type, but represented by other macrophyte species belonging to this vegetation zone in another lake type. or All defined vegetation zones are present, but two or three of them not in sufficient abundance (CMI <3).	-0.2 -0.2; -0.3	>0.6 – 0.8
Moderate	The composition and abundance of macrophytic taxa differ moderately from the type-specific communities. Two of the defined vegetation zones are not represented by the expected plant groups, but by other macrophyte taxa (representatives of these zones in other lake types). or One defined vegetation zone is missing completely (no macrophytes) and the abundance of one or two other zones is lower than expected (CMI <3)	-0.4 -0.4; -0.5	>0.4 – 0.6

Status	Definitions and interpretation	Reduction value (rv)	Range EQR_Z
Poor	Macrophyte communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions. Two of the defined vegetation zones are missing completely. or Three of the defined vegetation zones are replaced by other macrophytes. or Two vegetation zones are missing completely and one shows only low abundance.	-0.6 -0.7	>0.2 – 0.4
Bad	Large portions of the macrophyte community normally associated with the lake type under undisturbed conditions are absent. Two of the defined vegetation zones are missing completely and one is replaced by other macrophytes. or Three vegetation zones are missing completely Total lack of macrophytes without natural reasons.	-0.8 -0.9 -1.0	≤0.2

In a first step the CMI_{raw} of all for a single zone representative species has to be calculated. Type specific species lists will be provided in Pall (2009). If a CMI_{raw}-value of at least 3 is reached, the zone can be considered as "existing". In case all necessary zones exist, an EQR = 1 is given. Are one ore more vegetation zones lacking, reduction values (rv's) are introduced. If representative species of a defined zone are found, but do not reach the expected amount (*CMI* <3), a rv of 0,1 for this zone is given. If there are no representative species of a defined zone, an rv of 0,2 is introduced. Finally an rv of 0,3 is applied, if there are no macrophytes at all in a designated zone. The EQR_Z has to be calculated as follows:

$$EQR_Z = 1 - \sum_{j=1}^{3} rv_j \qquad \text{Eq. 7}$$

EQR_Z = *EQR*, metric characteristic zonation, *rv* = reduction value,

j = current index of the different depth zones

4. EQRTi (Trophic Indication)

In order to analyze the trophic condition, the Macrophyte Index (*MI*) after Melzer et al. (1999) is used. This term is closely related to the trophic state of a lake, but, in contrast to quickly reacting metrics, such as the vegetation limit, the *MI* shows the trophic state of the whole littoral (water and in particular the sediments). Therefore this term is a slowly reacting metric and can deliver valuable information concerning the state of reoligotrophication.

In order to derive the trophic status from of the macrophyte vegetation, the Macrophyte Index after Melzer et al. (1986, 1988) has to be calculated. After Melzer (1988) a change of 1,0 of the Index value corresponds to a change of a whole trophic class (see Table A.4). Such a change has to lead to the change of two ecological classes correspondingly.

Table A.11 gives the used definitions and interpretations of the different status classes and the corresponding deviation MI- and EQR_{TI} values.

In order to derive EQR_{TI} the deviation of the MI_{Tr} from MI_{Ref} has to be calculated. As the Macrophyte Index reaches the lowest values at the best conditions the calculation algorithm has to include an inversion procedure. The equation to calculate EQR_{TI} is given in the following a way:

$$EQR_{TI} = Min\left(1 - Min\left(\left((7 - MI_{Ref}) - (7 - MI_{Tr})\right) \cdot 0.4, 1\right), 1\right) \qquad \text{Eq. 8}$$

EQR_{TI} = EQR, metric Trophic indication

MI_{Ref} = MI as expected under reference conditions

MI_{Tr} = MI of current transect

Table A.11 Boundary setting for the metric Trophic Indication

Status	Definitions and interpretation	Deviation MI	Range EQR_{TI}
High	The macrophyte species present indicate totally or nearly totally the trophic state under undisturbed conditions. Any taxa present, which are related to higher trophic levels, are uncommon or rare, their presence will not be indicative to disturbance. The Macrophyte Index differs not remarkably from the value expected at reference conditions.	<0.5	>0.8 – 1.0
Good	The majority of taxa present indicates the type specific trophic basic state, but taxa showing a higher trophic state and therefore commonly not found at reference conditions may constitute a significant part of the flora. The Macrophyte Index differs slightly from the value expected for reference conditions.	0.5 – <1	>0.6 – 0.8
Moderate	Taxa from outside the type specific list, particularly pollution-tolerant species, may dominate the flora. Therefore the Macrophyte Index differs moderately from the value expected for reference conditions.	1 – <1.5	>0.4 – 0.6
Poor	Macrophyte communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions. The lack of eutrophication sensitive species leads to high values of the Macrophyte Index.	1.5 – <2	>0.2 – 0.4
Bad	Large portions of the macrophyte community normally associated with the lake type under undisturbed conditions are absent.	≥2	≤0.2

Status	Definitions and interpretation	Deviation MI	Range EQR_{TI}
	Only disturbance indicators or highly eutrophication tolerant species are left in probably low abundances. Very high values up to the maximum value of Macrophyte Index can be reached.		

5. Species composition (SC)

For calculating the EQR_{SC} the species composition of the current transect is compared with the species composition of the reference sites. The data sets thereby consist of the maximum PMI-values of the different species in the different depth zones. The similarity of the datasets is measured as Bray-Curtis Distance

$$SD_{Tr,Ref} = \frac{\sum_{i=1}^{n} \left| PMI_{max\ Ref,i} - PMI_{max\ Tr,i} \right|}{\sum_{i=1}^{n} PMI_{max\ Ref,i} + \sum_{j=1}^{p} PMI_{max\ Tr,i}} \qquad \text{Eq. 9}$$

$SD_{Tr,\ Ref}$ = Bray-Curtis Distance between current transect and reference transect

$PMI_{max\ Ref}$ = maximum PMI of a species in a reference transect

$PMI_{max\ Tr}$ = maximum PMI of a species in current transect

i = current index of different plant species

The EQR_{SC} can be derived by an inversion of the minimum Bray-Curtis Distance of the dataset of a transect compared with the datasets of the reference sites:

$$EQR_{SC} = 1 - \underset{i=1}{\overset{n}{Min}} \left(SD_{Tr,Ref_i} \right) \qquad \text{Eq. 10}$$

EQR_{SC} = EQR, metric Species composition

$SD_{Tr,\ Ref}$ = Bray-Curtis Distance between current transect and reference transect

i = current index of different reference data sets

Calculation of EQR for the entire lake

In a first step for each transect the EQR's of the single metrics have to be averaged. The results give the ecological state for the single transects. With regard to the position of the different transects in the lake, places of impact may be detected. A further analysis of the results of the single metrics may be a helpful tool for finding the reasons of local impact.

$$EQR_{Tr} = \frac{\left(EQR_{Vd} + EQR_{Vl} + EQR_{Z} + EQR_{Tl} + EQR_{SC} \right)}{5} \qquad \text{Eq. 11}$$

EQR_{Tr} = EQR of current transect

EQR_{Vd} = EQR, metric Vegetation density

EQR_{Vl} = EQR, metric Vegetation limit

EQR_{Z} = EQR, metric Characteristic zonation

EQR_{SC} = EQR, metric Species composition

Table A.12 gives the used definitions and interpretations of the different status classes and the corresponding deviation of Sorensen-Distance- and EQR_{TI} values.

Table A.12 Boundary setting for the metric Species composition

Status	Definitions and interpretation	Sorensen Index	Range EQR_{VI}
High	The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. Nearly all the taxa present will be within their expected abundance values at reference condition.	0.0 - <0.2	>0.8 – 1.0
Good	There are slight changes in the composition and abundance of macrophytic taxa compared to the type-specific communities.	0.2 – <0.4	>0.6 – 0.8
Moderate	The taxonomic composition will differ moderately from the type specific reference condition. As few as half of the taxa present may be regularly found in the type specific taxa list. Many taxa will be outside their expected abundance at reference condition.	0.4 – <0.6	>0.4 – 0.6
Poor	Macrophyte communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions.	0.6 – <0.8	>0.2 – 0.4
Bad	Large portions of the macrophyte community normally associated with the lake type under undisturbed conditions are absent.	0.8 – 1.0	≤0.2

In a second step, the results for all transects have to be averaged. They are weighted according to the length of the shoreline for which they are regarded as representative. Eq. 12 gives the calculation algorithm for the EQR of the entire lake:

$$EQR_{Lake} = \frac{\sum_{i=1}^{n} \left(EQR_{Tr\,i} \cdot L_{Sl\,i} \right)}{\sum_{i=1}^{n} L_{Sl\,i}} \qquad \text{Eq. 12}$$

EQR_{Lake} = EQR of the entire lake

EQR_{Tr} = EQR of the single transects

L_{Sl} = Length of shoreline

i = current index of the different transects

Table A.13 gives the definitions and interpretations concerning the macrophyte vegetation of the whole lake and the corresponding EQR-values.

Table A.13 Boundary setting and EQR-values for the entire lake

Status	Definition given by the WFD	Interpretation	EQR
High	The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic [...] abundance. [...]	Vegetation density, Vegetation limit, Characteristic zonation, Macrophyte Index and Species composition correspond totally or nearly totally to undisturbed conditions.	1.0 - <0.8
Good	There are slight changes in the composition and abundance of macrophytic [...] taxa compared to the type-specific communities. [...]	Vegetation density, Vegetation limit, Characteristic zonation, Macrophyte Index and Species composition differ slightly from undisturbed conditions. Or (in cases of reoligotrophication): Vegetation density and Vegetation limit correspond nearly totally to undisturbed conditions, Characteristic zonation and the Macrophyte Index differ slightly, the specific set of species moderately from undisturbed conditions (reoligotrophication complete only in the water body).	0.8 - >0.6
Moderate	The composition of macrophytic [...] taxa differs moderately from the type-specific communities and is significantly more distorted than that observed at good quality. Moderate changes in the average macrophytic [...] abundance are evident. [...]	Vegetation density, Vegetation limit, Characteristic zonation, Macrophyte Index and Species composition differ moderately from undisturbed conditions. Or (in cases of reoligotrophication): Vegetation density corresponds nearly totally to undisturbed conditions, the Vegetation limit deviates slightly from undisturbed conditions, Characteristic zonation, Macrophyte Index and the specific set of species differ remarkably (reoligotrophication in progress).	0.6 - >0.4
Poor	Macrophyte communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions.	Vegetation density, Vegetation limit, Characteristic zonation, Macrophyte Index and Species composition deviate substantially from undisturbed conditions. Or (in cases of reoligotrophication): The Vegetation density differs only slightly from undisturbed conditions. Vegetation limit, Characteristic zonation, Macrophyte Index and Species composition differ remarkably (reoligotrophication starting).	0.4 - >0.2

Status	Definition given by the WFD	Interpretation	EQR
Bad	Large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent.	Very low macrophyte abundances or lack of macrophytes without natural reasons.	0.2 and below

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A.2 France

French macrophyte assessment method for lakes IBML (Indice Biologique Macrophytique en Lac)

Which indicators are used?

Macrophyte taxonomic composition

The taxonomic composition includes:

- Phanerogams (hydrophytes, amphiphytes and helophytes), also including aquatic forms of land species;
- Macroalgae (charophytes);
- Macroscopic colony of algae (benthic, epiphytic, floating);
- Pteridophytes (submerged, helophytic or floating);
- Bryophytes (mosses and liverworts);
- Aquatic lichens;
- Macroscopic colony of heterotrophs (bacteria and fungus).

Phanerogams, bryophytes, pteridophytes, lichens and charophytes are determined at species level. Unicellular organisms (heterotrophs and algae excepted charophytes) are determined at genius level.

Macrophyte abundance

The relative abundance of macrophyte in the littoral zone (section of shore) and the aquatic zone (profiles perpendicular to the shore) is surveyed separately. Abundance classes for each zone are proposed (see Table A.14).

Table A.14 The French abundance scale.

Littoral zone: abundance index	Description	Profiles: abundance index	Description
1	A few isolated specimens	*1*	*A few fragments of stem*
2	A few patches	*2*	*Frequent fragments of stem or a few whole plants*
3	Fairly frequent small patches	*3*	*Fragments all over the teeth of the rake*
4	Discontinuous large patches	*4*	*Taxon abundant*
5	Continuous cover	*5*	*Taxon present in large quantities all over the rake*

*Depth limit of macrophytes:*Depth limit is estimated on perpendicular profiles.

Bacterial tufts: Bacterial tufts are taken into account in the assessment.

Summary:

The IBML method is developed for lakes with a water level fluctuation less than 2 meters. Macrophyte communities are surveyed on observation units (one section of shore and three perpendicular profiles) located and selected according the description of the shore such that the main types of riparian zone around the lake are represented. The lake assessment is calculated as the mean of observation units results. The trophic score ($Note_{trophie}$ from 0 to 20) gives an estimation of the trophic level of the lake. It includes all the pressures linked or associated to the degradation of this trophic level (eutrophication, HYMO, general degradation, etc.). This score is calculated from the relative abundance of about 300 indicator taxa with their own specific value and stenoecy coefficient.

How are these indicators monitored?

This is a short summary of the **XP T90-328 French standard** for the sampling of macrophytes in lake.

Sampling strategy

The macrophytes are sampled on observation units (1 section of shore and 3 perpendicular profiles). These observation units are located by applying the Jensen's method (geometric positioning) and selected according the description of the shore such that the main types of riparian zone around the lake are represented. Four types of riparian zone (Table A.15) are available, based on the description of the vegetation structures and/or anthropic alterations of the shore. Three types of shore, noted 1 to 3 correspond to natural habitats or habitats not significantly modified by human pressure. They are described based on the nature of the vegetation present. The fourth type (4) indicates extensive human modification.

Table A.15 Description of the types of riparian zone defined in the French assessment method.

Type	Description of the vegetation and/or modifications of the riparian zone	
Natural habitats		
1	Typical wetland riparian types	Bog, Fringing reeds, Boggy heath, Marsh, Water meadows, Megaphorbs, Helophytic vegetation growing in hummocks, Hygrophilic forest / wet woodland (Alnus-Salix), etc.
2	Riparian zone colonised by dry-land shrubs and bushes	Mixed deciduous forest, Coniferous forest, Bushes and shrubs, Heathland/ ericacae heath, etc.
3	Riparian zone not colonised by dry-land shrubs and bushes	Scrubland, Tall plants, Rocky shoreline, Beaches/bare ground, etc.
Artificial areas or areas visibly subjected to human pressure		
4	Ports, moorings, jetties, marinas docks, boats	

	Areas with artificial banks and infrastructures: *controlled shore vegetation, woodland clearance, accumulations of litter, dumping, rubble, walls, dykes, artificial revetment, artificial beaches, roads and tracks, hydraulic workings, etc.*

A short description of the structure of the observation unit is given Figure A.1.

Survey of the littoral zone: the width of the area explored depends on the slope of the bottom, finishing when the depth reaches 1m. In the event of a shallow slope the width explored will reach at least 10 metres. The record will also include the occurrence of helophytes and wetland plants up to the high water line.

Profiles perpendicular to the shore: Each profile is at least 20 m long and at maximum 100 m long according to the slope and the Secchi depth. The profile begins near the water limit on the shore line and finishes when the depth limit of the euphotic zone is reached. For each of the profiles, thirty samples are evenly taken by point contact using a rake or a grapnel depending on the depth.

Data to be collected: list of taxa and relative abundances for each taxa (littoral zone and each profile); substrate and depth (recorded on each contact point for each profile), maximum colonization depth. On the field, for each observation unit, a short description of the riparian zone, the shore (bank and beach) and the littoral zone is made, including the dominant vegetation, signs of erosion, dominant substrate, visible human impacts, etc. The frequency of the different elements composing the riparian zone (Table A.15) is also estimated with a 1 to 5 scale score.

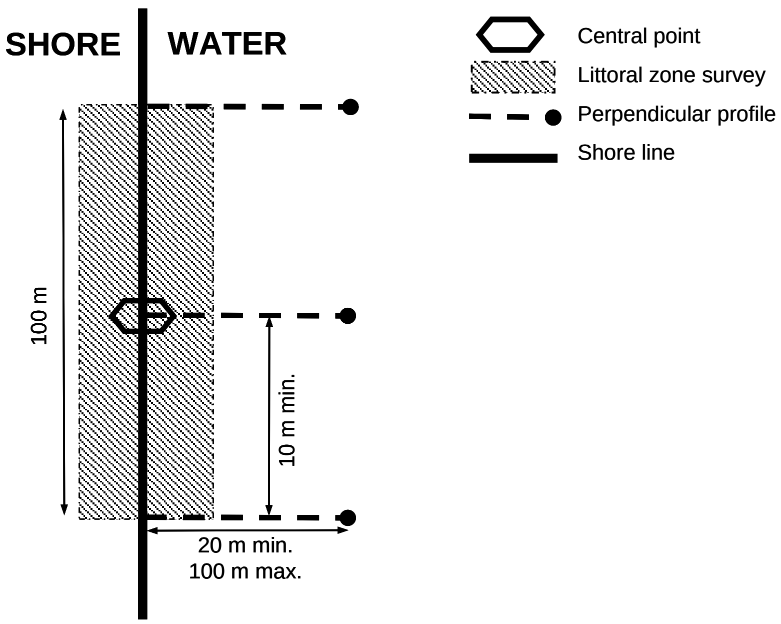

Figure A.1 Structure of the observation unit

Number of samples per lake

The number of observation units can never be less than 3 for a lake of 50 to 250 ha, 6 from 250 ha to 10 km^2 and should reach 8 for a lake of over 10 km^2, the aim being to locate at least one observation unit on each major category of shore in order to provide the most representative image possible of the macrophyte population of the whole water body.

When is monitored and with which frequency?

Samples are taken once in the summer period (early July to the end of September).

Use of equipment

The littoral zone survey is made on foot or by boat according to the depth. On the profiles, a rake (with a scaled handle) or a grapnel (with a scaled rope) are used according to the depth. Bathyscope, Secchi disc and GPS device are also used. Sampling bags and preservation liquids (alcohol, sémichon, lugol) are used to store samples for later determination (charophytes, filamentous algae, mosses, etc.).

Analysis of sample and level of determination

Most of plants are determined to species in the field, and partly validated in the laboratory. Phanerogams, bryophytes, pteridophytes, lichens and charophytes are determined at species level. Unicellular organisms (heterotrophs and algae excepted charophytes) are determined at genius level.

Way of reporting basic data

There is a standard set of survey sheets to be completed for each observation units. The national tools such as the databases and the data capture softwares (Naïades) are under development leaded by the French Agency for Water and Aquatic Environment (ONEMA). The data are currently hosted by the Cemagref on MS Excel (data capture) and MS Access (database).

