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

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J R C T E C H N I C A L R E P O R T S

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Central Baltic 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 Central Baltic Macrophyte ecological assessment methods.

Contents

Annexes

1. Introduction

In the Central Baltic Macrophyte Geographical Intercalibration Group (GIG):

- Ten countries participated in the intercalibration with finalised macrophyte assessment methods (FR was later excluded because of the
- All methods address eutrophication pressure and follow a similar assessment principle (including biomass metrics and trophic index based on indicator taxa);
- Intercalibration "Option 3" was used - direct comparison of assessment methods using a common dataset via application of all assessment methods to all data available;
- Additionaly, IC pseudo-common metric (average of all countries EQRs) was used, it was benchmark-standardized using "continuous benchmarking" approach;
- Some methods initially had a low correlation with common metrics (UK, DE, BE-FL), but during the harmonisation process these were improved;
- The final comparability analysis show that methods give a closely similar assessment, so no additional boundary adjustment was needed (LV and LT methods are more precautionary);
- The final results include the harmonised BE, DK, EE, DE, LT, LV, NL, PL and UK lake macrophyte assessment systems for 2 common types: LCB-1 and LCB-2.

2. Description of national assessment methods

In the Central Baltic Macrophyte GIG, ten countries participated in the intercalibration with finalised macrophyte assessment methods (Table 2.1).

Table 2.1 Overview of the national macrophyte assessment methods.

Member State	Method	Status
Belgium - Flanders	Flemish macrophyte assessment system	Finalized formally agreed national method
Denmark	Danish Lake Macrophytes Index	Intercalibration-ready finalized method
Estonia	Assessment of status of lakes on the basis of macrophytes	Finalized formally agreed national method
France	IBML Indice Biologique Macrophytique en Lac (French macrophyte index for lakes)	Finalized but not formally agreed national method (for type LCB3)
Germany	German Assessment System for Macrophytes & Phytobenthos for the WFD (Reference Index)	Finalized but not formally agreed national method
Latvia	Lithuanian macrophyte assessment method	Finalized but not formally agreed national method

Member State	Method	Status
Lithuania	Latvian macrophyte assessment method	Finalized but not formally agreed national method
Netherlands	WFD-metrics for natural water types	Finalized but not formally agreed national method
Poland	Macrophyte based indication method for lakes - Ecological Status Macrophyte Index ESMI (multimetric)	Finalized but not formally agreed national method
UK	LEAFPACS lake macrophyte classification tool*	Finalized but not formally agreed national method (draft boundaries)

2.1. Required BQE parameters

Based on the information below, the GIG considers that all methods are compliant with respect to macrophytes. All macrophyte assessment systems include:

- Taxonomic composition metrics, mostly expressed as species composition indices;
- Abundance metrics, mostly expressed as maximum colonization depth (see table below), except French method (which has included only relative abundance of hydrophyte, helophyte, macroalgae).

Table 2.2 Overview of the metrics included in the national macrophyte assessment methods. Macrophytes and phytobenthos intercalibrated separately

	Macrophytes		Phytobenthos	
	Taxonomic composition	Abundance	Taxonomic composition	Abundance
BE_FL	Type specificity score; Disturbance score; Evaluation of number of present growth forms	Submerged vegetation development (based on a four-class abundance scale)	There is a separate diatom metric combined with the macrophyte metric (one out, all out).	Presence of cyanobacterial films and abundance of filamentous algae are accounted for in macrophyte metric calculations.
DK	Presence of indicator species;	Depth limit of submerged plants in lakes with max depth >5 m. Total coverage (% of lake area) in lakes with max depth < 5 m		

	Macrophytes		Phytobenthos	
	Taxonomic composition	**Abundance**	**Taxonomic composition**	**Abundance**
EE	Main hydrophyte groups in order of importance; Various indicators based on relative abundance of sensitive/tolerant taxa	Depth limit of submerged plants (only LCB1)		Abundance of large filamentous algae
FR	IBML : Indicator species (specific values + stenoecy coefficient)	IBML : Relative abundance of hydrophyte, helophyte, macroalgae		
GE	Reference Index; Total quantity of selected macrophyte taxa	Total quantity of macrophytes Depth limit of macrophytes	Trophic Index by Schönfelder Ratio of reference taxa	Relative Abundance included in the trophic index
LT	Reference Index	Depth limit (m) of vegetation (additional criteria)	-	-
LV	Presence of characteristic taxa and indicator species; Abundance of Charophyta, ceratophyllids and lemnids, Isoetids, Elodeids, floating-leaved plants, free-floating plants, helophytes, number of taxa	Colonisation depth, also see taxonomic composition		Abundance of filamentous Chlorophyta
NL	Total score of characteristic species, depending on species indication value and species abundance.	Deviation of macrophytes cover from expected cover in suitable area under reference conditions (will probably be adjusted within intercalibration)		No separate index; floating filamentous algae beds are incorporated into macrophytes growth forms
PL	Pielou index (eveness)	Colonization index: relative proportion of total area occupied	Separate index for phytobenthos (not combined with	

	Macrophytes		Phytobenthos	
	Taxonomic composition	Abundance	Taxonomic composition	Abundance
		by macrophytes from littoral < 2.5 m	macrophytes)	
UK	Lake Macrophyte Nutrient Index (LMNI); Number of Functional Groups; Number of Taxa	Macrophyte Cover; Relative percent cover of Filamentous Algae	Taxonomic metric for diatoms	

MS use following combination rules:

- BE_FL - worst metric score; combination with phytobenthos score also as one out, all out;
- DK - sum of scores on indicator species and abundance metrics;
- EE - average of quality classes calculated for different indicators;
- FR - averaging of trophic score for littoral zone and perpendicular profiles. Weighted metric according the cover (%) of four predefined riparian types;
- GE - average metric scores (macrophytes and phytobenthos) per site. Averaging of sites for whole water body assessment;
- LT - average metric scores;
- LV - average of quality classes calculated for different indicators;
- NL - average of indicators for taxonomic composition and abundance;
- PL - in ESMI, the Pielou index and colonization index are combined into one formula, giving the results in a range from 0 (most disturbed) to 1 (reference, theoretical value);
- UK - weighted average of metrics for macrophytes, then take worst of macrophytes and diatom score.

For scientific literature and computation details see Annex F.1.

2.2. Sampling and data processing

Table 2.3 Overview of the sampling of the national macrophyte assessment methods

MS	Sampling device	Surveyed compartment/habitat/ecotope	Abundance scale
BE-FL	A 50 cm broad mesh-covered rake on a telescopic handle (up to 4 m long)	A variable number of fixed transects, chosen to cover spatial variation as completely as possible, are sampled in deeper parts from a motor boat or by wading. Transect observations are	Species composition and abundance of individual macrophytes are estimated the scale from 1-5. Additionally,

MS	Sampling device	Surveyed compartment/habitat/ecotope	Abundance scale
	or a similar double-sided rake fixed to a 20 m rope are used where necessary	supplemented by point observations to asses distribution patterns. If a boat is used in deep water, the double rake is thrown perpendicular to transect twice or three times on each side every 10 or 20 m; transect width is ca. 10 m.	the total abundance of submerged vegetation is estimated for each segment in 4 class scale, and the growth forms occurring in the water are listed.
DE	SCUBA or by boat using a water viewer and a double rake with rope.	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), is divided into 0–1 m, 1–2 m, 2–4 m and >4 m depth classes 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).	The species composition uses a 5 classes of abundance, for each depth zone at each transect is recorded separately.
DK	SCUBA diving or boat using a water viewer and a rake with a rope	Macrophyte data are obtained from transect investigations. Each lake is divided into a number of transects representing the whole lake area.	Macrophyte coverage at each observation point is estimated according to scale from 0 -6.
EE	Plant hook (in very shallow water also rake), observation tube Diving - rarely	Usually, small lakes are circled by boat, partly in deeper zone and along transects, partly in shallower zone near the water edge On the largest lakes of Peipsi (3555 km^2) and Võrtsjärv (270 km^2) monitoring is carried out on transects.	Relative abundance are given according 5 abundance classes originally used by Braun-Blanquet, separately among three groups: helophytes, floating and floating-leaved plants, submerged plants
FR	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	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.	Relative abundance in 5 class sale
LT	Grapnel,	Macrophytes was sampled in	5 degree scale: 1 = very

MS	Sampling device	Surveyed compartment/habitat/ecotope	Abundance scale
	Aquascope	perpendicular to shoreline transects divided into 0–1 m, 1–2 m, 2–4 m and >4 m depth zones. At least three samples of macrophytes were taken from each depth zone (totally 3x4 per transect).	rare, 2 = rare, 3 = common, 4 = frequent and 5 = very frequent
LV		The examination of the lake is organized in transects. Passing the littoral of the whole lake by boat relative abundances of the macrophyte species of all belts and all taxonomical groups are estimated	Relative abundances of the macrophyte species in the 5 or 7 point scale
NL	In most cases a double rake is used connected to a rope. In some cases snorkeling or estimation with the naked eye (clear and shallow water).	Each lake comprises 6 - 20 sampling points. - In shallow, large lakes (> 500 ha) each sampling point has a size of 200x200m and is sampled at each corner 5 times with a rake. - In smaller and medium lakes, as well as deeper lakes, 10 transects perpendicular to the banks are sampled. - Small lakes are sampled by random crossing the lake, aiming to record the complete species composition and estimate a total cover of growth forms.	Usually in a 9-classes cover scale for species and percentage for growth forms
PL	In most cases a rake is used connected to a scaled rope	Number of transects depends on the area and the shape of the lake; normally it makes one transect for app. 500m length of shoreline. The width of transect is about 20-30 m the length is from the shoreline to the max. depth of plant growth.	Share of each plant community in 7 point scale and % of total plant cover within a transect
UK		4 - 8 lake sectors should be surveyed depending on lake area . A sector should comprise a 100 metre length of shoreline. It should extend from the shore to the centre of the lake or to the maximum depth of colonisation of macrophytes. The sectors should be arranged to give an approximately equal spread around the perimeter of the lake.	Each indicator taxon present in the lake should be assigned a value (0 -100 %) which is an estimate of the percentage cover of the taxon in the area of the lake surveyed.

2.3. National reference conditions and class boundaries

Ecological status classifications of national methods were established individually by the Member States prior to the intercalibration process (see below).

Belgium:

- Contemporary references are absent for all types. The assessment is therefore based on vegetation attributes estimated from the remaining sites presenting higher quality, historical records, and information on the behaviour of species and the structural response of aquatic vegetations in relation to pressures, making as few assumptions as possible. This information is integrated by expert judgement;
- Boundary values are set by expert judgement with the requirement that good status can only be attained if taxa which are not specific for the water type or show increased abundance with disturbance remain notably less abundant relative to type-specific and non-disturbance species.

Estonia:

- Reference lakes are not present in Estonia. Conception of high status is based on the data from the 1950s, or older data;
- H/G boundary is the state where the first signs of vegetation change appear;
- G/M boundary is the state where the representatives of H and G state are present, but not prevailing;
- The vegetation of the lakes on G/M boundary seems to be unstable.

Denmark:

- The method uses the total points score of two indicators, with a maximum of 4 points for indicator species and a maximum of 9 points for abundance (maximum colonized depth (LCB1) or total cover (LCB2)), resulting in a scale from 0-13 points;
- These have been assigned to ecological status classes, with 0-1 point = bad, 2-4 points = poor, 5-7 points = moderate, 8-10 points = good, and 11-13 points is high;
- The boundaries were set within the intercalibration process during the harmonization phase, by adjusting the score system for the two indicators.

Germany:

- The reference is based on (few) existing reference sites;
- High Status: EQR values lie within the range of reference sites;
- Good Status: EQR values are slightly below high status and always positive (Taxa of species group A (sensitive taxa) have higher abundances than species group C (impact) taxa);

- Moderate: EQR values are around zero or negative (species group C taxa equal or slightly outweigh species group A taxa);
- Poor: EQR values are very low (species group A taxa are nearly replaced by species group C taxa);
- Bad: Very low macrophyte abundances without natural reasons. (Calculation of RI/EQR is often not possible).

Lithuania:

- For setting reference conditions, existing near-natural sites were chosen. These sites were selected according to expert knowledge, historical data and in which the least disturbed conditions are present. The criteria were: the absence or minimal human impact in the site or in all catchment area, the macrophyte community corresponds with description of reference community description, diversity of macrophyte species corresponds with diversity of substrates, low quantity of nutrients, unaltered morphology and hydrology;
- In high alkalinity lakes cover of submerged vegetation with dominant Chara spp. is well developed. Sensitive submerged species are very abundant and dominant. Occurrence of tolerant and indifferent species is insignificant. The belt of helophytes and floating leaved plant not developed or very badly developed;
- Boundary setting: Preliminary ecological status boundaries estimated for German RI were used;
- In a "Good status" community the cover of Chara spp. in high alkalinity lakes is well developed and sensitive species have higher abundance than tolerant species, but are decreasing and replaced by tolerant and indifferent species.

Netherlands:

- The number of reference sites is too low for setting reference values. Plant communities that are considered to be present in reference conditions are based on earlier work on target types in nature management (Bal et al.) and improved by expert judgement. The reference score for the sum of the scores of the species is derived from frequency data in this database;
- Class boundaries are expressed as percentage of the reference score -H/G 70%, G/M 40%, M/P 20%, P/B 10%;
- Final adjustment of the reference scores and class boundaries are based on intercalibration results.

Poland:

- Reference: median value of ESMI from real reference lakes identified according to the pressure criteria, for stratified and non-stratified lakes separately;

- H/G boundaries were determined as 75th percentile from the distribution of reference lakes;
- The whole range of ESMI from the H/G boundary to the minimum value was divided in four classes in logarithmic scale;
- During the intercalibration process it became clear that boundary values for the G/M boundary were too relaxed in the case of both, stratified and non-stratified lakes. In a harmonization process it has been suggested to tighten the G/M and M/P boundaries by 20% and leave H/G boundary unchanged.

UK:

Selection of reference sites:

- Putative reference sites were identified at a type-specific level initially from their biology, using individual species-pressure relationships indicated by empirical analysis, historical macrophyte records and expert opinion;
- Finally all reference sites were checked against available land cover, total P and chlorophyll data. Within-type regressions between pressures and biological metrics were used to identify sites where deviating biology was related to increased pressure. Any such outliers or sites with known hydromorphological modifications were then removed.

Individual metrics were modelled using environmental variables to determine their expected value at reference sites. These expected values are used to calculate an EQR for each metric. A multimetric EQR is then calculated based on the national combination rules.

National boundary setting:

- The H/G boundary corresponds to the lower 5th percentile of the multimetric EQR in reference sites and is interpreted as representing the lower limit of undisturbed status of the quality element;
- The GM boundary is based on the interval between the median EQR of the national reference site dataset and the HG boundary and is approximately equivalent to the lower 1%tile of the reference site multimetric EQR. This point is interpreted to represent the limit of slight change in the quality element since there is some but minimal overlap with the natural variation in the population of reference sites;
- Below this the EQR range is divided equally to form the MP and PB boundaries.

Based on this information, the GIG considers that all methods are compliant with respect to macrophytes.

Table 2.4 Overview of the methodologies used to derive the reference conditions for the national macrophyte assessment methods

BE-FL	Expert knowledge, historical data, least disturbed conditions
DK	Expert knowledge, historical data, least disturbed conditions (no actual existing natural sites in lakes; spatial references from foreign countries)
EE	Existing near-natural reference sites, expert knowledge, historical data, least disturbed conditions, modelling (extrapolating model results)
FR	Existing least disturbed conditions sites following the criteria given in the National Circular DCE 2004/08.,
GE	Existing near-natural reference sites, Expert knowledge, Historical data, Modelling (extrapolating model results), palaeo data (sediment-cores)
LT	Existing near-natural reference sites, expert knowledge, historical data, least disturbed conditions
LV	Existing near-natural reference sites, expert knowledge.
NL	Expert knowledge, historical data, least disturbed conditions (no actual existing natural sites in lakes; spatial references from foreign countries)
PL	Existing near-natural reference sites, expert knowledge, least disturbed conditions
UK	Existing near-natural reference sites, Historical data, modelling (extrapolating model results) Sites selected by iterative application of biological and physicochemical criteria, ca 600 surveys (mixture of historic and contemporary surveys)

Table 2.5 summarizes the methodology used to derive ecological class boundaries. Based on the information, the GIG considers that all methods are compliant with respect to macrophytes.

Table 2.5 Overview of the methodology used to derive ecological class boundaries

BE-FL	Equidistant division of the EQR gradient; reasoning behind it is not necessary a linear scale for different metrics
DK	DK use a point scale for different indicators; these are combined and translated to a EQR value, based on maximum colonization depth or cover, indicative species and total number of taxa
EE	Using discontinuities in the relationship of anthropogenic pressure and the biological response and expert judgement. G/M boundary is the state where sensitive taxa are present, but not prevailing, other boundaries set proportional.
FR	H/G boundaries determined as 75th percentile from the distribution of reference lakes divided over Alpine/LCB3 GIG. Equidistant division of continuum.
GE	The boundaries were set at the zones of distinct changes of the biocoenosis (macrophytes and diatoms (eg Schaumburg et al 2004 etc)
LT	Preliminary ecological status boundaries estimated for German RI were used
LV	Expert judgement based on ecological changes and normative definitions?
NL	Division of the EQR gradient as function of the total score for composition and the abundance metric
PL	H/G boundaries determined as 75th percentile from the distribution of reference

	lakes Division of the EQR gradient in original (not harmonised) method in logarithmic scale, differing between stratified and non-stratified lakes
UK	Using paired metrics (sensitive and tolerant taxa) that respond in different ways to the influence of the pressure. EQR boundaries are subsequently adjusted to equidistant divisions.

3. Results of WFD compliance checking

The table below lists the criteria from the IC guidance and compliance checking conclusions.

Based on the information above, the GIG considers that all methods are compliant with respect to macrophytes. All methods show a significant correlation with eutrophication parameters.

Several countries (BE-FL, GE, UK, PL) have developed a separate metric for phytobenthos, others (NL, EE, LV) have included filamentous algae in their macrophyte metric, and argue that macrophytes taxonomic composition calculated this way and abundance are indicative for the quality element as a whole.

The GIG agrees in majority that macrophytes are indicative for the quality element as a whole for long-term changes and are responsive to the main anthropogenic pressures on lakes. It is acknowledged that phytobenthos can be used to detect short-term changes, but rapid year-to-year changes in maximum colonised depth for macrophytes as observed in many lakes also detect these short-term changes. Combination of these two would require intercalibrated separated metrics on the two before they can be combined.

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

Compliance criteria	Compliance checking conclusions
1. Ecological status is classified by one of **five classes** (high, good, moderate, poor and bad).	Yes, fulfilled by all countries that have completed methods; except EE method does not distinct between Poor/Bad
2. High, good and moderate ecological status are set in line with the WFD's **normative definitions (Boundary setting procedure)**	Yes, see table above
3. **All relevant parameters** indicative of the biological quality element are covered (). A **combination rule** to combine para-meter assessment into BQE assessment has to be defined.	Yes, see table above

4. The water body is assessed against **type-specific near-natural reference conditions?**	Yes, see table above
5. Assessment results are expressed as **EQRs**	Yes, national EQR's or classes can also be transformed to normalized (0-1) EQR's. DK has discrete EQR values.
6. Sampling procedure allows for **representative** information about water body quality/ ecological status **in space and time**	**In time:** status is by all member states assessed per sampled growing season (lake-years); For macrophytes this is the appropriate time scale, with at least one sample during the peak of the growing season (June-Aug) **In space:** yes, with use of transects and/or profiles or mapping. Member states have rules for the % of shoreline or number of transects, often depending on size and heterogeneity of the lake.
7. All data relevant for assessing the biological **parameters** specified in the WFD's normative definitions are covered by the **sampling procedure**	Parameters for abundance and species composition are covered, but are differing between countries.
8. Selected taxonomic level achieves adequate **confidence and precision** in classification	All countries that have delivered data have determined at the desired species level, with few exceptions, such as charophytes in LV which are lumped. The adequate confidence and precision needs to be demonstrated during the phase where the assessments with the different national methods on the CBGIG database and/or with the common metrics are compared.

4. Results IC Feasibility checking

4.1. Typology

Intercalibration feasible in terms of typology - all assessment methods are appropriate for the common types LCB1 and LCB2 (see Table 4.1 and Table 4.2):

- All countries (except FR) share LCB1 and LCB2, therefore intercalibration is feasible for these two types;
- EE, DK, FR and LV have LCB3, and UK has lakes of similar type in the NGIG. However, this is insufficient for intercalibration within time frame due to large geographical differences and lack of data.

Only few countries have LCB3 lakes, but it was concluded within the GIG that even these few lakes were geographically too different to intercalibrate. Making

subcategories on LCB3 therefore is not possible due to the fact that this would give too small lake populations.

Table 4.1 Description of Lake Central/Baltic GIG common intercalibration types

Common IC type	Type characteristics	MS sharing IC common type
LCB1	Shallow (3-15 m), alk > 1 meq/l	All countries except FR
LCB2	Very shallow (<3 m), alk > 1 meq/l	All countries except FR
LCB3	Shallow (3-15 m), alk < 1 meq/l	EE, LV & DK. UK has lakes of similar type in NGIG. FR has LCB3 lakes not comparable to the others due to geographic differences. IC for LCB3 not possible due to large geographical differences and lack of data.

Table 4.2 Feasibility of IC of MS macrophyte assessment methods for IC common types

Method	Appropriate for IC types/subtypes	Remarks
BE_FL	LCB1, LCB2	Feasible
DK	LCB1, LCB2	Feasible
EE	LCB1, LCB2	Feasible
FR	Was developed for LCB3, can be used for LCB1, LCB2	Not feasible due to large geographical differences with other countries LCB3 lakes; There are no lakes for LCB1 and LCB2 in FR
GE	LCB1, LCB2	Feasible
LT	LCB1, LCB2	Feasible
LV	LCB1, LCB2	Feasible
NL	LCB1, LCB2	Feasible
PL	LCB1, LCB2	Feasible
UK	LCB1, LCB2	Feasible

4.2. Pressures addressed

Lake macrophyte assessment methods addressed eutrophication + wide range of pressures :

- BE_FL method - eutrophication + wide range of pressures (hydromorphology, habitat destruction, fish stocking, alien species);
- DK – eutrophication;
- EE - eutrophication + hydromorphological pressures;
- FR – eutrophication;
- GE - eutrophication + general degradation, habitat destruction;
- LT - eutrophication;

- LV - eutrophication + wide range of pressures;
- NL - eutrophication + hydromorphological pressures;
- PL - eutrophication + also general degradation, organic pollution;
- UK – eutrophication.

Nevertheless, pressure-response relationships were developed only for eutrophication pressure. Hydromorphological pressures (water level fluctuations, residence time, lake shore morphology) are generally not well defined, both with respect to the pressure-response relationships and the monitoring of the pressures. This hampers the possibility to check pressure-response relationships

Intercalibration is feasible in terms of pressures addressed by the methods as all countries showed that their method responds significantly to eutrophication (TP, TN, Chlorophyll-a).

In the table below, the relationships of national methods with eutrophication variables TP, TN and chl-a are expressed as their Pearson R.

Table 4.3 Evaluation of IC feasibility regarding addressed pressures

Relationship with pressure		Pearson R								
Type	Ln	UK	GE	PL	LV	NL	BE-FL	LT	EE	DK
LCB1	TP	-0.53	-0.42	-0.52	-0.39	-0.48	-0.33	-0.41	-0.64	-0.52
	TN	-0.32	-0.51	-0.57	-0.41	-0.48	-0.29	-0.39	-0.60	-0.50
	Chl-a	-0.47	-0.46	-0.71	-0.52	-0.57	-0.28	-0.41	-0.58	-0.61
LCB2	TP	-0.46	-0.25	-0.32 (n.s)	-0.45	-0.38	-0.34	-0.34	-0.42	-0.39
	TN	-0.35	-0.30	-0.70	-0.37	-0.31	-0.29	-0.46	-0.50	-0.28
	Chl-a	-0.53	-0.39	-0.64	-0.52	-0.54	-0.36	-0.47	-0.55	-0.50
All lakes	TP	-0.47	-0.28	-0.46	-0.47	-0.45	-0.34	-0.35	-0.52	-0.46
	TN	-0.31	-0.35	-0.63	-0.43	-0.38	-0.30	-0.38	-0.55	-0.38
	Chl-a	-0.46	-0.36	-0.70	-0.56	-0.57	-0.33	-0.42	-0.58	-0.55

All relationships are significant at $p<0.001$, except PL for LCB2 with TP ($R=-0.32$, $n=26$, $p=0.112$)

4.3. Assessment concept

Intercalibration is feasible for assessment concept (see Table 4.4):

- However, not all indicators needed for all the national methods can be calculated for the common database. In those cases "compromised" versions of the national methods are used, and is it needed to demonstrate the

relationship between the "complete" and the "compromised" method as applied to the CBGIG database. If this relationship is insufficient, then preferably an option 2 comparison with common metrics can be used;
- Translation to national types based on the intercalibration database may be a source of uncertainty;
- Methods may be changed based on the intercalibration results; final methods and assessment concepts will be described as result of the intercalibration.

Table 4.4 Evaluation of IC feasibility regarding assessment concept of MS methods.

Method	Assessment concept
Method BE	The method based on the following metrics: • TS: type-specific species composition (relative abundance ratio) separately for riparian and aquatic vegetation; • V: abundance of disturbance indicators (relative abundance ratio) separately for riparian and aquatic vegetation; • GV: number of growth forms for aquatic vegetation only; • VO: submerged vegetation development for aquatic vegetation only; • riparian vegetation assessment considers all phreatophytes; aquatic vegetation assessment considers all hydrophytes and helophytes plus filamentous algae and cyanobacterial films up to a type-specific depth (≤ 2 m for LCB2; ≤ 4 m for LCB1)
Method DE	The method based on the following metrics: • Macrophytes reference index (RI): relative abundance of the macrophyte species of three different type specific ecological species groups (reference indicators, indifferent taxa, degradation indicators; according to growth depth); • limit of vegetation: used as an additional criteria; • dominant stands: used as an additional criteria if a single species (e.g. Ceratophyllum demersum or Myriophyllum spicatum) reaches at least 80% of total plant quantity.
Method DK	The method based on the following metrics: • presence of indicator species • Mean % cover submerged macrophytes (shallow lakes) • Maximum growth depth (deep lakes)
Method EE	• Main hydrophyte taxa • Relative abundance of Potamogeton perfoliatus or P. lucens among submergents • Relative abundance of charophytes or bryophytes among submergents • Relative abundance of Ceratophyllum among submergents or of lemnids among nymphaeids& lemnids • Abundance of large green filamentous algae (epiphytes included)

Method	Assessment concept
	• Maximum colonization depth (LCB1 only) • Maximum depth of mosses (only LCB3 with depth>3 m)
Method FR	IBML method : Relative abundance of indicator taxa (specific value + stenoecy coefficient) including hydrophytes, helophytes and macroalgae (riparian + water)
Method LT	Reference Index calculated according to Lithuanian list of indicatory species (A – sensitive, C–insensitive and B – indifferent taxa) and named L-RI. Depth limit (m) of vegetation (additional criteria) Index is calculated fore each transect and calculation is based on list of taxa and its abundance, estimated at different depth zones. Adapted from German method using modified specific list of LT species; uses occurrence of species in different depth zones
Method LV	The method based on the following metrics: characteristics species, indicator species, macrpjhyte species number, abundance of charophytes, isoetids, elodeids, freely floating species, nympheids, green algae, colonisation depth
Method PL	The method based on the following metrics: • Pielou index of evenness of species distribution • area covered relative to area with depth < 2.5 m • Phytobenthos index is a separate assessment not part of macrophyte based assessment. No integration rules at the moment
Method NL	The method based on the following metrics: • total sum of abundance related scores of all species encountered • covered area compared to potential area (area with depth <2.7 m in LCB2; area with depth < 4.5 m in LCB1) • covered area of helophytes relative to potential area
Method UK	The method based on the following metrics: • Lake Macrophyte Nutrient Index (LMNI); • Number of functional groups of macrophyte taxa (NFG). • Number of macrophyte taxa (NTAXA); • Mean percent cover of hydrophytes (COV); • Relative percent cover of filamentous algae (ALG)

5. IC dataset collected

Huge dataset was collected within the CB macrophyte GIG, including 254 lake years from LCB1 (8 MS) and 274 lake years from LCB2 (9 MS), see tables below.