Assessment

Data requirement

A national software tool for the automatically calculation of the IBML is under development (SEEE). Therefore some parameters in the given tables may be changed in near future.

Table A.16 and Table A.17 give an example for input files of environmental data and macrophyte data.

Table A.16 Example of environmental data

Code	Area	Altitude	Perimeter	Volume	Level fluctuation	Max. depth	Mean depth	Residence time	Alcalinity
BOU73	43.9	231.5	44330.8	3600000000	0.7	145	81	2555	2.6
ECH33	57.6	13	66504.4	210000000	1	10	3.64	665	0.56

Table A.17 Example of macrophyte data (perpendicular profile)

Contact point	Depth	Substratum 1	Substratum 2	Taxa code	Abundance
1	1	D		NAJMIN	1
2	1,2	D	S	NAJMIN	2
3	1,3	D		NAJMIN	2

Method of calculation

IBML Algorithms

Relative abundance formula:

$$Ab_k = \frac{\left[\sum_{j=0}^{Nb\_Point\_Prelev} Ab_k\right]}{Nb\_Point\_Prelev}$$

Zelinka & Marvan equation type (Zelinka and Marvan 1961);

Ab_k - abundance of taxon k; Nb_Point_Prelev - occurrence of taxon k

For each observation unit, *Note* is calculated on the littoral zone and on the perpendicular profiles:

$$Note = \sum_{i=1}^{n} \frac{(CS_i * Ab_i * E_i)}{\sum (Ab_i * E_i)}$$

CS - specific value (0 to 20); E - stenoecy coefficient (0 to 3); n - number of taxa; Note - 0 to 20 score

About 300 taxa have their own specific value and stenoecy coefficient. Indicators taxa are presented in Table A.20.

Here, the riparian type of each observation unit, as defined in the national protocol (4 types), is taken into account. It is used either for littoral zone (*rive*) and perpendicular profiles (*profil*):

$$Note_{Rive\_ou\_profil} = \sum_{k=1}^{4} \frac{\left(\overline{Note_k} * Pourcentage\_Type_k\right)}{4}$$

$\overline{Note_k}$: average score of the riparian type k (1 to 4)

$Note_{Rive\_ou\_Profil}$: Score calculated on the littoral zone or the perpendicular profiles

$PourcentageType_k$: Percentage of the riparian type k estimated on the whole lake perimeter

Whole lake score :

$$Note_{trophie} = \frac{(Note_{Rive} + Note_{Profil})}{2}$$

$Note_{trophie}$= this score from 0 to 20 gives an estimation of the trophic level of the lake. It includes all the pressures linked or associated to the degradation of this trophic level (eutrophication, HYMO, general degradation, etc.)

Calculation rules

These rules allow a better representativeness of IBML metrics:

- On the profiles and the littoral zone, at least 2 recorded taxa with CS and E are needed;
- at least 3 observation units done on the lake;
- the riparian types must be estimated on at least 70 % of the whole lake perimeter;
- at least 50 % of the observation units (littoral zone or perpendicular profiles) including at least 2 taxa with CS and E.

Lake types

4 French lake types are defined according to the altitude and the alkalinity:

- B-Alc : low altitude (< 200 m) and high alkalinity (> 1 meq/l^{-1});
- B-Aci : low altitude (< 200 m) and low alkalinity (< 1 meq/l^{-1});
- H-Alc : high altitude (> 200 m) and high alkalinity (> 1 meq/l^{-1});
- H-Aci : high altitude (> 200 m) and low alkalinity (< 1 meq/l^{-1}).

Normalization and standardization of the boundaries

A unified scale from “0” to “1” is suitable. The value “1” represents the best ecological status according to the WFD. The value “0” stands for the highest degree of degradation of a water body. First, the EQR values are normalized (where the minimum EQR value is 1/the reference value for “lakes types”).

Then, the boundaries are transformed to EQR values, where H/G equals 0.8 and G/M equals 0.6 by a linear equation:

- B-Alc : y= 1.09*x - 0.12
- B-Aci : y= 1.13*x - 0.15
- H-Alc : y= 0.96*x - 0.1
- H-Aci : y=1.15*x - 0.16

Table A.18 Index limits for classification of the ecological status

Ecological status	EQR Value
High	0.8 – 1
Good	0.6 – 0.8
Moderate	0.4 – 0.6

Poor	0.2 – 0.4
Bad	0 - 0.2

How are reference conditions, H/G and G/M boundaries derived?

The reference is based on existing least disturbed reference sites following the criteria given in the National Circular DCE 2004/08: mostly based on the land use data on the catchment area and the chemical/physicochemical data on the lake. Regarding the macrophyte communities, only the presence of invasive aquatic species is taken into account. About 13 reference lakes, most of them located in Alpine region and the West side of Aquitaine (South-West of France).

The reference value for "lake types" is given by the median of IBML from reference lakes identified according to the pressure criteria. The H/G boundary is as 75th percentile from the distribution of reference lakes. The other boundaries are given by the equidistant division of the continuum.

Due to lack of data, the classification of IBML values into the categories of ecological status is under development.

How well correlate the indicators with pressure indicators?

An example of correlation is presented in the Table A.19

Table A.19 Spearman correlation between the pressures variables and the EQR value

Variables	B-Alc	B-Aci	H-Alc
NK	0.18	-0.47*	0.12
Chlo a	-0.29	-0.22	-0.14
TP	0.17	-0.72*	-0.08
PO4	0.06	-0.48*	0.39
Population density	-0.39	-0.38	-0.19
Urban area	-0.57*	-0.32	-0.19
Agricultural area	0.06	-0.42	-0.3
Intensive agricultural area	0.06	-0.21	-0.39
Type 4 (as described in the national protocol)	-0.3	0.16	-0.56*
Total pressures LHS	0.09	-0.12	-0.18

* Significant value

How is dealt with differences between national and assessment vs. GIG data and assessment?

The IBML method is developed for lakes with a water level fluctuation less than 2 meters. The French macrophyte assessment method uses the taxonomic composition and abundance surveyed on observation units. The metrics are calculated on several sections of shore (including helophytes) and profiles perpendicular to the shore. The ecological status is given by the combination of these results according to the proportion of each different types of riparian zone around the lake.

<u>Assessment transformation to the GIG data base</u>

For intercalibration, the surveys on the sections of shore are not taken into account, only the profiles are considered. The helophytes are not included in the intercalibration assessment (only in the Lake Central-Baltic exercise). The intercalibration results are given at transects scale. The results from IBML are given at the lake scale (calculated as the mean of observation units results) including the proportion of each types of riparian zone which are not taken into account in the GIGs.

Table A.20 Specific values and stenoecy coefficients of indicator species

Name	Specific value	Stenoecy coefficient
Acorus calamus	7	3
Agrostis stolonifera	10	1
Alisma lanceolatum	9	2
Alisma plantago-aquatica	8	2
Amblystegium fluviatile	11	2
Amblystegium riparium	5	2
Amblystegium tenax	15	2
Aneura pinguis	14	2
Apium inundatum	17	3
Apium nodiflorum	10	1
Audouinella	13	2
Aulacomnium palustre	15	2
Azolla filiculoides	6	3
Baldellia ranunculoides	13	2
Baldellia repens	12	3
Bangia	10	2
Batrachospermum	16	2
Berula erecta	14	2
Bidens frondosa	7	3
Bidens tripartita	8	3
Binuclearia	14	2
Bolboschoenus maritimus	11	2
Brachythecium plumosum	18	3
Brachythecium rivulare	15	2
Butomus umbellatus	9	2
Caltha palustris	13	1
Calliergonella cuspidata	11	1
Calliergon giganteum	14	2

Name	Specific value	Stenoecy coefficient
Callitriche hamulata	12	1
Callitriche obtusangula	8	2
Callitriche truncata subsp. occidentalis	10	2
Callitriche platycarpa	10	1
Callitriche stagnalis	12	2
Carex acutiformis	11	2
Carex demissa	14	3
Carex elata	11	2
Carex hirta	13	2
Carex limosa	14	3
Carex nigra	13	2
Carex paniculata	12	1
Carex pendula	10	2
Carex pseudocyperus	13	2
Carex remota	13	2
Carex riparia	8	2
Carex rostrata	15	3
Carex vesicaria	12	2
Catabrosa aquatica	11	2
Ceratophyllum demersum	5	2
Ceratophyllum submersum	2	3
Chara delicatula	18	2
Chara canescens	18	2
Chara contraria	18	2
Chara connivens	18	2
Chara globularis	13	1
Chara hispida	15	2
Chara intermedia	18	2
Chara polyacantha	18	2
Chara strigosa	18	2
Chara tomentosa	18	3
Chara vulgaris	13	1
Chaetophora	12	2
Chiloscyphus pallescens	14	2
Chiloscyphus polyanthos	15	2
Cinclidotus aquaticus	15	2
Cinclidotus danubicus	13	3
Cinclidotus fontinaloides	12	2
Cinclidotus riparius	13	2

Name	Specific value	Stenoecy coefficient
Cladophora	6	1
Cladium mariscus	12	3
Collema fluviatile	17	3
Cratoneuron commutatum	15	2
Cratoneuron filicinum	18	3
Cyperus fuscus	11	3
Dermatocarpon weberii	16	3
Diatoma	12	2
Draparnaldia	18	3
Drepanocladus aduncus	15	3
Drepanocladus fluitans	14	2
Egeria densa	8	1
Elatine hexandra	13	3
Elodes palustris	15	3
Eleocharis acicularis	12	2
Eleocharis palustris	12	2
Elodea canadensis	10	2
Elodea nuttalii	8	2
Enteromorpha	3	2
Epilobium hirsutum	9	1
Epilobium palustre	14	2
Equisetum fluviatile	12	2
Equisetum palustre	10	1
Eriophorum angustifolium	15	3
Filipendula ulmaria	9	2
Fissidens crassipes	12	2
Fissidens gracilifolius	14	3
Fissidens grandifrons	15	3
Fissidens polyphyllus	20	3
Fissidens pusillus	14	2
Fissidens rufulus	14	3
Fissidens viridulus	11	2
Fontinalis antipyretica	10	1
Fontinalis hypnoides var. duriaei	14	3
Fontinalis hypnoides	14	2
Fontinalis squamosa	16	3
Galium palustre	9	1
Glyceria aquatica	11	2
Glyceria fluitans	14	2

Name	Specific value	Stenoecy coefficient
Groenlandia densa	11	2
Heleochloris pallida	17	3
Hildenbrandia	15	2
Hippuris vulgaris	12	2
Hottonia palustris	12	2
Hydrocharis morsus-ranae	11	3
Hygrohypnum duriusculum	19	3
Hygrohypnum luridum	19	3
Hygrohypnum ochraceum	19	3
Hydrodictyon	6	2
Hyocomium armoricum	20	3
Hydrocotyle vulgaris	14	2
Hydrurus	16	2
Iris pseudacorus	10	1
Isnardia palustris	13	3
Isoëtes boryana	18	3
Isoëtes lacustris	17	3
Jungermannia atrovirens	19	3
Jungermannia gracillima	20	3
Juncus articulatus	12	2
Juncus bufonius	12	2
Juncus bulbosus	16	3
Juncus conglomeratus	9	1
Juncus effusus	8	1
Juncus filiformis	14	2
Juncus inflexus	8	1
Juncus subnodulosus	17	3
Lagarosiphon major	9	1
Lemanea	15	2
Leersia oryzoides	7	3
Lemna gibba	5	3
Lemna minor	10	1
Lemna trisulca	12	2
Leptomitus	0	3
Littorella uniflora	15	3
Lobelia dortmanna	17	3
Lotus pedunculatus	9	1
Luronium natans	14	3
Lycopus europaeus	11	1

Name	Specific value	Stenoecy coefficient
Lyngbya	10	2
Lysimachia nummularia	11	2
Lysimachia vulgaris	9	1
Lythrum portula	12	2
Lythrum salicaria	9	1
Marsupella aquatica	19	2
Marsupella emarginata	20	3
Melosira	10	1
Mentha aquatica	12	1
Mentha arvensis	11	1
Mentha longifolia	12	2
Menyanthes trifoliata	16	3
Microspora	12	2
Montia fontana	15	2
Monostroma	13	2
Mougeotia	13	2
Myosotis scorpioides	12	1
Myriophyllum alterniflorum	13	2
Myriophyllum aquaticum	9	1
Myriophyllum spicatum	8	2
Myriophyllum verticillatum	12	3
Najas marina	5	3
Najas minor	6	3
Nardia compressa	20	3
Nardia scalaris	20	3
Nasturtium officinale	11	1
Nitella flexilis	14	2
Nitella gracilis	14	2
Nitella mucronata	14	2
Nitella translucens	14	2
Nostoc	9	1
Nuphar lutea	9	1
Nuphar pumila	16	3
Nymphaea alba	12	3
Nymphoides peltata	10	2
Octodiceras fontanum	7	3
Oedogonium	6	2
Oenanthe aquatica	11	2
Oenanthe crocata	12	2

Name	Specific value	Stenoecy coefficient
Oenanthe fluviatilis	10	2
Orthotrichum rivulare	15	3
Oscillatoria	11	1
Osmunda regalis	14	3
Phalaris arundinacea	10	1
Philonotis calcarea	18	2
Phormidium	13	2
Phragmites australis	9	2
Potentilla palustris	16	3
Polygonum amphibium	9	2
Polygonum hydropiper	8	2
Polygonum lapathifolium	8	1
Polygonum persicaria	8	1
Porella pinnata	12	2
Potamogeton acutifolius	12	3
Potamogeton alpinus	13	2
Potamogeton berchtoldii	9	2
Potamogeton coloratus	20	3
Potamogeton compressus	6	3
Potamogeton crispus	7	2
Potamogeton friesii	10	1
Potamogeton gramineus	13	2
Potamogeton lucens	7	3
Potamogeton natans	12	1
Potamogeton nodosus	4	3
Potamogeton obtusifolius	10	2
Potamogeton panormitanus	9	2
Potamogeton pectinatus	2	2
Potamogeton perfoliatus	9	2
Potamogeton polygonifolius	17	3
Potamogeton praelongus	13	2
Potamogeton trichoides	7	2
Racomitrium aciculare	18	3
Ranunculus aquatilis	11	2
Ranunculus circinatus	10	2
Ranunculus flammula	16	3
Ranunculus fluitans	10	2
Ranunculus hederaceus	12	3
Ranunculus lingua	11	3

Name	Specific value	Stenoecy coefficient
Ranunculus ololeucos	19	3
Ranunculus omiophyllus	19	3
Ranunculus peltatus	12	2
Ranunculus penicillatus	12	1
Ranunculus repens	9	1
Ranunculus reptans	19	3
Ranunculus trichophyllus	11	2
Rhizoclonium	4	2
Rhynchostegium riparioides	12	1
Riccardia chamedryfolia	15	2
Riccardia multifida	15	2
Riccia fluitans	8	3
Rorippa amphibia	9	1
Rorippa palustris	10	1
Rumex hydrolapathum	9	1
Sagittaria sagittifolia	6	2
Salvinia natans	7	1
Samolus valerandi	13	3
Scapania paludosa	20	3
Scapania undulata	17	3
Schizomeris	1	3
Scirpus fluitans	18	3
Scirpus lacustris	8	2
Scirpus sylvaticus	10	2
Schoenoplectus pungens	13	2
Schistidium rivulare	15	3
Scutellaria galericulata	10	1
Sirogonium	12	2
Sparganium angustifolium	19	3
Sparganium emersum fo. brevifolium	13	2
Sparganium emersum	9	1
Sparganium emersum fo. longissimum	7	1
Sparganium erectum	10	1
Sparganium minimum	15	3
Sphagnum denticulatum	20	3
Sphagnum palustre	20	3
Spirogyra	10	1
Spirodela polyrhiza	6	2
Sphaerotilus	1	3

Name	Specific value	Stenoecy coefficient
Stachys palustris	10	1
Stigeoclonium	13	2
Stigeoclonium tenue	1	3
Stratiotes aloides	13	2
Subularia aquatica	17	3
Tetraspora	12	1
Thamnobryum alopecurum	15	2
Thelypteris palustris	12	2
Thalictrum flavum	11	2
Thorea	14	3
Chara glomerata	12	2
Tolypella prolifera	15	3
Trapa natans	10	3
Tribonema	11	2
Typha angustifolia	6	2
Typha latifolia	8	1
Ulothrix	10	1
Utricularia australis	12	3
Utricularia minor	12	3
Vallisneria spiralis	8	2
Vaucheria	4	1
Veronica anagallis-aquatica	11	2
Veronica beccabunga	10	1
Veronica catenata	11	2
Veronica scutellata	11	2
Viola palustris	15	3
Wolffia arrhiza	6	2
Zannichellia palustris	5	1
Zygnema	13	3

A.3 Germany

PHYLIB for Lakes (German Assessment system for Macrophytes & Phytobenthos for Lakes)

Which indicators are used?

Macrophyte taxonomic composition:

The taxonomic composition of hydrophytes is assessed on species level. Hydrophytes include angiosperms, charophytes and some mosses. Other macroalgae (e.g.

Hydrodiction sp.) are not included. Only submerged, floating-leaved and free floating macrophytes are considered as indicators.

Table A.21   The German species abundance scale.

1	very rare
2	rare
3	common
4	frequent
5	abundant/predominant

Macrophyte abundance:

The species composition uses a 5 classes of abundance, see Table A.21. The abundance of the species for each depth zone at each transect is recorded separately.

Composition and abundance of phytobenthos:

Only benthic diatoms (*Bacillariophyceae)* are used as indicators for Phytobenthos. In order to obtain a representative distribution, 500 valves are determined in a prepared slide to the species level. The frequencies are presented as percentages.

Bacterial tufts:

Bacterial tufts are not used in the assessment of the quality element, because of lack of data and information for suitable indicators and its reference values.

Summary

For the German method macrophtes and diatoms are assessed separately and then combined to one EQR. The lake assessment is calculated as the mean of transect results.

Macrophytes:

- Reference index (RI): relative abundance of the macrophyte species of three different typespecific ecological species groups (reference indicators, indifferent taxa, degradation indicators; according to growth depth, most taxa are assigned to different groups);
- Limit of vegetation: used as an additional criteria;
- Dominant stands: used as an additional criteria if a single species (e.g. *Elodea canadensis/nuttallii* or *Myriophyllum spicatum*) reaches at least 80% of total plant quantity (see below).