Table 5.1 Description of data collection within the GIG per MS

Member State	Macrophyte data	Chlorophyll	TotalP	TotalN
LCB1 lake type				
BE	5	4	5	5
DK	25	19	21	21
EE	13	8	12	12
GE	32	32	32	0
UK	21	20	14	18
LV	67	67	66	55
NL	14	14	14	7
PL	77	71	77	77
LCB2 lake type				
BE	14	4	6	6
DK	62	55	56	56
EE	13	9	10	12
GE	18	16	18	0
UK	39	38	31	32
LT	21	21	21	21
LV	45	45	45	39
NL	36	36	36	19
PL	26	26	26	26

Table 5.2 Distribution of CB lakes in the CB Macrophyte GIG database across quality classess

	LCB1	LCB2	LCB3	total
High	16	7	3	26
Good	61	43	5	109
Moder	28	45	5	78
Poor	5	17	0	22
Bad	7	23	3	33
Unknown	101	112	46	259
total	218	247	62	527

U=Unknown

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 and optional)	Abundances are determined at the species level; genus level may be acceptable if this does not hamper assessment by other methods (this is the case with charophytes in Latvian lakes); supporting physico-chemical data and lake characteristics should be provided. The GIG used a template in the date request that was filled by all member states providing data.
The sampling and analytical methodology	Member states use different scales for abundance of macrophytes species. UK and PL use a continuous scale, the other member states use point scales with a variable number of classes. DK use presence/absence data for species composition. Conversion from one scale to another was done by a conversion table based on the description of the various abundance scales as provided by the member states, and agreed within the group.
Level of taxonomic precision required and taxalists with codes	An extended taxon list (compared to that of the 1st round) was used, containing 173 species. Countries provided data on missing species that are used in their national methods
The minimum number of sites/samples per intercalibration type	For LCB1 and LCB2 there are sufficient sites in the database. For LCB3 this is not the case, and it is intended to combine LCB3 with similar types from the NGIG. France has 3 sites in CBGIG (only LCB3).
Sufficient covering of all relevant quality classes per type	Preliminary status assessment of national methods on their own lakes shows that for LCB1 a large fraction of lakes is assessed high or good. For LCB2 the majority is assessed as good or moderate, with few lakes assessed s high status. Many lakes (from countries with no method and from LV) were not assessed. Especially LV may have more LCB2 lakes in high status.

6. Common benchmarking

The intercalibration dataset does contain **reference sites** as assigned by the member states. However, their number is considered to be insufficient, and also the TP and chlorophyll-a range of the assigned reference sites is considered quite broad (see Figure 6.1). Therefore other approaches as alternative benchmarks or continuous benchmarking were considered.

Graph below shows that the assigned reference sites have a relatively broad spread of TP and chl-a values, but that there are many more sites with comparable TP and chl-a values.

Also **alternative benchmarking** was not possible because of limited number of sites within a narrow range of pressure. Therefore **continuous benchmarking** was used:

- The list of sites with a range of TP (0–0.2 mg P/l) were included for the continuous benchmarking;
- These lakes provide a sufficient number of benchmarking sites and sufficient geographical distribution within the CBGIG (together 426 lakes - 222 LCB1 and 204 LCB2 lakes);
- There is sufficient spread of sites over eastern and western part of GIG;
- For each combination of the application of method from MS A to the lakes of MS B a benchmark correction factor to the standardised EQR was calculated (see table below).

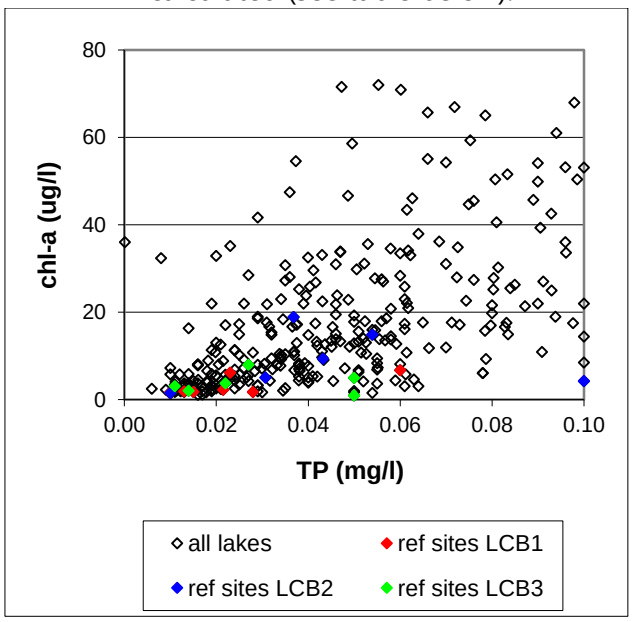

Figure 6.1 Range of TP and chl-a values of Central/Baltic GIG reference sites.

Table 6.1 Benchmark standardization correction factors

	MS assesment method								
Lakes	**UK**	**DE**	**PL**	**LV**	**NL**	**BE**	**LT**	**EE**	**DK**
UK	-0.03	-0.03		-0.05	-0.01	-0.09	-0.02	0.03	-0.01
DE	-0.05	0.05		0.05	0.03			0.05	0.05
PL	-0.01	-0.03	0.00	-0.01	-0.03	0.15	-0.04	-0.03	-0.03
LV	0.07	0.09		-0.01	0.01	-0.01	0.10	0.07	0.09
NL	-0.09	-0.01		0.01	-0.01	-0.09	0.04	-0.09	-0.05
BE	-0.05	-0.03		0.01	0.05	0.15	-0.18	0.05	0.01
LT	0.07	0.01		-0.17		-0.07	0.06	-0.05	
EE	0.09	-0.03		0.03	0.09	0.05	-0.04	-0.01	0.09
DK	-0.03	-0.05		0.05	-0.01	-0.15	-0.10		-0.05

Explanations:

- Empty fields imply that a method was not applied to the lakes of the corresponding country;
- The benchmark factor for application of the BE_FL method to the BE-FL lakes was corrected to 0.0 based on the estimated systematic bias between full BE-FL method applied to Belgian lakes and the compromised BE-FL method applied to all other lakes;
- The PL method was only applied to PL lakes. Intercalibration of the PL method was possible nonetheless, because large number of PL lakes in CB-GIG database (n=99).

7. Comparison of methods and boundaries

IC Option and Common Metrics

Intercalibration "Option 3" was used - direct comparison of assessment methods using a common dataset via application of all assessment methods to all data available.

However, not all indicators needed for all the national methods can be calculated for the common database. In those cases **"compromised" versions of the national methods** are used, and is it needed to demonstrate the relationship between the "complete" and the "compromised" method as applied to the CBGIG database.

If insufficient agreement was reached between the full MS method and the "compromised" method that can be applied to the CBGIG database, then **a method was only applied to the member state's own lakes**. This is the case for PL (the missing information on helophytes and depth distribution compromised the PL method too much, so the full PL method was applied only to PL lakes). In case of BE-FL (unable to calculate 1 out of 4 metrics: the abundance metric), a correction factor was applied.

For comparison of the MS assessments, **a pseudo-common metric** based on the average of the benchmark corrected standardised EQR's of all other member states.

Methods harmonization process

Some methods initially had a low correlation (UK, DE, BE-FL) but during the harmonization process these were improved. Before final calculation a number of steps have been performed:

- Because the Polish method had to be compromised too much it was decided that PL could use their full method applied only to the PL lakes. This was possible because of a sufficiently large number of PL lakes in CBGIG database (n=99);
- The Latvian assessments were slightly changed by calculation of index for characteristic taxa;

- UK method was applied to German lakes based on estimates of alkalinity from total hardness → for UK overall correlation decreased from R=0.5 to R=0.4;
- Adaptation of NL method to include abundance metric → NL metric became less precautionary;
- French method was not taken into account due to lack of lakes and data in the LCB1 and LCB2 type → this lowered correlation for UK, but improve it for EE, also PL method became relatively too loose (boundary bias increased to +0.38);
- Germany have adapted their method to meet with criteria for correlation with the pseudo common metric;
- NL have adjusted scoring system for individual metrics within their method;
- DK have adjusted their method (no longer use metric on total number of taxa, have adjusted class boundaries for abundance and indicator species;
- UK has provided new method, to comply with criteria for correlation with pseudo common metric and pressure.

Furthermore, additional changes were performed:

- DK method was further adjusted with respect to class boundaries for individual indicators,
- Class EQR boundaries were adjusted where needed (PL, EE, GE) to make countries comply with comparability criteria for HG and GM boundary bias.
- BE-FL have further adjusted their results by screening the assignment of lakes from the CBGIG database to the national BE-FL types. This resulted in a change of national type for 4 PL lakes, which improved the correlation with the PCM brought the HG boundary bias for LCB2 within the accepted range, and that for LCB1 very close to the lower limit for acceptance, at -0.27;
- UK have adjusted their G/M boundary from 0.67 to 0.66 for both LCB1 and LCB2. This made the UK method less precautionary for LCB1, although still more precautionary than needed, while for LCB2 and LCB1&LCB2 combined all boundary biases remain within the accepted range. As the UK method does not distinguish between LCB1 and LCB2, the combined LCB1&LCB2 results should be used. This adjustment also moves the LCB1 H/G boundary bias for BE-FL further up from -0.27 to -0.25, bringing it just within the accepted range.

Results of the regression comparison (National EQRs vs. common metrics)

After several adjustments (UK, BE-FL, DE methods) for all Member States (and for LCB1, LCB2 as well as LCB1 and LCB2 types combined) correlation between national methods and pseudo-common metrics is significant at least at $p<0.001$ (and usually much smaller p-value).

Table 7.1 Correlation coefficients (R) for the relationship of each method with the pseudo-common metric (PCM).

LCB1 type										
		UK	GE	PL	LV	NL	BE	LT	EE	DK
R with PCM	>0.5	0.62	0.72	0.75	0.64	0.79	0.57	0.70	0.75	0.75
LCB2 type										
		UK	GE	PL	LV	NL	BE	LT	EE	DK
R with PCM	>0.5	0.72	0.63	0.73	0.58	0.85	0.65	0.76	0.73	0.82
LCB1 & LCB2 types combined										
		UK	GE	PL	LV	NL	BE	LT	EE	DK
R with PCM	>0.5	0.67	0.65	0.76	0.61	0.83	0.63	0.73	0.74	0.80

The pseudo-common metric is also significantly correlated (all $p << 0.001$) with TP for all countries. Note: these differ only slightly between countries, as they are the average of the assessments by all methods minus one

Table 7.2 Correlation coefficients (Pearson R) for the relationship of the pseudo-common metric (PCM) with total phosphorus (TP).

MS	UK	GE	PL	LV	NL	BE	LT	EE	DK
Pearson R	-0.53	-0.55	-0.56	-0.52	-0.56	-0.56	-0.56	-0.53	-0.55
n	423	481	481	423	481	434	480	471	481

The overall PCM (avg of EQRs of all intercalibrated methods) is also significantly correlated to TP for both LCB1 and LCB2 (Figure 7.1).

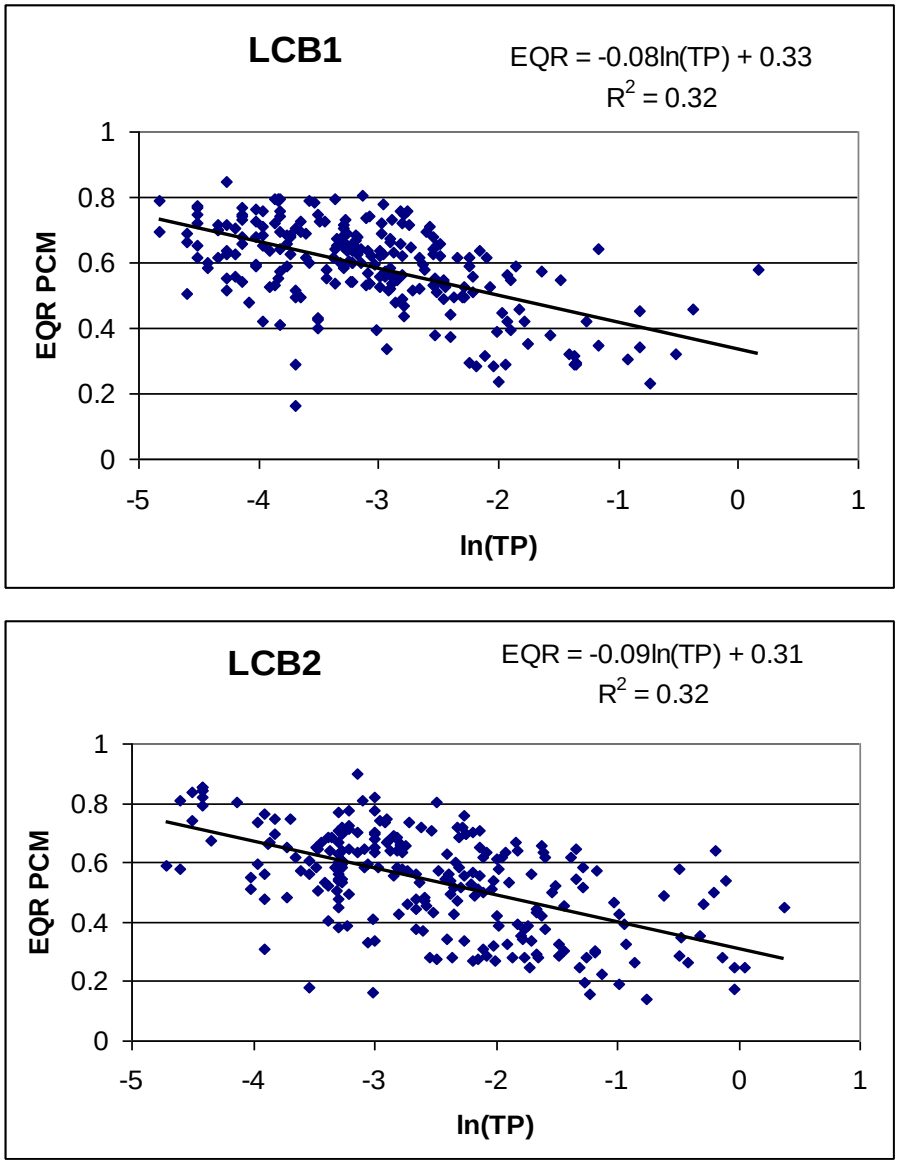

Figure 7.1 Relationships between TP and the overall PCM (avg of EQRs of all intercalibrated methods) for common lake types LCB1 and LCB2.

7.1. Evaluation of comparability criteria

Finally a class comparison was made by comparing the classifications when each method was applied to as many countries as possible (Option 3a).

The absolute class difference was calculated. In all cases the methods achieved the comparability criteria of <1.0 absolute class difference, ranging from 0.6 to 0.8, average 0.69 (see

Table 7.3)

Boundary bias was calculated (see

Table 7.3):

- LT, LV and UK have a positive boundary bias exceeding 0.25 class limit - means that these methods are precautionary with respect to the average boundary of all MS
- UK complies based on combined LCB1 and LCB2 results (as UK boundaries are too precautionary only for LCB1 lakes;
- LV and LT have agreed to keep their relatively strict class boundaries.

Table 7.3 Overview of the IC comparability criteria

Compliance criteria	Limit	Type LCB1								
		UK	GE	PL	LV	NL	BE-FL	LT	EE	DK
Class agreement	<1.0	0.69	0.68	0.63	0.72	0.60	0.74	0.66	0.63	0.64
HG Bias	-0.25 +0.25	**0.36**	0.20	-0.09	-0.22	0.07	-0.25	**0.69**	-0.21	0.20
GM Bias	-0.25 +0.25	**0.27**	0.03	-0.13	-0.23	-0.03	-0.02	**0.42**	-0.10	0.15
Compliance criteria	**Limit**	**Type LCB2**								
		UK	GE	PL	LV	NL	BE-FL	LT	EE	DK
Class agreement	<1.0	0.73	0.65	0.70	0.77	0.67	0.78	0.80	0.68	0.70
HG Bias	-0.25 +0.25	-0.12	-0.12	0.04	**0.27**	0.08	-0.18	**0.47**	0.05	0.22
GM Bias	-0.25 +0.25	-0.12	-0.24	-0.08	0.18	0.09	-0.01	**0.56**	0.21	0.17
Compliance criteria	**Limit**	**Types LCB1 & LCB2 combined**								
		UK	GE	PL	LV	NL	BE-FL	LT	EE	DK
Class agreement	<1.0	0.71	0.66	0.65	0.75	0.63	0.76	0.73	0.66	0.67
HG Bias	-0.25 +0.25	0.08	-0.05	0.02	0.01	0.10	-0.17	**0.55**	-0.06	0.25
GM Bias	-0.25 +0.25	0.05	-0.18	-0.07	-0.02	0.05	-0.02	**0.52**	0.08	0.18

Class boundaries to be included in the IC Decision

Table 7.4 Ecological quality ratios of national classification systems intercalibrated

Member State	National classification systems intercalibrated	IC type	Ecological Quality Ratios	
			High-good boundary	Good-moderate boundary
Belgium (Flanders)	Flemish macrophyte assessment system	All types	0.80	0.60
Denmark	Danish Lake Macrophytes Index	All types	0.80	0.60
Estonia	Estonian surface water ecological	LCB1	0.78	0.52

Member State	National classification systems intercalibrated	IC type	Ecological Quality Ratios	
			High-good boundary	Good-moderate boundary
	quality assessment – lake macrophytes	LCB2	0.76	0.50
Germany	Verfahrensanleitung für die ökologische Bewertung von Seen zur Umsetzung der EG-Wasserrahmenrichtlinie: Makrophyten und Phytobenthos (Phylib), Modul Makrophyten	All types	0.80	0.60
Lithuania	Lithuanian macrophyte assessment method	All types	0.75	0.50
Latvia	Latvian macrophyte assessment method	All types	0.80	0.60
Netherlands	WFD-metrics for natural water types	All types	0.80	0.60
Poland	Macrophyte based indication method for lakes - Ecological Status Macrophyte Index ESMI (multimetric)	All types	0.68	0.41
United Kingdom	LEAFPACS lake macrophyte classification tool*	All types	0.80	0.66

*Will be used in England, Wales and Scotland

Table 7.5 Correspondence between common intercalibration types and common boundaries to the national typologies/assessment systems

	LCB1	LCB2
BE-FL	Type AW-e, AW-om	Type Ai Types AMI-e, AMI-om
DE	Type TKg 13 Type TKg 10	Type TKp
DK	Type 10	Type9
EE	Type III	Type II
LT	Type II Type III	Type I
LV	Type 5 Type 6 Type 9	Type 1 Type 2
NL	M20 M21	M14 M27
PL	Part of 2a, 3a, 5a, 7a (only stratified with mean depth >3)	Part of 2b, 3b, 4, 5b, 6b, 7b (only non-stratified with mean depth <3)
UK	HAS (alk > 0.1mEq/l, depth 3-15 m)	HAVS (alk >0.1mEq/l, depth < 3m)

The harmonisation process to meet the comparability criteria for the different MS methods has been completed

8. Description of IC type-specific biological communities

The GIG has described taxa descriptive for high and good status on one hand, and taxa descriptive for less than good status (moderate, poor, bad). In summary:

- This has resulted in a list of taxa that occur for more than 2/3 in lakes with EQR of the PCM >0.6. This list contains many charophyte taxa and a number of Potamogeton species, as well as several others. These are the taxa that are according to the common view of the member states, considered as descriptive for good and high status, and are included in the indicators for good ecological status used by the national methods, and that disappear with decreasing PCM.
- On the other hand there is a large number of taxa that occur both at PCM>0.6 and PCM<0.6. These are considered the tolerant taxa. There are very few taxa that mainly (>2/3) occur at PCM<0.6.
- To describe borderline communities is considered an inherent impossibility, as at these borderlines the changes occur, and there is usually a mixture of species indicative for good and moderate status.

Background

As part of the 2nd phase of intercalibration, the GIGs are required to provide a narrative description of communities at borderline conditions between Good and Moderate status. However, since borderline conditions reflect a transition between good and moderate conditions and therefore reflect the position along the gradient where large changes in the presence of taxa occur, a description of borderline communities themselves seems an inherent impossibility. Therefore it was agreed (Ecostat, October 2011) that GIGs can instead provide a narrative description of communities at high, good and less than good status, with a list of taxa that show preference for these conditions. Then the emphasis can be put on the differences between taxa occurring at high, good and less than good status. This then reflects the (dis)appearance and of taxa along the EQR gradient and the pressures that the EQR is responsive to.

This section provides the analysis to come to a more narrative description of the common view of the member states participating in the Central-Baltic GIG lake macrophytes group of what macrophyte communities look like under good and moderate status

Selection of taxa to describe high, good and moderate conditions

We analysed the frequency distribution of taxa over the gradient of the PCM (= pseudo common metric, which is the average standardised EQR of all available assessments by

all intercalibrated member state methods after benchmark standardisation). This frequency distribution was calculated from the lake(year)s in which the taxa were found,

Taxa occurring mainly at PCM>0.8 are considered indicative for high status, taxa occurring mainly at a PCM 0.6 - 0.8 to be descriptive for Good status, and taxa occurring mainly at PCM<0.6 Taxa occurring over the whole PCM gradient are considered to be insensitive.

Method

The CBGIG Macrophytes common database was used for this analysis. Assessments of lakes by all intercalibrated member states methods (BE-FL, UK, NL, DK, GE, PL, LT, LV, EE) were transformed to standardised EQR values and corrected for country effects by continuous benchmark standardisation. The average EQR of all assessments is referred to as the PCM (scale 0-1, with H/G boundary at EQR=0.8; G/M boundary at EQR=0.6). The gradient along this PCM is used for further analysis of the occurrence and disappearance of taxa.

For all taxa the lowest, 25-percentile, median(=50%-percentile), 75-percentile, and highest PCM value of the lake years in which a taxa occurred were calculated. Only taxa that occurred in at least 7 lake(year)s for either LCB1 and LCB2 from the CBGIG common database were selected.

Frequency distributions of taxa on the PCM scale were calculated from the number of lake(year)s with PCM>0.6 (good and high status) and PCM<0.6 (moderate, poor and bad status).

Results and discussion

The lowest, 25-percentile, median(=50%-percentile), 75-percentile, and highest PCM value of individual taxa are listed in Table 8.1 (LCB1) and (LCB2), where taxa are sorted after their median values. Taxa in the upper parts of Table 8.1 *and have* the highest frequency of occurrence at less than good status (median value <0.6). However, most taxa even in the upper part of the Table 8.1 and Table 8.2 also occur for a considerable fraction at PCM >0.6, and none of them have a median below 0.5. They therefore cannot be considered as descriptive for less than good status, but rather as taxa indifferent to the PCM value and hence for the pressures to which the PCM is responsive.

On the other hand there is a considerable number of taxa in the lower parts of the tables, with high median PCM that can be considered as descriptive for Good status. They occur only for a small part at PCM's < 0.6. These reflect the taxa that disappear from the communities going down the PCM gradient. There are no taxa found to be exclusively descriptive for High status. This may be due to the relatively small number of lake years in the CBGIG database with PCM>0.8.

Many taxa however show a wide distribution over the PCM gradient.

The selection of descriptive taxa is based on frequency of occurrence at either PCM>0.6 and PCM<0.6, Taxa are considered descriptive for less than good status if more than

2/3 of the lake-years in which they occur have a PCM < 0.6. Taxa that are considered descriptive for good status are selected if more than 2/3 of the lake-years in which they occur have a PCM>0.6.

With these criteria, 39% and 32% of the taxa in Table 8.1 and Tbel 8.2. are considered descriptive for good and high status in LCB1 and LCB2 respectively. On the other hand only one out of 61 taxa is descriptive for less than good status in LCB1, and only 6 out of 58 for LCB2, including filamentous algae (Table 8.4).

The number of sites where the pseudo common metric was >0.8 is quite small to do a similar analysis for high status. Also, the taxa that are descriptive for good status tend to occur at the PCM range from 0.6 up to the maximum. Taxa that are indicative solely for high status can therefore not be assigned, but would be a subset of the list in Table 8.3, where taxa closest to the bottom in Table 8.1 and Table 8.2. are the most indicative for high status.

The majority of the taxa descriptive for good status are the same for LCB1 and LCB2 (Table 8.3). Some taxa were found to be descriptive for only one lake type.

Most of the taxa selected as descriptive for good status could be expected into this selection because they are generally incorporated in national metrics as indicators for good ecological status (mainly charophytes and several Potamogeton species), and therefore reflect the common view of the member states on what macrophyte communities in lakes should look like. The national assessment methods only use to a lesser extent taxonomic indicators for moderate, poor or bad status (these states are mainly associated with a reduction of macrophyte abundance). This is reflected in the small number of taxa that were selected as descriptive for less than good status..

Table 8.1 Percentiles of taxa along the PCM gradient for LCB1. Taxa are sorted to increasing median value. Cells in columns with percentiles are coloured according to their quality classes (red = bad, orange = poor, yellow = moderate, green = good, blue =high). Cells in columns with fractions for status ≤M and ≥G are coloured yellow and green respectively when they are > 0.66.

	Percentiles					Fractions	
	low	25%	med	75%	high	≤M	≥G
Ranunculus aquatilis	0.38	0.52	0.55	0.62	0.74	0.67	0.33
Potamogeton sp.	0.46	0.5	0.55	0.62	0.66	0.57	0.43
Lemna minor	0.29	0.49	0.56	0.67	0.74	0.59	0.41
Zannichellia palustris	0.35	0.53	0.56	0.7	0.79	0.56	0.44
Butomus umbellatus	0.32	0.46	0.56	0.65	0.79	0.6	0.4
Elodea nuttallii	0.35	0.49	0.57	0.69	0.76	0.53	0.47
Filamentous algae	0.24	0.5	0.58	0.69	0.79	0.55	0.45
Menyanthes trifoliata	0.42	0.52	0.58	0.65	0.79	0.59	0.41
Spirodela polyrhiza	0.41	0.55	0.59	0.69	0.72	0.62	0.38
Enteromorpha	0.38	0.49	0.59	0.65	0.74	0.5	0.5

	Percentiles					Fractions	
	low	25%	med	75%	high	≤M	≥G
Persicaria amphibia	0.29	0.51	0.59	0.67	0.79	0.52	0.48
Sparganium erectum	0.28	0.5	0.6	0.65	0.79	0.53	0.47
Nuphar lutea	0.28	0.52	0.6	0.67	0.8	0.53	0.47
Nymphaea alba	0.32	0.52	0.6	0.67	0.79	0.51	0.49
Ceratophyllum demersum	0.17	0.55	0.62	0.68	0.85	0.46	0.54
Nymphaea candida	0.51	0.57	0.62	0.69	0.8	0.46	0.54
Hydrocharis morsus-ranae	0.17	0.55	0.62	0.66	0.77	0.48	0.53
Sparganium emersum	0.35	0.57	0.62	0.68	0.74	0.47	0.53
Nuphar pumila	0.41	0.55	0.62	0.68	0.79	0.47	0.53
Schoenoplectus lacustris	0.29	0.55	0.62	0.68	0.8	0.45	0.55
Potamogeton crispus	0.46	0.53	0.62	0.68	0.79	0.47	0.53
Potamogeton perfoliatus	0.35	0.55	0.63	0.7	0.85	0.42	0.58
Potamogeton obtusifolius	0.53	0.56	0.63	0.7	0.75	0.38	0.63
Ceratophyllum submersum	0.17	0.57	0.63	0.69	0.77	0.36	0.64
Lemna trisulca	0.46	0.59	0.63	0.69	0.79	0.33	0.67
Myriophyllum spicatum	0.32	0.56	0.64	0.7	0.8	0.38	0.62
Potamogeton natans	0.41	0.57	0.64	0.7	0.8	0.38	0.62
Ranunculus lingua	0.52	0.59	0.64	0.66	0.68	0.38	0.63
Elodea canadensis	0.24	0.54	0.64	0.69	0.79	0.38	0.62
Ranunculus circinatus	0.42	0.56	0.64	0.7	0.8	0.35	0.65
Chara sp.	0.39	0.59	0.64	0.68	0.79	0.29	0.71
Potamogeton berchtoldii	0.53	0.58	0.64	0.68	0.79	0.4	0.6
Myriophyllum verticillatum	0.5	0.6	0.64	0.72	0.85	0.32	0.68
Sagittaria sagittifolia	0.35	0.58	0.64	0.7	0.79	0.36	0.64
Potamogeton pusillus	0.39	0.54	0.64	0.73	0.79	0.43	0.57
Potamogeton pectinatus	0.29	0.56	0.64	0.7	0.85	0.35	0.65
Potamogeton trichoides	0.49	0.6	0.65	0.74	0.79	0.31	0.69
Potamogeton lucens	0.45	0.58	0.65	0.71	0.8	0.34	0.66
Potamogeton compressus	0.52	0.58	0.65	0.69	0.79	0.4	0.6
Fontinalis antipyretica	0.44	0.6	0.65	0.7	0.8	0.26	0.74
Najas marina	0.42	0.61	0.65	0.73	0.85	0.24	0.76
Chara virgata	0.46	0.59	0.66	0.71	0.85	0.3	0.7
Myriophyllum alterniflorum	0.42	0.57	0.66	0.74	0.76	0.36	0.64
Stratiotes aloides	0.41	0.61	0.66	0.71	0.85	0.25	0.75
Chara vulgaris	0.54	0.64	0.66	0.73	0.79	0.09	0.91
Chara globularis	0.48	0.63	0.66	0.73	0.79	0.22	0.78
Utricularia	0.48	0.59	0.67	0.71	0.8	0.29	0.71
Chara fragilis	0.53	0.63	0.67	0.73	0.79	0.12	0.88

	Percentiles					Fractions	
	low	25%	med	75%	high	≤M	≥G
Utricularia vulgaris	0.49	0.63	0.68	0.71	0.79	0.24	0.76
Potamogeton friesii	0.59	0.64	0.68	0.72	0.79	0.06	0.94
Potamogeton praelongus	0.51	0.62	0.68	0.71	0.79	0.18	0.82
Charophyta	0.39	0.63	0.69	0.73	0.85	0.16	0.84
Eleocharis acicularis	0.46	0.51	0.69	0.7	0.74	0.43	0.57
Nitellopsis obtusa	0.55	0.64	0.7	0.75	0.85	0.11	0.89
Chara aspera	0.59	0.63	0.71	0.75	0.79	0.2	0.8
Chara contraria	0.54	0.66	0.71	0.75	0.85	0.1	0.9
Chara tomentosa	0.57	0.68	0.73	0.76	0.79	0.13	0.88
Potamogeton filiformis	0.61	0.66	0.73	0.78	0.85	0	1
Chara rudis	0.59	0.64	0.73	0.77	0.85	0.08	0.93
Nitella flexilis	0.61	0.69	0.73	0.76	0.79	0	1
Chara hispida	0.6	0.72	0.76	0.77	0.79	0.11	0.89

Table 8.2 Percentiles of taxa along the PCM gradient for LCB2. Taxa are sorted to increasing median value. Cells in columns with percentiles are coloured according to their quality classes (red = bad, orange = poor, yellow = moderate, green = good, blue =high). Cells in columns with fractions for classes ≤M and ≥G are coloured yellow and green respectively when they are >0.66.

	Percentiles					Fractions	
	low	25%	med	75%	high	≤M	≥G
Lemna minuta	0.3	0.34	0.51	0.62	0.82	0.7	0.3
Persicaria amphibia	0.28	0.44	0.53	0.61	0.74	0.73	0.27
Sparganium erectum	0.17	0.38	0.54	0.65	0.9	0.64	0.36
Nymphoides peltata	0.42	0.52	0.54	0.62	0.73	0.67	0.33
Lemna minor	0.27	0.42	0.54	0.64	0.84	0.66	0.35
Filamentous algae	0.22	0.48	0.56	0.64	0.78	0.69	0.31
Nymphaea alba	0.31	0.49	0.56	0.67	0.9	0.61	0.38
Zannichellia palustris	0.28	0.48	0.56	0.64	0.8	0.68	0.32
Elodea nuttallii	0.32	0.51	0.57	0.63	0.82	0.65	0.35
Enteromorpha	0.19	0.49	0.57	0.66	0.71	0.64	0.36
Nuphar pumila	0.38	0.52	0.57	0.69	0.76	0.6	0.4
Callitriche agg.	0.29	0.5	0.58	0.66	0.77	0.63	0.38
Potamogeton pusillus	0.39	0.52	0.58	0.65	0.8	0.56	0.44
Potamogeton crispus	0.27	0.5	0.58	0.66	0.8	0.54	0.46
Nuphar lutea	0.17	0.49	0.58	0.66	0.9	0.58	0.42
Sagittaria sagittifolia	0.31	0.52	0.58	0.64	0.77	0.68	0.32

	Percentiles					Fractions	
	low	25%	med	75%	high	≤M	≥G
Butomus umbellatus	0.33	0.46	0.59	0.63	0.71	0.58	0.42
Ceratophyllum demersum	0.21	0.53	0.6	0.66	0.78	0.52	0.48
Ranunculus lingua	0.51	0.57	0.6	0.7	0.75	0.55	0.45
Elodea canadensis	0.28	0.54	0.61	0.69	0.81	0.5	0.5
Myriophyllum spicatum	0.27	0.54	0.61	0.69	0.82	0.47	0.53
Sparganium emersum	0.26	0.53	0.62	0.69	0.9	0.46	0.55
Spirodela polyrhiza	0.29	0.56	0.62	0.69	0.84	0.45	0.55
Lemna trisulca	0.3	0.54	0.62	0.67	0.84	0.49	0.51
Schoenoplectus lacustris	0.18	0.54	0.62	0.69	0.84	0.47	0.53
Hydrocharis morsus-ranae	0.28	0.56	0.62	0.7	0.84	0.4	0.6
Ceratophyllum submersum	0.34	0.51	0.62	0.65	0.71	0.44	0.56
Potamogeton pectinatus	0.29	0.54	0.63	0.68	0.9	0.47	0.53
Nymphaea candida	0.45	0.55	0.63	0.7	0.84	0.44	0.56
Potamogeton perfoliatus	0.31	0.56	0.63	0.7	0.81	0.42	0.57
Najas marina	0.43	0.55	0.64	0.67	0.72	0.46	0.54
Ranunculus circinatus	0.34	0.56	0.64	0.67	0.8	0.47	0.54
Fontinalis antipyretica	0.37	0.57	0.64	0.68	0.78	0.3	0.7
Potamogeton berchtoldii	0.41	0.55	0.64	0.7	0.82	0.41	0.59
Chara sp.	0.43	0.56	0.64	0.69	0.9	0.36	0.64
Potamogeton lucens	0.31	0.59	0.64	0.7	0.9	0.31	0.69
Chara vulgaris	0.54	0.57	0.64	0.7	0.77	0.43	0.57
Potamogeton natans	0.45	0.58	0.64	0.71	0.84	0.36	0.63
Stratiotes aloides	0.48	0.58	0.64	0.7	0.9	0.3	0.7
Potamogeton obtusifolius	0.39	0.59	0.65	0.73	0.82	0.28	0.73
Chara contraria	0.51	0.59	0.65	0.68	0.7	0.31	0.69
Chara globularis	0.47	0.6	0.66	0.7	0.8	0.26	0.74
Hippuris vulgaris	0.59	0.63	0.67	0.69	0.81	0.14	0.85
Nitella sp	0.55	0.63	0.67	0.74	0.8	0.14	0.85
Myriophyllum verticillatum	0.55	0.63	0.67	0.77	0.82	0.13	0.86
Charophyta	0.43	0.61	0.67	0.73	0.9	0.24	0.76
Utricularia vulgaris	0.52	0.64	0.67	0.73	0.84	0.19	0.81
Chara tomentosa	0.56	0.64	0.68	0.74	0.8	0.13	0.87
Nitellopsis obtusa	0.56	0.64	0.68	0.71	0.8	0.13	0.87
Nitella flexilis	0.51	0.61	0.69	0.72	0.81	0.25	0.76
Potamogeton friesii	0.6	0.65	0.69	0.73	0.8	0	1
Utricularia	0.48	0.62	0.7	0.75	0.81	0.2	0.8
Chara aspera	0.64	0.68	0.7	0.75	0.81	0	1
Potamogeton compressus	0.5	0.61	0.71	0.76	0.84	0.25	0.75

	Percentiles					Fractions	
	low	25%	med	75%	high	≤M	≥G
Menyanthes trifoliata	0.49	0.57	0.71	0.78	0.9	0.31	0.69
Chara hispida	0.64	0.68	0.73	0.78	0.8	0	1.01
Potamogeton gramineus	0.59	0.69	0.73	0.78	0.81	0.11	0.89
Potamogeton praelongus	0.6	0.69	0.75	0.8	0.84	0.07	0.93

Table 8.3 Selected taxa to describe good condition. These are the taxa that disappear down the PCM gradient, and occur for > 2/3 at PCM >0.6 for either LCB1 or LCB2 or both. Y = >2/3, N = < 2/3, - = < 7 sites (cannot be determined)

Taxa / Type	LCB1	LCB2		LCB1	LCB2
Chara aspera	Y	Y	Najas marina	Y	N
Chara contraria	Y	Y	Nitella flexilis	Y	Y
Chara fragilis	Y	-	Nitella sp	-	Y
Chara globularis	Y	Y	Nitellopsis obtusa	Y	Y
Chara hispida	Y	Y	Potamogeton compressus	-	Y
Chara rudis	Y	-	Potamogeton filiformis	Y	-
Chara sp.	Y	Y	Potamogeton friesii	Y	Y
Chara tomentosa	Y	Y	Potamogeton gramineus	-	Y
Chara vulgaris	Y	N	Potamogeton lucens	N	Y
Chara virgata	Y	-	Potamogeton obtusifolius	N	Y
Charophyta	Y	Y	Potamogeton praelongus	Y	Y
Fontinalis antipyretica	Y	Y	Potamogeton trichoides	Y	-
Hippuris vulgaris	-	Y	Stratiotes aloides	Y	Y
Menyanthes trifoliata	N	Y	Utricularia	Y	Y
Myriophyllum verticillatum	Y	Y	Utricularia vulgaris	Y	Y

Table 8.4 Taxa that occur for more than 2/3 at PCM < 0.6.

Taxa	Type
Ranunculus aquatilis	LCB1
Lemna minuta	LCB2
Persicaria amphibia	LCB2
Nymphoides peltata	LCB2
Filamentous algae	LCB2
Zannichellia palustris	LCB2
Sagittaria sagittifolia	LCB2

Annexes

A. Lake Macrophyte classification systems of Member States

A.1 Belgium: Flanders

Flemish macrophyte assessment system

For full details see Schneiders et al. (2004) and Leyssen et al. (2005). Internet source:

http://www.instnat.be/content/page.asp?pid=PUB_Rapporten

Indicators

Macrophyte taxonomic composition

Species composition covers all charophytes and all angiosperms classified as hydrophyte or phreatophyte, as well as selected aphreatophytes, mosses, liverworts and non-charophyte algae (Enteromorpha, Hydrodyction); cyanobacterial films and filamentous algae are also considered. All taxa included in the assessment are listed in Annex 1. Fourteen growth forms are distinguished: lemnid, large pleustophyte (incl. stratiotid, hydrocharitid, salvinid), submerse non-rooting (incl. ceratophyllid, ricciellid and some aquatic mosses), charid, magnopotamid, other rooting caulescent hydrophyte (incl. parvopotamid, myriophyllid, elodeid, batrachid and peplid), nymphaeid, vallisnerid, isoetid, small and medium-sized riparian plant, large monocotyledonous riparian plant, peat moss, cyanobacterial film.

Macrophyte abundance

The abundance of macrophytes in the aquatic and riparian zone are surveyed separately. The aquatic vegetation of the entire water body is considered to a depth of 4 m for deep (stratified) waters and to a depth of 2 m for shallow (fully mixed) waters; parts where vegetation growth is limited by substrate conditions (e.g. concrete flooring, very steep inclination) or intense shading may be excluded. The riparian vegetation is considered along the entire lake margin in the emerged zone between the water level and normal winter level; parts where plant growth is hampered by substrate may be excluded. The water surface of the part shallower than 4 or 2 m, respectively, is divided into surface segments with more or less homogeneous vegetation, morphology, substrate and adjacent land use. The relative surface area of these segments is determined (by GIS) and used as a weighting factor for the contribution of each segment to calculate the EQRs. Similar to the water surface, the emerged zone is divided into stretches; these are weighted by their length. Species composition and abundance of individual macrophytes are estimated in all segments and stretches using the scale shown in Table A.1.

Table A.1 Abundance scale for individual lake macrophytes in BE-FL.

Rare and occasional	1	very few individuals, insignificant quantity
Frequent	2	larger number of individuals, low quantity
Abundant	3	large number of individuals, substantial quantity

Co-dominant	4	large number of individuals, several species ± equally represented with very substantial quantity
Dominant	5	large number of individuals, only species with very substantial quantity

Additionaly, the total abundance of submerged vegetation is estimated for each segment as in Table A.2, and the growth forms occurring in the water are listed.

Table A.2 Abundance scale for submerged lake vegetation in BE-FL

0	(nearly) absent
1	scarce
2	(fairly) abundant but not filling the water column
3	filling the entire water column *or* filamentous algae covering most part of bottom or surface

Bacterial tufts

Presence is noted (cf. metric 'growth forms' for assessment).

Summary

The EQR is derived from 4 complementary metrics, all taking the form of separate EQRs (scaled 0-1):

- relative abundance of type-specific taxa,
- relative abundance of disturbance indicators, selected according to type,
- diversity of growth forms relative to expectations, specified according to type, and,
- development of submerse vegetation.

The relative abundance of type-specific taxa and disturbance indicators are calculated for the riparian zone and for the aquatic zone; diversity of growth forms and development of submerged vegetation are only relevant for the aquatic zone. All the metrics are considered equally important and are combined by taking the lowest value for any one of them as the final EQR ('one out, all out'). A standard list of macrophytes is used for the calculation of the first two metrics (see Annex 1). Macrophyte assessment is not constrained by requiring the presence of a minimum number of species or an abundance treshold. Macrophytes and phytobenthos are assessed independently of each other and considered on an equal basis using the 'one out, all out' principle.

Monitoring

Strategy

The entire water body is considered, including its riparian zone.

When, frequency?

Once a year. Preferably in summer (mid June to August), possibly extending into early Autumn for certain sites. Depending on the vegetation composition or observed phenology, an additional visit may be made in spring (May) or early summer to allow complementary observations.

Equipment

Vegetation is surveyed from the shore, wading through the water, and/or from a boat, whatever is most appropriate or possible. A 50 cm broad mesh-covered rake on a telescopic handle (up to 4 m long) or a similar double-sided rake fixed to a 20 m rope are used where necessary. If necessary, a variable number of fixed transects, chosen to cover spatial variation as completely as possible, are sampled in deeper parts from a motor boat or by wading. Transect observations are supplemented by point observations to asses distribution patterns. If a boat is used in deep water, the double rake is thrown perpendicular to the transect twice or three times on each side every 10 or 20 m; transect width is ca. 10 m.

Analysis

Identification is done in the field, if possible, using appropriate keys, magnifying glass,... If necessary, this is validated or completed in the laboratory. In case identification proves impossible due to lack of certain parts at the time of survey, additional visits to the site are made in a more appropriate season. Voucher material is retained, dried or in a preserving liquid, of difficult or dubious specimens. Angiosperms, charophytes, mosses and liverworts are identified to species level. Some non-charophyte algae are considered at genus level (Enteromorpha, Hydrodyction); cyanobacterial films and filamentous algae are recognized by general aspect, only.

Reporting

No procedures have been established, yet.

Assessment

Data requirements

Attribution of the site to a water type. Map of water-surface segments and shoreline stretches; relative weighths for segments and stretches. Macrophyte survey data for individual segments and strectches.

Calculation

The index for **type-specific species composition** (TS) indicates the relative abundance-weighted agreement between observed species composition and that expected for the water type. For each water type, a list of species which may occur in the type in the absence of human disturbance was compiled (0: species does not occur naturally; 1:

occurrence possible in natural conditions). Invasive neophytes are never considered to be type specific (see Annex 1). For each segment and stretch the index is given by:

$$TS = \frac{\sum_{i=1}^{n} (Ab_i \cdot ts_i)}{\sum_{i=1}^{n} Ab_i}$$

Ab_i : abundance of taxon i;

ts_i : type-specificity value of taxon i (0 or 1);

n : number of observed taxa included in the standard list;

TS : index for type specificity.

The EQR is derived for riparian and water vegetation, separately, by weighing the scores of stretches or segments by their relative importance, giving a set of two EQRs: TS_o and TS_w.

The indexecartje benthos'gelijkheden open houdenescvoeren orgevoerd worden op hoger niveause water= en oeervetetaties37373737373737373737373737373737373737 for the **abundance of disturbance indicators** (V) gives the relative abundance-weighted occurrence of pollution (sewage, eutrophication, acidification) indicating species. Disturbance indicators are listed for each water type, separately (0: no marked indication; 1: deteriorating quality with increasing abundance); only the most reliable disturbance indicators are included. Type-specific taxa can still be disturbance indicators. For each segment and stretch the index is given by:

$$V = 1 - \frac{\sum_{i=1}^{n} (Ab_i \cdot v_i)}{\sum_{i=1}^{n} Ab_i}$$

Ab_i : abundance of taxon i;

v_i : perturbation score of taxon i (0 or 1);

n : number of observed taxa included in the standard list;

V : index for disturbance.

The index is derived for riparian and water vegetation, separately, by weighing the scores of stretches or segments by their relative importance, yielding two EQRs: V_o and V_w.

For each water type, an expected spectrum and diversity of macrophyte **growth forms** (GV) is described for the aquatic vegetation (= only vegetation in the water at the time of surveying, not the riparian vegetation; Table A.2). Only the presence of growth forms is taken into account, not their abundance. For each water type (*cf*. Jochems *et al*. 2002),

the number and expected combination of growth forms is scored according to Table A.5. Presence of cyanobacterial films is scored negatively. The scores are summed and the number of species indicating a more exceptional ecological quality (as indicated in Annex 1) is added. The resulting sum is used to calculate the ratio to the 'basic sum' for the water type. A list is provided of the possible growth forms for all taxa considered in the assessment, but their actual growth form should be noted in the field.

The fourth EQR considers submerged **vegetation development** (VO). From the abundance of submerged vegetation (cf. Table A.2, a score is derived for each segment according to Table A.3. A weighted average of these scores is calculated for the entire lake, which is then transformed using Table 5.

Table A.3 Scoring of submerged vegetation abundance.

abundance	score
0	0
1	1
2	2
3	1

Table A.4 Conversion of the weighted submerged vegetation abundance score to an EQR.

average score	EQR
1,6-2	0,8-1
1,2-<1,6	0,6-<0,8
0,8-<1,2	0,4-<0,6
0,4-<0,8	0,2-<0,4
0-<0,4	0-<0,2

Table A.5 Scoring of growth forms for selected water types.

BE-FL type	Ami-om mixed, alkaline, moderate ionic concentration, lower background nutrients	Ami-e mixed, alkaline, moderate ionic concentration, higher background nutrients	Ai mixed, alkaline, higher ionic concentration	Aw-om stratified, lower background nutrients	Aw-e stratified, higher background nutrients
GIG type	**LCB-2**		**LCB-1**		
lemnid	1	1	1	1	1
large pleustophyte	1	1	1	-	-
submerse, non-rooting	1	1	1	-	1
charid	2	2	2	2	2
magnopotamid	1	1	1	2	2
other rooting caulescent hydrophtyte	1	1	1	1	1
nymphaeid	1	1	1	1	1
vallisnerid	-	-	-	-	-
isoetid	-	-	-	2	-
small and medium-sized riparian plant	1	1	1	1	1
large monocot	1	1	1	1	1
peat moss	-	-	-	1	-
BASIC SUM	10	10	10	12	10
cyanobacterial film	-1	-1	-1	-1	-1

(alkalinity < or > 2 meq L^{-1} can be used as a rough guideline to distinguish Ami from Ai types)

The EQR scale is divided into five equal classes for all metrics (Table A.6).

Table A.6 EQR values in relation to classification.

class	EQR = minimum (TS_W, TS_o, V_o, V_w , GV, VO)
high	0.80 – 1
good	0.60 – <0.80
moderate	0.40 – <0.60
poor	0.20 – <0.40
bad	0 – <0.20

The **overall quality** (EQR) for a lake is given by the lowest scoring metric ('one out – all out' principle).

Example

Site descriptors:

- regional type: Ami-e (LCB-2), maximum depth 1.8 m;
- riparian zone: 2 stretches; A 750 m, B 250 m;
- aquatic zone: 2 segments; segment A 46875 m^2, segment B 15625 m^2
- vegetation data : see Table A.7.

Table A.7 Example data for an imaginary Ami-e site.

Relative importance	Riparian zone		Aquatic zone	
	Stretch A	Stretch B	Segment A	Segment B
	75 %	25 %	75 %	25 %
presence cyanobacterial films	not rel.	not rel.	-	+
abundance submerged vegetation < 2 m (0-3)	not rel.	not rel.	2	1
Alisma plantago-aquatica	-	1	1	-
Phragmites australis	2	5	1	-
Urtica dioica	3	2	-	-
Ceratophyllum demersum	-	-	5	
Lemna minor	-	-	-	1
Nitella mucronata	-	-	1	-
Potamogeton acutifolius	-	-	-	1
P. pusillus	-	-	-	2

Metric 1 - TS: Alisma plantago-aquatica, Phragmites australis, Ceratophyllum demersum, Lemna minor, Nitella mucronata, Potamogeton acutifolius and P. pusillus are type specific (cf. Annex 1).

- TS_o: 0.75(2/5) + 0.25(6/8) = 0.3 + 0.1875 = 0.4875 (moderate)
- TS_w: 0.75(8/8) + 0.25(4/4) = 0.75 + 0.25 = 1 (high)

Metric 2 - V: *Urtica dioica*, *Ceratophyllum demersum* and *Lemna minor* are disturbance indicators (cf. Annex 1, S).

- V_o = 1 - (0.75(3/5) + 0.25(2/8)) = 1 - (0.5625 + 0.0625) = 0.375 (poor)
- V_w = 1- (0.75(5/8) + 0.25(1/4)) = 1 - (0.8333 + 0.0625) = 0.1042 (bad)

Metric 3 - GV: cf. Table A.5.

- present are: lemnid (*Lemna*), submerse non-rooting (*Ceratophyllum*), charid (*Nitella*), other rooting caulescent hydrophyte (both *Potamogeton* spp.), small-medium sized riparian (*Alisma*), large monocotyledonous (*Phragmites*): sum = 7;
- one species indicates exceptional quality (*Potamogeton acutifolius*; Annex 1, B): sum = 7 + 1 = 8;
- cyanobacterial films are present: sum = 8 – 1 = 7
- basic sum for Ami-e is 10 (Table A.5): GV = 7/10 = 0.70 (good)

Metric 4 - VO:

- score: (0.75 x 2) + (0.25 x 1) = 1.75
- VO = 1.75/2 = 0.875 (high)

Final EQR: MIN(0.4875, 1, 0.375, 0.1042, 0.70, 0.875) = 0.1042 (bad; due to V_w)

Reference, H/G, G/M

Contemporary references are absent or extremely scarce for all types prohibiting a spatial reference approach. The assessment is therefore based on vegetation attributes which can be estimated from the remaining sites presenting higher quality, historical records, and information on the behaviour of species and the structural response of aquatic vegetations in relation to pressures, making as few assumptions as possible. This information is integrated by expert judgement. Expectations for growth form diversity are based mainly on expert judgement, envisaging a functionally 'complete' system with undisturbed vegetation succession (incl. terrestrialization) for each water type. Development of submerged vegetation is added as a robust semi-quantitative assessment of the expected response in productivity to eutrophication, mainly, with both reduced and superfluous abundance leading to a lower status assessment. Boundary values are set by expert judgement with the requirement that good status can only be attained if taxa which are not specific for the water type or indicate disturbance remain notably less abundant relative to type-specific and non-disturbance species.

Correlation to pressures

The EQR shows a highly significant negative correlation to measured pressure-related variables, such as chlorophyl concentration and TP. Indication of high or good status is unlikely to occur if the values of such variables are markedly elevated (e.g. Figure A.1). However, the degree of submerged vegetation development (VO) is an essential element of the EQR. If this metric is not taken into account, such relations deteriorate particularly in the range from bad to moderate. The EQR is not specifically or exclusively aimed at detecting eutrophication, but will also reflect the impact of other kinds of pollution, exclusion of native by invasive species, functional impairment and habitat loss by other biological pressures.