Phytobenthos:

- Trophic-Index ($TI_{Süd(South)}$): diatom index related to trophic status according to Hofmann (1999);
- Quotient of Reference Species" (RAQ): number of the diatom species of two different ecological species groups (reference indicators (A) and degradation indicators (C)).

How are these indicators monitored?

Sampling strategy

Macrophytes

Each transect covers a minimum of 20 m of homogeneous shoreline and is divided into 0–1 m, 1–2 m, 2–4 m and >4 m depth classes. Transects can be surveyed either using SCUBA or by boat using a water viewer and a double rake with rope. For data analyses, the macrophyte abundance data is transformed into “plant abundance” using the function $y = x^3$.

Phytobenthos

Preferably stones are sampled in their original position and the periphyton (Aufwuchs) or

sediment cover is scratched off with a tea spoon, spatula or a similar device and is transferred into a labeled wide neck sampling container. Generally, sampling is carried out in the open water and not amidst dense stands of macrophytes. The sampling depth should exceed 30 cm. Fluctuations of the water level must be kept in mind when scheduling sampling dates. If mainly sand or soft sediments are present, the upper millimetres are lifted off with a spoon.

The sites are the same as surveyd for macrophytes. The sampling can be done together once during summer.

Numbers of samples per lake

Macrophytes

According to lake size and shape, usage of shore and catchment area 4 to 30 transects (=sites) are investigated. Each transect covers a minimum of 20 m of homogeneous shoreline (=width) and reaches from shore to vegetation limit (=variable length). If transects are investigated by a rake, at least five samples are taken in each depth class (20 samples per transect). Macrophyte abundance is recorded for each depth class separately but not for each sample.

Phytobenthos

At each transect approximately 5 stones or subsamples are sampled.

When is monitored and with which frequency?

Macrophytes

Samples are taken once in the middle of growing season i.e. 15th June-15th August.

Phytobenthos

The sampling can be done together with macrophyte monitoring once during summer.

Use of equipment

Macrophytes

Sampling can be done in two different ways:

- using SCUBA equipment;
- by boat, using a water viewer in combination with a double rake connected to a rope.

In any case sampling bags and cool bags are used to store species for later determination (mosses, charophytes).

Phytobenthos

Samples are taken with a tea spoon, spatula or a similar device and transferred into a labeled wide neck sampling jar. Diatoms are preserved by adding ethanol.

Analysis of sample and level of determination

Macrophytes

Most plants are determined to species in the field, and partly validated in the laboratory. Charophytes and mosses are determined to genus or higher taxa in the field and collected for species determination.

Phytobenthos

Samples are oxidized (KRAMMER & LANGE-BERTALOT (1986)). Determination with microscope (interference/phase contrast) with 1000- to 1200 fold magnification. A number of 500 shells is determined in a prepared slide to the species level. "Diatomeen im Süßwasserbenthos von Mitteleuropa" of Hofmann et al. (2011) is used as standard determination literature. It can be completed by the volumes of the "Diatoms of Europe", 4 volumes of KRAMMER & LANGE-BERTALOT (1986–1991), supplementary volumes and revisions of individual species published since 1993 by the following authors: KRAMMER (2000, 2002), LANGE-BERTALOT (1993, 2001), LANGE-BERTALOT & MOSER (1994), LANGE-BERTALOT & METZELTIN (1996).

Assessment

Data requirements

A software tool for the automatically calculation of the German assessment is available.

The following information is needed for correct assessment:

- lake type according to LAWA;
- macrophyte lake type (for macrophyte assessment);

- diatom lake type (for diatom assessment);
- natural/ artificial/ HMWB;
- changes in waterlevel;
- vegetation limit with plausibility;
- maximum lake depth;
- in case of depopulation of macrophytes give possible reason;
- for each taxon: growthform (submerged/emerged), abundance (5 classes for macrophytes), percentage (for diatoms), depth zone (for macrophytes).

Methods of calculation

Macrophytes

Prior to performing any calculations, the nominally scaled values of plant abundance are converted into metric quantities using the following function:

macrophyte abundance^3 = quantity

The taxa occurring at the sampling site will be assigned to type specific species groups (compare

Table A.25 and Table A.26). Taxa found in differing depth zones are treated as different taxa (e.g. taxon A in 0–1 m, taxon A in 1–2 m, ...). The quantities of the different species will be summed up separately for each group and for all submerged species of a sampling site.

The Reference Index is calculated according to the following formula (Equation 1):

Equation 1: Calculation of the Reference Index

$$RI = \frac{\sum_{i=1}^{n_A} Q_{Ai} - \sum_{i=1}^{n_C} Q_{Ci}}{\sum_{i=1}^{n_g} Q_{gi}} * 100$$

RI = Reference Index

QAi = Quantity of the i-th taxon of species group A

QCi = Quantity of the i-th taxon of species group C

Qgi = Quantity of the i-th taxon of all groups

nA = Total number of taxa in group A

nC = Total number of taxa in group C

ng = Total number of taxa in all groups

The RI is an expression of the “plant quantity” ratio of type-specific sensitive taxa, dominating at reference conditions, compared to the “plant quantity” of insensitive taxa and is therefore a tool for estimating the deviation of observed macrophyte communities from reference communities. The resulting index values range from +100 (only species group A taxa) to –100 (only species group C taxa).

The additional criteria provided in Table A.22 used are type related correcting factors of the RI.

In order to calculate the Reference Index, the respective type specific characteristics and prerequisites have to be considered.

Table A.22 Correcting factors for different lake types

German lake type	Correcting factors
TKg10	if RI > 0 and vegetation limit between 4 m and 6 m → RI is reduced by 10 if RI > 0 and vegetation limit between 2,5 m and 4 m → RI is reduced by 20 if vegetation is limit < 2,5 m → RI is reduced by 50 if RI > -50 and dominant stands of one of the following taxa occur, RI is reduced by 50: *Ceratophyllum demersum, C. submersum, Elodea canadensis/ nuttallii, Myriophyllum spicatum, Najas marina subsp. intermedia* or *Potamogeton pectinatus*
TKg13	if RI > 0 and vegetation limit > 5 m and < 8 m → RI is reduced by 10 if RI > 0 and vegetation limit > 2,5 m and < 5 m → RI is reduced by 20 if vegetation limit is < 2,5 m → RI is reduced by 50 if RI > -50 and dominant stands of one of the following taxa occur, RI is reduced by 50: *Ceratophyllum demersum, C. submersum, Elodea canadensis/ nuttallii, Myriophyllum spicatum, Najas marina subsp. intermedia* or *Potamogeton pectinatus*
TKp	if RI > 0 and vegetation limit between 2,5 m and 4 m → RI is reduced by 10, in case of a maximum depth >= 4 m if vegetation limit ist < 2,5 m → RI is reduced by 50, in case of a maximum depth >= 2,5 m if RI > -50 and dominant stands of one of the following taxa occur, RI is reduced by 50:*Ceratophyllum demersum, C. submersum, Elodea canadensis/ nuttallii, Myriophyllum spicatum, Najas marina subsp. intermedia* or *Potamogeton pectinatus*

In order to create a basis for comparison for the metrics Macrophytes and Diatoms and to obtain EQR values, the index values must be transformed. A unified scale from "0" to "1" is suitable. The value "1" represents the best ecological status according to the WFD, i.e. status class 1. The value "0" stands for the highest degree of degradation of a water body, i.e. status class 5. The transformation for the module „Macrophytes" (Reference Index, RI) is carried out according to Equation 2.

Equation 2 Transformation of the module RISeen/Lakes (Reference IndexSeen/Lakes Macrophytes) on a scale from 0 to 1.

$$M_{MP} = \frac{(RI_{Seen} + 100) * 0,5}{100}$$

M_{MP} = Module Macrophyte Assessment

$RI_{Seen/Lakes}$= type specifically calculated Reference $Index_{Seen/Lakes}$

The classification of the EQR values into the categories of ecological status is based on the definitions for ecological status, given by Annex V of the WFD (Table A.23)

Table A.23 Classification of the EQR values into the categories of ecological status

ecological status	Range of EQR	Definition given by the WFD	Interpretation
High	>0.76	"The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic [...] abundance. [...]"	EQR values lie within the range of reference sites.
Good	0.51 to 0.76	"There are slight changes in the composition and abundance of macrophytic [...] taxa compared to the type-specific communities. [...]"	EQR values are slightly below high status and always positive (Taxa of species group A have higher abundances than species group C taxa).
Moderate	0.26 to 0.75	"The composition of macrophytic [...] taxa differ moderately from the type specific communities and-are significantly more distorted than those observed at good quality. Moderate changes in the average macrophytic [...] abundance are evident. [...]"	EQR values are around zero or negative (species group C taxa equal or slightly outweigh species group A taxa).
Poor	0.01 to 0.25	Macrophyte "communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions".	EQR values are very low (species group A taxa are nearly replaced by species group C taxa).
Bad	< 0.01	"Large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are	Very low macrophyte abundances without natural reasons. (Calculation of RI/EQR is often not possible)

In all ecoregions the reason for an absence of macrophytes and therefore an unreliable module Macrophytes must be determined. If, for example due to physicochemical parameters, structural modifications (embankments), mowing, introduction of fish or other anthropogenic influences a macrophyte depopulation is proved, must be downgraded to the RI value -100.

Phytobenthos: trophic index

The indicative species of the trophic index which were found at the littoral site to be assessed and their percentages are the basis for calculating the Trophic Index according to Hofmann (1999) (Equation 3).

Equation 3: Trophic-Index according to Hofmann (1999) $TI_{Süd(South)}$

$$TI_{SÜD} = \frac{\sum_{i=1}^{n} H_i * G_i * T_i}{\sum_{i=1}^{n} H_i * G_i} x$$

$TI_{Süd(South)}$ = Trophic-Index Süd(South)

H_i = Percentage of the i-th species

G_i = Weight of the i-th species

T_i = Trophic value of the i-th species

For the combination with the „Quotient of Reference Species (RAQ)" the calculated values of the „Trophic-Index (TI)" are transformed according to the following equation 4.

Equation 4: Transformation of the calculated trophic value $TI_{Süd(South)}$

$$M_{TI_{Süd}} = 1 - ((TI_{Süd} - 1) * 0{,}25)$$

$M_{TISüd}$ = Module Trophic-Index $_{Süd(South)}$

$TI_{Süd}$ = calculated Trophic-Index$_{Süd(South)}$

Phytobenthos: „Quotient of Reference Species" (RAQ)

The type specific occurrence in different ecological conditions is used to distinguish two different species groups.

For assessment the quotient of reference species is determined under consideration of the type specific reference species and their ecological groups. Only the number of species is considered whereas the abundance of the individual species is neglected (compare Equation 5).

Equation 5: Calculation of the Quotient of Reference Species for the lakes of the North German Lowland

$$RAQ = \frac{Number\ of\ taxa\ A - Number\ of\ taxa\ C}{Number\ of\ taxa\ A + Number\ of\ taxa\ C}$$

The RAQ-values are transformed according to equation 6.

Equation 6: Transformation of the type specifically calculated quotient of reference species

$$M_{RAQ} = (RAQ + 1) * 0{,}5$$

M_{RAQ} = Module Quotient of Reference Species

RAQ = calculated Quotient of Reference Species

The overall assessment of the component Phytobenthos-Diatoms is carried out by a combination of the modules „Trophic-Index (TI)“ and „Quotient of Reference Species (RAQ)“. For this purpose the arithmetic mean of the results is determined to obtain the Diatom- Index_{Seen} ($DI_{Seen(Lakes)}$) following Equation 7.

Equation 7: Calculation of the $DI_{Seen(Lakes)}$

$$DI_{Seen} = \frac{M_{RAQ} + M_{TI}}{2}$$

DI_{Seen} = $\text{Diatom-Index}_{Seen(Lakes)}$

M_{RAQ} = Module Quotient of Reference Species

M_{TI} = Module Trophic-Index

Combination of the metrics Macrophytes and Diatoms

Calculation of the index is carried out according to Equation 8. If an individual module cannot be considered reliable, the Macrophyte-Phytobenthos Index for lakes ($M\&P_{Seen/Lakes}$) corresponds to the reliably calculated module. However, the result must critically be verified.

Equation 8: Calculation of the Index $M\&P_{Seen/Lakes}$ for determination of the ecological status in case of two reliable modules.

$$M\&P_{Seen/Lakes} = \frac{M_{MP} + M_{D}}{2}$$

$M\&P_{seen/Lakes}$ = Macrophyte & Phytobenthos-Index for lakes

M_{MP} = Module Macrophytes

M_{D} = Module Diatoms

According to lake types, the $M\&P_{Seen/Lakes}$-values are assigned to ecological quality classes.

The classification of the EQR values into the categories of ecological status is based on the definitions for ecological status, given by Annex V of the WFD (

Table A.24).

Table A.24 Classification of the EQR values into the categories of ecological status

Ecological status	Range of EQR	Definition given by the WFD
High	>0.74	"The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic [...] abundance. [...]"
Good	0.47 to 0.74	"There are slight changes in the composition and abundance of [...] taxa compared to the type-specific communities. [...]"
Moderate	0.26 to 0.46	"The composition of [...] taxa differ moderately from the type specific communities and-are significantly more distorted than those observed at good quality. Moderate changes in the average [...] abundance are evident. [...]"
Poor	0.04 to 0.25	Macrophyte "communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions".
Bad	< 0.03	"Large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are

Table A.25 Original list of type specific macrophyte indicator species. .

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
1	Acorus calamus_0_1	C
2	Acorus calamus_1_2	C
3	Acorus calamus_2_4	C
4	Acorus calamus_>4	C
5	Alisma gramineum_0_1	B
6	Alisma gramineum_1_2	B
7	Alisma gramineum_2_4	B
8	Alisma gramineum_>4	B
9	Alisma lanceolatum_0_1	B
10	Alisma lanceolatum_1_2	B
11	Alisma lanceolatum_2_4	B
12	Alisma lanceolatum_>4	B
13	Alisma plantago-aquatica_0_1	B
14	Alisma plantago-aquatica_1_2	B

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
15	Alisma plantago-aquatica_2_4	B
16	Alisma plantago-aquatica_>4	B
17	Brachythecium rivulare_0_1	B
18	Brachythecium rivulare_1_2	B
19	Brachythecium rivulare_2_4	B
20	Brachythecium rivulare_>4	B
21	Butomus umbellatus_0_1	C
22	Butomus umbellatus_1_2	C
23	Butomus umbellatus_2_4	C
24	Butomus umbellatus_>4	C
25	Calliergonella cuspidata_0_1	B
26	Calliergonella cuspidata_1_2	B
27	Calliergonella cuspidata_2_4	B
28	Callitriche cophocarpa_0_1	C
29	Callitriche cophocarpa_1_2	C
30	Callitriche cophocarpa_2_4	C
31	Callitriche cophocarpa_>4	C
32	Callitriche hamulata_0_1	A
33	Callitriche hamulata_1_2	A
34	Callitriche hamulata_2_4	A
35	Callitriche hamulata_>4	A
36	Callitriche hermaphroditica_0_1	B
37	Callitriche hermaphroditica_1_2	B
38	Callitriche hermaphroditica_2_4	B
39	Callitriche hermaphroditica_>4	B
40	Callitriche obtusangula_0_1	C
41	Callitriche obtusangula_1_2	C
42	Callitriche obtusangula_2_4	C
43	Callitriche obtusangula_>4	C
44	Callitriche palustris_0_1	A
45	Callitriche palustris_1_2	A
46	Callitriche palustris_2_4	A
47	Callitriche palustris_>4	A
48	Carex riparia_0_1	B
49	Carex riparia_1_2	B
50	Carex riparia_2_4	B
51	Carex riparia_>4	B
52	Ceratophyllum demersum_0_1	C
53	Ceratophyllum demersum_1_2	C

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
54	Ceratophyllum demersum_2_4	C
55	Ceratophyllum demersum_>4	C
56	Ceratophyllum submersum_0_1	C
57	Ceratophyllum submersum_1_2	C
58	Ceratophyllum submersum_2_4	C
59	Ceratophyllum submersum_>4	C
60	Chara aspera var. curta_0_1	A
61	Chara aspera var. curta_1_2	A
62	Chara aspera var. curta_2_4	A
63	Chara aspera var. curta_>4	A
64	Chara aspera_0_1	A
65	Chara aspera_1_2	A
66	Chara aspera_2_4	A
67	Chara aspera_>4	A
68	Chara braunii_0_1	
69	Chara braunii_1_2	
70	Chara braunii_2_4	
71	Chara braunii_>4	
72	Chara contraria var. hispidula_0_1	B
73	Chara contraria var. hispidula_1_2	B
74	Chara contraria var. hispidula_2_4	B
75	Chara contraria var. hispidula_>4	A
76	Chara contraria_0_1	B
77	Chara contraria_1_2	B
78	Chara contraria_2_4	a
79	Chara contraria_>4	A
80	Chara delicatula_0_1	B
81	Chara delicatula_1_2	B
82	Chara delicatula_2_4	A
83	Chara delicatula_>4	A
84	Chara denudata_0_1	B
85	Chara denudata_1_2	B
86	Chara denudata_2_4	B
87	Chara denudata_>4	B
88	Chara filiformis_0_1	
89	Chara filiformis_1_2	
90	Chara filiformis_2_4	
91	Chara filiformis_>4	
92	Chara globularis_0_1	B

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
93	Chara globularis_1_2	B
94	Chara globularis_2_4	a
95	Chara globularis_>4	A
96	Chara hispida_0_1	A
97	Chara hispida_1_2	A
98	Chara hispida_2_4	A
99	Chara hispida_>4	A
100	Chara intermedia_0_1	A
101	Chara intermedia_1_2	A
102	Chara intermedia_2_4	A
103	Chara intermedia_>4	A
104	Chara polyacantha_0_1	A
105	Chara polyacantha_1_2	A
106	Chara polyacantha_2_4	A
107	Chara polyacantha_>4	A
108	Chara rudis_0_1	A
109	Chara rudis_1_2	A
110	Chara rudis_2_4	A
111	Chara rudis_>4	A
112	Chara strigosa_0_1	A
113	Chara strigosa_1_2	A
114	Chara strigosa_2_4	A
115	Chara strigosa_>4	A
116	Chara tomentosa_0_1	A
117	Chara tomentosa_1_2	A
118	Chara tomentosa_2_4	A
119	Chara tomentosa_>4	A
120	Chara vulgaris_0_1	B
121	Chara vulgaris_1_2	B
122	Chara vulgaris_2_4	B
123	Chara vulgaris_>4	a
124	Cladium mariscus_0_1	B
125	Cladium mariscus_1_2	B
126	Cladium mariscus_2_4	B
127	Cladium mariscus_>4	B
128	Drepanocladus aduncus_0_1	B
129	Drepanocladus aduncus_1_2	B
130	Drepanocladus aduncus_2_4	B
131	Drepanocladus aduncus_>4	B