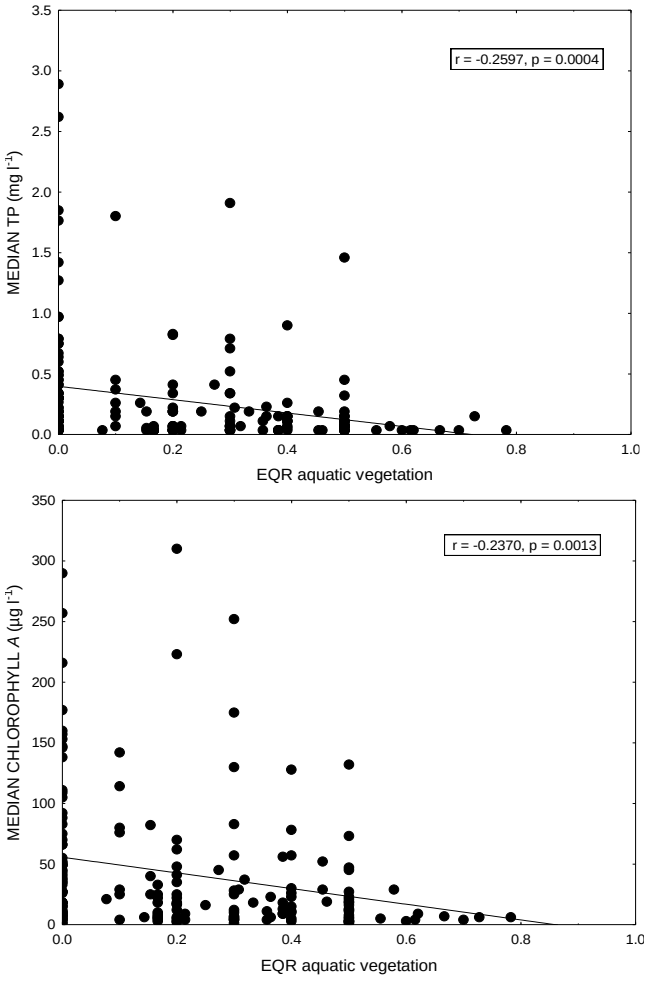

Figure A.1 EQR values for the aquatic vegetation in relation to TP and chlorophyll concentration in alkaline BE-FL water bodies (G/M at EQR 0.6).

Differences between national data and assessment vs. GIG data and assessment

Completeness of method

Riparian vegetation can not be considered for the GIG data, as most MSs did not provide such data. All helophytes were removed from the relevées of the water vegetation and some additional taxa were left unconsidered in the final data as well (e.g. *Pillularia*, *Nitella gracilis*, *Hydrodyction*, *Enteromorpha*, mosses). These alterations

may possibly influence the outcome of the BE-FL assessment, which considers the aquatic vegetation more completely. Presence of cyanobacterial films, and for some MSs abundance of filamentous algae are unknown, also. The lack of data on 'segment level' and the conversion to a less precise abundance scale (Table A.8) further constrain the assessment result. Development of submerged vegetation can not be inferred reliably from the GIG data and is not included in the reported results. The growth forms 'medium-sized riparian plant', and 'large monocotyledonous riparian plant' are assumed to be present in the aquatic vegetation of all the lakes.

Data transformation to GIG data base

The BE-FL abundance data are scaled-up to the entire water surface and converted according to Table A.8.

Table A.8 Conversion of BE-FL abundance scale to GIG abundance scale.

Original abundance	Abundance GIG
1-2	1
3	2
4-5	3

Assessment transformation to the GIG data base

VO can not be calculated from the available data, so the BE-FL GIG assessment only considers the metrics TS_W, V_w and GV. Lakes where both the summed abundance of submerged plants (thus excl. floating-leaved plants) and the abundance of individual submerged taxa are extremely low are excluded from the comparison because of the very high risk for a too positive classification. This selection can produce a bias towards higher values in the distribution of classification results, influencing the comparison by 'method 3'. The effect of leaving out VO can easily result in an overestimation of the EQR. With survey data from 221 BE-FL sites, the EQR values dropped by including an overall estimate of VO on average with 0.03 units for sites originally classified as bad status, with 0.09 units (almost ½ of a class) for sites of poor and moderate status, 0.19 units (almost 1 class) for 4 sites of good status and 0.33 units (> 1.5 class) for one site considered to be of high status by the other EQRs. The number of sites in each status class with both classification methods is shown in Figure A.2. In this case, changes in the classification at class level are most marked for the categories good, poor and bad.

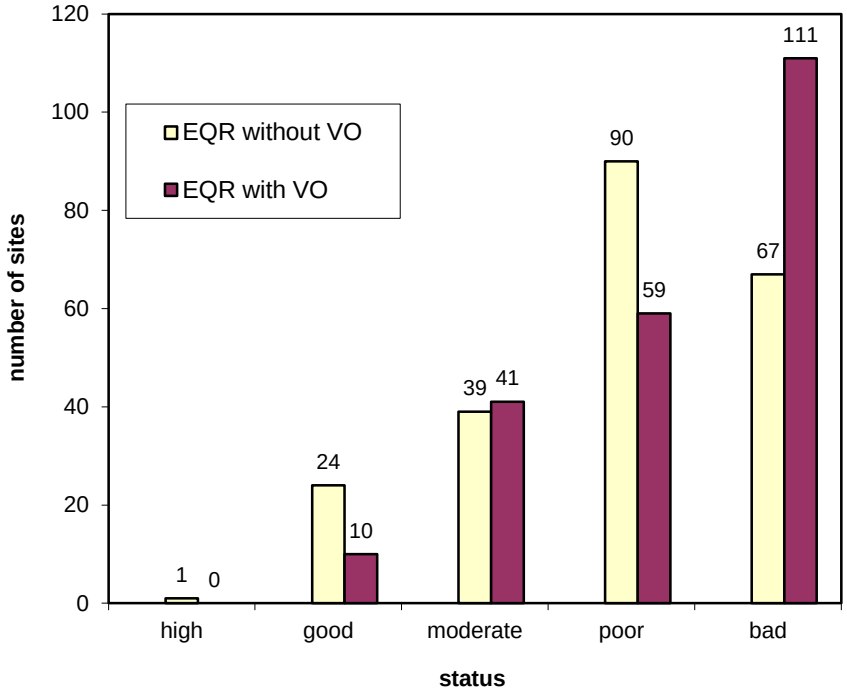

Figure A.2 The effect of including VO in the classification of BE-FL sites.

At the level of GIG lake types, the difference amounts, on average, to 0.11 ± 0.20 EQR units for LCB-1 sites (N=21) and to 0.10 ± 0.14 units for LCB-2 (123 sites), or a decrease with
about 1/2 of a class interval.

If the summed abundance of taxa that are not indigenous in BE-FL, nor present there as neophytes, exceeds 10 % of the total abundance no class or EQR is calculated. In case their summed abundance is less than 10 %, such taxa are excluded from the calculation of TS_W and V_w, but included for GV. Similary, some taxa can not be accounted for because of an insufficient degree of taxonomic discrimination (e.g. Charophyta, where at least an indication of the genus is required). Taxa for which only the growth form is considered by the BE-FL assessment of GIG sites are:

- for LCB-1: Callitriche hermaphroditica, Chara filiformis, C. intermedia, C. rudis, C. strigosa, C. tomentosa, Charophyta, Hydrilla verticillata, Isoetes lacustris, Potamogeton rutilus, P. x nitens, P. x suecicus, Sagittaria sagittifolia x natans, Utricularia, Nuphar x spenneriana;
- for LCB-2: Callitriche hermaphroditica, Chara intermedia, C. rudis, C. tomentosa, Charophyta, Isoetes lacustris, Najas flexilis, N. tenuissima, Potamogeton rutilus, P. vaginatus, P. x nitens, P. x sparganiifolius, Ranunculus confervoides, Sagittaria sagittifolia x natans, Nuphar x spenneriana, Nymphaea candida x tetragona, Utricularia, Trapa natans;
- for LCB-3 Callitriche hermaphroditica, Charophyta, Isoetes lacustris, Potamogeton rutilus, P. x nitens, Sparganium gramineum, S. angustifolium x gramineum, Utricularia, Nuphar x spenneriana.

To select between Aw-om and Aw-e as the 'most appropriate' regional type for non-BE-FL LCB-1 lakes, the following criteria are applied: Aw-om if EC < 300 µS; cm^{-1} and/or presence of *Eleocharis acicularis*, *Elatine* spp., *Littorella*, *Potamogeton alpinus*, *P. gramineus*, *Myriophyllum alterniflorum*, *Chara hispida*, *Utricularia minor* or *U. intermedia*; to choose between Ami-om and Ami-e for LCB-2: Ami-om in case of presence of *Chara aspera*, *C. hispida*, *C. tomentosa*, *Potamogeton alpinus*, *P. gramineus* or *Utricularia minor*. Eutrophied sites where such species have been lost can not be discerned from naturally more eutrophic lakes on this basis, which can lead to a too positive classification. With HU sites exluded, 35 % of the LCB-1 sites and 20.5 % of the LCB-2 sites are attributed to Aw-om and Ami-om, respectively. The assessment is more lenient with regard to trophic background conditions for the types Aw-e and Ami-e to which most of the lakes are referred to. Typological misclasifications will affect the results.

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Schneiders A., Denys L., Jochems H., Vanhecke L., Triest L., Es K., Packet J., Knuysen K., Meire P. (2004). Ontwikkelen van een monitoringsysteem en een beoordelingssysteem voor macrofyten in oppervlaktewateren in Vlaanderen overeenkomstig de Europese Kaderrichtlijn Water. Rapport Instituut voor Natuurbehoud IN.R.2004.1, Brussel.

A.2 Denmark: Danish Lake Macrophyte Index (DLMI)

Pressure addressed

Eutrophication. Data on DLMI relationship to total phosphorus concentrations has been demonstrated in the CB-intercalibration report (Milestone 6 report CBGIG macrophyte final, by Rob Portielje, December 2011).

Reference conditions

No reference lakes have been identified in Denmark, and in the CBGIG report it was concluded that the number of reference sites was considered to be insufficient, and also the TP range of the assigned reference sites was considered quite broad. Due to absence of Danish reference lakes, reference conditions in Danish lakes are set by expert judgment.

Danish lake makrophyte flora under nutrient poor conditions, which will be close to reference conditions are for LCB1 and LCB2 lakes dominated by the species presented in Table A9.

In LCB1 and LCB2 lakes the number of indicator species are: for lakes > 100 ha: ≥ 4, lakes 10-100 ha: ≥ 3 and lakes < 10 ha: ≥ 3 (Table A.10 and Table A.11)

In LCB1 lakes the max colonization (m) depth will > 7 m and in LCB2 lakes the coverage (% of total lake area) are > 40% (Table A.10 and Table A.11).

Which indicators are used?

Two types of indicators are used: macrophyte abundance and macrophyte taxonomic composition.

Macrophyte abundance

Macrophyte abundance indicators are based on the relative mean coverage of submerged macrophytes in shallow lakes (mean depth < 3m) and in deep lakes (mean depth > 3 m) on the maximum depth of colonization of submerged macrophytes.

Macrophyte taxonomic composition

The taxonomic composition of submerged, floating-leaved and free floating macrophytes is assessed for the whole lake at species level. Filamentous algae and mosses (apart from *Fontinalis antipyretica*) are not identified to species level, but their presence is recorded/. Number of species indicating nutrient poor conditions is recorded.

Composition and abundance of phytobenthos

Due to uncertainty about validation and lack of intercalibration results (for lake types), the metric for phytobenthos/the phytobenthos metric is not yet included in the assessment.

Bacterial tufts

Bacterial tufts are not used in the assessment of the quality element due to lack of data and information on suitable indicators and reference values.

Summary

The EQR is derived from 2 complementary metrics based on an abundance score and a taxonomic score:

- Macrophyte abundance (average coverage in shallow lakes and maximum depth of colonization in deep lakes).
- Presence of species indicative of nutrient poor conditions. Includes a list of 21 species.

Table A.9 Macrophyte indicator species indicative of nutrient poor conditions. Indicator species are here defined as species where at least 50% of the observations are from lakes with TP < 50 µg P/l and chlorophyll a < 20 µg/l, and where less than 25% of the observations are derived from lakes with TP > 100 µg P/l or chlorophyll a above 30 µg/l. This analyses is based on data from 233 Danish lakes.

Species type	Species
Isoëtids	*Isoetes lacustris* *I. echinospora* *Lobelia dortmanna* *Littorella uniflora*
Charophytes	*Chara tomentosa* *Nitella flexilis* *Nitella translucens*
Potamogeton	*Potamogeton natans f. submersus* *P. gramineus* *P. gramineus*perfoliatus* *P. alpinus* *P. praelongus* *P. filiformis*
Others	*Ranunculus peltatus ssp. peltatus* *R. aquatilis var. aquatilis* *Myriophyllum verticillatum* *M. alterniflorum* *Callitriche hermaphroditica* *C. hamulata* *Utricularia australis* *Elatine hexandra*

Table A.10 Calculation of points in deep lakes (LCB1/LCB3) used for calculating the total score and macrophyte-EQR.

For deep lakes (LCB1/LCB3): (mean depth > 3 m):									
Number of indicator species required to obtain 1-4 points (p)									
4 p		3 p		2 p		1 p			
> 100 ha: ≥ 4 10-100 ha: ≥ 3 < 10 ha: ≥ 3		> 100 ha: 3 10-100 ha: 2 < 10 ha: 2		> 100 ha: 2 10 -100 ha: 1 < 10 ha: 1		> 100 ha: 1 10- 100 ha: 1 < 10 ha: 0			
Max depth colonization (m) required to obtain 1-9 points									
9 p	8 p	7 p	6 p	5 p	4 p	3 p	2 p	1 p	0 p
> 7m	5-7 m	4-5 m	3-4 m	2.5-3 m	2-2.5 m	1.5-2 m	1-1.5 m	0-1 m	0*

(*) = no submerged macrophytes found

Table A.11 Calculation of points in shallow lakes (LCB2/LCB3) used for calculating the total score and macrophyte-EQR.

For shallow lakes (LCB2/LCB3) (mean depth ≤ 3 m):									
Number of indicator species required to obtain 1-4 points									
4 p		3 p		2 p		1 p			
> 100 ha: ≥ 4 10-100 ha: ≥ 3 < 10 ha: ≥ 3		> 100 ha: 3 10-100 ha: 2 < 10 ha: 2		> 100 ha: 2 10 -100 ha: 1 < 10 ha: 1		> 100 ha: 1 10- 100 ha: 1 < 10 ha: 0			
Coverage (% of total lake area) required to obtain 1-9 points									
9 p	8 p	7 p	6 p	5 p	4 p	3 p	2 p	1 p	0 p
> 40	30-40	15-30	7.5-15	3.5-7.5	2-3.5	1-2	0.5-1	0-0.5	0

How are these indicators monitored?

Strategy

The entire water body is considered. Macrophyte abundance and the presence of indicator species are based on investigations along transects representing the whole lake area. To supplement the taxa list a further effort is made to identify more species than those found on the transects. Number of total observation points and the extra time used to supplement the taxa list depend on lake size (Table A12)

Sampling strategy

Macrophyte data are obtained from transect investigations. Each lake is divided into a number of transects representing the whole lake area. The macrophyte monitoring is concentrated on vegetated areas (only few samplings in deep areas without vegetation to identify maximum growing depth). On each transects macrophytes are surveyed at a number of observations points either by SCUBA diving or boat using a water viewer and a rake with a rope. The number of observation points depends on lake area (Table A12)

Samples are taken once in the middle of the growing season, i.e. 1st July-15th August.

Macrophyte coverage at each observation point is estimated according to Table A.13.

Macrophyte species indicative of nutrient poor conditions is defined in Table A9.

The definition is based on the frequency distribution of individual species relative to the observed concentrations of total phosphorus and chlorophyll a in the lakes were they were found as described in the legend to Table A9.

Table A.12 Minimum number of observation points and time used to find additional species in each lake depending on lake area and monitoring programme.

	Intensively studied lakes		Extensively studied lakes	
Lake area (ha)	Observation points	Time for species (h)	Observation points	Time for species (h)
5-20	150	1.5	75	0.75
21-100	225	3	125	1.5
101-500	300	4.5	150	2.25
>500	375	4.5	200	2.25

Table A.13 The Danish species coverage scale used in shallow lakes.

Scale	% coverage	Description
0	0	No macrophytes
1	0-5	Few
2	5-25	Scattered
3	25-50	Common
4	50-75	Plenty
5	75-95	Covering
6	95-100	Completely covering

Assessment

Data requirements

For each lake data are needed on:

- Lake area
- Total species list of macrophytes (including submerged, floating-leaved, free-floating species)
- Mean coverage (as % of total lake area) if lake mean depth < 3 m
- Maximum depth of colonization if mean lake depth > 3 m.

Method of calculation

For each lake a macrophyte score is calculated based on Table A.10 and Table A.11 for shallow and deep lakes, respectively. The total macrophytes score to be obtained ranges between 0 and 13. A maximum of four points can be obtained by the presence of indicator species and a maximum of nine can be obtained by the abundance of macrophytes.

Final boundary, total score, ecological class and EQR

Final boundary settings, calculation of total score (based on Table A.10 and Table A.11), ecological class based on total score and macrophyte-EQR is shown in Table 14.

Table A.14 Calculation of final EQR (based on macrophytes)

Score (points)	Ecological class	Macrophyte-EQR
0	Bad	0.07
1	Bad	0.14
2	Poor	0.23
3	Poor	0.30
4	Poor	0.37
5	Moderate	0.44
6	Moderate	0.50
7	Moderate	0.57
8	Good	0.64
9	Good	0.70
10	Good	0.77
11	High	0.84
12	High	0.90
13	High	0.97

A.3 Estonia: Assessment of status of lakes on the basis of macrophytes

Which indicators are used?

Macrophyte composition:

The taxonomic composition of hydrophytes is assessed for angiosperms, mosses and charophytes in most cases on species level (sometimes lacking for mosses and charophytes). Large filamentous green algae are included on genus or higher level. Also emergent macrophytes and hygrophytes (hydrophilous plants growing outside from water edge or in temporarily flooded zone) are included. The amount and composition of emergent plants and hygrophytes may be indicative *e.g.* for LCB3 lakes.

Growth forms for hydrophytes are understood as not very strictly indicative. Following characterization of different groups forms the basis for our classification:

Bottom plants – isoetids (*Isoëtes, Lobelia*), mosses (*Fontinalis*, *Drepanocladus, Warnstorfia etc.*), charophytes (*Chara*, *Nitella, Nitellopsis etc.*) are the most sensitive, as they need favourable light and bottom conditions (oxygen, mineral sediment). Also many of small-sized amphibious species need open littoral (without tall emergent plants) and mineral sediments, characteristic of lakes of lower trophy levels. However, charophytes may be very abundant in nitrogen-rich but phosphorus-poor alkaline water bodies. In the most alkaline water bodies phosphorus may be bound into complex with carbonate compounds and is not available for producers. So in alkalitrophic charophyte-lakes enrichment with P may be hidden, and N-loading serious.

Elodeids = plants rooting in bottom, growing up to water surface and flowering there – waterweeds (*Elodea*), pondweeds (*Potamogeton*), milfoils (*Myriophyllum*), crowfoots

(*Ranunculus* = *Batrachium*) are related to high, good or moderate status. Generally (not all!) species with fine-divided leaves tolerate better turbid water, and some relatively weakly rooted turion-producing species as *Potamogeton friesii* are more tolerant to organic-rich sediments. The shoots of *P. friesii* may be decayed already in July, and the plant survives by turions. The indicators of high or good quality in this group are broad-leaved pondweeds such as *Potamogeton perfoliatus, P. lucens, P. praelongus, P. alpinus* and *P.gramineus*.

Ceratophyllids or weakly rooted plants – hornworts (*Ceratophyllum*), water soldier (*Stratiotes*), bladderworts (*Utricularia*) – are quite different regarding the indicativity. *Ceratophyllum* seems to be more indicative for shallow hard-water lakes of moderate or poor status, where it usually reflects accumulation of organic matter and oxygen-deficiency in bottom layer. In larger and deeper hard-water lakes the correlation with lake quality is not clear. *Stratiotes* is also usually connected with areas of more organic-rich sediments, but it is sensitive to anaerobic conditions. Among bladderworts, *Utricularia vulgaris* may grow in the lakes from high to moderate status; the other species seem to be more sensitive.

Lemnids or floating plants – duckweeds (*Lemna, Spirodela etc.*), frogbit (*Hydrocharis*), some liverworts (*Riccia, Ricciocarpus*) can grow in these lakes or their parts where nutrients are available from water, and in boreal region they are mostly characteristic of increased trophy level. However, indicativity of the species is very probably different. Most of them seem to prefer sheltered places rich in dissolved organic matter. *Spirodela polyrhiza* is a characteristic species of wastewater inflows in hard-water lakes. Some species, as *Lemna minor*, are found also on the surface of the brown-water lakes where pH is low (to 5.5). In such lakes abundant duckweeds and floating-leaved plants may be the single indicator of nutrient loading, as submerged plants are naturally absent.

Nymphaeids or floating-leaved plants – water lilies (*Nuphar, Nymphaea etc.*), amphibious bistort (*Persicaria amphibia* = *Polygonum amphibium*), bur-reed (*Sparganium*) and broad-leaved pondweed (*Potamogeton natans*) are very different regarding indicativity. This group includes more or less "cosmopolitic" species, as *Nuphar lutea*, as well as extremely sensitive strictly adapted species, as *Sparganium angustifolium*. The first can grow at very different alkalinity and water colour, and also in lakes where all submerged plants are extinct. Increase in "common" nymphaeid species, in our opinion, reflects the eutrophication and the accumulation of organic sediment.

Macrophyte abundance:

*The estimations of **relative** abundance are given according 5 abundance classes (*

Table A.15) originally used by Braun-Blanquet (1951) for geobotanical quadrates. For the lakes we have given the estimations for the whole water body. Besides, the description of abundance classes differs slightly from that by Braun-Blanquet.

Table A.15 The species abundance scale.

Abundance	Description
1	Rare, single plants or small stands
2	In some places, several small or two-three medium-sized stands
3	Frequently, may be among subdominants or co-dominants
4	In large amounts, dominant or co-dominant
5	In masses, absolute dominant (quite rare situation!)

The estimations of relative abundance are given separately among three groups:

a. emergent plants (helophytes) and hygrophilous plants;
b. floating and floating-leaved plants (lemnids and nymphaeids),
c. submerged plants (bottom plants, elodeids, ceratophyllids);

For large filamentous algae – not relative abundance, but related to volume or coverage (5= covering all submerged plants or forming wide floating carpets)

The major weakness is subjectivity of estimation. Depending on researcher, the points may differ ±1. In macrophyte-rich lakes higher abundance classes for the dominating species may be given more easily than for the dominants in the lakes poor of macrophytes.

Depth limit of macrophytes

Depth limit has been measured for all rooted plant groups growing in the lake. Usually, submerged plants are the most deep-reaching group, but in some lakes nymphaeids may grow deeper. In Lobelia-lakes without Isoëtes and mosses, also emergent plants (reed) may exceed isoetids. Despite these circumstances, for the estimation of quality classes only depth limit of submerged groups has been used. Depth limit of submerged plants is more indicative for deeper hard-water (LCB1) lakes than for very shallow hard-water (LCB2) lakes. In LCB3 lakes the indicativity of depth limit depends on presence of mosses, growing mostly in deeper soft-water lakes. Isoetids in EE lakes are restricted with 2-2.5 m depth limit. In some cases, at slightly increased alkalinity (disturbance?) also charophytes, especially Chara delicatula and Nitella flexilis can grow in deeper zone.

Macrophyte coverage

It is not used for quality estimations in the latest version of our method, but coverage, and in some cases also PVI, have been calculated or estimated in different ways. At the availability of bathymetric maps and vegetation scheme, and knowing the common depth limit of macrophytes, it is possible to extirpate vegetated areas from the lake scheme and to compare their weight with weighted pelagial part. In small lakes without bathymetric map the calculations are based on length of shoreline, vegetation scheme and estimated/measured widths of plant stands. For calculating PVI, the height of plants must be measured too for more exact calculating. Also very general subjective coverage estimations, and rake method for the estimation of PVI classes have been

used for some projects. Despite the absence of coverage % among indicators at present, it may be useful in more differentiated way, and probably will be again included in future. Our analysis on the coverage % for all submerged groups as total, revealed low indicative value of this parameter (Mäemets & Freiberg, submitted).

Diatoms and bacterial tufts

These groups are not monitored in lakes, but diatoms are monitored in rivers.

Sampling strategy

Frequency for macrophyte investigations is not prescribed yet. It has been depending on labour and changing monitoring strategy.

Monitoring procedure

Usually, small lakes are circled by boat, partly in deeper zone and along transects, partly in shallower zone near the water edge. Composition of submerged plants and depth limits have been studied using plant hook (in very shallow water also rake) with marked rope (stock). Diving has been used rarely. Turbid or dark water and loose mud in deeper zone hinder the diving in many cases. In shallow water (until 1 m) species composition and coverage mostly have been described without equipment, and in the clearest lakes with observation tube in 1-2 m zone. On the largest lakes of Peipsi (3555 km^2) and Võrtsjärv (270 km^2) monitoring is carried out on transects.

Numbers of transects per lake

The number of transects has not been prescribed/calculated until now, and has been depending on the experience of the investigator. In lakes with more articulate or geologically variable shore (sandy, peaty, limestone *etc*.) more transects have been studied than in the case of monotonous or obviously macrophyte-poor shore stretches. Transects starts from the water border and reaches to deepest part of littoral (maximum growth depth).

Analyses

Determination

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.

Assessment

Data requirements

The following tables (Table A.16, Table A.17 and Table A.18) present quality parameters and their values for different EE lake types, as they were in 2007. In cooperation with Dutch colleagues they were modified and used for the calculation of EQR-s in the GIG database. Most unclear are the criteria for bad status, as there are no many examples of such lakes in Estonia. So the values of the parameters for this class are mostly absent. All values, excluding depth limits, are based on expert opinion.

Table A.16 The criteria for quality estimations of alkalitrophic, LCB1 and LCB2 lakes

Parameters/Classes	High	Good	Moderate	Poor	Bad
Only for LCB1: Depth limit of submergent plants, m	<4	<3.0-4.0	>1.6-3.0	1-1.6	<1
More important taxa* arranged according their role	Char, Pot, Bry	Char, Pot, Bry	Batr, Cer, Pot, Nym	Cer, Nym, Nu, Lem	-
Relative abundance of *Potamogeton perfoliatus* and /or *P. lucens*	2-4	2-4	1	0-1	-
Abundance of charophytes and/or bryophytes	≥3	2-3	1	0	0
Abundance of ceratophyllids and/or lemnids	1	1-2	3	4-5	-
Abundance of large filamentous algae	0	1	2	3-4	5

*Char – charophytes; Bry – Bryophytes; Pot – *Potamogeton*; Batr – *Batrachium*; Cer – *Ceratophyllum*; Nym – *Nymphaea*; Nu – *Nuphar*; Lem – lemnids (*Lemna, Spirodela*)

Table A.17 The criteria for quality estimations of LCB3 lakes.

Parameters/Classes	High	Good	Moderate	Poor	Bad
Depth limit of mosses, m (only in lakes with mean depth > 3 m)	>7	>4-7	2-4	<2	-
More important taxa* arranged according their role	Iso, Bry	Iso, Bry, Char	El, Pot, Char	-	-
Abundance of isoetids	4	3-4	2	1	absent
Abundance of elodeids**	0	1	2	3	-

*Iso – isoetids: *Isoëtes, Lobelia*; Bry – Bryophyta; El – *Elodea*; Pot – *Potamogeton*; Char – Charophyta

** *Elodea, Potamogeton, Batrachium, Myriophyllum*

Table A.18 The criteria for quality estimation of coastal lakes (lagoons).

Parameters/Classes	High	Good	Moderate	Poor	Bad
Relative abundance of Chara aspera	4-5	3	1-2	0	-
Relative abundance of Chara tomentosa	4-5	2-3	1	0	-
Relative abundance of Cladium mariscus	4-5	3	1-2	0	-

In order to report an EQR value the different classes are assigned with the following values: Bad 0.00; Poor 0.30; Moderate 0.50; Good 0.7; High 1, where 0.2, 0.4, 0.6, 0.8 are the boundaries vor B/P; P/M; M/G; and G/H respectively. The median value of all parameters represents the final assessment of the quality element macrophytes.