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
132	Drepanocladus fluitans_0_1	B
133	Drepanocladus fluitans_1_2	B
134	Drepanocladus fluitans_2_4	B
135	Drepanocladus fluitans_>4	B
136	Elatine hexandra_0_1	
137	Elatine hexandra_1_2	
138	Elatine hexandra_2_4	
139	Elatine hexandra_>4	
140	Elatine hydropiper_0_1	
141	Elatine hydropiper_1_2	
142	Elatine hydropiper_2_4	
143	Elatine hydropiper_>4	
144	Elatine triandra_0_1	
145	Elatine triandra_1_2	
146	Elatine triandra_2_4	
147	Elatine triandra_>4	
148	Eleocharis acicularis_0_1	B
149	Eleocharis acicularis_1_2	B
150	Eleocharis acicularis_2_4	B
151	Eleocharis acicularis_>4	B
152	Eleocharis palustris_0_1	C
153	Eleocharis palustris_1_2	C
154	Eleocharis palustris_2_4	C
155	Eleocharis palustris_>4	C
156	Elodea canadensis_0_1	C
157	Elodea canadensis_1_2	C
158	Elodea canadensis_2_4	C
159	Elodea canadensis_>4	C
160	Elodea nuttallii_0_1	C
161	Elodea nuttallii_1_2	C
162	Elodea nuttallii_2_4	C
163	Elodea nuttallii_>4	C
164	Epilobium hirsutum_0_1	B
165	Epilobium hirsutum_1_2	B
166	Epilobium hirsutum_2_4	B
167	Epilobium hirsutum_>4	B
168	Equisetum fluviatile_0_1	B
169	Equisetum fluviatile_1_2	B
170	Equisetum fluviatile_2_4	B

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
171	Equisetum fluviatile_>4	B
172	Fontinalis antipyretica_0_1	B
173	Fontinalis antipyretica_1_2	B
174	Fontinalis antipyretica_2_4	B
175	Fontinalis antipyretica_>4	B
176	Fontinalis hypnoides_0_1	B
177	Fontinalis hypnoides_1_2	B
178	Fontinalis hypnoides_2_4	B
179	Fontinalis hypnoides_>4	B
180	Fontinalis squamosa_0_1	B
181	Fontinalis squamosa_1_2	B
182	Fontinalis squamosa_2_4	B
183	Fontinalis squamosa_>4	B
184	Galium palustre ssp. palustre_0_1	B
185	Galium palustre ssp. palustre_1_2	B
186	Galium palustre ssp. palustre_2_4	B
187	Galium palustre ssp. palustre_>4	B
188	Glyceria fluitans_0_1	B
189	Glyceria fluitans_2_4	B
190	Glyceria fluitans_>4	B
191	Groenlandia densa_0_1	C
192	Groenlandia densa_1_2	C
193	Groenlandia densa_2_4	C
194	Groenlandia densa_>4	C
195	Hippuris vulgaris_0_1	C
196	Hippuris vulgaris_1_2	C
197	Hippuris vulgaris_2_4	C
198	Hippuris vulgaris_>4	C
199	Hottonia palustris_0_1	A
200	Hottonia palustris_1_2	A
201	Hottonia palustris_2_4	A
202	Hottonia palustris_>4	A
203	Hydrocharis morsus-ranae_0_1	A
204	Hydrocharis morsus-ranae_1_2	A
205	Hydrocharis morsus-ranae_2_4	A
206	Hydrocharis morsus-ranae_>4	A
207	Hydrocotyle vulgaris_0_1	A
208	Hydrocotyle vulgaris_1_2	A
209	Hydrocotyle vulgaris_2_4	A

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
210	Hydrocotyle vulgaris_>4	A
211	Hygrohypnum duriusculum_0_1	
212	Hygrohypnum duriusculum_1_2	
213	Hygrohypnum duriusculum_2_4	
214	Hygrohypnum duriusculum_>4	
215	Hygrohypnum ochraceum_0_1	B
216	Hygrohypnum ochraceum_1_2	B
217	Hygrohypnum ochraceum_2_4	B
218	Hygrohypnum ochraceum_>4	B
219	Isoetes echinospora_0_1	
220	Isoetes echinospora_1_2	
221	Isoetes echinospora_2_4	
222	Isoetes echinospora_>4	
223	Isoetes lacustris_0_1	
224	Isoetes lacustris_1_2	
225	Isoetes lacustris_2_4	
226	Isoetes lacustris_>4	
227	Juncus articulatus_0_1	B
228	Juncus articulatus_1_2	B
229	Juncus articulatus_2_4	B
230	Juncus articulatus_>4	B
231	Juncus bulbosus_0_1	B
232	Juncus bulbosus_1_2	B
233	Juncus bulbosus_2_4	B
234	Juncus bulbosus_>4	B
235	Juncus subnodulosus_0_1	A
236	Juncus subnodulosus_1_2	A
237	Juncus subnodulosus_2_4	A
238	Juncus subnodulosus_>4	A
239	Jungermannia sphaerocarpa_0_1	B
240	Jungermannia sphaerocarpa_1_2	B
241	Jungermannia sphaerocarpa_2_4	B
242	Jungermannia sphaerocarpa_>4	B
243	Lagarosiphon major_0_1	C
244	Lagarosiphon major_1_2	C
245	Lagarosiphon major_2_4	C
246	Lagarosiphon major_>4	C
247	Lemna gibba_0_1	C
248	Lemna gibba_1_2	C

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
249	Lemna gibba_2_4	C
250	Lemna minor_0_1	C
251	Lemna minor_1_2	C
252	Lemna minuta_0_1	C
253	Lemna trisulca_0_1	C
254	Lemna trisulca_1_2	C
255	Lemna trisulca_2_4	C
256	Lemna trisulca_>4	B
257	Lemna turionifera_0_1	C
258	Leptodictyum riparium_0_1	B
259	Leptodictyum riparium_1_2	B
260	Leptodictyum riparium_2_4	B
261	Leptodictyum riparium_>4	B
262	Littorella uniflora_0_1	A
263	Littorella uniflora_1_2	A
264	Littorella uniflora_2_4	A
265	Littorella uniflora_>4	A
266	Lobelia dortmanna_0_1	A
267	Lobelia dortmanna_1_2	A
268	Lobelia dortmanna_2_4	A
269	Lobelia dortmanna_>4	A
270	Luronium natans_0_1	A
271	Luronium natans_1_2	A
272	Luronium natans_2_4	A
273	Luronium natans_>4	A
274	Lycopus europaeus_0_1	B
275	Lysimachia vulgaris_0_1	B
276	Lythrum salicaria_0_1	B
277	Mentha aquatica_0_1	B
278	Mentha aquatica_1_2	B
279	Mentha aquatica_2_4	B
280	Mentha aquatica_>4	B
281	Myosotis scorpioides_0_1	B
282	Myosotis scorpioides_1_2	b
283	Myosotis scorpioides_2-4	b
284	Myriophyllum alterniflorum_0_1	B
285	Myriophyllum alterniflorum_1_2	A
286	Myriophyllum alterniflorum_2_4	A
287	Myriophyllum alterniflorum_>4	A

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
288	Myriophyllum heterophyllum_0_1	C
289	Myriophyllum heterophyllum_1_2	C
290	Myriophyllum heterophyllum_2_4	C
291	Myriophyllum heterophyllum_>4	C
292	Myriophyllum spicatum_0_1	B
293	Myriophyllum spicatum_1_2	B
294	Myriophyllum spicatum_2_4	B
295	Myriophyllum spicatum_>4	B
296	Myriophyllum verticillatum_0_1	B
297	Myriophyllum verticillatum_1_2	B
298	Myriophyllum verticillatum_2_4	B
299	Myriophyllum verticillatum_>4	B
300	Najas flexilis_0_1	B
301	Najas flexilis_1_2	B
302	Najas flexilis_2_4	B
303	Najas flexilis_>4	B
304	Najas marina ssp. intermedia_0_1	B
305	Najas marina ssp. intermedia_1_2	B
306	Najas marina ssp. intermedia_2_4	B
307	Najas marina ssp. intermedia_>4	B
308	Najas marina_0_1	C
309	Najas marina_1_2	C
310	Najas marina_2_4	C
311	Najas marina_>4	C
312	Najas minor_0_1	B
313	Najas minor_1_2	B
314	Najas minor_2_4	A
315	Najas minor_>4	A
316	Nasturtium officinale_0_1	B
317	Nasturtium officinale_1_2	B
318	Nitella batrachosperma_0_1	A
319	Nitella batrachosperma_1_2	A
320	Nitella batrachosperma_2_4	A
321	Nitella batrachosperma_>4	A
322	Nitella capillaris_0_1	
323	Nitella capillaris_1_2	
324	Nitella capillaris_2_4	
325	Nitella capillaris_>4	
326	Nitella flexilis_0_1	B

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
327	Nitella flexilis_1_2	B
328	Nitella flexilis_2_4	B
329	Nitella flexilis_>4	A
330	Nitella gracilis_0_1	A
331	Nitella gracilis_1_2	A
332	Nitella gracilis_2_4	A
333	Nitella gracilis_>4	A
334	Nitella mucronata_0_1	B
335	Nitella mucronata_1_2	B
336	Nitella mucronata_2_4	B
337	Nitella mucronata_>4	A
338	Nitella opaca_0_1	B
339	Nitella opaca_1_2	A
340	Nitella opaca_2_4	A
341	Nitella opaca_>4	A
342	Nitella syncarpa_0_1	A
343	Nitella syncarpa_1_2	A
344	Nitella syncarpa_2_4	A
345	Nitella syncarpa_>4	A
346	Nitella tenuissima_0_1	A
347	Nitella tenuissima_1_2	A
348	Nitella tenuissima_2_4	A
349	Nitella tenuissima_>4	A
350	Nitella translucens_0_1	
351	Nitella translucens_1_2	
352	Nitella translucens_2_4	
353	Nitella translucens_>4	
354	Nitellopsis obtusa_0_1	B
355	Nitellopsis obtusa_1_2	B
356	Nitellopsis obtusa_2_4	B
357	Nitellopsis obtusa_>4	A
358	Nuphar lutea_0_1	B
359	Nuphar lutea_1_2	B
360	Nuphar lutea_2_4	B
361	Nuphar lutea_>4	B
362	Nymphaea alba_0_1	B
363	Nymphaea alba_1_2	B
364	Nymphaea alba_2_4	B
365	Nymphaea alba_>4	B

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
366	Nymphoides peltata_0_1	B
367	Nymphoides peltata_1_2	B
368	Nymphoides peltata_2_4	B
369	Peplis portula_0_1	
370	Peplis portula_1_2	
371	Persicaria amphibia_0_1	B
372	Persicaria amphibia_1_2	B
373	Persicaria amphibia_2_4	B
374	Persicaria amphibia_>4	B
375	Phalaris arundinacea_0_1	B
376	Phalaris arundinacea_1_2	B
377	Pilularia globulifera_0_1	A
378	Pistia stratiotes_0_1	C
379	Potamogeton acutifolius_0_1	C
380	Potamogeton acutifolius_1_2	C
381	Potamogeton acutifolius_2_4	C
382	Potamogeton acutifolius_>4	C
383	Potamogeton alpinus_0_1	A
384	Potamogeton alpinus_1_2	A
385	Potamogeton alpinus_2_4	A
386	Potamogeton alpinus_>4	A
387	Potamogeton berchtoldii_0_1	B
388	Potamogeton berchtoldii_1_2	B
389	Potamogeton berchtoldii_2_4	B
390	Potamogeton berchtoldii_>4	B
391	Potamogeton compressus_0_1	C
392	Potamogeton compressus_1_2	C
393	Potamogeton compressus_2_4	C
394	Potamogeton compressus_>4	C
395	Potamogeton crispus_0_1	C
396	Potamogeton crispus_1_2	C
397	Potamogeton crispus_2_4	C
398	Potamogeton crispus_>4	C
399	Potamogeton filiformis_0_1	A
400	Potamogeton filiformis_1_2	A
401	Potamogeton filiformis_2_4	A
402	Potamogeton filiformis_>4	A
403	Potamogeton friesii_0_1	C
404	Potamogeton friesii_1_2	C

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
405	Potamogeton friesii_2_4	B
406	Potamogeton friesii_>4	B
407	Potamogeton gramineus_0_1	A
408	Potamogeton gramineus_1_2	A
409	Potamogeton gramineus_2_4	A
410	Potamogeton gramineus_>4	A
411	Potamogeton lucens_0_1	C
412	Potamogeton lucens_1_2	C
413	Potamogeton lucens_2_4	B
414	Potamogeton lucens_>4	B
415	Potamogeton natans_0_1	B
416	Potamogeton natans_1_2	B
417	Potamogeton natans_2_4	B
418	Potamogeton natans_>4	B
419	Potamogeton nodosus_0_1	C
420	Potamogeton nodosus_1_2	C
421	Potamogeton nodosus_2_4	C
422	Potamogeton nodosus_>4	C
423	Potamogeton obtusifolius_0_1	C
424	Potamogeton obtusifolius_1_2	C
425	Potamogeton obtusifolius_2_4	C
426	Potamogeton obtusifolius_>4	C
427	Potamogeton pectinatus_0_1	C
428	Potamogeton pectinatus_1_2	C
429	Potamogeton pectinatus_2_4	C
430	Potamogeton pectinatus_>4	B
431	Potamogeton perfoliatus_0_1	B
432	Potamogeton perfoliatus_1_2	B
433	Potamogeton perfoliatus_2_4	B
434	Potamogeton perfoliatus_>4	B
435	Potamogeton polygonifolius_0_1	
436	Potamogeton polygonifolius_1_2	
437	Potamogeton polygonifolius_2_4	
438	Potamogeton polygonifolius_>4	
439	Potamogeton praelongus_0_1	B
440	Potamogeton praelongus_1_2	B
441	Potamogeton praelongus_2_4	B
442	Potamogeton praelongus_>4	B
443	Potamogeton pusillus_0_1	C

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
444	Potamogeton pusillus_1_2	C
445	Potamogeton pusillus_2_4	B
446	Potamogeton pusillus_>4	B
447	Potamogeton rutilus_0_1	A
448	Potamogeton rutilus_1_2	A
449	Potamogeton rutilus_2_4	A
450	Potamogeton rutilus_>4	A
451	Potamogeton trichoides_0_1	B
452	Potamogeton trichoides_1_2	B
453	Potamogeton trichoides_2_4	A
454	Potamogeton trichoides_>4	A
455	Potamogeton x angustifolius_0_1	A
456	Potamogeton x angustifolius_1_2	A
457	Potamogeton x angustifolius_2_4	A
458	Potamogeton x angustifolius_>4	A
459	Potamogeton x cognatus_0_1	B
460	Potamogeton x cognatus_1_2	B
461	Potamogeton x cognatus_2_4	B
462	Potamogeton x cognatus_>4	B
463	Potamogeton x cooperi_0_1	B
464	Potamogeton x cooperi_1_2	B
465	Potamogeton x cooperi_2_4	B
466	Potamogeton x cooperi_>4	B
467	Potamogeton x nitens_0_1	B
468	Potamogeton x nitens_1_2	B
469	Potamogeton x nitens_2_4	B
470	Potamogeton x nitens_>4	B
471	Potamogeton x salicifolius_0_1	B
472	Potamogeton x salicifolius_1_2	B
473	Potamogeton x salicifolius_2_4	B
474	Potamogeton x salicifolius_>4	B
475	Potentilla palustris_0_1	B
476	Potentilla palustris_1_2	B
477	Potentilla palustris_2_4	B
478	Potentilla palustris_>4	B
479	Ranunculus aquatilis_0_1	B
480	Ranunculus aquatilis_1_2	B
481	Ranunculus aquatilis_2_4	B
482	Ranunculus aquatilis_>4	B

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
483	Ranunculus circinatus_0_1	C
484	Ranunculus circinatus_1_2	C
485	Ranunculus circinatus_2_4	C
486	Ranunculus circinatus_>4	C
487	Ranunculus flammula_0_1	A
488	Ranunculus fluitans_0_1	B
489	Ranunculus fluitans_1_2	B
490	Ranunculus fluitans_2_4	B
491	Ranunculus fluitans_>4	B
492	Ranunculus lingua_0_1	A
493	Ranunculus peltatus ssp. baudotii_0_1	C
494	Ranunculus peltatus ssp. baudotii_1_2	C
495	Ranunculus peltatus ssp. baudotii_2_4	C
496	Ranunculus peltatus ssp. baudotii_>4	C
497	Ranunculus peltatus_0_1	C
498	Ranunculus peltatus_1_2	C
499	Ranunculus peltatus_2_4	C
500	Ranunculus peltatus_>4	C
501	Ranunculus penicillatus_0_1	B
502	Ranunculus penicillatus_1_2	B
503	Ranunculus penicillatus_2_4	B
504	Ranunculus penicillatus_>4	B
505	Ranunculus reptans_0_1	B
506	Ranunculus reptans_1_2	B
507	Ranunculus trichophyllus ssp. eradicatus_0_1	A
508	Ranunculus trichophyllus ssp. eradicatus_1_2	A
509	Ranunculus trichophyllus ssp. eradicatus_2_4	A
510	Ranunculus trichophyllus ssp. eradicatus_>4	A
511	Ranunculus trichophyllus ssp. rionii_0_1	C
512	Ranunculus trichophyllus ssp. rionii_1_2	C
513	Ranunculus trichophyllus ssp. rionii_2_4	C
514	Ranunculus trichophyllus ssp. rionii_>4	C
515	Ranunculus trichophyllus ssp. trichophyllus_0_1	C
516	Ranunculus trichophyllus ssp. trichophyllus_1_2	C
517	Ranunculus trichophyllus ssp. trichophyllus_2_4	C
518	Ranunculus trichophyllus ssp. trichophyllus_>4	C