Table A.19 The criteria for quality estimation of lakes (update 2009). RA - Relative abundance, A – abundance

Parameter	Unit	High class	Good class	Moderate	Poor
Type I: hard-water lakes (HCO3 >240 mg/l)					
Main hydrophyte taxa	Taxa ordered according importance (=equal importance)	n.a	*Chara,= Utricularia*, Bryophyta, *Myriophyllum verticillatum*	*Potamogeton natans, Ceratophyllum, Ranunculus, Chara, lemnids*	Lemnids = *Ceratophyllum*, *Potamogeton natans*
Relative abundance of *Chara* among submergents	Braun-Blanquet scale, 0-5	n.a	3-5	1-2	0
RA of *Ceratophyllum* or *Zannichelia* among submergents **or** RA of lemnids	Braun-Blanquet scale, 0-5	n.a	1	2-3	4-5
A of large green filamentous algae (epiphytes included)	Scale 1-5	n.a	1	2-3	4-5
Type II: shallow (non-stratified) lake with medium hardness (HCO3- 80-240 mg/l)					
Main hydrophyte taxa	Taxa ordered according importance (= equal importance)	Bryophyta, Charophyta, *Potamo-geton*	*Charophyta= Potamogeton,* Bryophyta= *Elodea= Myriophyllum= Ceratophyllum*	*Ceratophyllum= Ranunculus=* nymphaeids, *Myriophyllum*, lemnids= *Potamogeton=* Charophyta	Lemnids= Nymphaeids= *Ceratophyllum*
RA of *Potamogeton perfoliatus* or *P. lucens* among submergents	Braun-Blanquet scale, 0-5	≥4	2-3	1	0
RA of charophytes or	Braun-Blanquet scale, 0-5	3	4-5	2	0

Parameter	Unit	High class	Good class	Moderate	Poor
bryophytes among submergents					
Relative abundance of *Ceratophyllum* among submergents or of lemnids among nymphaeids& lemnids	Braun-Blanquet scale, 0-5	0	1-2	3	4-5
A of large green filamentous algae (epiphytes included)	Scale 1-5	0	1	2	3-4
Maximum depth of submerged macrophytes	m	>4	4->3	3->1.6	1.6-1
Type III: deep (stratified) lake of medium hardness (HCO3- 80-240 mg/l)					
Main hydrophyte taxa	Taxa ordered according importance (= : equal importance)	Bryophyta= Charophyta, *Potamogeton*	Charophyta= *Potamogeton*, Bryophyta, *Myriophyllum=Elodea*	*Ranunculus, Ceratophyllum, Potamogeton,* Charophyta	*Ceratophyllum, Ranunculus*, lemnids
RA of *Potamogeton perfoliatus* or *P. lucens* among submergents	Braun-Blanquet scale, 0-5	3	4-5	1-2	0
RA of charophytes or bryophytes among submergents	Braun-Blanquet scale, 0-5	3	4-5	1-2	0
RA of *Ceratophyllum* among submergents or of lemnids	Braun-Blanquet scale, 0-5	0	1-2	3	4-5
Abundance of large green filamentous algae (epiphytes included)	Scale 1-5	0	1	2	3-4

Parameter	Unit	High class	Good class	Moderate	Poor
Type IV: dark soft-water lakes (HCO3- <80 mg/l; CODCr >35 mg/L)					
Main hydrophyte taxa	Taxa ordered according importance (= : equal importance)	*Sphagnum* spp. or macrophytes absent	*Sphagnum* spp. or macrophytes absent	lemnids and nymphaeids	indefinite or lemnids
Type V: light soft-water lakes (HCO3- <80 mg/l; CODCr <35 mg/L) ~LCB3					
Depth limit of mosses (only at mean depth>3 m)	m	>7	7-4	4-2	>2
Main hydrophyte taxa	Taxa ordered according importance (= : equal importance)	*Lobelia, Isoëtes*= Bryophyta, *Myriophyllum alterniflorum*	*Isoëtes, Lobelia*= *Myriophyllum alterniflorum*= *Nitella*= *Chara delicatula*	nymphaeids, submerged *Potamogeton*, *Elodea,* Bryophyta, *Isoëtes, Lobelia*	submergents absent
Relative abundance of *Isoëtes* or *Lobelia* among submergents	Braun-Blanquet scale, 0-5	5	3-4	1-2	0
Relative abundance of *Myriophyllum alterniflorum* among submergents (only Võru county)	Braun-Blanquet scale, 0-5	3-4	5	1-2	0
Relative abundance of *Elodea* or submergent *Potamogeton* among submergents	Braun-Blanquet scale, 0-5	0	1	2-3	submergents absent
Abundance of large green filamentous algae (epiphytes included)	Scale 1-5	0	1-2	3	4
Type VI: Lake Võrtsjärv (270 km2, transects, special characteristics)					

Parameter	Unit	High class	Good class	Moderate	Poor
Type VII: Lake Peipsi (3550 km2, transects, special characteristics) **Type VIII: coastal lakes and lagoons (very shallow, fresh or brackish)**					
Relative abundance of *Chara aspera* among submergents	Braun-Blanquet scale, 0-5	4-5	3	1-2	0
Relative abundance of *Chara tomentosa* among submergents	Braun-Blanquet scale, 0-5	4-5	2-3	1	0
In limestone-bottom lakes: relative abundance of *Utricularia* among submergents	Braun-Blanquet scale, 0-5	5	3-4	1-2	Information not available
Relative abundance of *Cladium mariscus* among emergents	Braun-Blanquet scale, 0-5	4-5	3	1-2	0

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

Reference lakes are not presented (regarding macrophytes), as almost all studied EE lakes have been under the human impact earlier or later. Diatom analyses from the sediments of some "reference" lakes with recently weakly inhabited and not polluted catchment areas have revealed earlier events, changing the following development. Conception of high status is based on the data from the 1950s, in some cases also on the older data. Following (in database) the changes in the second half of the 20th century, understanding of the indicators of declining quality has been formed. H/G boundary is the state where the first signs of vegetation change appear, and G/M boundary is the state where the representatives of H and G state are present, but not prevailing. The vegetation of the lakes on G/M boundary seems to be unstable.

How well correlate the indicators with pressure indicators?

Correlations of coverage % and depth limit are analysed. The last parameter seems to be useful for quality classification, *e.g.* correlation between depth limit of submerged plants with Chl α content in midsummer samples from surface layer (Figure A.3) was –0.3276 (p=0.017). Coverage % of submerged macrophytes may be high in the lakes of good state, *e.g.* charophyte-rich coastal lagoons on nature protection areas, but charophyte-rich are also the lakes with lowered water level and heavily fertilized catchment area, *e.g.* overgrowing lakes on Vooremaa drumlin area, where impact of agriculture has been strong during long *ti*me.

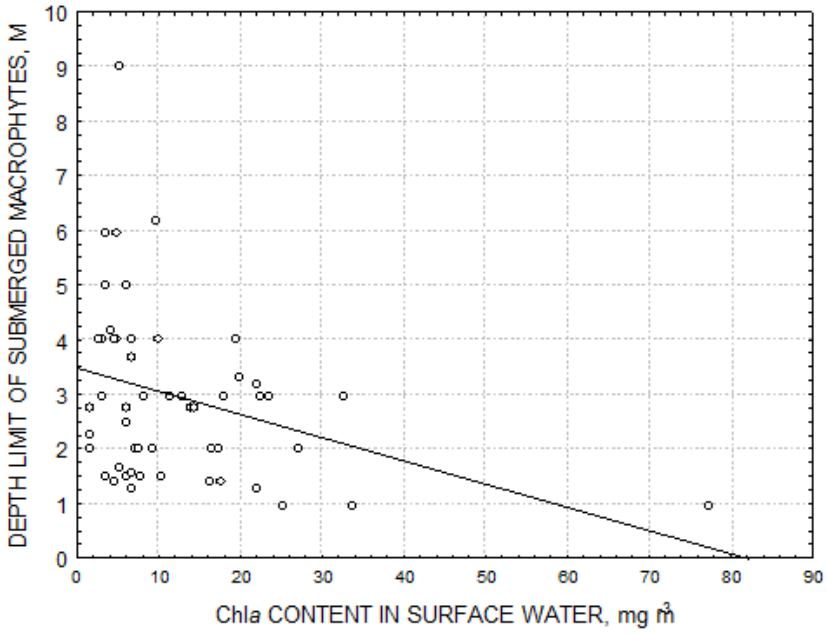

Figure A.3 Chlα content in midsummer samples and depth limit of submerged macrophytes in EE lakes of different types according 55 parallel measurements (Mäemets & Freiberg, submitted).

Table A. 20 Example of quality estimation for Lake Verevi (LCB1) according the EE criteria.

Parameter/Year	2002	2003	2005	2006	Comments
Depth limit of submergent plants, m	4.0: II	4.0: II	3.0: III	4.0: II	
More important taxa* arranged according their role	Pot, Char: I-II	Cer, Myr: III	Bry: I	Bry, Cer, Myr, Batr, Char: II	Only *Myriophyllum verticillatum*
Relatve abundance of Potamogeton perfoliatus and /or P. lucens	2: I-II	1: III	1: III	0: IV-V	
Abundance of charophytes and/or bryophytes	3: II	2: II	5: I	4: I	
Abundance of ceratophyllids and/or lemnids	3: III	4: IV	2: II	3: III	
Abundance of large filamentous algae	1: II	4: IV	2: III	4: IV	
General estimation	**II**	III	II	III	

A.4 Germany

Status: national input for intercalibration, accepted national method, slight adjustments are still possible

Which indicators are used?

Macrophyte taxonomic composition:

The taxanomic composition of hydrophytes is assessed on species level. Hydrophytes includes angiosperms, charophytes and some mosses. Other macroalgea (e.g. *Hydrodiction* sp.) are not included. Only submerged, floating-leaved and free floating macrophytes are considered as indicators.

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.

Table A.21 The German species abundance scale.

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

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. *Ceratophyllum demersum* or *Myriophyllum spicatum*) reaches at least 80% of total plant quantity (see below).

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 $y = x^3$.

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.

When is monitored and with which frequency?

Macrophytes

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

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).

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.

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;
- Makrophyte lake typ (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.40). 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 A22 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	Intercalibration type	Correcting factors
TKg10	LCB 1	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	LCB 1	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	LCB 2	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 Water Framework Directive (Table A.23.

Table A.24 provides an example for the German macrophyte assessment.

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.

Table A.23 Classification of the EQR values into the categories of ecological status (H/G and G/M boundaries for type TKp were corrected during the harmonisation process, the corrected boundaries are given here).

Ecological status	Range of EQR	Definition given by the WFD	Interpretation
High	>0.78 (Type TKp) >0.68 (Type TKg10) >0.71 (Type TKg13)	"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	0.58 to 0.78 (TKp) 0.51 to 0.68/0.71 (TKg10/13)	"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 0.57 (TKp) 0.26 to 0.50 (TKg10/13)	"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)

Table A.24 An example for calculation of species metric for a TKg10 (= LCB 1) type lake.

Species at transekt 1	Abundance (0-5) / quantity	Species group (see Annex A)	Calculation	EQR
P. pectinatus (0-1m)	3/27	B	RI = 12.66;	0.59 (good)
P. pectinatus (1-2m)	4/64	B	vegetation limit = 3,8m	
P. perfoliatus (2-4m)	2/8	B		
L. minor (0-1m)	2/8	C		
Chara contraria (0-1m)	2/8	B	→ RI is reduced by 20 to **–17.33**	
Chara contraria (1-2m)	2/8	B		
Chara contraria (2-4m)	3/27	A		

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

The reference is based on (few) existing reference sites. For macrophyte assessment the classification of the RI values into the categories of ecological status is proved in Table A.25

How well correlate the indicators with pressure indicators?

The German assessment metrics are correlating quite well with eutrophication indicating parameters (SRP and Secchi depth). Figure A.4 and Figure A.5 show examples for the correlation of the macrophyte assessment with SRP and Secci depth.

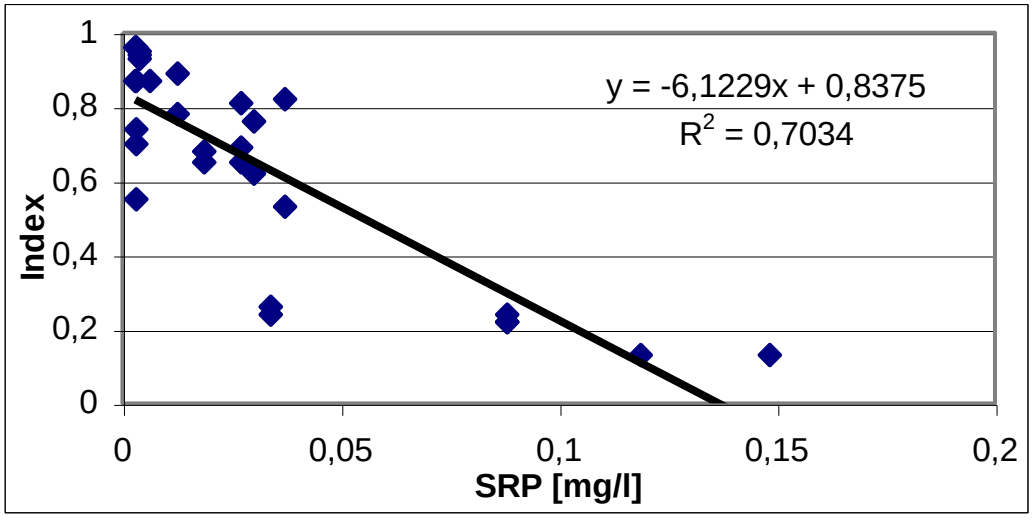

Figure A.4 Correlation between German EQR for macrophyte assessment and SRP concentration in German lakes.

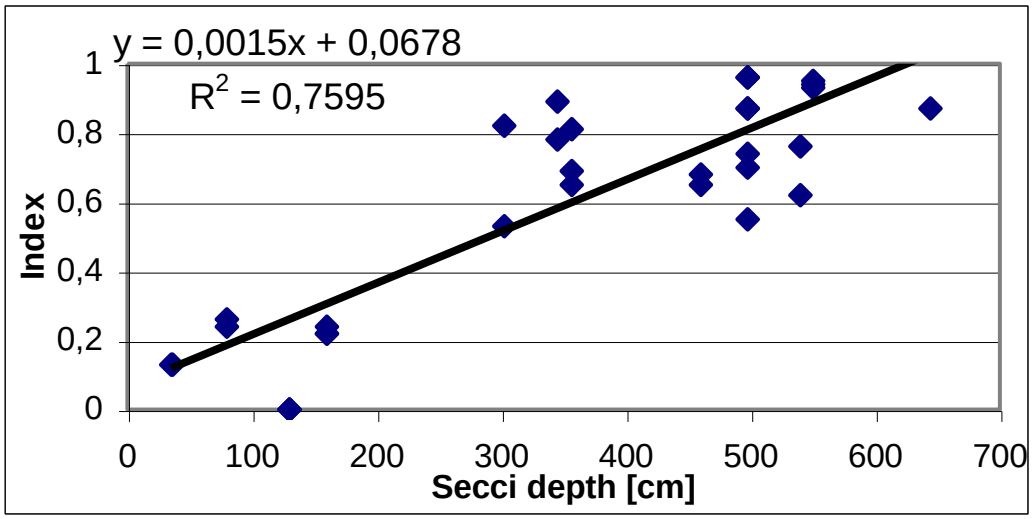

Figure A.5 Correlation between German EQR for macrophyte assessment and Secci depth in German lakes.

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

Completeness of method

The German macrophyte assessment method uses a combination of metrics (Table A.25).

Table A.25 Metrics used for German method

metric	data requirements	used for intercalibratio
macrophyte abundance	5 level scale	yes
depth distribution of macrophytes	macrophytes recorded by 4 depth classes (see Table A.40)	no, all taxa are treated equal no matter in which depth they occur
dominant stands of *Ceratophyllum demersum, C. submersum, Elodea canadensis/ nuttallii, Myriophyllum spicatum, Najas marina subsp. intermedia* or *Potamogeton pectinatus*	abundance data on 1 to 5 scale	yes
vegetation limit	depth of lowest macrophyte stands	information not available for all lakes in GIG data

Data transformation to GIG data base

The German lake typology is slightly different from the GIG typology and distinguishes three different lake Types for LCB 1 and LCB2 lakes considering natural nutrient load of lakes:

- classification of polymictic lakes is less strict
- classification of lakes with large catchment is less strict
- classification of lakes with small catchment is more strict

Table A.26 Assignment of national lake types to GIG typology

IC lake type	LCB1	LCB2
description	shallow lake	very shallow lake
mean depth	3 - 15 m	< 3 m
mixing type	polymictic or stratified	polymictic
German biotic lake type	two types of stratified lakes and one type of polymictic lakes	one type of polymictic lakes
conclusion	three possible biotic lake types	clearly to assign

Assessment transformation to the GIG data base

Depth distribution

Taxa are assigned to indicator groups A (reference taxa) B (indifferent taxa) and C (disturbance indicators). Many species are treated different for growing in different depth zones. So the indicator value for most species is improving the deeper they grow. Table A.27 gives an example.

For intercalibration the original table (Table A.28) had to be reduced to only one species group per taxon. These species groups were derived by the most common indicator group in the original table (e.g. Chara contraria: "A"). If the species groups were even (e.g. two times "B" and two times "C") the resulting Group was "B" (= indifferent species).

Table A.27 Species groups for Chara contraria in lake type Tkp (= LCB2) according to depth classes

Depth class	Species group
0-1 m	B
1-2 m	A
2-4 m	A
> 4 m	A

Vegetation limit

The depth of the lowest macrophyte stands is used as an additional metric to correct EQR values. If the vegetation does not reach a requested depth (e.g. 3 m in TKp/LCB2 Lakes) the assessment is downgraded by one ecological quality class.

As the GIG data provides not always information about vegetation limit the German assessment seems to be less strict than it is.

Effects on final results

Figure A.6 shows how important the information about depth distribution are for the final macrophytes assessment.

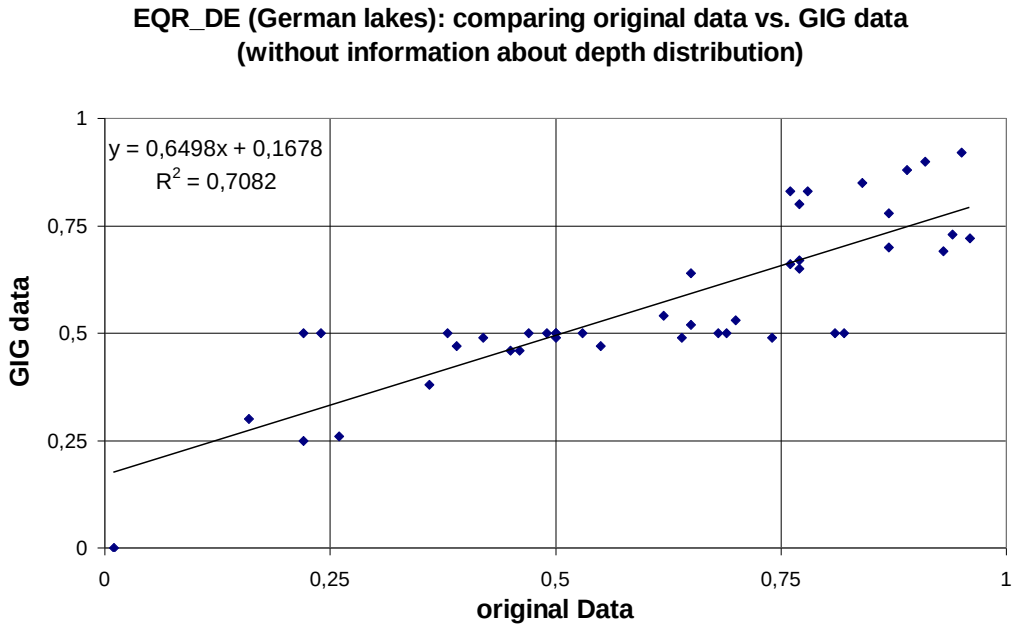

Figure A.6 Correlation between German EQR for macrophyte assessment based on original data and without information about depth distribution (GIG Data) German lakes

Transformations on national methodology

For intercalibration all EQR-values were transformed to normalised EQRs with equidistant class boundaries (H/G = 0,8; G/M = 0,6; M/P=0,4 and P/B=0,2). All EQRs given in this chapter (e.g. Table A.23) are not normalized EQRs.

Table A.28 Original list of type specific indicator species. The table continues at the next pages.

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Acorus calamus_0_1	B	B	B
Acorus calamus_1_2	B	B	B
Acorus calamus_2_4	B	B	B

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Acorus calamus_>4	B	B	B
Alisma gramineum_0_1	B	B	B
Alisma gramineum_1_2	B	B	B
Alisma gramineum_2_4	B	B	B
Alisma gramineum_>4	B	B	B
Alisma lanceolatum_0_1	B	B	B
Alisma lanceolatum_1_2	B	B	B
Alisma lanceolatum_2_4	B	B	B
Alisma lanceolatum_>4	B	B	B
Alisma plantago-aquatica_0_1	B	B	B
Alisma plantago-aquatica_1_2	B	B	B
Alisma plantago-aquatica_2_4	B	B	B
Alisma plantago-aquatica_>4	B	B	B
Brachythecium rivulare_0_1	B	B	B
Brachythecium rivulare_1_2	B	B	B
Brachythecium rivulare_2_4	B	B	B
Brachythecium rivulare_>4	B	B	B
Butomus umbellatus_0_1	B	B	B
Butomus umbellatus_1_2	B	B	B
Butomus umbellatus_2_4	B	B	B
Butomus umbellatus_>4	B	B	B
Calliergonella cuspidata_0_1	B	B	B
Calliergonella cuspidata_1_2	B	B	B
Calliergonella cuspidata_2_4	B	B	B
Callitriche cophocarpa_0_1	B	B	B
Callitriche cophocarpa_1_2	B	B	B
Callitriche cophocarpa_2_4	B	B	B
Callitriche cophocarpa_>4	B	B	B
Callitriche hamulata_0_1	A	A	A
Callitriche hamulata_1_2	A	A	A
Callitriche hamulata_2_4	A	A	A
Callitriche hamulata_>4	A	A	A
Callitriche hermaphroditica_0_1	B	B	B
Callitriche hermaphroditica_1_2	B	B	B
Callitriche hermaphroditica_2_4	B	B	B
Callitriche hermaphroditica_>4	B	B	B
Callitriche obtusangula_0_1	B	B	B
Callitriche obtusangula_1_2	B	B	B
Callitriche obtusangula_2_4	B	B	B

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Callitriche obtusangula_>4	B	B	B
Callitriche palustris_0_1	A	A	A
Callitriche palustris_1_2	A	A	A
Callitriche palustris_2_4	A	A	A
Callitriche palustris_>4	A	A	A
Carex riparia_0_1	B	B	B
Carex riparia_1_2	B	B	B
Carex riparia_2_4	B	B	B
Carex riparia_>4	B	B	B
Ceratophyllum demersum_0_1	C	C	C
Ceratophyllum demersum_1_2	c	B	B
Ceratophyllum demersum_2_4	B	B	B
Ceratophyllum demersum_>4	B	B	B
Ceratophyllum submersum_0_1	C	C	B
Ceratophyllum submersum_1_2	B	B	B
Ceratophyllum submersum_2_4	B	B	B
Ceratophyllum submersum_>4	B	B	B
Chara aspera var. curta_0_1	A	A	A
Chara aspera var. curta_1_2	A	A	A
Chara aspera var. curta_2_4	A	A	A
Chara aspera var. curta_>4	A	A	A
Chara aspera_0_1	A	A	A
Chara aspera_1_2	A	A	A
Chara aspera_2_4	A	A	A
Chara aspera_>4	A	A	A
Chara braunii_0_1	A	A	A
Chara braunii_1_2	A	A	A
Chara braunii_2_4	A	A	A
Chara braunii_>4	A	A	A
Chara contraria var. hispidula_0_1	B	B	B
Chara contraria var. hispidula_1_2	B	B	B
Chara contraria var. hispidula_2_4	B	B	B
Chara contraria var. hispidula_>4	A	A	A
Chara contraria_0_1	B	B	B
Chara contraria_1_2	B	B	A
Chara contraria_2_4	A	A	A
Chara contraria_>4	A	A	A
Chara delicatula_0_1	B	B	B
Chara delicatula_1_2	B	B	A

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Chara delicatula_2_4	A	A	A
Chara delicatula_>4	A	A	A
Chara denudata_0_1	B	B	B
Chara denudata_1_2	B	B	B
Chara denudata_2_4	B	B	B
Chara denudata_>4	B	B	B
Chara filiformis_0_1	A	A	A
Chara filiformis_1_2	A	A	A
Chara filiformis_2_4	A	A	A
Chara filiformis_>4	A	A	A
Chara globularis_0_1	B	B	B
Chara globularis_1_2	B	B	A
Chara globularis_2_4	a	A	A
Chara globularis_>4	A	A	A
Chara hispida_0_1	A	A	A
Chara hispida_1_2	A	A	A
Chara hispida_2_4	A	A	A
Chara hispida_>4	A	A	A
Chara intermedia_0_1	A	A	A
Chara intermedia_1_2	A	A	A
Chara intermedia_2_4	A	A	A
Chara intermedia_>4	A	A	A
Chara polyacantha_0_1	A	A	A
Chara polyacantha_1_2	A	A	A
Chara polyacantha_2_4	A	A	A
Chara polyacantha_>4	A	A	A
Chara rudis_0_1	A	A	A
Chara rudis_1_2	A	A	A
Chara rudis_2_4	A	A	A
Chara rudis_>4	A	A	A
Chara tomentosa_0_1	A	A	A
Chara tomentosa_1_2	A	A	A
Chara tomentosa_2_4	A	A	A
Chara tomentosa_>4	A	A	A
Chara vulgaris_0_1	B	B	A
Chara vulgaris_1_2	B	B	A
Chara vulgaris_2_4	a	a	A
Chara vulgaris_>4	a	A	A
Cladium mariscus_0_1	B	B	B

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Cladium mariscus_1_2	B	B	B
Cladium mariscus_2_4	B	B	B
Cladium mariscus_>4	B	B	B
Drepanocladus aduncus_0_1	B	B	B
Drepanocladus aduncus_1_2	B	B	B
Drepanocladus aduncus_2_4	B	B	B
Drepanocladus aduncus_>4	B	B	B
Drepanocladus fluitans_0_1	B	B	B
Drepanocladus fluitans_1_2	B	B	B
Drepanocladus fluitans_2_4	B	B	B
Drepanocladus fluitans_>4	B	B	B
Elatine hexandra_0_1	A	A	A
Elatine hexandra_1_2	A	A	A
Elatine hexandra_2_4	A	A	A
Elatine hexandra_>4	A	A	A
Elatine hydropiper_0_1	A	A	A
Elatine hydropiper_1_2	A	A	A
Elatine hydropiper_2_4	A	A	A
Elatine hydropiper_>4	A	A	A
Elatine triandra_0_1	A	A	A
Elatine triandra_1_2	A	A	A
Elatine triandra_2_4	A	A	A
Elatine triandra_>4	A	A	A
Eleocharis acicularis_0_1	B	B	B
Eleocharis acicularis_1_2	B	B	B
Eleocharis acicularis_2_4	B	B	B
Eleocharis acicularis_>4	B	B	B
Eleocharis palustris_0_1	C	C	C
Eleocharis palustris_1_2	C	C	C
Eleocharis palustris_2_4	C	C	C
Eleocharis palustris_>4	C	C	C
Elodea canadensis_0_1	C	C	C
Elodea canadensis_1_2	C	C	B
Elodea canadensis_2_4	C	C	B
Elodea canadensis_>4	B	B	B
Elodea nuttallii_0_1	C	C	C
Elodea nuttallii_1_2	C	C	B
Elodea nuttallii_2_4	C	C	B
Elodea nuttallii_>4	C	C	B