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
519	Ranunculus trichophyllus_0_1	C
520	Ranunculus trichophyllus_1_2	C
521	Ranunculus trichophyllus_2_4	C
522	Ranunculus trichophyllus_>4	C
523	Ranunculus x cookii_0_1	C
524	Ranunculus x cookii_1_2	C
525	Ranunculus x cookii_2_4	C
526	Ranunculus x cookii_>4	C
527	Rhynchostegium riparioides_0_1	B
528	Rhynchostegium riparioides_1_2	B
529	Rhynchostegium riparioides_2_4	B
530	Rhynchostegium riparioides_>4	B
531	Riccia fluitans_0_1	B
532	Riccia fluitans_1_2	B
533	Ricciocarpos natans_0_1	B
534	Ricciocarpos natans_1_2	B
535	Rorippa amphibia_0_1	B
536	Rorippa amphibia_1_2	B
537	Rumex hydrolapathum_0_1	B
538	Rumex hydrolapathum_1_2	B
539	Rumex hydrolapathum_2_4	B
540	Sagittaria sagittifolia_0_1	C
541	Sagittaria sagittifolia_1_2	C
542	Sagittaria sagittifolia_2_4	C
543	Sagittaria sagittifolia_>4	C
544	Salvinia natans_0_1	C
545	Salvinia natans_1_2	C
546	Schoenoplectus lacustris_0_1	B
547	Schoenoplectus lacustris_1_2	B
548	Schoenoplectus lacustris_2_4	B
549	Schoenoplectus lacustris_>4	B
550	Schoenoplectus tabernaemontani_0_1	B
551	Schoenoplectus tabernaemontani_1_2	B
552	Schoenoplectus tabernaemontani_2_4	B
553	Schoenoplectus tabernaemontani_>4	B
554	Sium latifolium_0_1	B
555	Sium latifolium_1_2	B
556	Solanum dulcamara_0_1	B
557	Solanum dulcamara_1_2	B

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
558	Sparganium emersum_0_1	B
559	Sparganium emersum_1_2	B
560	Sparganium emersum_2_4	B
561	Sparganium emersum_>4	B
562	Sparganium erectum_0_1	B
563	Sparganium erectum_1_2	B
564	Sparganium erectum_2_4	B
565	Sparganium erectum_>4	B
566	Sphagnum_0_1	
567	Sphagnum_1_2	
568	Sphagnum_2_4	
569	Sphagnum_>4	
570	Spirodela polyrhiza_0_1	C
571	Spirodela polyrhiza_1_2	C
572	Spirodela polyrhiza_2_4	C
573	Stachys palustris_0_1	B
574	Stachys palustris_1_2	B
575	Stratiotes aloides_0_1	B
576	Stratiotes aloides_1_2	B
577	Stratiotes aloides_2_4	B
578	Stratiotes aloides_>4	B
579	Tolypella glomerata_0_1	B
580	Tolypella glomerata_1_2	a
581	Tolypella glomerata_2_4	a
582	Tolypella glomerata_>4	A
583	Tolypella intricata_0_1	A
584	Tolypella intricata_1_2	A
585	Tolypella intricata_2_4	A
586	Tolypella intricata_>4	A
587	Tolypella prolifera_0_1	A
588	Tolypella prolifera_1_2	A
589	Tolypella prolifera_2_4	A
590	Tolypella prolifera_>4	A
591	Trapa natans_0_1	B
592	Trapa natans_1_2	B
593	Trapa natans_2_4	B
594	Trapa natans_>4	B
595	Typha angustifolia_0_1	B
596	Typha angustifolia_1_2	B

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
597	Typha angustifolia_2_4	B
598	Typha angustifolia_>4	B
599	Typha latifolia_0_1	B
600	Typha latifolia_1_2	B
601	Typha latifolia_2_4	B
602	Typha latifolia_>4	B
603	Utricularia australis_0_1	B
604	Utricularia australis_1_2	B
605	Utricularia australis_2_4	A
606	Utricularia australis_>4	A
607	Utricularia intermedia_0_1	A
608	Utricularia intermedia_1_2	A
609	Utricularia intermedia_2_4	A
610	Utricularia intermedia_>4	A
611	Utricularia minor_0_1	A
612	Utricularia minor_1_2	A
613	Utricularia minor_2_4	A
614	Utricularia minor_>4	A
615	Utricularia ochroleuca_0_1	A
616	Utricularia ochroleuca_1_2	A
617	Utricularia ochroleuca_2_4	A
618	Utricularia ochroleuca_>4	A
619	Utricularia stygia_0_1	A
620	Utricularia stygia_1_2	A
621	Utricularia stygia_2_4	A
622	Utricularia stygia_>4	A
623	Utricularia vulgaris_0_1	B
624	Utricularia vulgaris_1_2	B
625	Utricularia vulgaris_2_4	A
626	Utricularia vulgaris_>4	A
627	Vallisneria spiralis_0_1	C
628	Vallisneria spiralis_1_2	C
629	Vallisneria spiralis_2_4	C
630	Vallisneria spiralis_>4	C
631	Veronica anagallis-aquatica_0_1	B
632	Veronica anagallis-aquatica_1_2	B
633	Veronica anagallis-aquatica_2_4	B
634	Veronica anagallis-aquatica_>4	B
635	Warnstorfia fluitans_0_1	B

lfd. Nr.	Taxon_Tiefenstufe	AK(s)
636	Warnstorfia fluitans_1_2	B
637	Warnstorfia fluitans_2_4	B
638	Warnstorfia fluitans_>4	B
639	Zannichellia palustris_0_1	C
640	Zannichellia palustris_1_2	C
641	Zannichellia palustris_2_4	B
642	Zannichellia palustris_>4	B

Table A.26 Original list of type specific RAQ indicator species. .

lfd. Nr.	Taxon	DS 1.2
1	Achnanthes altaica	
2	Achnanthes bahusiensis	
3	Achnanthes biasolettiana	
4	Achnanthes bioretii	
5	Achnanthes calcar	
6	Achnanthes caledonica	A
7	Achnanthes carissima	
8	Achnanthes catenata	C
9	Achnanthes chlidanos	
10	Achnanthes clevei	C
11	Achnanthes daonensis	
12	Achnanthes daui	
13	Achnanthes delicatula	C
14	Achnanthes delicatula ssp. engelbrechtii	C
15	Achnanthes didyma	
16	Achnanthes distincta	
17	Achnanthes exigua	C
18	Achnanthes exilis	A
19	Achnanthes flexella	A
20	Achnanthes flexella var. alpestris	A
21	Achnanthes grana	
22	Achnanthes helvetica	
23	Achnanthes holsatica	C
24	Achnanthes hungarica	C
25	Achnanthes impexiformis	
26	Achnanthes joursacense	
27	Achnanthes kolbei	C
28	Achnanthes kranzii	
29	Achnanthes kryophila	

lfd. Nr.	Taxon	DS 1.2
30	Achnanthes kuelbsii	
31	Achnanthes lacus-vulcani	
32	Achnanthes laevis	
33	Achnanthes laevis var. austriaca	
34	Achnanthes laevis var. diluviana	
35	Achnanthes laevis var. quadratarea	
36	Achnanthes lanceolata ssp. frequentissima	
37	Achnanthes lanceolata ssp. rostrata	
38	Achnanthes lapidosa	
39	Achnanthes laterostrata	
40	Achnanthes lauenburgiana	C
41	Achnanthes levanderi	
42	Achnanthes lutheri	
43	Achnanthes marginulata	
44	Achnanthes microscopica	
45	Achnanthes minuscula	C
46	Achnanthes minutissima	
47	Achnanthes minutissima var. affinis	C
48	Achnanthes minutissima var. gracillima	A
49	Achnanthes minutissima var. saprophila	
50	Achnanthes minutissima var. scotica	A
51	Achnanthes nodosa	
52	Achnanthes oblongella	
53	Achnanthes oestrupii	
54	Achnanthes peragalli	
55	Achnanthes petersenii	A
56	Achnanthes ploenensis	C
57	Achnanthes pseudoswazi	
58	Achnanthes pusilla	A
59	Achnanthes rechtensis	
60	Achnanthes rosenstockii	A
61	Achnanthes rossii	
62	Achnanthes silvahercynia	
63	Achnanthes straubiana	
64	Achnanthes subatomoides	
65	Achnanthes subexigua	
66	Achnanthes suchlandtii	
67	Achnanthes trinodis	A
68	Achnanthes ventralis	

lfd. Nr.	Taxon	DS 1.2
69	Achnanthes ziegleri	C
70	Amphipleura pellucida	
71	Amphora fogediana	
72	Amphora hemicycla	
73	Amphora inariensis	
74	Amphora libyca	
75	Amphora normannii	
76	Amphora ovalis	C
77	Amphora thumensis	A
78	Amphora veneta	C
79	Amphora veneta var. capitata	A
80	Aneumastus stroesei	
81	Anomoeoneis sphaerophora	C
82	Asterionella ralfsii	
83	Brachysira brebissonii	
84	Brachysira calcicola	A
85	Brachysira follis	
86	Brachysira garrensis	
87	Brachysira hofmanniae	A
88	Brachysira liliana	A
89	Brachysira neoexilis	A
90	Brachysira procera	A
91	Brachysira serians	
92	Brachysira styriaca	A
93	Brachysira vitrea	A
94	Brachysira wygaschii	
95	Brachysira zellensis	A
96	Caloneis aerophila	
97	Caloneis alpestris	A
98	Caloneis amphisbaena	C
99	Caloneis bacillum	C
100	Caloneis latiuscula	A
101	Caloneis lauta	
102	Caloneis leptosoma	
103	Caloneis obtusa	A
104	Caloneis schumanniana	A
105	Caloneis tenuis	A
106	Caloneis undulata	
107	Cocconeis disculus	

lfd. Nr.	Taxon	DS 1.2
108	Cocconeis neothumensis	C
109	Cocconeis pediculus	C
110	Cocconeis placentula var. pseudolineata	
111	Cocconeis pseudothumensis	
112	Cocconeis scutellum var. parva	
113	Cymatopleura elliptica	
114	Cymatopleura solea	C
115	Cymbella affinis	
116	Cymbella affinis 2	
117	Cymbella alpina	A
118	Cymbella amphicephala	A
119	Cymbella amphicephala var. hercynica	A
120	Cymbella amphioxys	
121	Cymbella angustata	
122	Cymbella austriaca	A
123	Cymbella austriaca var. erdobenyiana	A
124	Cymbella brehmii	A
125	Cymbella caespitosa	
126	Cymbella cesatii	A
127	Cymbella cistula	
128	Cymbella compacta	C
129	Cymbella cuspidata	
130	Cymbella cymbiformis	A
131	Cymbella delicatula	A
132	Cymbella descripta	A
133	Cymbella elginensis	
134	Cymbella excisa var. excisa	
135	Cymbella falaisensis	A
136	Cymbella gaeumannii	A
137	Cymbella gracilis	
138	Cymbella hebridica	
139	Cymbella helvetica	A
140	Cymbella helvetica var. compacta	C
141	Cymbella hustedtii	A
142	Cymbella hybrida	A
143	Cymbella hybrida var. lanceolata	A
144	Cymbella incerta	A
145	Cymbella lacustris	
146	Cymbella laevis	A

lfd. Nr.	Taxon	DS 1.2
147	Cymbella lange.bertalotii	
148	Cymbella lapponica	A
149	Cymbella lata	
150	Cymbella mesiana	
151	Cymbella microcephala	
152	Cymbella minuta	A
153	Cymbella naviculacea	
154	Cymbella norvegica	
155	Cymbella obscura	
156	Cymbella paucistriata	
157	Cymbella parva	
158	Cymbella perpusilla	
159	Cymbella prostrata	C
160	Cymbella proxima	A
161	Cymbella reichardtii	C
162	Cymbella reinhardtii	
163	Cymbella rupicola	
164	Cymbella schimanskii	A
165	Cymbella simonsenii	A
166	Cymbella sinuata	
167	Cymbella stauroneiformis	
168	Cymbella subaequalis	A
169	Cymbella subcuspidata	
170	Cymbella subhelvetica	
171	Cymbella subleptoceros	
172	Cymbella tumida	C
173	Cymbella tumidula	A
174	Cymbella tumidula var. lancettula	A
175	Cymbella vulgata	
176	Cymbellonitzschia diluviana	
177	Cymbopleura anglica	
178	Delphineis minutissima	
179	Delphineis surirella	
180	Denticula kuetzingii	A
181	Denticula tenuis	A
182	Diatoma ehrenbergii	
183	Diatoma hyemalis	
184	Diatoma mesodon	A
185	Diatoma moniliformis	

lfd. Nr.	Taxon	DS 1.2
186	Diatoma moniliformis ssp. ovalis	C
187	Diatoma problematica	C
188	Diatoma tenuis	
189	Diatoma vulgaris	C
190	Diatomella balfouriana	
191	Diploneis alpina	
192	Diploneis didyma	
193	Diploneis elliptica	A
194	Diploneis mauleri	
195	Diploneis oblongella	A
196	Diploneis oculata	
197	Diploneis ovalis	A
198	Diploneis petersenii	
199	Encyonema hophense	
200	Entomoneis ornata	
201	Epithemia frickei	
202	Epithemia goeppertiana	A
203	Epithemia smithii	A
204	Epithemia westermannii	
205	Eunotia	
206	Eunotia angusta	
207	Eunotia arcubus	A
208	Eunotia arculus	
209	Eunotia arcus	
210	Eunotia arcus var. bidens	A
211	Eunotia bilunaris	
212	Eunotia bilunaris var. linearis	
213	Eunotia bilunaris var. mucophila	
214	Eunotia botuliformis	
215	Eunotia circumborealis	
216	Eunotia denticulata	
217	Eunotia diadema	
218	Eunotia diodon	
219	Eunotia elegans	
220	Eunotia exigua	
221	Eunotia exigua var. undulata	
222	Eunotia faba	
223	Eunotia fallax	
224	Eunotia fallax var. groenlandica	

lfd. Nr.	Taxon	DS 1.2
225	Eunotia flexuosa	
226	Eunotia formica	
227	Eunotia glacialis	A
228	Eunotia hexaglyphis	
229	Eunotia implicata	
230	Eunotia incisa	
231	Eunotia intermedia	
232	Eunotia islandica	
233	Eunotia jemtlandica	
234	Eunotia lapponica	
235	Eunotia lunaris	
236	Eunotia major	
237	Eunotia meisteri	
238	Eunotia microcephala	
239	Eunotia minor	
240	Eunotia monodon	
241	Eunotia monodon var. bidens	
242	Eunotia muscicola var. perminuta	
243	Eunotia muscicola var. tridentula	
244	Eunotia naegelii	
245	Eunotia neofallax	
246	Eunotia nymanniana	
247	Eunotia paludosa	
248	Eunotia paludosa var. trinacria	
249	Eunotia parallela	
250	Eunotia parallela var. angusta	
251	Eunotia pectinalis	
252	Eunotia pectinalis var. undulata	
253	Eunotia praerupta	A
254	Eunotia praerupta var. bidens	
255	Eunotia praerupta var. bigibba	
256	Eunotia praerupta var. curta	
257	Eunotia praerupta var. inflata	
258	Eunotia pseudopectinalis	
259	Eunotia rhomboidea	
260	Eunotia rhynchocephala	
261	Eunotia rhynchocephala var. satelles	
262	Eunotia ruzickae	
263	Eunotia septentrionalis	

lfd. Nr.	Taxon	DS 1.2
264	Eunotia serra	
265	Eunotia serra var. diadema	
266	Eunotia serra var. tetraodon	
267	Eunotia silvahercynia	
268	Eunotia soleirolii	
269	Eunotia steineckei	
270	Eunotia subarcuatoides	
271	Eunotia sudetica	
272	Eunotia tenella	
273	Eunotia tetraodon	
274	Eunotia triodon	
275	Eunotia veneris	
276	Fragilaria acidoclinata	
277	Fragilaria berolinensis	
278	Fragilaria bicapitata	
279	Fragilaria bidens	
280	Fragilaria capucina	C
281	Fragilaria capucina distans - Sippen	
282	Fragilaria capucina var. amphicephala	A
283	Fragilaria capucina var. austriaca	A
284	Fragilaria capucina var. gracilis	
285	Fragilaria capucina var. mesolepta	C
286	Fragilaria capucina var. perminuta	C
287	Fragilaria capucina var. vaucheriae	C
288	Fragilaria constricta	
289	Fragilaria delicatissima	A
290	Fragilaria exigua	
291	Fragilaria famelica	
292	Fragilaria fasciculata	C
293	Fragilaria lapponica	
294	Fragilaria leptostauron var. dubia	
295	Fragilaria nanana	
296	Fragilaria nitzschioides	
297	Fragilaria parasitica	
298	Fragilaria pulchella	
299	Fragilaria robusta	A
300	Fragilaria tenera	A
301	Fragilaria ulna	
302	Fragilaria virescens	

lfd. Nr.	Taxon	DS 1.2
303	Frustulia vulgaris	
304	Frustulia rhomboides	
305	Frustulia rhomboides var. crassinervia	
306	Frustulia rhomboides var. saxonica	
307	Frustulia rhomboides var. viridula	
308	Frustulia vulgaris	C
309	Gomphonema acutiusculum	
310	Gomphoneis transsylvanica	
311	Gomphonema acuminatum	
312	Gomphonema amoenum	
313	Gomphonema angustum	A
314	Gomphonema augur	
315	Gomphonema auritum	A
316	Gomphonema bavaricum	A
317	Gomphonema bohemicum	
318	Gomphonema coronatum	
319	Gomphonema dichotomum	A
320	Gomphonema gracile	
321	Gomphonema grovei var. lingulatum	
322	Gomphonema hebridense	A
323	Gomphonema helveticum	A
324	Gomphonema insigne	
325	Gomphonema lagerheimii	
326	Gomphonema lateripunctatum	A
327	Gomphonema micropus	
328	Gomphonema minutum	C
329	Gomphonema occultum	A
330	Gomphonema olivaceum	C
331	Gomphonema olivaceum var. minutissimum	A
332	Gomphonema olivaceum var. olivaceoides	A
333	Gomphonema olivaceum var. olivaceolacuum	C
334	Gomphonema parvulum	C
335	Gomphonema parvulum var. exilissimum	
336	Gomphonema procerum	A
337	Gomphonema productum	
338	Gomphonema pseudoaugur	
339	Gomphonema pseudotenellum	
340	Gomphonema pumilum	C
341	Gomphonema sarcophagus	

lfd. Nr.	Taxon	DS 1.2
342	Gomphonema stauroneiforme	
343	Gomphonema subtile	
344	Gomphonema tenue	A
345	Gomphonema tergestinum	C
346	Gomphonema ventricosum	
347	Gomphonema vibrio	A
348	Gomphoneis transsylvanica	
349	Gyrosigma acuminatum	
350	Gyrosigma attenuatum	
351	Gyrosigma nodiferum	
352	Hantzschia amphioxys sensu stricto	
353	Hippodonta costulatiformis	
354	Mastogloia baltica	A
355	Mastogloia elliptica	A
356	Mastogloia grevillei	A
357	Mastogloia smithii var. lacustris	A
358	Melosira varians	
359	Meridion circulare	
360	Navicula absoluta	A
361	Navicula accomoda	C
362	Navicula adversa	
363	Navicula angusta	
364	Navicula antonii	C
365	Navicula arvensis var. major	
366	Navicula asellus	
367	Navicula atomus	C
368	Navicula atomus var. permitis	C
369	Navicula bacillum	C
370	Navicula brockmannii	
371	Navicula bryophila	
372	Navicula canoris	
373	Navicula capitata	C
374	Navicula capitata var. hungarica	C
375	Navicula capitata var. lueneburgensis	C
376	Navicula capitatoradiata	C
377	Navicula cari	C
378	Navicula catalanogermanica	
379	Navicula caterva	
380	Navicula cincta	C