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Epilobium hirsutum_0_1	B	B	B
Epilobium hirsutum_1_2	B	B	B
Epilobium hirsutum_2_4	B	B	B
Epilobium hirsutum_>4	B	B	B
Equisetum fluviatile_0_1	B	B	B
Equisetum fluviatile_1_2	B	B	B
Equisetum fluviatile_2_4	B	B	B
Equisetum fluviatile_>4	B	B	B
Fontinalis antipyretica_0_1	B	B	B
Fontinalis antipyretica_1_2	B	B	A
Fontinalis antipyretica_2_4	B	B	A
Fontinalis antipyretica_>4	A	A	A
Fontinalis hypnoides_0_1	B	B	B
Fontinalis hypnoides_1_2	B	B	B
Fontinalis hypnoides_2_4	B	B	B
Fontinalis hypnoides_>4	B	B	B
Fontinalis squamosa_0_1	B	B	B
Fontinalis squamosa_1_2	B	B	B
Fontinalis squamosa_2_4	B	B	B
Fontinalis squamosa_>4	B	B	B
Galium palustre ssp. palustre_0_1	B	B	B
Galium palustre ssp. palustre_1_2	B	B	B
Galium palustre ssp. palustre_2_4	B	B	B
Galium palustre ssp. palustre_>4	B	B	B
Glyceria fluitans_0_1	B	B	B
Glyceria fluitans_2_4	B	B	B
Glyceria fluitans_>4	B	B	B
Groenlandia densa_0_1	A	A	A
Groenlandia densa_1_2	A	A	A
Groenlandia densa_2_4	A	A	A
Groenlandia densa_>4	A	A	A
Hippuris vulgaris_0_1	B	B	B
Hippuris vulgaris_1_2	B	B	B
Hippuris vulgaris_2_4	B	B	B
Hippuris vulgaris_>4	B	B	B
Hottonia palustris_0_1	A	A	A
Hottonia palustris_1_2	A	A	A
Hottonia palustris_2_4	A	A	A
Hottonia palustris_>4	A	A	A

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Hydrocharis morsus-ranae_0_1	A	A	A
Hydrocharis morsus-ranae_1_2	A	A	A
Hydrocharis morsus-ranae_2_4	A	A	A
Hydrocharis morsus-ranae_>4	A	A	A
Hydrocotyle vulgaris_0_1	A	A	A
Hydrocotyle vulgaris_1_2	A	A	A
Hydrocotyle vulgaris_2_4	A	A	A
Hydrocotyle vulgaris_>4	A	A	A
Hygrohypnum ochraceum_0_1	B	B	B
Hygrohypnum ochraceum_1_2	B	B	B
Hygrohypnum ochraceum_2_4	B	B	B
Hygrohypnum ochraceum_>4	B	B	B
Isoetes echinospora_0_1	A	A	A
Isoetes echinospora_1_2	A	A	A
Isoetes echinospora_2_4	A	A	A
Isoetes echinospora_>4	A	A	A
Isoetes lacustris_0_1	A	A	A
Isoetes lacustris_1_2	A	A	A
Isoetes lacustris_2_4	A	A	A
Isoetes lacustris_>4	A	A	A
Juncus articulatus_0_1	B	B	B
Juncus articulatus_1_2	B	B	B
Juncus articulatus_2_4	B	B	B
Juncus articulatus_>4	B	B	B
Juncus bulbosus_0_1	B	B	B
Juncus bulbosus_1_2	B	B	B
Juncus bulbosus_2_4	B	B	B
Juncus bulbosus_>4	B	B	B
Juncus subnodulosus_0_1	A	A	A
Juncus subnodulosus_1_2	A	A	A
Juncus subnodulosus_2_4	A	A	A
Juncus subnodulosus_>4	A	A	A
Jungermannia sphaerocarpa_0_1	B	B	B
Jungermannia sphaerocarpa_1_2	B	B	B
Jungermannia sphaerocarpa_2_4	B	B	B
Jungermannia sphaerocarpa_>4	B	B	B
Lagarosiphon major_0_1	C	C	C
Lagarosiphon major_1_2	C	C	C
Lagarosiphon major_2_4	C	C	C

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Lagarosiphon major_>4	C	C	C
Lemna gibba_0_1	C	C	B
Lemna gibba_1_2	C	C	B
Lemna gibba_2_4	C	C	B
Lemna minor_0_1	C	C	B
Lemna minor_1_2	C	C	B
Lemna minuta_0_1	C	C	B
Lemna trisulca_0_1	C	C	B
Lemna trisulca_1_2	C	C	B
Lemna trisulca_2_4	C	B	B
Lemna trisulca_>4	B	B	B
Lemna turionifera_0_1	C	C	B
Leptodictyum riparium_0_1	B	B	B
Leptodictyum riparium_1_2	B	B	B
Leptodictyum riparium_2_4	B	B	B
Leptodictyum riparium_>4	B	B	B
Littorella uniflora_0_1	A	A	A
Littorella uniflora_1_2	A	A	A
Littorella uniflora_2_4	A	A	A
Littorella uniflora_>4	A	A	A
Lobelia dortmanna_0_1	A	A	A
Lobelia dortmanna_1_2	A	A	A
Lobelia dortmanna_2_4	A	A	A
Lobelia dortmanna_>4	A	A	A
Luronium natans_0_1	A	A	A
Luronium natans_1_2	A	A	A
Luronium natans_2_4	A	A	A
Luronium natans_>4	A	A	A
Lycopus europaeus_0_1	B	B	B
Lysimachia vulgaris_0_1	B	B	B
Lythrum salicaria_0_1	B	B	B
Mentha aquatica_0_1	B	B	B
Mentha aquatica_1_2	B	B	B
Mentha aquatica_2_4	B	B	B
Mentha aquatica_>4	B	B	B
Myosotis scorpioides_0_1	B	B	B
Myosotis scorpioides_1_2	b	b	b
Myosotis scorpioides_2-4	b	b	b
Myriophyllum alterniflorum_0_1	b	b	A

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Myriophyllum alterniflorum_1_2	b	A	A
Myriophyllum alterniflorum_2_4	A	A	A
Myriophyllum alterniflorum_>4	A	A	A
Myriophyllum heterophyllum_0_1	B	B	B
Myriophyllum heterophyllum_1_2	B	B	B
Myriophyllum heterophyllum_2_4	B	B	B
Myriophyllum heterophyllum_>4	B	B	B
Myriophyllum spicatum_0_1	B	B	B
Myriophyllum spicatum_1_2	B	B	B
Myriophyllum spicatum_2_4	B	B	B
Myriophyllum spicatum_>4	B	B	B
Myriophyllum verticillatum_0_1	B	B	A
Myriophyllum verticillatum_1_2	B	A	A
Myriophyllum verticillatum_2_4	B	A	A
Myriophyllum verticillatum_>4	B	A	A
Najas flexilis_0_1	A	A	A
Najas flexilis_1_2	A	A	A
Najas flexilis_2_4	A	A	A
Najas flexilis_>4	A	A	A
Najas marina ssp. intermedia_0_1	B	B	B
Najas marina ssp. intermedia_1_2	B	B	B
Najas marina ssp. intermedia_2_4	B	B	A
Najas marina ssp. intermedia_>4	B	A	A
Najas marina_0_1	C	C	C
Najas marina_1_2	C	C	C
Najas marina_2_4	C	C	C
Najas marina_>4	C	C	C
Najas minor_0_1	B	B	B
Najas minor_1_2	B	B	B
Najas minor_2_4	B	A	A
Najas minor_>4	B	A	A
Nasturtium officinale_0_1	B	B	B
Nasturtium officinale_1_2	B	B	B
Nitella batrachosperma_0_1	A	A	A
Nitella batrachosperma_1_2	A	A	A
Nitella batrachosperma_2_4	A	A	A
Nitella batrachosperma_>4	A	A	A
Nitella capillaris_0_1	A	A	A
Nitella capillaris_1_2	A	A	A

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Nitella capillaris_2_4	A	A	A
Nitella capillaris_>4	A	A	A
Nitella flexilis_0_1	B	B	A
Nitella flexilis_1_2	B	B	A
Nitella flexilis_2_4	B	A	A
Nitella flexilis_>4	A	A	A
Nitella gracilis_0_1	A	A	A
Nitella gracilis_1_2	A	A	A
Nitella gracilis_2_4	A	A	A
Nitella gracilis_>4	A	A	A
Nitella mucronata_0_1	B	B	A
Nitella mucronata_1_2	B	B	A
Nitella mucronata_2_4	B	A	A
Nitella mucronata_>4	A	A	A
Nitella opaca_0_1	B	A	A
Nitella opaca_1_2	A	A	A
Nitella opaca_2_4	A	A	A
Nitella opaca_>4	A	A	A
Nitella syncarpa_0_1	A	A	A
Nitella syncarpa_1_2	A	A	A
Nitella syncarpa_2_4	A	A	A
Nitella syncarpa_>4	A	A	A
Nitella tenuissima_0_1	A	A	A
Nitella tenuissima_1_2	A	A	A
Nitella tenuissima_2_4	A	A	A
Nitella tenuissima_>4	A	A	A
Nitella translucens_0_1	A	A	A
Nitella translucens_1_2	A	A	A
Nitella translucens_2_4	A	A	A
Nitella translucens_>4	A	A	A
Nitellopsis obtusa_0_1	B	B	B
Nitellopsis obtusa_1_2	B	B	B
Nitellopsis obtusa_2_4	B	A	A
Nitellopsis obtusa_>4	A	A	A
Nuphar lutea_0_1	B	B	B
Nuphar lutea_1_2	B	B	B
Nuphar lutea_2_4	B	B	B
Nuphar lutea_>4	B	B	B
Nymphaea alba_0_1	B	B	B

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Nymphaea alba_1_2	B	B	B
Nymphaea alba_2_4	B	B	B
Nymphaea alba_>4	B	B	B
Nymphoides peltata_0_1	B	B	B
Nymphoides peltata_1_2	B	B	B
Nymphoides peltata_2_4	B	B	B
Peplis portula_0_1	A	A	A
Peplis portula_1_2	A	A	A
Persicaria amphibia_0_1	B	B	B
Persicaria amphibia_1_2	B	B	B
Persicaria amphibia_2_4	B	B	B
Persicaria amphibia_>4	B	B	B
Phalaris arundinacea_0_1	B	B	B
Phalaris arundinacea_1_2	B	B	B
Pilularia globulifera_0_1	A	A	A
Pistia stratiotes_0_1	C	C	C
Potamogeton acutifolius_0_1	B	B	A
Potamogeton acutifolius_1_2	B	B	A
Potamogeton acutifolius_2_4	A	A	A
Potamogeton acutifolius_>4	A	A	A
Potamogeton alpinus_0_1	A	A	A
Potamogeton alpinus_1_2	A	A	A
Potamogeton alpinus_2_4	A	A	A
Potamogeton alpinus_>4	A	A	A
Potamogeton berchtoldii_0_1	B	B	B
Potamogeton berchtoldii_1_2	B	B	B
Potamogeton berchtoldii_2_4	B	A	A
Potamogeton berchtoldii_>4	A	A	A
Potamogeton compressus_0_1	B	A	A
Potamogeton compressus_1_2	B	A	A
Potamogeton compressus_2_4	B	A	A
Potamogeton compressus_>4	B	A	A
Potamogeton crispus_0_1	C	C	C
Potamogeton crispus_1_2	C	C	B
Potamogeton crispus_2_4	C	C	B
Potamogeton crispus_>4	B	B	B
Potamogeton filiformis_0_1	A	A	A
Potamogeton filiformis_1_2	A	A	A
Potamogeton filiformis_2_4	A	A	A

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Potamogeton filiformis_>4	A	A	A
Potamogeton friesii_0_1	B	B	B
Potamogeton friesii_1_2	B	B	B
Potamogeton friesii_2_4	B	B	A
Potamogeton friesii_>4	B	A	A
Potamogeton gramineus_0_1	A	A	A
Potamogeton gramineus_1_2	A	A	A
Potamogeton gramineus_2_4	A	A	A
Potamogeton gramineus_>4	A	A	A
Potamogeton lucens_0_1	B	B	B
Potamogeton lucens_1_2	B	B	A
Potamogeton lucens_2_4	B	A	A
Potamogeton lucens_>4	A	A	A
Potamogeton natans_0_1	A	A	A
Potamogeton natans_1_2	A	A	A
Potamogeton natans_2_4	A	A	A
Potamogeton natans_>4	A	A	A
Potamogeton nodosus_0_1	C	B	B
Potamogeton nodosus_1_2	C	B	B
Potamogeton nodosus_2_4	C	B	B
Potamogeton nodosus_>4	C	B	B
Potamogeton obtusifolius_0_1	B	B	B
Potamogeton obtusifolius_1_2	B	B	B
Potamogeton obtusifolius_2_4	B	B	B
Potamogeton obtusifolius_>4	B	B	B
Potamogeton pectinatus_0_1	B	B	B
Potamogeton pectinatus_1_2	B	B	B
Potamogeton pectinatus_2_4	B	B	B
Potamogeton pectinatus_>4	B	B	B
Potamogeton perfoliatus_0_1	B	B	B
Potamogeton perfoliatus_1_2	B	B	B
Potamogeton perfoliatus_2_4	B	B	B
Potamogeton perfoliatus_>4	B	B	B
Potamogeton polygonifolius_0_1	A	A	A
Potamogeton polygonifolius_1_2	A	A	A
Potamogeton polygonifolius_2_4	A	A	A
Potamogeton polygonifolius_>4	A	A	A
Potamogeton praelongus_0_1	A	A	A
Potamogeton praelongus_1_2	A	A	A

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Potamogeton praelongus_2_4	A	A	A
Potamogeton praelongus_>4	A	A	A
Potamogeton pusillus_0_1	C	B	B
Potamogeton pusillus_1_2	B	B	B
Potamogeton pusillus_2_4	B	B	B
Potamogeton pusillus_>4	B	A	B
Potamogeton rutilus_0_1	A	A	A
Potamogeton rutilus_1_2	A	A	A
Potamogeton rutilus_2_4	A	A	A
Potamogeton rutilus_>4	A	A	A
Potamogeton trichoides_0_1	B	B	B
Potamogeton trichoides_1_2	a	A	A
Potamogeton trichoides_2_4	A	A	A
Potamogeton trichoides_>4	A	A	A
Potamogeton x angustifolius_0_1	A	A	A
Potamogeton x angustifolius_1_2	A	A	A
Potamogeton x angustifolius_2_4	A	A	A
Potamogeton x angustifolius_>4	A	A	A
Potamogeton x cognatus_0_1	A	A	A
Potamogeton x cognatus_1_2	A	A	A
Potamogeton x cognatus_2_4	A	A	A
Potamogeton x cognatus_>4	A	A	A
Potamogeton x cooperi_0_1	B	B	B
Potamogeton x cooperi_1_2	B	B	B
Potamogeton x cooperi_2_4	B	B	B
Potamogeton x cooperi_>4	B	B	B
Potamogeton x nitens_0_1	B	A	A
Potamogeton x nitens_1_2	B	A	A
Potamogeton x nitens_2_4	B	A	A
Potamogeton x nitens_>4	B	A	A
Potamogeton x salicifolius_0_1	B	B	B
Potamogeton x salicifolius_1_2	B	B	B
Potamogeton x salicifolius_2_4	B	B	B
Potamogeton x salicifolius_>4	B	B	B
Potentilla palustris_0_1	B	B	B
Potentilla palustris_1_2	B	B	B
Potentilla palustris_2_4	B	B	B
Potentilla palustris_>4	B	B	B
Ranunculus aquatilis_0_1	B	B	B

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Ranunculus aquatilis_1_2	B	B	B
Ranunculus aquatilis_2_4	B	B	B
Ranunculus aquatilis_>4	B	B	B
Ranunculus circinatus_0_1	C	C	C
Ranunculus circinatus_1_2	B	B	B
Ranunculus circinatus_2_4	b	B	B
Ranunculus circinatus_>4	B	B	B
Ranunculus flammula_0_1	A	A	A
Ranunculus fluitans_0_1	B	B	B
Ranunculus fluitans_1_2	B	B	B
Ranunculus fluitans_2_4	B	B	B
Ranunculus fluitans_>4	B	B	B
Ranunculus lingua_0_1	A	A	A
Ranunculus peltatus ssp. baudotii_0_1	B	B	B
Ranunculus peltatus ssp. baudotii_1_2	B	B	B
Ranunculus peltatus ssp. baudotii_2_4	B	B	B
Ranunculus peltatus ssp. baudotii_>4	B	B	B
Ranunculus peltatus_0_1	B	B	A
Ranunculus peltatus_1_2	B	B	A
Ranunculus peltatus_2_4	B	B	A
Ranunculus peltatus_>4	B	B	A
Ranunculus penicillatus_0_1	A	A	A
Ranunculus penicillatus_1_2	A	A	A
Ranunculus penicillatus_2_4	A	A	A
Ranunculus penicillatus_>4	A	A	A
Ranunculus reptans_0_1	B	B	B
Ranunculus reptans_1_2	B	B	B
Ranunculus trichophyllus ssp. eradicatus_0_1	A	A	A
Ranunculus trichophyllus ssp. eradicatus_1_2	A	A	A
Ranunculus trichophyllus ssp. eradicatus_2_4	A	A	A
Ranunculus trichophyllus ssp. eradicatus_>4	A	A	A
Ranunculus trichophyllus ssp. rionii_0_1	B	B	A
Ranunculus trichophyllus ssp. rionii_1_2	B	B	A
Ranunculus trichophyllus ssp. rionii_2_4	B	B	A
Ranunculus trichophyllus ssp. rionii_>4	B	B	A
Ranunculus trichophyllus ssp. trichophyllus_0_1	B	B	A
Ranunculus trichophyllus ssp. trichophyllus_1_2	B	B	A
Ranunculus trichophyllus ssp. trichophyllus_2_4	B	B	A
Ranunculus trichophyllus ssp. trichophyllus_>4	B	B	A

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Ranunculus trichophyllus_0_1	B	B	A
Ranunculus trichophyllus_1_2	B	B	A
Ranunculus trichophyllus_2_4	B	B	A
Ranunculus trichophyllus_>4	B	B	A
Ranunculus x cookii_0_1	B	B	B
Ranunculus x cookii_1_2	B	B	B
Ranunculus x cookii_2_4	B	B	B
Ranunculus x cookii_>4	B	B	B
Rhynchostegium riparioides_0_1	B	B	B
Rhynchostegium riparioides_1_2	B	B	B
Rhynchostegium riparioides_2_4	B	B	B
Rhynchostegium riparioides_>4	B	B	B
Riccia fluitans_0_1	A	A	A
Riccia fluitans_1_2	A	A	A
Ricciocarpos natans_0_1	B	B	B
Ricciocarpos natans_1_2	B	B	B
Rorippa amphibia_0_1	B	B	B
Rorippa amphibia_1_2	B	B	B
Rumex hydrolapathum_0_1	B	B	B
Rumex hydrolapathum_1_2	B	B	B
Rumex hydrolapathum_2_4	B	B	B
Sagittaria sagittifolia_0_1	C	C	B
Sagittaria sagittifolia_1_2	C	C	B
Sagittaria sagittifolia_2_4	C	C	B
Sagittaria sagittifolia_>4	C	C	B
Salvinia natans_0_1	B	B	B
Salvinia natans_1_2	B	B	B
Schoenoplectus lacustris_0_1	B	B	B
Schoenoplectus lacustris_1_2	B	B	B
Schoenoplectus lacustris_2_4	B	B	B
Schoenoplectus lacustris_>4	B	B	B
Schoenoplectus tabernaemontani_0_1	B	B	B
Schoenoplectus tabernaemontani_1_2	B	B	B
Schoenoplectus tabernaemontani_2_4	B	B	B
Schoenoplectus tabernaemontani_>4	B	B	B
Sium latifolium_0_1	B	B	B
Sium latifolium_1_2	B	B	B
Solanum dulcamara_0_1	B	B	B
Solanum dulcamara_1_2	B	B	B

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Sparganium emersum_0_1	B	B	B
Sparganium emersum_1_2	B	B	B
Sparganium emersum_2_4	B	B	B
Sparganium emersum_>4	B	B	B
Sparganium erectum_0_1	B	B	B
Sparganium erectum_1_2	B	B	B
Sparganium erectum_2_4	B	B	B
Sparganium erectum_>4	B	B	B
Spirodela polyrhiza_0_1	C	C	B
Spirodela polyrhiza_1_2	C	C	B
Spirodela polyrhiza_2_4	C	C	B
Stachys palustris_0_1	B	B	B
Stachys palustris_1_2	B	B	B
Stratiotes aloides_0_1	A	A	A
Stratiotes aloides_1_2	A	A	A
Stratiotes aloides_2_4	A	A	A
Stratiotes aloides_>4	A	A	A
Tolypella glomerata_0_1	a	A	A
Tolypella glomerata_1_2	a	A	A
Tolypella glomerata_2_4	A	A	A
Tolypella glomerata_>4	A	A	A
Tolypella intricata_0_1	A	A	A
Tolypella intricata_1_2	A	A	A
Tolypella intricata_2_4	A	A	A
Tolypella intricata_>4	A	A	A
Tolypella prolifera_0_1	A	A	A
Tolypella prolifera_1_2	A	A	A
Tolypella prolifera_2_4	A	A	A
Tolypella prolifera_>4	A	A	A
Trapa natans_0_1	B	B	B
Trapa natans_1_2	B	B	B
Trapa natans_2_4	B	B	B
Trapa natans_>4	B	B	B
Typha angustifolia_0_1	B	B	B
Typha angustifolia_1_2	B	B	B
Typha angustifolia_2_4	B	B	B
Typha angustifolia_>4	B	B	B
Typha latifolia_0_1	B	B	B
Typha latifolia_1_2	B	B	B

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Typha latifolia_2_4	B	B	B
Typha latifolia_>4	B	B	B
Utricularia australis_0_1	B	B	A
Utricularia australis_1_2	B	B	A
Utricularia australis_2_4	B	A	A
Utricularia australis_>4	A	A	A
Utricularia intermedia_0_1	A	A	A
Utricularia intermedia_1_2	A	A	A
Utricularia intermedia_2_4	A	A	A
Utricularia intermedia_>4	A	A	A
Utricularia minor_0_1	A	A	A
Utricularia minor_1_2	A	A	A
Utricularia minor_2_4	A	A	A
Utricularia minor_>4	A	A	A
Utricularia ochroleuca_0_1	A	A	A
Utricularia ochroleuca_1_2	A	A	A
Utricularia ochroleuca_2_4	A	A	A
Utricularia ochroleuca_>4	A	A	A
Utricularia stygia_0_1	A	A	A
Utricularia stygia_1_2	A	A	A
Utricularia stygia_2_4	A	A	A
Utricularia stygia_>4	A	A	A
Utricularia vulgaris_0_1	B	B	A
Utricularia vulgaris_1_2	B	A	A
Utricularia vulgaris_2_4	a	A	A
Utricularia vulgaris_>4	A	A	A
Vallisneria spiralis_0_1	C	C	C
Vallisneria spiralis_1_2	C	C	C
Vallisneria spiralis_2_4	C	C	C
Vallisneria spiralis_>4	C	C	C
Veronica anagallis-aquatica_0_1	B	B	B
Veronica anagallis-aquatica_1_2	B	B	B
Veronica anagallis-aquatica_2_4	B	B	B
Veronica anagallis-aquatica_>4	B	B	B
Warnstorfia fluitans_0_1	B	B	B
Warnstorfia fluitans_1_2	B	B	B
Warnstorfia fluitans_2_4	B	B	B
Warnstorfia fluitans_>4	B	B	B
Zannichellia palustris_0_1	C	C	C

Taxon_Tiefenstufe	TKg13	TKg10	TKp
Zannichellia palustris_1_2	C	C	B
Zannichellia palustris_2_4	B	B	B
Zannichellia palustris_>4	B	B	B

A.5 Latvia

Assessment method

For investigation of macrophytes of lakes in Latvia the field method based on Estonian method will be used. This is a transect method with combination of phytolittoral mapping method. The phytolittoral along the entire lake perimeter is examined from a boat. Within each shore section of the 200-500 m length (depending on lake size), transect is investigated. The more developed or geologically variable the shore stretch, the more transects should be studied. Each transect starts from the edge of water and reaches to the maximum depth of macrophyte occurrence. The width of the profile is not fixed and extends to both sides of the boat to a distance where the species can still be well recognized. In transects, the composition and coverage of visible emergent and floating-leaved plants are estimated from the boat and their growing depth is measured by the scaled rope of the grapnel. Composition of submerged plants and their depth limits are studied using random grapnel sampling (in very shallow water also rake) at every 1-10 m (depending on coverage and diversity of plants) along the transect. The abundance of species is based on Braun-Blanquet [1964] scale that was modified by condensing it to five points. Species abundances are estimated separately in three groups: emergent plants (helophytes) and hygrophilous plants; floating and floating-leaved plants (lemnids and nymphaeids) and submerged plants (isoetids, mosses, charophytes, elodeids, ceratophyllids).

Table A.29 The criteria for quality estimation of LCB1 and LCB2 lakes

Parameter	High	Good	Moderate	Poor	Bad
Onlu for LCB1 Depth limit of submergent plants, m	>4	2.5-4	1.5-2.5	1-1.5	<1
Charasteristic taxa	Char, Pot, Bry	Char, Pot, Bry	Batr, Cer, Pot, Nym	Cer, Nym, Nu, Lem	-
Number of taxa	>10	>10	3-10	0-3	-
Abundance of *Potamogeton perfoliatus* and/or *P.lucens*	2-4	2-4	1	0-1	-
Abundance of charophytes and/or briophytes	>4	3	1-2	1	-
Abundance of free-floating species	1	1-2	3	4-5	-
Abundance of large filamenous algae	0	1	1-2	3-4	5

Char – charophytes, Bry – briophytes, Pot – *Potamogeton,* Batr – *Batrachium,* Cer – *Ceratophyllum,* Nym – *Nymphaea,* Nu – *Nuphar,* Lem – lemnīdi (*Lemna, Spirodela*)

Table A.30 The criteria for quality estimation of LCB3

Parameter	High	Good	Moderate	Poor	Bad
Depth limit of mosses, m (only in lakes with mean depth >3m)	>7	4-7	2-3	<2 vai nav sastopamas	nav sastopamas
Charasteristic taxa	Iso, Bry	Iso, Bry, Char	El, Pot, Char	-	-
Abundance of helophytes*	0	1-2	3	3-4	-
Abundance of isoetids	4	3-4	2	1	0
Abundance of elodeids **	0	0-1	1-2	3	4
Abundance of floating-leaved species***	0	1	2-3	4	-
Total coverage of macrophytes	>50	30-50	23-30	>20	-

Iso – *Isoetes, Lobelia,* Bry – briophytes, El – *Elodea,* Pot – *Potamogeton,* Char - charophyta

* *Acorus calamus, Butomus umbellatus, Glyceria maxima, Phragmites australis, Schoenoplectus lacustris, Sparganium erectum, Typha sp.*

***Elodea sp., Potamogeton sp., Batrachium sp., Myriophyllum sp.*

****Potamogeton natans, Nuphar lutea, Nymphaea candida, Numphaea alba*

A.6 Lithuania: Assessment of lakes condition using modified German Reference Index. Original name: Ežerų būklės vertinimas pagal modifikuotą Vokietijos etaloninį indeksą.