lfd. Nr.	Taxon	DS 1.2
381	Navicula citrus	
382	Navicula clementioides	C
383	Navicula clementis	C
384	Navicula cocconeiformis	A
385	Navicula concentrica	A
386	Navicula constans	C
387	Navicula costulata	C
388	Navicula cryptocephala	C
389	Navicula cryptofallax	
390	Navicula cryptotenelloides	
391	Navicula cuspidata	C
392	Navicula dealpina	A
393	Navicula declivis	
394	Navicula decussis	C
395	Navicula densilineolata	A
396	Navicula detenta	
397	Navicula digitoradiata	
398	Navicula digitulus	
399	Navicula diluviana	A
400	Navicula disjuncta	
401	Navicula elginensis	C
402	Navicula erifuga	
403	Navicula exilis	
404	Navicula festiva	
405	Navicula gallica var. perpusilla	
406	Navicula gastrum	C
407	Navicula gastrum var. signata	C
408	Navicula goeppertiana	C
409	Navicula gotlandica	A
410	Navicula gregaria	C
411	Navicula halophila	C
412	Navicula heimansioides	
413	Navicula helensis	
414	Navicula hoefleri	
415	Navicula hustedtii	
416	Navicula ignota var. palustris	
417	Navicula integra	C
418	Navicula jaagii	A
419	Navicula jaernefeltii	A

lfd. Nr.	Taxon	DS 1.2
420	Navicula jakovljevicii	
421	Navicula jentzschii	
422	Navicula joubaudii	
423	Navicula kotschyi	
424	Navicula krasskei	
425	Navicula lacunolaciniata	
426	Navicula laevissima	A
427	Navicula lanceolata	C
428	Navicula lapidosa	
429	Navicula laterostrata	
430	Navicula lenzii	A
431	Navicula leptostriata	
432	Navicula levanderii	
433	Navicula libonensis	
434	Navicula longicephala var. vilaplanii	
435	Navicula maceria	
436	Navicula mediocris	
437	Navicula menisculus	C
438	Navicula menisculus var. grunowii	C
439	Navicula menisculus var. upsaliensis	
440	Navicula minuscula var. muralis	
441	Navicula minima	
442	Navicula minuscula	
443	Navicula minuscula var. muralis	
444	Navicula minusculoides	C
445	Navicula molestiformis	C
446	Navicula monoculata	C
447	Navicula moskalii	
448	Navicula notha	
449	Navicula oblonga	
450	Navicula oligotraphenta	A
451	Navicula opportuna	
452	Navicula oppugnata	C
453	Navicula ordinaria	
454	Navicula perminuta	
455	Navicula phyllepta	
456	Navicula placentula	C
457	Navicula porifera var. opportuna	
458	Navicula praeterita	A

lfd. Nr.	Taxon	DS 1.2
459	Navicula protracta	C
460	Navicula pseudanglica	C
461	Navicula pseudobryophila	
462	Navicula pseudolanceolata	
463	Navicula pseudoscutiformis	A
464	Navicula pseudosilicula	
465	Navicula pseudotuscula	
466	Navicula pseudoventralis	
467	Navicula pusio	
468	Navicula pygmaea	
469	Navicula radiosa	
470	Navicula recens	C
471	Navicula reichardtiana	C
472	Navicula reichardtiana var. crassa	
473	Navicula reinhardtii	C
474	Navicula rhynchotella	C
475	Navicula rotunda	
476	Navicula saprophila	C
477	Navicula schadei	A
478	Navicula schmassmannii	
479	Navicula schoenfeldii	C
480	Navicula schroeterii	
481	Navicula scutelloides	C
482	Navicula seibigiana	
483	Navicula seminulum	C
484	Navicula slesvicensis	C
485	Navicula soehrensis	
486	Navicula soehrensis var. hassiaca	
487	Navicula soehrensis var. muscicola	
488	Navicula splendicula	
489	Navicula stroemii	A
490	Navicula stroesei	
491	Navicula subalpina	A
492	Navicula subconcentrica	
493	Navicula subhamulata	
494	Navicula sublucidula	
495	Navicula subminuscula	C
496	Navicula submolesta	
497	Navicula subplacentula	

lfd. Nr.	Taxon	DS 1.2
498	Navicula subrotundata	C
499	Navicula subtilissima	
500	Navicula suchlandtii	
501	Navicula tridentula	
502	Navicula tripunctata	C
503	Navicula trivialis	C
504	Navicula trophicatrix	
505	Navicula tuscula	A
506	Navicula tuscula f. minor	C
507	Navicula utermoehlii	C
508	Navicula variostriata	
509	Navicula veneta	C
510	Navicula ventraloconfusa	
511	Navicula viridula	C
512	Navicula viridula - Sippen	C
513	Navicula viridula var. linearis	
514	Navicula viridula var. rostellata	
515	Navicula vitabunda	
516	Navicula vulpina	A
517	Navicula wildii	A
518	Navicula witkowskii	
519	Naviculadicta schaumburgii	
520	Neidium affine	A
521	Neidium alpinum	
522	Neidium ampliatum	A
523	Neidium binodeforme	
524	Neidium binodis	
525	Neidium bisulcatum	
526	Neidium carterii	
527	Neidium densestriatum	
528	Neidium dubium	
529	Neidium iridis	
530	Neidium ladogensis	
531	Neidium productum	
532	Neidium septentrionale	
533	Nitzschia acicularis	
534	Nitzschia acula	
535	Nitzschia alpina	A
536	Nitzschia alpinobacillum	A

lfd. Nr.	Taxon	DS 1.2
537	Nitzschia amphibia	C
538	Nitzschia angustata	
539	Nitzschia angustatula	
540	Nitzschia aurariae	
541	Nitzschia bacilliformis	A
542	Nitzschia bryophila	
543	Nitzschia calida	C
544	Nitzschia capitellata	C
545	Nitzschia clausii	
546	Nitzschia communis	C
547	Nitzschia constricta	C
548	Nitzschia dealpina	A
549	Nitzschia debilis	
550	Nitzschia dissipata	C
551	Nitzschia dissipata ssp. oligotraphenta	
552	Nitzschia dissipata var. media	
553	Nitzschia diversa	A
554	Nitzschia draveillensis	
555	Nitzschia fibulafissa	A
556	Nitzschia filiformis	C
557	Nitzschia fonticola	C
558	Nitzschia fossilis	C
559	Nitzschia frustulum	C
560	Nitzschia garrensis	
561	Nitzschia gessneri	A
562	Nitzschia gisela	A
563	Nitzschia graciliformis	
564	Nitzschia heufleriana	C
565	Nitzschia homburgiensis	
566	Nitzschia hungarica	C
567	Nitzschia inconspicua	C
568	Nitzschia intermedia	
569	Nitzschia lacuum	
570	Nitzschia levidensis	C
571	Nitzschia levidensis var. salinarum	C
572	Nitzschia liebetruthii	C
573	Nitzschia linearis	C
574	Nitzschia linearis - Sippen	
575	Nitzschia linearis var. subtilis	C

lfd. Nr.	Taxon	DS 1.2
576	Nitzschia linearis var. tenuis	C
577	Nitzschia microcephala	C
578	Nitzschia palea var. palea	C
579	Nitzschia palea var. debilis	
580	Nitzschia paleacea	C
581	Nitzschia paleaeformis	
582	Nitzschia pura	
583	Nitzschia pusilla	
584	Nitzschia radicula	A
585	Nitzschia regula	A
586	Nitzschia sigmoidea	
587	Nitzschia sinuata var. delognei	
588	Nitzschia sinuata var. tabellaria	
589	Nitzschia sociabilis	C
590	Nitzschia solita	
591	Nitzschia subacicularis	
592	Nitzschia sublinearis	
593	Nitzschia subtilis	C
594	Nitzschia supralitorea	C
595	Nitzschia tryblionella	
596	Nitzschia umbonata	C
597	Nitzschia valdestriata	
598	Nitzschia vermicularis	
599	Nitzschia wuellerstorffii	
600	Peronia fibula	
601	Pinnularia	
602	Pinnularia acoricola	
603	Pinnularia acrosphaeria	
604	Pinnularia acrosphaeria	
605	Pinnularia acuminata	
606	Pinnularia alpina	
607	Pinnularia anglica	
608	Pinnularia angusta	
609	Pinnularia appendiculata	
610	Pinnularia bacilliformis	
611	Pinnularia balfouriana	
612	Pinnularia biceps	
613	Pinnularia borealis	
614	Pinnularia borealis var. rectangularis	

lfd. Nr.	Taxon	DS 1.2
615	Pinnularia borealis var. scalaris	
616	Pinnularia borealis var. thuringiaca	
617	Pinnularia brandeliformis	
618	Pinnularia brandelii	
619	Pinnularia brauniana	
620	Pinnularia braunii	
621	Pinnularia brebissonii	
622	Pinnularia brevicostata	
623	Pinnularia cardinaliculus	
624	Pinnularia cardinalis	
625	Pinnularia carminata	
626	Pinnularia cleveiformis	
627	Pinnularia cleveiformis var. ventricosa	
628	Pinnularia cuneola	
629	Pinnularia dactylus	
630	Pinnularia divergens	
631	Pinnularia divergens var. bacillaris	
632	Pinnularia divergens var. decrescens	
633	Pinnularia divergens var. elliptica	
634	Pinnularia divergens var. ignorata	
635	Pinnularia divergens var. linearis	
636	Pinnularia divergens var. undulata	
637	Pinnularia divergentissima	
638	Pinnularia divergentissima var. martinii	
639	Pinnularia divergentissima var. minor	
640	Pinnularia elegans	
641	Pinnularia episcopalis	
642	Pinnularia esox	
643	Pinnularia esoxiformis	
644	Pinnularia esoxiformis var. eifeliana	
645	Pinnularia falaiseana	
646	Pinnularia frauenbergiana	
647	Pinnularia gentilis	
648	Pinnularia gibba	
649	Pinnularia gibba var. linearis	
650	Pinnularia gibba var. mesogongyla	
651	Pinnularia gibbiformis	
652	Pinnularia gigas	
653	Pinnularia globiceps	

lfd. Nr.	Taxon	DS 1.2
654	Pinnularia halophila	
655	Pinnularia hemiptera	
656	Pinnularia ignobilis	
657	Pinnularia inconstans	
658	Pinnularia infirma	
659	Pinnularia intermedia	
660	Pinnularia interrupta	
661	Pinnularia irrorata	
662	Pinnularia karelica	
663	Pinnularia kneuckeri	
664	Pinnularia krookiformis	
665	Pinnularia krookii	
666	Pinnularia kuetzingii	
667	Pinnularia lagerstedtii	
668	Pinnularia lata	
669	Pinnularia legumen	
670	Pinnularia legumiformis	
671	Pinnularia leptosoma	
672	Pinnularia lundii	
673	Pinnularia lundii var. baltica	
674	Pinnularia macilenta	
675	Pinnularia maior	
676	Pinnularia maior var. transversa	
677	Pinnularia mayeri	
678	Pinnularia mayeri var. similis	
679	Pinnularia mesolepta	
680	Pinnularia mesolepta var. gibberula	
681	Pinnularia mesolepta var. intermedia	
682	Pinnularia mesolepta var. minuta	
683	Pinnularia microstauron	A
684	Pinnularia microstauron var. biundulata	
685	Pinnularia microstauron var. brebissonii	
686	Pinnularia neomajor	
687	Pinnularia nobilis	
688	Pinnularia nodosa	
689	Pinnularia notabilis	
690	Pinnularia obscura	
691	Pinnularia oriunda	
692	Pinnularia ovata	

lfd. Nr.	Taxon	DS 1.2
693	Pinnularia parallela	
694	Pinnularia platycephala	
695	Pinnularia polyonca	
696	Pinnularia problematica	
697	Pinnularia pseudogibba	
698	Pinnularia pseudogibba var. rostrata	
699	Pinnularia pulchra	
700	Pinnularia pulchra var. angusta	
701	Pinnularia renata	
702	Pinnularia rupestris	
703	Pinnularia rupestris var. cuneata	
704	Pinnularia ruttneri var. lauenburgiana	
705	Pinnularia schoenfelderi	
706	Pinnularia schroederii	
707	Pinnularia silvatica	
708	Pinnularia similiformis	
709	Pinnularia similis	
710	Pinnularia sinistra	
711	Pinnularia stauroptera	
712	Pinnularia stomatophora	
713	Pinnularia stomatophora var. triundulata	
714	Pinnularia streptoraphe	
715	Pinnularia streptoraphe var. minor	
716	Pinnularia streptoraphe var. parva	
717	Pinnularia subcapitata	
718	Pinnularia subcapitata var. elongata	
719	Pinnularia subcapitata var. hilseana	
720	Pinnularia subcapitata var. subrostrata	
721	Pinnularia subcommutata	
722	Pinnularia subdivergens	
723	Pinnularia subgibba	A
724	Pinnularia subgibba var. hustedtii	
725	Pinnularia subgibba var. undulata	
726	Pinnularia subinterrupta	
727	Pinnularia submicrostauron	
728	Pinnularia subrostrata	
729	Pinnularia subrupestris	
730	Pinnularia subrupestris var. parva	
731	Pinnularia suchlandtii	

lfd. Nr.	Taxon	DS 1.2
732	Pinnularia sudetica	
733	Pinnularia sudetica var. brittanica	
734	Pinnularia transversa	
735	Pinnularia undulata	
736	Pinnularia viridiformis	
737	Pinnularia viridis	
738	Pinnularia viridis var. commutata	
739	Pinnularia viridoides	
740	Pinnularia woerthensis	
741	Rhaphoneis amphiceros	
742	Rhoicosphenia abbreviata	C
743	Rhopalodia gibba	
744	Rhopalodia gibba var. parallela	A
745	Rhopalodia rupestris	
746	Sellaphora alastos	
747	Simonsenia delognei	
748	Stauroneis anceps	
749	Stauroneis anceps var. siberica	A
750	Stauroneis gracilis	
751	Stauroneis kriegerii	C
752	Stauroneis nobilis	
753	Stauroneis siberica	A
754	Stauroneis smithii	C
755	Stauroneis undata	
756	Stenopterobia curvula	
757	Stenopterobia delicatissima	
758	Stenopterobia densestriata	
759	Surirella angusta	C
760	Surirella barrowcliffia	
761	Surirella bifrons	
762	Surirella brebissonii	C
763	Surirella linearis	
764	Surirella linearis var. constricta	
765	Surirella linearis var. helvetica	
766	Surirella minuta	C
767	Surirella roba	
768	Surirella robusta	
769	Surirella spiralis	
770	Surirella tenera	

lfd. Nr.	Taxon	DS 1.2
771	Surirella turgida	
772	Tabellaria binalis	
773	Tabellaria flocculosa	
774	Tabellaria ventricosa	
775	Triceratium favus	

A.4 Italy

AIM for Lakes (Austrian Index Macrophytes for lakes), Method summary and boundary setting protocol for assigning macrophytes status in Italy for

Summary

This document outlines how status is assigned for the biological quality element macrophytes and how boundaries will be assigned in Italy. We describe the Italian macrophytes assessment method, whose acronym is MacroIMMI (Macrophytic index for the evaluation of the ecological quality of the Italian lakes), composed by three metrics, Vegetation limit, Trophic score and Dissimilarity index and a threshold value (80%) for the abundance of the invasive species. The status assessment is based on lake type specific reference condition and consider species composition and abundance of hydrophytes of the lakes of the alpine region.

Introduction

The Italian macrophytes assessment method was developed using historical data from Italian lakes (32 lakes) and from the GIG Alpine lakes dataset including natural lakes of the Alpine ecoregion, belonging to L-AL3 and L-AL4 types: L-AL3 are Lowland or mid-altitude(50-800 m.a.s.l.) , deep, moderate to high alkalinity (alpine influence), large; L-AL4 are medium or low altitude lakes (200-800 m a.s.l.), calcareous (alk > 1meq/l), with a surface area higher than 0.5 km^2 and an average depth lower than 15 m. During the second phase of the intercalibration exercise we have modified the first version of the assessment method adopted by the Italian law in 2006 and it will adopted at the next updating of the specific set of rules. The information collected related to aquatic macrophytes in lakes belonging to the following 3 categories: submerged, rooted floating-leaved and freely floating, according to the taxonomic classification by Flora of Italy (Pignatti 1982). These categories include both the lower plants such as seagrass both mosses (eg. Fontinalis), ferns (eg. Salvinia) and sessile macro-algae (eg. Chara) and colony forming macroscopically visible aggregates.

Metric description: sampling, analyses, principles for setting reference value and boundaries

Sampling strategies

MacroIMMI is a transect -based method and the investigation procedure for each body of water is composed of 4 stages:

I. Gathering preliminary information about the presence of macrophytes through consultation and frequent users of the lake and the literature search.

II. Identification of sites based on information collected during Phase 1 and the outcome of the preparatory reconnaissance sampling.

III. Description of the environmental characteristics of sites and land close to the sites themselves.

IV. Enforcement of observations or samples along the transects.

Sites, continuous area of the shore where it is possible to identify an homogeneous community in terms of specific composition, that despite having similar characteristics between them are distributed on separate stretches of coastline are considered separate sites and, as such, are all samples. For each site one transect must be covered, and among the trasect all the depth zone must be sampled. The abundance of the recorded species is determined according to Kolher five class scale.

Calculation of EQR for all metrics

Reference values and class boundaries for all the metrics were calculated using the values of the whole AlpGIG dataset. Reference values correspond to the median value of the reference lakes. As H/G boundary the 10th %ile of the values of the reference lakes was taken. The GM, MP and PB metric boundaries were set using equidistant class widths on a log scale.

1. Maximum depth colonization (Z-cmax)

As it suggests, Maximum Depth of Colonisation is the maximum depth at which plants were recorded in the entire water body. For this metric we have distinct reference values and boundary classes for each intercalibration typologies, L-AL3 and L-AL4 see Table A.26.

Table A.27 Boundaries value and classes for Z-cmax.

Z-cmax (m)	L-AL3	L-AL4	EQR normalised
REF	-18	-8.5	1
H/G	-12	-6.5	0.8
G/M	-8.4	-6	0.6
M/P	-6	-4.5	0.4
P/B	-4.3	-3.5	0.2

Polymictic lakes

1) Z-c max is not considered for polymictic lakes

2) Z-c max for polymictic lakes has other boundaries, reported in Table A.28

Table A.28 Boundaries value and classes for Z-cmax, only for polymictic lakes.

Polymictic lakes	Z-cmax % of maximum depth	EQR normalised
REF	100	1
H/G	70	0.8
G/M	50	0.6
M/P	40	0.4
P/B	30	0.2

2. *Trophic score (s_k)*

Trophic score Sk is calculated by weighted average of the abundance of the single species scores Vk for each site. In a second step all Sk values are weighted according to the length of the shoreline of each site to obtain the final value for the lake.

$$s_k = 1 - \frac{\sum A_k \cdot v_k}{\sum A_k}$$

A_k= species abundance

V_k= trophic score of species k

Table A.29 Boundary value and classes for Sk

	Sk	EQR normalised	EQR
REF	0.66		
H/G	0.95	0.8	0.63
G/M	0.72	0.6	0.47
M/P	0.48	0.4	0.31
P/B	0.24	0.2	0.16

V_k were obtained by weighted average abundance of macrophytes on log of Total Phosphorus and then rescaled to between 0 and 1, with an increase of ecological quality in a ascending order.

Table A.30 Vk values for all species collected in Italy

Species	Code	V_k
Chara aspera Deth. Ex Wild.	Cha asp	0,30

Species	Code	V_k
Chara canescens Desv. & Lois	Cha can	0,39
Chara contraria A. Br.	Cha con	0,34
Chara delicatula Ag.	Cha del	0,71
Chara denudata	Cha den	0,42
Chara filiformis	Cha fil	0,25
Chara globularis Thuill.	Cha glo	0,55
Chara gymnophylla A. Braun	Cha gym	0,56
Chara hispida L.	Cha his	0,29
Chara intermedia A. Braun	Cha int	0,45
Chara polyacantha A. Braun	Cha pol	0,29
Chara strigosa A. Braun	Cha stri	0,23
Chara tomentosa	Cha tom	0,30
Chara virgata	Cha del	0,33
Chara vulgaris L.	Cha vul	0,55
Chara sp. L. ex Vaillant	Cha sp.	0,61
Nitella flexilis L. C.Ag.	Nit fle	0,44
Nitella gracilis (Smith) Ag	Nit gra	0,51
Nitella hyalina	Nit hya	0,52
Nitella opaca Ag.	Nit opa	0,37
Nitella syncarpa (Thuill.) Chevall.	Nit syn	0,21
Nitellopsis obtusa (Desv.) J. Groves	Nit obt	0,32
Tolypella glomerata	Tol glo	0,34
Brachythecium rivulare Schimp.	Bra riv	0,56
Bryum sp.	Bry sp.	0,39
Calliergonella cuspidata	Cal cus	0,83
Campylium stellatum	Cam ste	0,81
Cratoneuron filicinum	Cra fil	0,71
Cratoneuron sp. (Sull.) Spruce	Cra sp.	0,71
Drepanocladus	Dre sp.	0,83
Fissidens adianthoides Hedw.	Fis adi	0,80
Fissidens sp. Hedw.	Fis sp.	0,39
Fontinalis antipyretica Hedw.	Fon ant	0,47
Fontinalis hypnoides	Fon hyp	0,39
Fontinalis sp.	Fon sp.	0,39
Hygrohypnum sp.	Hyg sp.	0,83
Leptodictyum riparium	Lep rip	0,52
Palustriella commutata (Hedw.) Ochyra	Cra com	0,71
Platyhypnidium riparioides	Rhy rip	0,56
Plagiothecium sp. B., S. & G.	Pla sp.	0,71

Species	Code	V_k
Plagiomnium medium (B. & S.) T. Kop.	Pla med	0,83
Rhizomnium punctatum (Hedw.) T. J. Kop.	Rhi pun	0,83
Equisetum sp.	Equ sp.	0,30
Equisetum fluviatile L.	Equ flu	0,43
Equisetum palustre	Equ pal	0,30
Thelypteris palustris	The pal	0,33
Callitriche hamulata Kutz ex W.D.J. Koch	Cal ham	0,67
Callitriche cophocarpa	Cal cop	0,45
Callitriche obtusangula Le Gall	Cal obt	0,67
Ceratophyllum demersum L.	Cer dem	0,70
Egeria densa	Ege den	0,74
Eleocharis acicularis (L) Roem et Schult	Ele aci	0,41
Elodea canadensis Michx.	Elo can	0,37
Elodea nuttallii (Planch.) H. St. John	Elo nut	0,62
Groenlandia densa (L.) Fourr.	Gro den	0,49
Hippuris vulgaris L.	Hip vul	0,49
Lagarosiphon major	Lag maj	0,66
Lemna minor L.	Lem min	0,40
Lemna trisulca L.	Lem tri	0,67
Littorella uniflora (L.) Ascherson	Lit uni	0,61
Myriophyllum alterniflorum DC.	Myr alt	0,00
Myriophyllum spicatum L.	Myr spi	0,63
Myriophyllum verticillatum L.	Myr ver	0,19
Najas flexilis (Willd.) Rostk. & W.L.E. Schmidt	Naj fle	0,29
Najas marina ssp. intermedia (Wolfg. ex Gorski) Casper	Naj int	0,43
Najas marina ssp. marina L.	Naj mar	0,65
Najas minor All.	Naj min	0,56
Nelumbo nucifera Gaertn.	Nel nuc	0,94
Nuphar lutea (L.) Sibth. & Sm.	Nup lut	0,65
Nuphar pumila (Timm) DC.	Nup pum	0,39
Nuphar	Nup sp.	0,39
Nymphaea alba L.	Nym alb	0,58
Nymphoides peltata (S. G. Gmelin) O. Kuntze	Nym pel	0,88
Persicaria amphibia (L.) Gray	Per amp	0,43
Potamogeton acutifolius Link	Pot acu	0,39
Potamogeton alpinus Balbis	Pot alp	0,26
Potamogeton berchtoldii Fieber	Pot ber	0,00
Potamogeton crispus L.	Pot cri	0,51

Species	Code	V_k
Potamogeton filiformis Pers.	Pot fil	0,32
Potamogeton friesii Rupr.	Pot fri	0,28
Potamogeton gramineus L.	Pot gra	0,56
Potamogeton lucens L.	Pot luc	0,52
Potamogeton natans L.	Pot nat	0,38
Potamogeton nodosus Poir.	Pot nod	0,00
Potamogeton pectinatus L.	Pot pec	0,51
Potamogeton perfoliatus L.	Pot per	0,60
Potamogeton praelongus Wulfen	Pot pra	0,42
Potamogeton pusillus L.	Pot pus	0,49
Potamogeton x nitens Weber	Pot nit	0,48
Potamogeton sp.	Pot sp.	0,27
Ranunculus aquatilis L.	Ran aqu	0,39
Ranunculus circinatus Sibth	Ran cir	0,43
Ranunculus trichophyllus Chaix	Ran tri	0,68
Ranunculus trichophyllus ssp. eradicatus Chaix	Ran era	0,25
Ranunculus	Ran sp.	0,55
Spirodela polyrhiza (L.) Schleid	Spi pol	0,80
Trapa natans L.	Tra nat	0,87
Utricularia australis Thor	Utr aus	0,23
Vallisneria spiralis L.	Val spi	0,76
Zannichellia palustris L.	Zan pal	0,50

3. Dissimilarity index

Species composition of the current transects is compared with the species composition of the reference sites. The Bray&Curtis (BC) distance between current transects and reference ones is calculated using the maximum abundance recorded in the different depth zones. Then dissimilarity index is obtained subtracting BC value from 1.

$$Dissimilarity\ index = 1 - BC$$

$$BC = Bray\&Curtis\ distance\ from\ reference\ transect$$

Table A.31 Boundary classes for Dissimilarity index

	EQR normalised
REF	
H/G	0.8
G/M	0.6
M/P	0.4
P/B	0.2

The final classification is obtained by the average of normalised EQR of the 3 single metrics as follows:

$$MacroIMMI = \frac{EQR_{Norm} Sk + EQR_{Norm} Zc\_lake + EQR_{Norm} Dissimilarity\_index}{3}$$

Table A.32 Ecological status class

MacroIMMI	Ecological status class
1.0 - 0.80	HIGH
0.79 - 0.60	GOOD
0.59 - 0.40	MODERATE
0.39 - 0.20	POOR
0.19 - 0.0	BAD

Additional criteria

When the abundance of exotic (Celesti-Grapow L., 2010) species is greater than 70 % of the total abundance of the macrophytes of the entire lake, the ecological status class is lowered to the previous class obtained from the calculation of MacroIMMI.

Calculation of normalised EQR

In order to allow combination of all metrics to a whole BQE assessment, each metric EQR has to be converted to the normalised scale with equal class widths and standardised class boundaries, where the HG, GM, MP, and PB boundaries are 0.8, 0.6, 0.4, 0.2 respectively. When using indices with classes ranges different from each other, the normalization equation is based on a linear interpolation between classes boundaries. Moreover, the interpolation process takes into account the reference value as upper limit of the High-Quality class (EQR and normalised EQR equal to 1) as well as the minimum EQR value as the lower threshold of the Bad-Quality class (normalised EQR equal to 0).

Therefore, the normalization equations will be different for each quality class, as below.

Equation 7: $EQR_{norm} = 1 - 0.2*(1-EQR)/(1-EQR_{HG})$ Class "High"

Equation 8: $EQR_{norm} = 0,8 - 0,2*(EQR_{HG} - EQR)/(EQR_{HG} - EQR_{GM})$ Class "Good"

Equation 9: $EQR_{norm} = 0,6 - 0,2*(EQR_{MP} - EQR)/(EQR_{GM} - EQR_{MP})$ Class "Moderate"

Equation 10: $EQR_{norm} = 0,4 - 0,2*(EQR_{MP} - EQR)/(EQR_{MP} - EQR_{PB})$ Class "Poor"

Equation 11: $EQR_{norm} = 0,2 - 0,2*(EQR_{PB} - EQR)/(EQR_{PB} - EQR_{min})$ Class "Bad"

Where: EQR are the measured values, EQR_{HG}, EQR_{GM}, EQR_{MP}, EQR_{PB} are the EQR values (not normalized) at the boundary between two quality classes and EQR_{min} is the minimum EQR of each metric.

Reference values and class boundaries for each type

The approach to define reference sites of Alpine lakes, prepared by the Phytoplankton group of the Alpine GIG, was considered (see separate document of the Phytoplankton group). Furthermore the following criteria were used:

Criteria	Requirement
Lake	
Trophic state	No deviation of the actual from the natural trophic state
pH, salinity	No deviation from reference conditions
Hydrology	Artificial water level fluctuations not larger than the range between the natural mean low water level (MNW) and the natural mean high water level (MHW)
Transect	(at least 100 m shore length)
Surrounding	No intensive agriculture or settlements in the near surrounding
Nutrient input	No direct local nutrient input near the transect
Hydrology	No tributary near the transect
Morphology	No (or insignificant) artificial modifications of the shore line at the transect
Other pressures	No recreation area near the transect

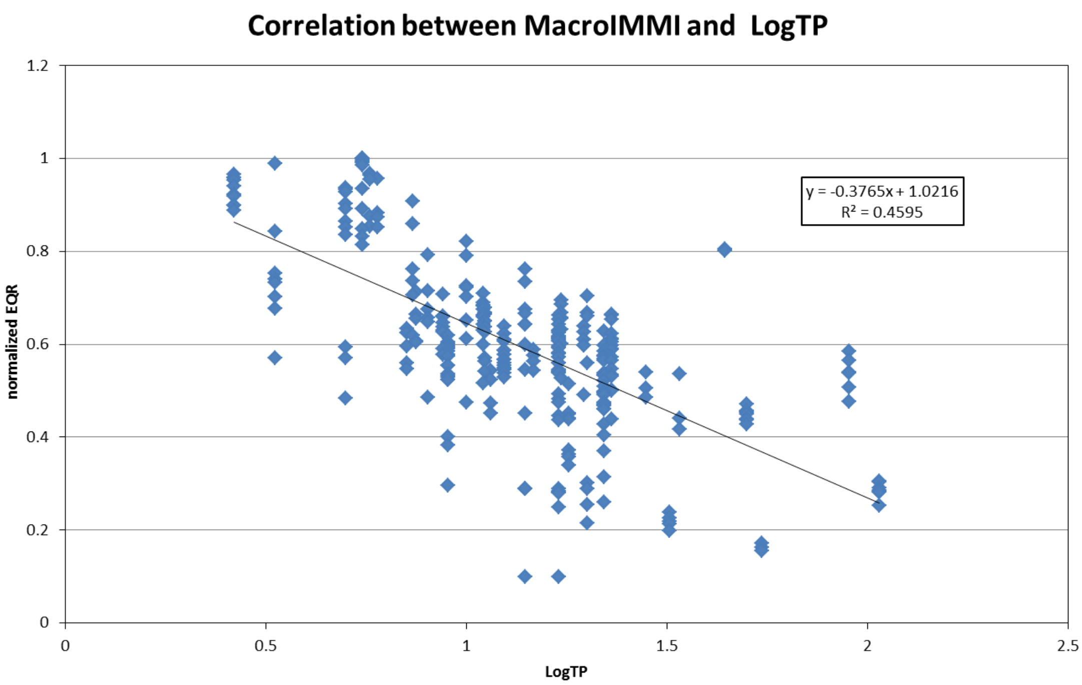

Figure A.2 Correlation of Italian combined whole BQE phytoplankton method against pressure (total-P)

ITALY had no own reference sites. For defining reference conditions we used the data of the ALP-GIG database. In particular we used the reference transect of Austrian and German lakes Attersee, . Reference condition for the single metrics were calculated as the median of values calculated for reference transects respectively.

MacroIMMI respond to eutrophication and general degradation. It was tested the correlation with Total Phosphorus as pressure factor with a national dataset. The results of the regression (P<0,001) are showed in Figure A.2

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A.5 Slovenia

AIM for Lakes (Austrian Index Macrophytes for lakes), Slovenian macrophyte-based index for lake ecosystems (SMILE)

Short description of the **Slovenian macrophyte-based index for lake ecosystems (SMILE)** given below incudes all crucial information for calculation of the SMILE and classification of the sampling sites in ecological status classess according to the Water Framework Directive (Directive 2000/60/ES). Macrophyte data were obtained using the transect method (transects width is ca. 6 m) in two Alpine lakes (Bohinjsko jezero, Blejsko jezero).

1. Lake types

According to Slovenian national lake typology (Urbanič et al. 2007) two lake-types can be found in Slovenia. Lake Bled is described as deep-sub-Alpine lake, whereas Lake Bohinj as deep Alpine lake. However, in a development of the SMILE both lakes were considered as same type.

2. Assessment system

Reference sites

Criteria for selection of referene sites followed a national approach (Urbanič & Smolar-Žvanut 2005) where lake-specific and site-specific criteria are used addressing trophic status, pollution sources, lakeshore modifications and water use. In addition to national criteria some more site-specific criteria were used addressing land use in a 200 m belt:

- urbanisation = 0%
- forest >90%

Based on these criteria 46 transects (sites) in the lake Bohinj were recognised as reference. However, not all sites fulfilled criteria for calcualtion of all metrics included in the SMILE.

Pressure gradient

Pressure gradient used in the development of the SMILE was defined as combination of the mean annual total phosphorous concentration, land use (Corine Land Cover categories) in the 200 m belt and lakeshore morphological alteration class. Pressure gradient was defined on the scale between 0 and 100. Sampling sites used in the analyses covered half of the pressure gradient (low pressure sites to medium pressure sites were available). Three pressure classes were defined. Sites with a pressure score <10 were classified as pressure class 1, sites with a pressure score between 10 and 30 were classified as pressure class 2 and sites with a score between 30 and 60 as a pressure class 3. Sites with site scores >60 were not available.

Metrics, index calculation and classification

SMILE is a multimetric index consisting of three metrics;

1. Macrophyte Index (Melzer et al. 1986),
2. Vegetation limit (m) and
3. Characae vegetation limit (m).

Reference values of selected metrics were defined as median values calculated using reference sites (transects) (Table A.33).

Table A.33 Reference values and lower anchors of three metrics used in Slovenian macrophyte-based index for lake ecosystems (SMILE).

Metric	Metric code	Reference value	Lower anchor
Macrophyte Index (Melzer 1999)	MI	2.06	5
Vegetation limit (m)	VL	6.5	0
Vegetation limit of Characae (m)	VLC	6.5	0

SMILE index is calculated according to the equation:

$$SMILE = \frac{2 * MI + VL + VLC}{4}$$

Boundary values between ecological status classes were defined based on the distribution of the SMILE values among the three pressure classes (Figure A.3). However, due to absence of moderate to high pressure sites boundary values moderate/poor and poor/bad were defined by equidistant divison of the EQR gradient between good/moderate boundary and lower anchor (Table A.34). In order to combine EQR values of sites with phytobenthos data, EQR values were pieceweise lineary transformed and five equidistant classes were obtained (Table A.35 and Table A.36). Final classification of the lake is obtained calculating Lake-SMILE value averaging seven Site-SMILE values calculated at seven sites in the lake.

Table A.34 Boundary setting between ecological status classes using Slovenian macrophyte-based index for lake ecosystems (SMILE).

Boundary	SMILE	Boundary setting
High/Good	0,92	25th percentile pressure class 1
Good	0,53	25th percentile pressure class 2
Moderate/Poo	0,36	Equidistant division (Good/Moderate-Lower
Poor /Bad	0,18	Equidistant division (Good/Moderate-Lower

Table A.35 Piecewise linear transformation equations for Slovenian macrophyte-based index for lake ecosystems (SMILE).

Ecological status	SMILE	Transformed SMILE
High	>0.91	0.8+0.2*(SMILE-0.91)/(0.08)
Good	0.53-0.91	0.6+0.2*(SMILE -0.52)/(0.38)
Moderate	0.36-0.52	0.4+0.2*(SMILE -0.38)/(0.16)
Poor	0.18-0.35	0.2+0.2*(SMILE -0.17)/(0.17)
Bad	0.00-0.17	0.2*(SMILE)/(0.17)

Table A.36 Transformed boundary values between five ecological status classes using Slovenian macrophyte-based index for lake ecosystems (SMILE).