Sampling and data analysis

Macrophytes are sampled 1 time per year per water body from July to August. The sampling sites are selected according to expert knowledge, random and stratified sampling, covering all available habitats per water body. The minimal number of transects is determined according to the lake area size-class (Keskitalo, Salonen, 1993). The sampling is made in perpendicular to shoreline transects divided into 0–1 m, 1–2 m, 2–4 m and >4 m depth zones. At least three samples of macrophytes are taken from each depth zone. The tools used are grapnel and aquascope. Indicatory species belong to these ecological groups: lemnids (freely floating), floating and submerged macrophytes, but the abundance of emerged macrophytes species is also evaluated. Mosses and macrophytes from Charophyta and Angiospermae (Magnoliophyta) divisions are described in species or genus level, filamentous algae – in group level. The minimal size of organisms sampled and processed is 2-3 mm. The abundance of species/groups is estimated according to 5 degree scale: 1 = very rare, 2 = rare, 3 = common, 4 = frequent and 5 = very frequent.

Additional information for every transect and depth zones is also collected. Maximum depth of growth (vegetation limit), the development of macrophytes ecological groups belts (helophytes belt, nimpheids belt, lemnids belt, potameids belt and limneids belt), type of shore (natural or altered by humans), terrestrial vegetation and land use along the transect and shading are noted for transects. Substrate and bottom slope are assessed for every depth zone.

Metrics and calculation of final EQRs

The mectric used in assessment of lakes ecological condition of Lithuania is Reference Index (RI), which is calculated in same way for all types of water bodies (Equation 1.) It is calculated according to Lithuanian list of indicatory species (A – sensitive, C– insensitive and B – indifferent taxa, Table A.31) and named LRI. Index is calculated for each transect and calculation is based on list of taxa and its abundance, estimated at different depth zones. The LRI correcting factors for different lake types are described in Table A.32. The necessary conditions for LRI calculation for different lake types are described in Table A.33. If there conditions are not fulfilled, the LRI cannot be

calculated. Transformation of LRI values into EQR values is described in Equation 2. Relation between LRI and EQR values and classes are shown in Table A.34.

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

Quantity= abundance[3]

Table A.31 List of species, occurring in >3 m and <3 m middle depth lake types (A – sensitive, B – indifferent, C – insensitive/tolerant, "+" – found in this lake type, "rare" – rare species of Lithuania, for which indicatory value is not determined, "-" – not found in this lake type)

Species	Lake types	
	>3 m average depth	<3 m average depth
Alisma gramineum	B	–
Batrachium circinatum	C	B
Butomus umbellatus	B	B
Callitriche hermaphroditica	B	B
Ceratophyllum demersum	B	B
Ceratophyllum submersum	B	–
Chara aspera	A	A
Chara contraria	B	A
Chara delicatula (virgata)	B	A
Chara filiformis	A	A
Chara globularis	B	A
Chara hispida	A	A
Chara intermedia	A	A
Chara rudis	A	A
Chara strigosa	A	A
Chara tomentosa	A	A

Species	Lake types	
	>3 m average depth	<3 m average depth
Drepanocladus aduncus	B	B
Drepanocladus sendtneri	B	B
Eleocharis acicularis	B	B
Elodea canadensis	C	C
Fontinalis antipyretica	B	B
Hippuris vulgaris	B	B
Hydrilla verticillata	B	A
Hydrocharis morsus-ranae	C	B
Lemna minor	C	B
Lemna trisulca	C	B
Myriophyllum spicatum	B	B
Myriophyllum verticillatum	B	B
Najas intermedia	B	A
Najas marina	C	C
Nitella flexilis	B	A
Nitella mucronata	B	A
Nitella opaca	A	A
Nitellopsis obtusa	B	B
Nuphar lutea	B	B
Nymphaea alba	B	B
Nymphaea candida	B	B
Persicaria amphibia	B	B
Potamogeton acutifolius	B	A
Potamogeton alpinus	A	A
Potamogeton berchtoldii	B	B
Potamogeton compressus	B	A
Potamogeton crispus	C	B
Potamogeton filiformis	A	A
Potamogeton friesii	B	B
Potamogeton gramineus	A	A
Potamogeton lucens	B	A
Potamogeton natans	C	B
Potamogeton pectinatus	B	B
Potamogeton perfoliatus	B	B
Potamogeton praelongus	A	A
Potamogeton pusillus	B	B
Potamogeton rutilus	A	A
Potamogeton × nitens	B	A

Species	Lake types	
	>3 m average depth	<3 m average depth
Potamogeton × salicifolius	B	A
Potamogeton × zizii (angustifolius)	A	–
Ranunculus reptans	+	+
Rhynchostegium riparioides	B	B
Sagittaria sagittifolia	C	B
Scorpidium scorpioides	B	B
Sparganium emersum	C	B
Spirodela polyrhiza	C	B
Stratiotes aloides	B	A
Utricularia vulgaris	B	A
Zannichellia palustris	C	B
Fontinalis hypnoides	rare	rare
Najas flexilis	rare	rare
Najas minor	rare	rare
Nitella gracilis	–	rare
Nitella syncarpa	–	rare
Myriophyllum sibiricum	+	+
Potamogeton obtusifolius	rare	rare
Potamogeton trichoides	rare	rare
Tolypella prolifera	–	rare
Utricularia minor	–	+

Table A.32 correcting factors for different lake types

Intercalibration type	Depth	Correcting factors
LCB 1	>3 m	- if LRI > 0 and vegetation limit <5 m → LRI is reduced by 50; - if dominant stands of one of the following taxa occur, LRI is reduced by 50: *Ceratophyllum demersum, C. submersum, Elodea canadensis, Najas marina* or *Potamogeton pectinatus*.
LCB 2	<3 m	- if LRI > 0, maximum depth >= 3 m and vegetation limit <3 m → LRI is reduced by 50; - if dominant stands of one of the following taxa occur, LRI is reduced by 50: *Ceratophyllum demersum, C. submersum, Elodea canadensis, Najas marina* or *Potamogeton pectinatus*.

Table A.33 Necessary conditions for LRI calculation for different lake types

Intercalibration type	Depth	Necessary conditions

LCB 1	>3 m	- total plant quantity (abundance[3]) is >=55; - species belonging to genus Nymphaea and Nuphar make less than 80 % of total plant quantity.
LCB 2	<3 m	- total plant quantity (abundance[3]) is >=35; - species belonging to genus Nymphaea and Nuphar make less than 80 % of total plant quantity; - species for which indicatory value is not determined make no more than 25 % of total plant quantity.

Equation 2. Transformation of LRI values into EQR values:

EQR=(LRI+100)*0.5/100.

Table A.34 Relation between RI and EQR values and classes

LRI value	EQR value	Class of the water body's ecological condition
>50	>0.75	High
50 – 0	0.75 – 0.5	Good
<0 – -50	<0.5 – 0.25	Moderate
<-50 – -100	<0.25 – 0.00	Poor
Could not be assessed	0.0	Bad

Reference condition and boundary setting

For setting reference conditions, existing near-natural sites were chosen. These sites were selected according to expert knowledge, historical data and in which the least disturbed conditions are present. The criteria were:

- The absence or minimal human impact in the site or in all catchment area;
- The macrophyte community corresponds with description of reference community description;
- Diversity of macrophyte species corresponds with diversity of substrates;
- Low quantity of nutrients;
- Unaltered morphology and hydrology.

3 lakes were chosen as reference water bodies: Lake Germantas in Western part, lake Baltys in South–Western part and lake Alnis in Eastern part of Lithuania. These lakes have high alkalinity level. The cover of submerged vegetation with dominant *Chara* spp. is well developed. Sensitive submerged species are very abundant and dominant. Occurrence of tolerant and indifferent species is insignificant. The belt of helophytes and floating leaved plant are not developed or very poorly developed. For preliminary ecological status boundaries estimated for German RI were used.

Pressures addressed and pressure-response relationships

This assessment method shows eutrophication and general degradation as pressures. For 9 alcaline LCB 1 lakes significant negative correlation (-0,62, p<0,05) was estimated between average value of LRI and summer TP. As for 9 alcaline LCB 2 lakes, the negative correlation estimated between average value of LRI and summer TP was weak (-0,4, p<0,05).

A.7 Netherlands

Which indicators are used?

Macrophyte taxonomic composition:

The taxanomic composition of hydrophytes is assessed on species level. Hydrophytes includes angiosperms, charophytes and submerged and floating mosses. Other macroalgea (e.g. *Hydrodictyon* sp.) are not included. Besides an assessment of the species composition, growth forms are assessed separately. Six growth forms are used: submerged, nymphaeids, emergent, floating algae beds, free floating (*Lemnids*), and amphibious. Not all growth forms are considered as indicator for each lake type, and combinations of growth forms are made for some lake types.

Macrophyte abundance:

The metric for species composition uses 3 classes of abundance (and 0 if absent), see Table A.35. The abundance represents the occurrence of the species for the whole lake. The basic abundance data are however in a more precise scale (% cover or other abundance scales, and multiple sample locations).

Table A.35 The Dutch species abundance scale.

class	Description (Dutch)	Description	Nominal cover
1	Zeldzaam of schaars voorkomen	rarely/scarcely occurrence	< 5%
2	Frequent en/of plaatselijk voorkomen	locally/frequently occurrence	5 – 50%
3	Algemeen of (co)dominant voorkomen	common/dominant	> 50%

The growth forms are assessed in relation to the area potentionally covered.

For the true aquatic growth forms (all except amphibious) shallow lake typs (max 3 m depth) are considered to be potentionally fully covered. In deeper lake types the maximum colonised depth is assessed in relation tot the potentional maximum (adaption after intercalibration conclusions).

The amphibious growth form is expressed as percentage cover of well developped vegetation in the area which is naturally falling dry during summer. The area potentially covered with amphibious plants is estimated by taking the difference between averaged highest water level in winter and averaged lowest water level in summer. In

combination with the morphology of the lake, the area falling dry can be calculated. The area falling dry is assumed as the potential area to be covered with amphibious plants.

For emergent macrophytes and nympaeids the potential area is defined by depth and wind fetch. A statistical model predicts the area, but each area is maximally 10m ahead from the nearest point falling dry. Both growth forms emergent macrophytes and nympaeids are only considerd relevant in smaller lake types however.

Composition and abundance of phytobenthos:

Phytobenthos is only included in the assessment as part of the abundance metric of growth forms. The growth form 'floating algae beds' is considered as an indicator for high nutrient availability resulting in uncontroled growth of filamentous algae, starting from periphyton.

Species composition of phytobenthos is not assessed in alkaline lakes due to uncertainty about validation and lacking of intercalibration results for lake types. Floating algae beds are therefore used as a proxi for phytobenthos in alkaline lakes .

Bacterial tufts:

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

Summary

species composition: score of characteristic taxa

growth form: % cover of growth form (submerged, nymphaeids, emergent, floating algae beds, lemnids, and amphibious) per potential covered area or maxumum depth colonised (lakes > 3 m deep)

Both indicators have the same weight to calculate the final flora assessment.

How are these indicators monitored?

Sampling strategy

Species composition and growth form

Before the WFD has become into force, a number of methods have been used for monitoring macrophytes. Random sampling, transect sampling, and in some cases 'practical sampling' has been used in the past. For the data present in the GIG data base monitoring is carried out by transect sampling, and random sampling, and 'complete' sampling (i.e. very dense sampling network). Also different methods of sampling are used (double rake with rope, snorkeling, naked eye). Although different methods are used, they all aim to produce a species list as complete as possible and to estimate mean cover of macrophytes in whole lakes. It is assumened that all data collected for intercalibartion purpose meet the requirements of the GIG data base. Since 2010 a standard monitoring protocol is regulative that allows most of these methods still to use, but within vertain limits to guarantee comparability.

Numbers of samples per lake

Species composition and growth form

Each lakes consist of 6, 10 or 20 sampling points (resp. for lakes <100 ha, <500&>100, >500ha). In shallow, large lakes (> 500 ha) each sampling point has a size of 200x200m and is sampled at each corner 5 times with a rake. In smaller and medium lakes, as well as deeper lakes, sampling points in 6 reps. 10 transects perpendicular to the banks are sampled. Small lakes may be sampled by ramdom crossing the lake, aiming to record the complete species composition and estimate real total cover of growth forms.

When is monitored and with which frequency?

Species composition and growth form

Samples are taken once in the middle of growing season i.e. 15th June-15th August. Inter annual cycle depends on monitoring type.

Use of equipment

Species composition and growth form

For sampling plants in most cases a double rake is used connected to a rope. In some cases snorkeling is used, or an estimation with the naked eye (only possible in clear and shallow water). Sampling bags or jars with alcohol are used for fixation for species determination (mosses, charophytes).

Analysis of sample and level of determination

Species composition

Most plants are determined to species level 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.

Growth forms

Total cover of the different growth forms in the vegetation is estimated in percentage. Species can be part of more than one growth form (*Nuphar lutea* and *Potamogeton alpinus* are part of both submerged and nymphaeids, *Sagittaria sagittifolia* is part of emergent as well). Submerged filamentous algae are condidered as part of the submersed growth form, cover of floating filamentous algae is estimated separately as the growth form flab. The growth form amphibious is estimated as mean width and percentage of the shore length of well depelloped reed vegetation (cover of helophytes within the vegation >75%).

Depth limits of vergetation types are recorded along transects in small lakes, depth range of every sample is recorded in large lakes.

Way of reporting basic data

Sample data are reported as they are recorded, usually in a 9-classes cover scale for species and percentage for growth forms. There is a guideline to transform basic

species cover data from various scales into the 3-classes scale and a validation procedure to prevent aberrant data. Basically species covering < 5 % of the sampled area are regarde as low abundant, 5-50% are regarded asl medium abundant and > 50% are regarded are high abundant.

Growth forms are reported in percentages. Depth limits are record in m with 1 decimal.

Assessment

Data requirements

Species composition

The lakes should be typed and species list should contain a number ranging between 0 and 3 (integer). The GIG database can be used directly. That means that the data of sampling sites have to be consolidated to one list of species with their abundances.

Growth form

The lakes should be typed and the growth forms contain a percentage ranging between 0 and 100 of the potential area for each growth form. In deeper lake types (mean depth > 3 m) maximum colonized depth of submerged vegetation should be given in m with 1 decimal.

Table A.36 Example of an input file which can be used for automatically calculation of the Dutch macrophyte species metric.

Lake	Ankeveen	Bergumer meer	Botshol	Breukeleveense plas
Type	M14	M27	M30	M14
Year	1988	2006	2006	2006
Submerged	30	10	90	10
Nympaeids	5	5	10	10
Emergent	0	0	0	0
Lemnids	1	1	1	1
Flab	0	0	0	0
Amphibious	60	80	50	90
Callitriche stagnalis Scop.	1	0	0	0
Ceratophyllum demersum L.	0	0	0	1
Chara aspera Deth. Ex Wild.	0	0	1	0
Chara connivens SALZM.	0	0	3	0
Chara contraria A. Br.	0	0	1	0
Chara globularis Thuill.	0	0	1	0
Chara hispida L.	0	0	1	0
Chara sp. L. ex Vaillant	1	0	0	0
Elodea canadensis Michx.	1	0	0	0
Elodea nuttallii (Planch.) H. St. John	0	1	0	0
Hydrocharis morsus-ranae L.	1	1	0	0

Lake	Ankeveen	Bergumer meer	Botshol	Breukeleveense plas
Lemna minor L.	1	0	0	0
Myriophyllum spicatum L.	0	0	0	2
Myriophyllum verticillatum L.	1	0	0	0
Najas marina L.	1	0	3	0
Nitella flexilis L. C.Ag.	1	0	0	0
Nitella mucronata (A. Br.) Miquel	1	0	0	0
Nitellopsis obtusa (Desv.) J. Groves	0	0	3	0
Nuphar lutea (L.) Sibth. & Sm.	1	1	2	2
Nymphaea alba L.	1	1	1	2
Nymphoides peltata (S. G. Gmelin) O. Kuntze	1	1	0	2
Persicaria amphibia (L.) Gray	0	0	0	1
Potamogeton acutifolius Link	1	0	1	0
Potamogeton alpinus Balbis	1	0	0	0
Potamogeton compressus L.	1	0	0	0
Potamogeton crispus L.	0	0	1	0
Potamogeton friesii Rupr.	1	0	0	0
Potamogeton lucens L.	1	0	0	0
Potamogeton natans L.	1	0	0	0
Potamogeton obtusifolius Mert. & Koch	1	1	0	0
Potamogeton pectinatus L.	0	1	1	1
Potamogeton perfoliatus L.	0	0	0	2
Potamogeton trichoides Cham. & Schltdl	1	0	0	0
Ranunculus circinatus Sibth	1	0	0	0
Stratiotes aloides L.	0	0	1	1
Utricularia vulgaris L.	1	0	0	0

Methods of calculation

Species composition

For each type a list with species scores is constructed based on the expected abundance in reference conditions (Table A.41). For assessment all scores are summed and compared to the reference score. All class boundaries are also expressed as percentage of the reference score. H/G: 70% G/M:40%; M/P:20% P/B:10%. The boundary percentages are transformed to EQR values, where H/G equals 0.8 and G/M equals 0.6 etc. Intermediate scores are linearly interpolated between the boundaries.

Table A.37 The type specific reference score (M14, M21, M23, M27= LCB2, M20= LCB1, M30, M31 = brackish waters, not intercalibrated; M5 = isolated riverine lakes, not intercalibrated), adjusted after the intercalibration process

Type	M5	M14	M20	M21	M23	M27	M30	M31
Version 2007	65	47	44	43	34	53	18	11
Reference score, adjusted 2011	30	22	22	20	16	25	18	11

Table A.38 An example for calculation of species metric for a M14 type lake.

Species in the lake	Abundance (0-3)	Score (see Table A.41)
Potamogeton pectinatus	3	2
Potamogeton perfoliatus	1	1
Lemna minor	2	1
Chara aspera	1	3

Calculation:

1. Sum of scores = 7, reference score= 22 (see Table A.37)
2. EQR not transformed: 7/22=0,318 or 31,8 % of the reference score meaning MODERATE (between 20 and 40%)
3. EQR transformed (for averaging): linear interpolation within class boundaries 0.4 and 0.6 (20% and 40%) gives: 0.518.

Growth form

From the basic data one number for each growth form is aggregated. Example: a shallow lake of type M14 (LCB2) is covered with 500 ha by submerged macrophytes. The potential area is equal to the total size of the lake: 1000 ha. The covered area is 50% meaning HIGH status (Reference condition at 65%, H/G boundaries at 45% and 100%, see Table A.40). Linear interpolation within class boundaries 0.8 and 1.0 (45% and 65%) gives a transformed EQR of 0.850. The amphibious vegetation dominated by reed (Phragmites australis) is regarded well developed if the cover of the reeds is over 75%. This is the case at 90% of the shoreline and with a mean width of 20 m. In reference state the width should be 50 m at this particular lake. Therefor 90% of 20/50 of the potential area is covered which results in a POOR status (see Table A.40). Linear interpolation within class boundaries 0.2 and 0.4 (20% and 40%) gives a transformed EQR of 0.360.

Example2: a lake with maximum depth of 18 m of type M20 (LCB1) is covered by submerged macrophytes in the shallower parts, at average depth of 5,2 meter the cover decreases below 1%, resulting in GOOD status (see Table A.39). Linear interpolation within class boundaries 0.6 and 0.8 (4,0 m and 6,0 m) gives a transformed EQR of 0.720

Table A.39 The class boundaries for maximum colonized depth in lakes with mean depth > 3 m (M20 = LCB1), recommended after the intercalibration process

Boundaries	None	B/P	P/M	M/G	G/H	Ref
EQR transformed	0	0,2	0,4	0,6	0,8	1,0
Maximum colonized depth (m)	0	1,0	2,5	4,0	6,0	7,5

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

The number of reference sites is too low for setting reference values. The reference for species composition is based on the idea of having complete plant communities in reference conditions. The list of plant communities that are considered to be present in reference conditions is based on earlier work on target types in nature management (Bal *et al.*) and improved by expert judgedment. Vegetation data from the database on well developed plant communities in The Netherlands (Schaminée *et al.*) is used to list all characteristic and all frequent (>20% occurrence on relevé basis) species of these plant communities.

The weight given to species at the three abundance levels is derived from both the plant communities charactistics and expert judgment. The reference score for the sum of the scores of the species is derived from frequency data in the vegetation database, which is considered a good estimate for the probability of finding the species in a fixed amount of samples.

The fraction of species (or EQR or deviation from reference) at G/M and H/G are estimated with expert judgment, and adjustment may be needed because of too low number of reference sites. Final adjustment of the reference scores are based on intercalibration results.

The potential area where macrophytes can grow relies also on expert judgment, except for submerged macrophytes where a model technique is used (using estimates for reference tP, reference chf-a and reference light climate).

The boundary percentages are derived purely on expert judgment. G/M boundary for abundance is estimated at 25% cover on the assumption that this is the critical density for shifting between the two states of most shallow lakes: turbid, bentivorous fish dominated without macrophytes and clear, macrophytes dominated lakes (Scheffer, 1998). Abundance is considered to show an optimum-relation with density, with the reference conditions below 100%. Therefore H/G boundary is estimated at 100% cover and reference condition and the other H/G boundary are estimated in between 100 and 25 at 65% resp. 45%. For amphibious vegetation 100% was estimated as a reference and quality classes were equally devided between 100 and 0. Because of lack of data these boundaries are not validated, and amphibious vegetation was not included in intercalibration.

The species indicator is correlating quite well with eutrophication indicating parameters (TP, Chf-a and Secchi depth). Most clear is that the maximum value of EQR species composition is reduced at higher levels of phosphorus.

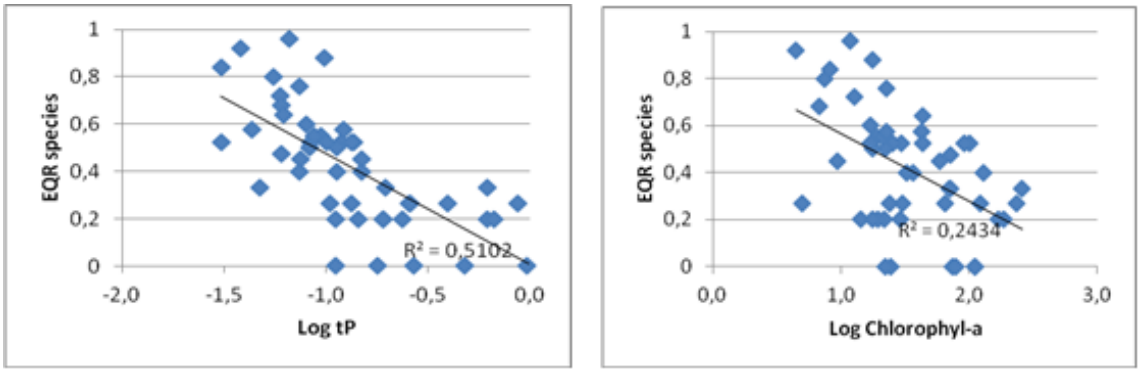

Figure A.7 Relationship between Dutch EQR for species composition and total phosphorus (left) resp. Chlorophyl-a concentration (right) in Dutch lakes (all 51 Dutch lakes in the intercalibration database).

How well correlate the indicators with pressure indicators?

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

Completeness of method

The Dutch method uses species composition and growth forms cover, both of which contribute equally to the final assessment. In the GIG comparison only the species composition metric could be used with original data. The growth forms metric of submerged species is calculated with estimated data from the species abundance data. Data needed for the growth form metric of total cover of amphibious plants is missing in the GIG database.

Data transformation to GIG data base

Data on species were 100% compatable with the GIG database format, the numerical scale for abundance of the species was equal. The GIG has agreed on a transformation between the various abundance scales used by different countries.

Some species had to be renamed after their synonyms.

Assessment transformation to the GIG data base

- The parameters for growth form cover could be derived from species abundance data but accuracy of such a transformation is too low for reliable assessment of individual lakes; when comparing a large number of assessments deviations are averaging out nevertheless.
- Species that do not occur in TheNetherlands and therefore are not listed in the Dutch metric, but have the same indicator value in other MS, were included in the metric when applied for the samples of other MS (please add separate list of added foreign taxa and their scoring)

The reference value for species composition was not adjusted for other MS. For MS with a lower species richness in reference state this results in an underestimation, for other MS this results in an overestimation. These effects are part of the country effects due to biogeographical differences and differences in sampling techniques that are cancelled out by the continuous benchmark standardisation that has been agreed for the 2nd phase intercalibration.

- refer to parameters which could not be assessed
- refer to species which were not present in the data base, but present in your national assessment
- refer how this is solved: eg. PL: only national data is used. eg. DE and BE: national complete method is compared with GIG method etc.
- if possible show the difference in final results

Transformations on national methodology

- especially relevant for UK, NL
- refer and be clear on which tables and values are used, and make updated tables and values where applicable.

The Dutch method was developed in 2004 with tentative reference values and class boundaries. In comparion with methods of other MS the methods was considered to stringent. December 2006 all reference values were recalculated and from then on the new values were used in the comparisons. At the Edinburg meeting it was concluded that the reference values and boundaries should even be adjusted an extra 10% less stringent. The result of this is published is the februari 2007 version of the Dutch method.

At the end of the Leiden meeting, 11 and 12 march 2007 it was concluded that the reference values and boundaries should be adjusted 15% less stringent in stead of 10%. The list of indicator species and their indicator value only changed in minor details in December 2006.

At the Amsterdam meeting 15 and 16 june 2011 the recommendation of the WISER work on macrophyte assessment methods (Deliverable D3.2-3) that maximum colonisation depth is used as a macrophyte abundance metric in lakes with mean depth> 3 m and total cover for lakes < 3m, was accepted for the Dutch metric as a basis for intercalibration and recommendation for acceptance in the national method. At the Copenhagen meeting of 26-27 september 2011 the reference scores for species composition were adjusted to the values in this text, they will be accepted in the national method in 2012. The adjustments have no impact on monitoring.

Table A.40 Overview of growth form boundaries (% cover) for shallow Dutch lake types (mean depth <3 m). The left column represent the transformed EQR. The

growth form "nymphaeids" is not included in this table because this table only presents the values for the larger water types.

	M5	M14	M21	M23	M27	M30	M31
Submerged							
0,0	0	0	0	0	0	0	0
0,2	20	1	1	1	1	10	5
0,4	30	5	5	5	5	20	10
0,6	40	25	25	25	25	40	30
0,8	50	45	45	45	45	50	40
1,0	75	65	65	65	65	60	55
0,8	100	100	100	100	100	70	70
0,6						80	80
0,4						100	100
Emergent							
0,0				0			
0,2				1			
0,4				3			
0,6				5			
0,8				10			
1,0				15			
0,8				100			
Floating algae							
0,8				0			
1,0				1		0	
0,8				5		1	
0,6				10		5	
0,4				30		10	
0,2				50		15	
Lemnids							
0,8				0			
1,0				0,5		0	
0,8				1		1	
0,6				2		5	
0,4				10		10	
0,2				20		20	
Amphibious vegetation							
0,0		0	0		0	0	
0,2		20	20		20	20	
0,4		40	40		40	40	
0,6		60	60		60	60	

	M5	M14	M21	M23	M27	M30	M31
0,8		80	80		80	80	
1,0		90	90		90	100	0
0,8		100	100		100		5
0,6							10
0,4							15
0,2							20
0,0							100

Table A.41 List of type specific characteristic species scores. Per type and per species the number should reed as three separate scores, the first for the lowest abundance (1), the second for the intermediate abundance (2), the third for the highest abundance. Example: Alsima gramineum found in abundance class of 3 in type M5 will get a score of 4. The table continues at the next page.