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

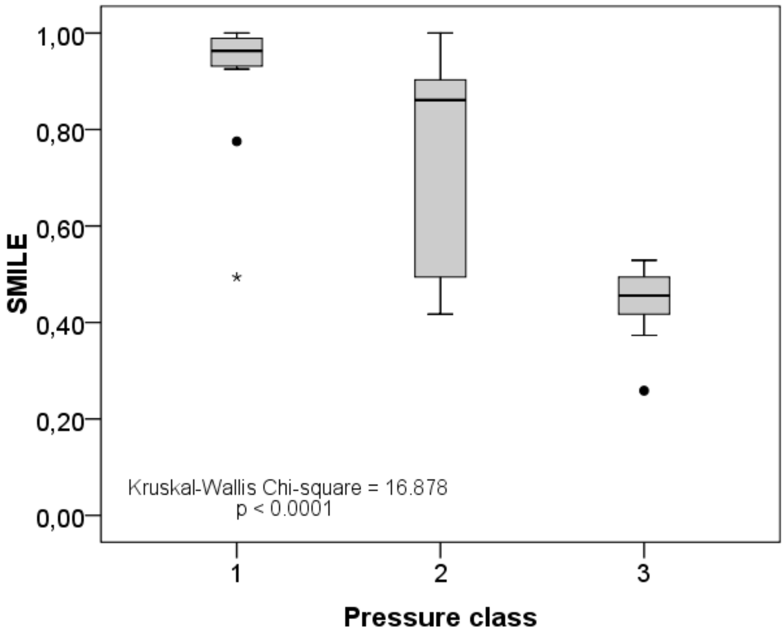

Figure A.3 Slovenian macrophyte-based index for lake ecosystems (SMILE) in rensponse to pressure class (N = 45).

4. Community description at ecologial status boundary values

At the high/good boundary Macrophyte Index is increased by 10 %, whereas vegetation limit and vegetation limit of Characae is decreased to the depth of 4 m. At the good/moderate boundary Macrophyte Index is increased by 30 %, vegetation limit is decreased to the depth of 2 m and characae species (they are specific for our Alpine lakes) are absent (vegetation limit of Characae is 0).

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B. Summary description of member states assessment methods

Table B.1 Survey Characteristics.

Member State	Austria	France	Germany	Italy	Slovenia
Sampling device	diving equipment	Rake or grapnel	Rake or diving equipment	Rake, underwater video	rake
Survey frequency	Once in the monitoring year	Once in the monitoring year	Once in the monitoring year	Once in the monitoring year	Once in the monitoring year
Survey month(s)	July, August (June, September)	July, August, September	July, August	June to September	July, August (June, September)
Surveyed compartment/ habitat/ecotope	Entire littoral of each transect down to the vegetation limit	Entire littoral of each transect down to the vegetation limit	Entire littoral of each transect down to the vegetation limit	Entire littoral of each transect down to the vegetation limit	Entire littoral of each transect down to the vegetation limit
Spatial replicates per sampling occasion	20 to100 transects, depending of lake size	3 to 8 observation units, depending of lake size	4 to 60, depending on lake size and heterogenity of shoreline	Minimum Number of transects fixed based on the extension of the site	6 transects per lake
Method to select sampling site/ replicates	Transects are selected following the results of echo-sounding the whole littoral zone	Jensen's method (1977) and selection according to the different riparian types	Transects are selected according to morphology and landuse of shoreline, number of transects according to surface area	Site: continuous area of the shore, of varying widths, where can identify a homogeneous community in terms of specific composition;	Transects are selected based on results from overall mapping
Total sampled area or volume	Transect width 25m From the long term mean water level down to vegetation limit	Transects width 6m From the long term mean water level down to vegetation limit or max 100m	Transect width 20 to 30m From the long term mean water level down to vegetation limit	Transect width All the water body in the littoral zone down to the vegetation limit	Transect width 6m From the long term mean water level down to vegetation limit

Member State	Austria	France	Germany	Italy	Slovenia
Sub-sampling procedure	No	No	No	No	No
Sample processing	Mapping of the vegetation of the entire transect. Single plants are taken for assurance of determinatioin.	Mapping of the vegetation of the entire transect. Single plants are taken for assurance of determinatioin	Mapping of the vegetation of the entire transect. Single plants are taken for assurance of determinatioin	Mapping of the vegetation of the entire transect. Single plants are taken for assurance of determinatioin	Mapping of the vegetation of the entire transect. Single plants are taken for assurance of determinatioin.
Minimum size of organisms sampled and processed	No size limitation	No size limitation	No size limitation	No size limitation	No size limitation
Recorded vegetation	Hydrophytes Amphiphytes Helophytes	Hydrophytes Amphiphytes Helophytes	Hydrophytes Amphiphytes Helophytes	Hydrophytes Amphiphytes Helophytes (only as species list)	Hydrophytes Amphiphytes Helophytes
Level of identification	Species	Species	Species	Species	Species
Recorded taxonomic groups	Spermatophytes Ferns Mosses Charophytes	Spermatophytes Ferns Mosses Charophytes Macroalgae	Spermatophytes Ferns Mosses Charophytes	Spermatophytes Ferns Mosses Charophytes	Spermatophytes Ferns Mosses Charophytes
How is abundance measured	PMI (according to Kohler, 1978)	PMI (according to Kohler, 1978)	PMI (according to Kohler, 1978)	PMI (according to Kohler, 1978)	PMI (according to Kohler, 1978)

Member State	Austria	France	Germany	Italy	Slovenia
Abundance is rela-ted to area/volume/ time and which unit	Related to plant mass	Related to plant mass	Related to plant mass	Related to plant mass	Related to plant mass
Procedure to quantify uncertainty of method	No	No	No	No	No

Table B.2 Overview of national assessment methods and common metric in the GIG intercalibration.

GIG	Alpine				
Country	**Austria**	**France**	**Germany**	**Italy**	**Slovenia**
Common IC Type(s)	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3**
A. Method documentation					
Name of method in English + abbreviation	AIM for Lakes (Austrian Index Macrophytes for Lakes)	IBML (French Macrophyte Index for Lakes	PHYLIB for Lakes (German Reference Index for Lakes)	MacroIMMI (Macrophytes Multi Metric Index)	SMILE (Slovenian macrophyte-based index for lake ecosystems)
Name in original language	AIM for Lakes	IBML	PHYLIB für Seen	MacroIMMI	SMILE
National literature reference	BMLFUW, 2011: Leitfaden zur Erhebung der biologischen	Sampling method: XPT90 328 (national standard)	Bayer.LFU, 2011: Bewertung von Seen mit Makrophyten &	Gruppo di lavoro per l'Armonizzazione dei	Urbanič G., Germ M., Gaberščik A. 2011. Razvoj sistema vrednotenja

GIG	Alpine				
Country	**Austria**	**France**	**Germany**	**Italy**	**Slovenia**
Common IC Type(s)	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3**
	Qualitätselemente Teil B3 – MAKROPHYTEN.- Hrsg. BMFLUW, Wien, 64pp.		Phytobenthos gemäß EG-WRRL – Anpassung des Verfahrens für natürliche und künstliche Gewässer sowie Unterstützung der Interkalibrierung.- S.37-148, Hrsg.: Bayerisches Landesamt für Umwelt, Wielenbach.	metodi biologici per le Acque Superficiali – Sottogruppo “Laghi”. 2007. Protocollo di campionamento di macrofite acquatiche in ambiente lacustre.	ekološkega stanja z makrofiti za jezerske ekosisteme (SMILE). Inštitut za vode Republike Slovenije.
Scientific literature reference	Pall, K. & Moser, V., 2009: Austrian Index Macrophytes (AIM – Module 1) for Lakes –, Hydrobiologia 633, 83-104.	Not yet published	Schaumburg, J., C. Schranz, G.,Hofmann, D.,Stelzer, S. Schneider & U. Schmedtje, 2004: Macrophytes and phytobenthosas indicators of ecological status in German lakes – a contribution to the implementation of the Water Framework Directive. Limnologica 34: 302–314.	Not yet published	Not yet published
Webpage describing method	www.lebensministerium.at	Sampling method: www.afnor.fr	www.lfu.bayern.de/wasser/gewässerqualität_see	www.apat.gov.it/site/it-IT/APAT/Pubblicazioni/metodi_bio_acque.html	Sampling method: www.mop.gov.si/fileadmin/mop.gov.si/pageuploa

GIG	Alpine				
Country	Austria	France	Germany	Italy	Slovenia
Common IC Type(s)	L-AL3, L-AL4	L-AL3, L-AL4	L-AL3, L-AL4	L-AL3, L-AL4	L-AL3
			n/phylib_deutsch/publikationen/index.htm		ds/podrocja/okolje/pdf/vode/ekolosko_stanje/metod_vzorc_lab_obd_vzorcev_vredn_ekoloskega_st_jezer_fitobentosom_makrofiti.pdf
Developed by institute/country	Systema GmbH, Vienna	Cemagref, Bordeaux	Bayererisches Landesamt für Umwelt, Wielenbach	ISE CNR, ARPA Lombardia, Università di Parma	Institute for Water of the Republic of Slovenia Biotechnical Faculty, University of Ljubljana
B. Assessment metrics and (pseudo-)common metric					
Assessment metrics for parameters (separate single metrics or multimetric)	Vegetation density Vegetation limit Zonation Trophic Index Reference Species Index	Trophic index	Reference Index Vegetation limit Mass stands of selected taxa	Multimetric system of 4 1. Maximum depth colonization ($Z\text{-}c_{max}$); 2. Trophic score (s_k) 3. Dissimilarity index Assessment result = avg of these 3 metrics 4. Percent frequencies of exotic species (exot) Used as limits of application of the index	Trophic index Vegetation limit Vegetation limit of charophytes
National method Abundance	PMI (five level scale following Kohler 1978)	PMI (five level scale following Kohler 1978)	PMI (five level scale following Kohler 1978)	PMI (five level scale following Kohler 1978)	PMI (five level scale following Kohler 1978)

GIG	Alpine				
Country	**Austria**	**France**	**Germany**	**Italy**	**Slovenia**
Common IC Type(s)	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3**
parameter + Computation details					
National method Diversity parameter + Computation details	Bray Curtis index, Included in the trophic index	Included in the trophic index	Included in the Reference Index	Dissimilarity index= 1- Bray Curtis Distance between current transects and reference transects	Included in the trophic index
National method Parameter distur-bance sensitive taxa + Computation details	Trophic Index	Trophic Index	Reference Index	Trophic score of the transect calculated as weighted average of species scores respect relative abundance of the species	Trophic Index, Vegetation limit of charophytes
Combination rule for multimetrics	Average	Not applicable	Average and/or downgrading	Average of normalised EQR of the metrics scores	Weighted Average
Different selection of metrics between types of water bodies?	No	No	No	No	No
Criteria of assessment validity	Minimum number of species Minimum abundance	Minimum of indicator taxa Minimum of observation units per site	Minimum number of species Minimum abundance	Presence of indicator species (trophic score)	Calculation of trophic index possible

GIG	Alpine				
Country	**Austria**	**France**	**Germany**	**Italy**	**Slovenia**
Common IC Type(s)	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3**
Assessment in five classes	Yes	Yes	Yes	Yes	Yes
Expressed as EQR	Yes	Yes	Yes	Yes	Yes
Combination rule for water body assessment	average of normalised EQR of the transects weighted for the length of the shoreline of homogeneous zone	average of trophic score of the observation units weighted for the length of the shoreline of homogeneous zone	average ecological class of the transects within a lake	average of normalised EQR of the transects weighted for the length of the shoreline of homogeneous zone	average of EQRs from transecs
IC Common metric or pseudo-common metric					
IC Common metric used	Average of assessment results of all member states				
ICCM Abundance parameter + Computation details	PMI (five level scale)				
ICCM Parameter disturbance sensiti-ve taxa + Computation details	Average of assessment results of all member states				
Purpose of the ICCM					
Relationship between common metric and national metric	R: 0,74, p: <0.001	R: 0.83, p: <0.001	R: 0.86, p: <0.001	R: 0.74, p: <0.001	R: 0.83, p: <0.001

GIG	Alpine				
Country	**Austria**	**France**	**Germany**	**Italy**	**Slovenia**
Common IC Type(s)	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3**
C. Reference conditions per type					
Key source to derive reference conditions (data, modelling, expert judgement)	Historical information, existing reference transects and expert judgement	Existing list of least disturbed condition sites according to national circular	Historical information, paleolimnological data, existing reference transects and expert judgement	Expert knowledge, historical data (no reference site in Italy available) Use of the reference sites of the IC common database	Existing reference transects
Geographical scope of reference definition	Alpine region	Alpine region	Alpine region	Alpine region	Alpine region
Number of reference sites	5 transects from 3 lakes	12 observation units (transects) from 3 lakes	4 transects from 1 lake	Use of all reference transects of the Alp-GIG database	2 transects from 1 lake
Location of reference sites	Attersee, Fuschlsee, Weißensee	Barterand, Grand Maclu, Etival	Alpsee	Attersee, Fuschlsee, Weißensee, Barterand, Grand Maclu, Etival, Alpsee, Lake Bohinj	Lake Bohinj
Time period of data of reference sites (months + years)	August 2005	July 2008	Juli 2004	August 2005 to July 2009	July 2009
(Pressure) criteria for reference sites	See details in MS-6 report, chapter 6.1				

GIG	Alpine				
Country	**Austria**	**France**	**Germany**	**Italy**	**Slovenia**
Common IC Type(s)	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3, L-AL4**	**L-AL3**
Reference community description	See details in MS-6 report, chapter 6.1				
Verification of the reference in each country	See details in MS-6 report, chapter 6.1				
Natural variability assessment of the reference condition	Median of parameter values in reference condition is used	Median of parameter values in reference condition is used	Median of parameter values in reference condition is used	Median of parameter values in reference condition is used	Median of parameter values in reference condition is used
How is a site with absence of BQE assessed?	Not assessable with macrophytes	Not assessable with macrophytes	Not assessable with macrophytes	Not assessable with macrophytes	Not assessable with macrophytes
D. Boundary setting procedure					
Pressure(s) assessed	Eutrophication and general degradation	Eutrophication and general degradation	Eutrophication and general degradation	Eutrophication and general degradation	Eutrophication and general degradation
Rationale/technique of quality class boundary setting	Use of discontinuities and equidistant division of continuum in different metrics	Use of percentiles and equidistant division of continuum	Use of change of species composition and abundance along a gradient of degradation in different metrics	Use of percentiles and equidistant division of continuum on a log scale	Use of percentiles and equidistant division of continuum
H/G boundary	Use of discontinuities in different metrics	75th percentile of reference sites	Use of change of species composition and abundance along a	95th percentile of common ALP-GIG database reference sites	25th percentile of pressure class 1

GIG	Alpine				
Country	Austria	France	Germany	Italy	Slovenia
Common IC Type(s)	L-AL3, L-AL4	L-AL3, L-AL4	L-AL3, L-AL4	L-AL3, L-AL4	L-AL3
			gradient of degradation in different metrics		
G/M boundary	Use of discontinuities in different metrics	Equidistant division of continuum	Use of change of species composition and abundance along a gradient of degradation in different metrics	Equidistant class widths on a log scale	25th percentile of pressure class 2
M/P boundary	Equidistant division of continuum	Equidistant division of continuum	Use of change of species composition and abundance along a gradient of degradation in different metrics	Equidistant class widths on a log scale	Equidistant division of continuum
P/B boundary	Equidistant division of continuum	Equidistant division of continuum	Use of change of species composition and abundance along a gradient of degradation in different metrics	Equidistant class widths on a log scale	Equidistant division of continuum
Pressure indicators used (National data)		TP, PO4, landuse in the catchment area, Results of lake habitat survey (hydromorpological)	TP, Secchi depth, SRP	Average Total Phosphorus concentration	TP, landuse in the 200m belt, lake shore morphological alteration class
Description of statistical test of		Regression analysis	Regression analysis	The relationship between the four metrics and TP	Regression analysis

GIG	Alpine				
Country	Austria	France	Germany	Italy	Slovenia
Common IC Type(s)	L-AL3, L-AL4	L-AL3, L-AL4	L-AL3, L-AL4	L-AL3, L-AL4	L-AL3
Pressure-impact relationship (National data)				(measured in winter stratification) showed significant correlation P<0.001	Kruskal Wallis (pressure classes)
Conclusion on pressure sensitivity (National data)		Spearman correlation between total pressure LHS and the EQR value in alpine lakes: -0.18		Significant correlation R^2= 0,4587	
Amount of data used (National data)		23 observation units (5 lakes)		Data from 330 transects	
Pressure indicators used (GIG data)	TP, Secchi depth, Chl a	TP, Secchi depth, Chl a	TP, Secchi depth, Chl a	TP, Secchi depth, Chl a	TP, Secchi depth, Chl a
Description of statistical test of Pressure-impact relationship (GIG)	Regression analysis	Regression analysis	Regression analysis	Regression analysis	Regression analysis
Conclusion on pressure sensitivity (GIG data)	TP: r^2 = 0.27 Secchi: r^2 = 0.36 Chl a: r^2 = 0.20	TP: r^2 = 0.33 Secchi: r^2 = 0.50 Chl a: r^2 = 0.29	TP: r^2 = 0.50 Secchi: r^2 = 0.41 Chl a: r^2 = 0.37	TP: r^2 = 0.30 Secchi: r^2 = 0.37 Chl a: r^2 = 0.37	TP: r^2 = 0.31 Secchi: r^2 = 0.53 Chl a: r^2 = 0.28

GIG	Alpine				
Country	Austria	France	Germany	Italy	Slovenia
Common IC Type(s)	L-AL3, L-AL4	L-AL3, L-AL4	L-AL3, L-AL4	L-AL3, L-AL4	L-AL3
Amount of data used (GIG data)	Data from 42 lakes	Data from 41 lakes	Data from 46 lakes	Data from 41 lakes	Data from 45 lakes

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Authors: Karin Pall, Vincent Bertrin, Fabio Buzzi, Sébastien Boutry, Alain Dutartre,
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Abstract

One of the key actions identified by the Water Framework Directive (WFD; 2000/60/EC) is to develop ecological assessment tools and carry out a European intercalibration (IC) exercise. The aim of the Intercalibration is to ensure that the values assigned by each Member State to the good ecological class boundaries are consistent with the Directive's generic description of these boundaries and comparable to the boundaries proposed by other MS.
In total, 83 lake assessment methods were submitted for the 2nd phase of the WFD intercalibration (2008-2012) and 62 intercalibrated and included in the EC Decision on Intercalibration (EC 2013). The intercalibration was carried out in the 13 Lake Geographical Intercalibration Groups according to the ecoregion and biological quality element. In this report we describe how the intercalibration exercise has been carried out in the Alpine Lake Macrophyte group.

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