Species	M5	M14	M20	M21	M23	M27	M30	M31
Alisma gramineum	134							
Apium inundatum	134				122			
Azolla filiculoides	100							
Azolla mexicana	100							
Callitriche hamulata	134				122			
Callitriche hermaphroditica	134							
Callitriche obtusangula					122		134	
Callitriche platycarpa	134	122	122	122	122	122		
Ceratophyllum demersum	122	110	110	110	110	110		
Ceratophyllum submersum	122				122		134	
Chara aspera	134	134	134	134	134	134	122	
Chara baltica					134		134	134
Chara canescens					134		134	134
Chara connivens					134		134	134
Chara contraria		134	134	134	134	134		
Chara globularis	134	134	134	134	134	134	122	122
Chara major	134	134	134	134	134	134		
Chara sp.		134	134	134	134	134		
Chara vulgaris	134	134	134	134	134	134	122	122
Echinodorus ranunculoides					122			
Eleocharis acicularis	134							
Elodea canadensis	122	122	122	122		122		
Elodea nuttallii	110	110	110	110	110	110		
Fontinalis antipyretica	134	122	122	122	110	122		
Groenlandia densa	134							

Species	M5	M14	M20	M21	M23	M27	M30	M31
Hippuris vulgaris	134							
Hottonia palustris	134	122				122		
Hydrocharis morsus-ranae	134	122	122	122		122		
Juncus bulbosus					110			
Lemna gibba	100	100	100	100		100	100	
Lemna minor	100	100	100	100	100	100	100	100
Lemna trisulca	100	110	110	110	110	110	100	100
Limosella aquatica	134							
Littorella uniflora					134			
Myriophyllum alterniflorum					122			
Myriophyllum spicatum	122	122	122	122	122	122		
Myriophyllum verticillatum	134	122	122	122		122		
Najas marina	134	122	122	122		122	134	
Nitella capillaris	134							
Nitella flexilis	122				134	134		
Nitella hyalina		134	134	134	134	134		
Nitella mucronata	134	134	134	134	134	134		
Nitella opaca	134	134	134	134	134	134	122	
Nitellopsis obtusa	122	134	134	134		134		
Nuphar lutea	134	122	122	122		122		
Nymphaea alba	134	122	122	122		122		
Nymphaea candida	122							
Nymphoides peltata	134	122				122		
Persicaria amphibia	122	122	122	122	110	122		
Potamogeton acutifolius						122		
Potamogeton alpinus	134							
Potamogeton berchtoldii		122	122	122		122		
Potamogeton coloratus					134			
Potamogeton compressus	134	122	122	122		122		
Potamogeton crispus	134	122	122	122	122	122	122	110
Potamogeton gramineus					134			
Potamogeton lucens	134	122	122	122		122		
Potamogeton mucronatus	134	122	122	122		122		
Potamogeton natans	122	122	122	122	122	122		
Potamogeton obtusifolius	134	122	122	122		122		
Potamogeton pectinatus	122	122	122	122	110	122	122	122
Potamogeton perfoliatus	134	122	122	122		122		
Potamogeton polygonifolius					122			
Potamogeton praelongus	134	122	122	122		122		

Species	M5	M14	M20	M21	M23	M27	M30	M31
Potamogeton pusillus	134	122	122	122	110	122	110	110
Potamogeton trichoides	134	122	122	122		122		
Potamogeton x zizii		122	122	122		122		
Ranunculus aquatilis	134	122	122	122	122	122		
Ranunculus baudotii					122		134	
Ranunculus circinatus	134	122	122	122	122	122		
Ranunculus peltatus	134				122			
Riccia fluitans	100	110	110	110		110		
Ricciocarpos natans	100					110		
Ruppia cirrhosa					122		134	134
Ruppia maritima					122		134	134
Schoenoplectus lacustris	122	122	122	134	122	122		
Spirodela polyrhiza	100	100	100	100	100	100		
Stratiotes aloides	134	122				122		
Tolypella glomerata					134			
Tolypella intricata	134				134			
Tolypella prolifera	134							
Utricularia vulgaris	134	122				122		
Wolffia arrhiza						100		
Zannichellia palustris	134	122	122	122	122	122	134	134

A.8 Poland

Status: the original method (so called MFI – MacroPhytoIndication) was developed in early 80'es (Rejewski 1981); during the project running 2005 and 2006 detailed sampling strategy was developed and assessment method was adopted to meet the WFD requirements; method was officially accepted by Ministry of Environment in November 2006 and has to bebeen implemented in monitoring program from 2007. (probably need to be upgraded after two years of using in routine monitoring - pilot study).

Which indicators are used?

Macrophyte syntaxonomic composition:

The Polish method is based on syntaxonomic composition (according to the phytosociological method by Braun-Blanquet 1964) which means that only plant communities are recorded. Plant community is the species association of the minimum area >1m^2 and the cover >25% (please, note that single plant is not a community and is not recorded). All plant communities occupying phytolitoral area are identified, submerged and emergent as well, including hydrophytes (charophytes, mosses and potamids), floating-leaves (nympheaids), non rooting limneids and emergent helophytes (rush and sedge rush).

Macrophyte abundance:

Sampling strategy is based on the belt-transect method. The abundance represents the %cover of each plant community on each belt transect in 7 point scale (see Table A.42).

Table A.42 Polish plant communities abundance scale

Estimated % cover of each plant community on the belt transect	Scale (acc. to Braun-Blanquet scale)
75 – 100	5
50 – 75	4
25-50	3
5-25	2
1-5	1
0,1 –1	+
<0,1	r

Composition and abundance of phytobenthos:

Phytobenthos is not used in the assessment acc. to this method (separate method of assessment based on phytobenthos will behas been developed).

Bacterial tufts:

Bacterial tufts are not used in the assessment.

Summary

In order to calculate all metrics used in Polish method following data is needed:

- number of plant communities recorded in phytolittoral (including all plant groups listed above);
- total area of phytolittoral (calculated from max. depth of plant growth, based on bathymetric plan)
- %share of each plant community in total phytolittoral area.

How are these indicators monitored?

Sampling strategy

Before the WFD has become into force, macrophytes were not examined in routine monitoring in Poland.

In early '80ies the MacroPhytoIndication method (so called MFI) was developed by Rejewski (1981) and used for scientific purposes only. In this method the vegetation was examined around the whole phytolittoral using rake or grapnel and the whole littoral was mapped.

During the last years MFI method was modified several times by Ciecierska (2003, 2004, 2005).

In 2005-2006 the "macrophyte project" supported by Polish Ministry of Environment was running. The aim of the project was to adopt the MFI method to meet WFD requirements and to develop a new, fully WFD compliant, monitoring method.

In order to adopt the sampling method to the capacities of the regional services (when mapping is a very time- and work-consuming method) also a new sampling strategy was developed based on belt transects.

Numbers of samples per lake

For each lake a minimum number of belt transects required is calculated according to Jensen formula (Jensen 1977, Keskitalo & Salonen 1994). Number of transects depends on the area and the shape of the lake; normally it makes one transect for app. 500m length of shoreline. The width of the a transect is about 20-30 m in order to enable boat manoeuvering and the length is from the shoreline to the max. depth of plant growth.

Each transect is sampled with a rake in order to identify all plant communities, share of each plant community in 7 point scale, % of total plant cover within a transect and maximum depth of plant growth.

When is monitored and with which frequency?

The field study is conducted in the middle of the vegetation season, normally mid of June – mid of September; ones for each lake designated to monitoring network in each 6 years plan.

Use of equipment

For sampling plants in most cases a rake is used connected to a scaled rope. Sampling bags or jars with alcohol are used for fixation for "problematic" species determination in lab (mosses, charophytes).

Analysis of sample and level of determination

Polish method is based on syntaxonomic level and not single plants but plant communities are identified. For this reason plants are determined to species level in the field. Some taxa (e.g. Charophytes and mosses) are validated in the laboratory.

Way of reporting basic data

Data from all transect is then averaged in order to determine indicators used in metric calculation: the number and list of plant communities, average colonization depth of plant growth, total phytollitoral area and the % shareproportion of the area occupied by of each plant community. They are then the basis to calculate all metrics of ESMI method.

In order to store the data and to calculate all metrics of ESMI method the special simple software was designed on national level.

Assessment

Data requirements

To calculate all metrics of Polish method following data is required:

- total lake area in ha or km^2 (P);
- total area of phytolittoral in ha in ha or km^2 (N);
- number of plant communities identified in phytolittoral (S);
- % share ofproporcion of the area occupied by particular plant communities in % of N (n_i);
- area of the minimum potential phytolittoral determined by the isobath 2,5 m (area from the shoreline, limited by the isob.where water depth < 2,5 m)

Methods of calculation

Using all data listed above it is possible to calculate three two metrics of Polish method:

- For taxonomic composition - Pielou index of eveness (J)

$$J = \frac{H}{H_{\max}}$$

where:

$$H = -\sum \frac{n_i}{N} \times \ln \frac{n_i}{N}, \quad H_{\max} = \ln S$$

Phytocenotic diversity index (H) from the Shannon – Weaver formula:

$$H = -\sum \frac{n_i}{N} \times \ln \frac{n_i}{N}$$

- Maximum phytocenotic diversity index (H_{max}):

$$H_{\max} = \ln S$$

- For abundance - cColonization index (Z):

$$Z = \frac{N}{izob.2{,}5}$$

where isob.2,5 – area where water depth is <2,5m

These are combined in one multimetric - Ecological State Macrophyte Index (ESMI):

$$ESMI = 1 - \exp\left[- J \times Z \times \exp\left(\frac{N}{P} \right) \right]$$

Exponential function in formula is used in order to get ESMI values in the range from 0 (most disturbed state) to 1 (reference stare, theoretical value).

The ESMI values is were classified into 5 classes of ecological state, separately but class boundaries are different for different two macrophyte lake types - stratified and non-stratified lakes, both highly alkaline (>1 meq/L) (Table A.43):.

Table A.43 Class boundary values in original Polish method ESMI elaborated in 2006

Ecological state	ESMI value:	
	Stratified lakes	Non-stratified lakes
High	≥0,680 – 1,000	≥0,680 – 1,000
Good	≥0,340 – 0,679	≥0,270 – 0,679
Moderate	≥0,170 – 0,339	≥0,110 – 0,269
Poor	≥0,090 – 0,169	≥0,050 – 0,109
Bad	<0,090	<0,050
	no submerged plantsvegetation	

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

The new method was elaborated on the basis of the scientific dataset comprises more than 150 lakes (lake-years) surveyed with MFI method (detailed mapping of the whole phytolittoral) in the last 30 years. In the dataset mostly reference lakes and lakes in high and good status were collected (due to scientific projects aimed on exploring natural ecosystems). For all lakes in dataset ESMI values were calculated.

Reference value was determined as a median value of ESMI from real reference lakes identified according to the pressure criteria, for stratified and non-stratified lakes separately (spatial method).

H/G boundaries were determined as 75th percentil from the distribution of reference lakes (it gave 0,676 for stratified lakes and 0,679 for mixed ones - in the classification both values rounded to nearest 0,010 –> 0,680). The whole range of ESMI from the boundary H/G to the minimum value identified in database (for stratified and non-stratified lakes separately) was then divided in four classes in logarithmic scale.

Table A.44 New class boundary values of Polish method ESMI suggested after the harmionisation process in 2011

Ecological state	ESMI value: Stratified lakes
High	≥0,680
Good	≥0,410
Moderate	≥0,205
Poor	≥0,070
Bad	<0,070
	no submerged plantsvegetation

During the infercalibration process it becames clear that boundary values G/M are too relaxed in the case of both, stratified and non-stratified lakes. In a harmonization process it has been suggested to tighten the G/M and M/P boundaries by 20% and leave H/G boundary not changed. Moreover, since the ESMI formula is completed with the typological factor (P/N) it has been decided to combine stratified and non-stratified

lakes and elaborate one classification system for all highly alkaline lakes. The class boundaries for ESMI after the harmonization process are given in Table A.44.

How well correlate the indicators with pressure indicators?

During our "macrophyte project" we tested the relationships between particular metrics and ESMIndex itself in the pressure gradient (expressed asand main eutrophication indicators (annual mean of TP, chl a a,and SD and cumulative indicator - water quality class acc. to Polish monitoring method: Lake Quality Evaluation System (Kudelska, Soszka & Cydzik 1994)) demonstrated in 2006 based on the data used for the national 'macrophyte project' are presented in tables and figures below.

After three years of using the method in routine monitoring (2007-2009) the analyses have been redone based on macrophyte data collected from 199 lakes (Table A.45).

Table A.45 Relationship between phytocenotic diversity index (H) and pressure indicators (chl a [ug/l], Secchi disc reading [m], TP [mgP/l] and water quality classes according to Polish Lake Quality Evaluation System [LQES]) in stratified and mixed lakes

Pressure indicators	Stratified hard-water lakes			Non-stratified hard-water lakes		
	r^2	r	p	r^2	r	p
log chl *a* (mean)	0,043	-0,206	0,234076	**0,095**	-0,309	0,015445
log SD (mean)	**0,129**	0,360	0,033747	**0,176**	0,420	0,000756
log TP (mean)	0,034	-0,184	0,288701	**0,136**	-0,369	0,003389
log LQES classes	**0,113**	-0,336	0,048280	**0,158**	-0,398	0,001509

Table A.46 Relationship between colonisation index (Z) and pressure indicators (chl a [ug/l], Secchi disc reading [m], TP [mgP/l] and water quality classes according to Polish Lake Quality Evaluation System [LQES]) in stratified and mixed lakes

Pressure indicators	Stratified hard-water lakes			Non-stratified hard-water lakes		
	r^2	r	p	r^2	r	p
log chl *a* (mean)	**0.576**	-0.759	0	**0.313**	-0.559	0.000003
log SD (mean)	**0.482**	0.694	0.000004	**0.389**	0.624	0
log TP (mean)	**0.290**	-0.538	0.000853	**0.303**	-0.550	0.000004
log LQES classes	**0.472**	-0.687	0.000005	**0.444**	-0.666	0

Table A.47 Relationships between Ecological State Macrophyte Index (ESMI) and pressure indicators (chl a [ug/l], Secchi disc reading [m], TP [mgP/l] and water

quality classes according to Polish Lake Quality Evaluation System [LQES]) in stratified and mixed lakes demonstrated in 2006; all significant at p<0,05

Pressure indicators	Stratified hard-water lakes (n=		Non-stratified hard-water lakes (n=	
	r^2	r	r^2	r
log TP	**0,315**	-0,561	**0,351**	-0,592
log chl *a* (mean)	**0,662**	-0,814	**0,360**	-0,600
log chl *a*	**0,662**	-0,814	**0,360**	-0,600
log SD	**0,552**	0,743	**0,464**	0,681
log TP (mean)	**0,315**	-0,561	**0,351**	-0,592
log LQES classes	**0,512**	-0,715	**0,457**	-0,676

Table A.48 Relationships between Ecological State Macrophyte Index (ESMI) and pressure indicators (annual mean of TP [mgP/l], TN [mgN/l], chl a [ug/l], Secchi disc reading [m]), in stratified and mixed lakes demonstrated based on the data collected within the klake monitoring in the years 2007-2009; all significant at p<0,05

Pressure indicators	Stratified hard-water lakes (n=112)		Non-stratified hard-water lakes (n=87)	
	r^2	r	r^2	r
log TP	**0,203**	-0,450	**0,140**	-0,375
Log TN	**0,250**	-0,500	**0,256**	-0,501
log chl *a*	**0,332**	-0,576	**0,461**	-0,679
log SD	**0,414**	0,643	**0,508**	0,713

A.9 United Kingdom: UKTAG Lake assessment methods Macrophyte and Phytobenthos

Macrophytes (Lake LEAFPACS)

Which indicators are used?

The method assesses the condition of the quality element by combining information on the parameters listed below. The parameters are calculated using information on macrophyte species and groups of such species. The results for each parameter are then used to produce an ecological quality ratio (EQR) for the combined parameters. The combined parameters are referred to as Lake LEAFPACS.

I. Lake Macrophyte Nutrient Index (LMNI);

II. Number of functional groups of macrophyte taxa (NFG).

III. Number of macrophyte taxa (NTAXA);

IV. Mean percent cover of hydrophytes (COV); and

V. Relative percent cover of filamentous algae (ALG)

How are these indicators monitored?

In order to obtain the data with which to calculate the observed values for each of the parameters, a minimum of four lake sectors should be surveyed. In the largest lakes eight lake sectors will be required. A sector should comprise a 100 metre length of shoreline. It should extend from the shore to the centre of the lake or to the maximum depth of colonisation of macrophytes, whichever is the shorter distance from the shore. The sectors should be arranged to give an approximately equal spread around the perimeter of the lake.

Surveys should normally be conducted from June until September.

The lake should be surveyed in order to establish the presence of each of the macrophyte taxa listed in column 1 of Table 1. Where it is not possible to identify a macrophyte to the taxonomic level listed in Column 1 of Table 1 it should be recorded using the next highest taxonomic level, provided this is listed in Column 1 of Table 1.

Each taxon listed in Column 1 of Table 1 and present in the lake should be assigned a value (0 -100 %) which is an estimate of the percentage cover of the taxon in the area of the lake surveyed.

The surveying method should conform to EN 15460 : 2007 Water quality – Guidance standard for the surveying of macrophytes in lakes.

Methods of calculation

Calculation of the observed value for each parameter

I. Lake Macrophyte Nutrient Index (LMNI)

In order to calculate the observed value of the parameter, LMNI, each macrophyte taxon listed in Column 1 of Table 1 and identified as being present in the lake should be assigned the corresponding lake macrophyte nutrient index score in Column 2 of that Table. The observed value of the parameter should be calculated by the equation:

$$\text{Observed value of LMNI} = \frac{\sum_{j=1}^{n} \text{LMNI}_j}{N}$$

where:

" LMNI_j " is the Lake Macrophyte Nutrient Index score for taxon "j" given in Column 2 of Table 1;

"j" represents a taxon listed in Column 1 of Table 1 and present in the sample. "j" has a value of 1 to "n" used to indicate which of the all the taxa (total number = "n") listed in Column 1 of Table 1 and present in the sample it represents; and

"N" is the total number of macrophyte taxa listed in Column 1 of Table 1 and identified as being present in the lake.

II. Number of functional groups of macrophyte taxa (NFG)

In order to calculate the observed value for the parameter, NFG, each taxon listed in Column 1 of Table 1 and identified as present in the lake should be assigned to the corresponding functional group in Column 3 of Table 1, if a corresponding functional group is listed for that taxon in that column.

The observed value for the parameter, NFG, is given by the sum of the number of different functional groups of taxa identified as present in the lake.

III. Number of macrophyte taxa (NTAXA)

The observed value for the parameter, NTAXA, is given by the sum of the number of taxa listed in Column 1 of Table 1 that are present in the lake.

IV. Mean percent cover of hydrophytes (COV)

The observed value for the parameter, COV, should be calculated according to the following equation:

$$\text{Observed value of COV} = \frac{\sum_{j=1}^{n} \%COV_j}{N}$$

where:

"$\%COV_j$" is the percentage cover of taxon "j" in the area of the lake surveyed;

"j" represents a taxon listed in Column 1 of Table A.49 and present in the sample. "j" has a value of 1 to "n" used to indicate which of the all the taxa (total number = "n") listed in Column 1 of Table A.49 and present in the sample it represents; and

"N" is the total number of macrophyte taxa listed in Column 1 of Table A.49 and identified as being present in the lake.

V. Relative percent cover of filamentous algae (ALG)

The observed value for the parameter, ALG, should be calculated according to the following equation:

$$\text{Observed value of ALG} = \frac{\sum_{k=1}^{n} \%F_k}{\sum_{j=1}^{n} \%COV_j}$$

where:

"$\%F_k$" is the percentage cover of taxon "k" in the area of the lake surveyed;

"k" represents a taxon listed in Column 1 of Table A.49, indicated as being a filamentous algal taxon in Column 4 of that Table and present in the sample. "k" has a value of 1 to "n" used to indicate which of the all the taxa (total number = "n") listed in Column 1 of Table A.49, indicated as being a filamentous algal taxon in Column 4 of that Table and present in the sample it represents.

Calculation of the reference value for each parameter

Reference conditions were derived using a combination of (a) information from a network of lakes identified as being subject to no or very minor alterations likely to affect their macrophyte communities; and (b) modelling using predictive models and hindcasting methods. For the purposes of the latter, data on individual species-pressure relationships indicated by empirical analysis and historical macrophyte records were used.

I. Lake Macrophyte Nutrient Index (LMNI)

The expected LMNI value is related to the Morpho-Edaphic Index (MEI) where

$$MEI = Log_{10} ([(Alk + 40) \div 1000] \div D)$$

The model that is used to calculate expected LMNI depends on the geology of the lake catchment. This is summarised using the weighted Freshwater Sensitivity Class (wFSC) where:

$wFSC = F_1/100 + [F_2/100 \times 2] + [F_3/100 \times 3] + [F_4/100 \times 4] + [F_5/100 \times 5]$;

"Freshwater Sensitivity Class" describes the relative capacity of geology and soils to neutralise incoming acidity and hence limit acid loadings to fresh surface waters. There are five classes ranging from F1 (highly sensitive) to F5 (low sensitivity).The classes are derived from the Centre for Ecology and Hydrology Freshwater Sensitivity Class map; Hornung et.al. (1995). In the above equation the terms F1 to F5 describes the % cover of the lake catchment assignable to each of the five possible sensitivity classes.

The value for the parameter, LMNI, in the reference conditions applicable to the lake should be calculated using the following equation:

If wFSC ≥ 4.0 (i.e. well buffered catchments with soft calcareous geology):

$$\text{Reference LMNI} = 4.969 + 1.272 \times MEI + 0.193 \times MEI^2$$

If wFSC< 4.0 (i.e. poorly buffered catchments or those with hard calcareous geology):

Reference LMNI = 4.969 + 1.272 x MEI + 0.193 x MEI^2 - 0.55

II. Number of functional groups of macrophyte taxa (NFG)

The value for the parameter, NFG, in the reference conditions applicable to the lake should be calculated using the following equation:

Reference N_FG = Exponent (0.703 – [0.049 x Log_{10} H] + [0.133 x Log_{10} S] + [0.287 x Log_{10} (Alk +40)] + [0.132 (only if lake is in GB)] + [0.356 (only if wFSC<4.0)])

III. Number of macrophyte taxa (NTAXA)

The value for the parameter, NTAXA, in the reference conditions applicable to the lake should be calculated using the following equation:

Reference NTAXA = Exponent (1.488 – [0.098 x Log_{10} H] + [0.185 x Log_{10} S] + [0.194 x Log_{10} (Alk +40)] + [0.149 (only if lake is in GB)] + [0.287 (only if wFSC <4.0)])

where, in the above equations:

"Alk" is the annual mean reference alkalinity in µeq L^{-1};

"D" is the mean depth of the lake in metres;

"H" is the height in metres of the surface of the lake above mean sea level;

"S" is the surface area of the lake in hectares;

GB refers to those lakes not situated on the island of Ireland.

IV. Mean percent cover of hydrophytes (COV)

The value used for the parameter, COV, in the reference conditions applicable to the lake is dependent on the method of data collection. This metric must be excluded if no formal assessment of cover or frequency has been undertaken, or if data has been collected using strand line surveys (e.g. due to the lack of a boat). Provided that data has been collected using the recommended survey method Reference COV = 8.2% should be applied in all lakes.

V. Relative percent cover of filamentous algae (ALG)

The value used for the parameter, ALG, in the reference conditions applicable to the lake should be 0.05

Calculation of the ecological quality ratio (EQR) for each parameter

I. Lake Macrophyte Nutrient Index (LMNI)

The ecological quality ratio for the parameter, LMNI, should be calculated using the following equation:

If the reference value for LMNI is ≥5:

EQR_{LMNI} = (observed value of LMNI - 10) ÷ (reference value for LMNI - 10)

If the reference value for LMNI is <5:

EQR_{LMNI} = (observed value of LMNI – (reference value for LMNI + 5)) ÷ (reference value for LMNI - (reference value for LMNI + 5))

II. Number of functional groups of macrophyte taxa (NFG)

The ecological quality ratio (EQR) for the parameter, NFG, should be calculated using the following equation:

EQR_{NFG} = observed value of NFG ÷ reference value for NFG

unless the observed value of NFG = 0 in which case EQR_{NFG} = 0.

III. Number of macrophyte taxa (NTAXA)

The ecological quality ratio (EQR) for the parameter, NTAXA, should be calculated using the following equation:

EQR_{NTAXA} = observed value of NTAXA ÷ reference value for NTAXA

unless the observed value of NTAXA = 0 in which case EQR_{NTAXA} = 0.

IV. Mean percent cover of hydrophytes (COV)

The ecological quality ratio (EQR) for the parameter, COV, should be calculated using the following equation:

EQR_{COV} = √ observed value of COV ÷ √ reference value for COV

V. (v) Relative percent cover of filamentous algae (ALG)

If the observed value of ALG is > 0.05, the ecological quality ratio for the parameter should be calculated using the following equation:

EQR_{ALG} = [observed value of ALG - 1] ÷ [0.05 – 1]

If the observed value of ALG is ≤ 0.05, the ecological quality ratio for the parameter should be given the value "1".

Combining the ecological quality ratios for the different parameters

The ecological quality ratio for the combined parameters ($EQR_{LEAFPACS}$) should be determined as follows:

If the values of either EQR_{NFG} or EQR_{NTAXA} are less than the value of EQR_{LMNI}, a diversity adjusted EQR (^{A}EQR) for the parameter, LMNI, should be calculated as follows:

$^{A}EQR_{LMNI}$ = [EQR_{LMNI} + ($^{A}EQR_{NFG}$ or $^{A}EQR_{NTAXA}$, whichever is the smaller x 0.5)] ÷ 1.5

If EQR_{LMNI} is less than the values of either EQR_{NFG} or EQR_{NTAXA} the value of EQR_{LMNI} is unchanged (i.e. EQR_{LMNI} = $^{A}EQR_{LMNI}$).

If the value of $^{A}EQR_{LMNI}$ is larger than whichever is the smaller of the values for EQR_{COV} and EQR_{ALG}, $EQR_{LEAFPACS}$ should be calculated using the following equation:

$EQR_{LEAFPACS}$ = [$^{A}EQR_{LMNI}$ + (0.25 × {EQR_{COV} or EQR_{ALG}, whichever is the smaller})] ÷ 1.25

If the value of $^{A}EQR_{LMNI}$ is smaller than or the same as whichever is the smaller of the values for EQR_{COV} and EQR_{ALG}, $EQR_{LEAFPACS}$ should be assigned the same value as $^{A}EQR_{LMNI}$

Application of the method for the purposes of classification

When using the method for the purposes of classifying the ecological status of a water body:

a. a standardised ecological quality ratio (^{S}EQR) should be calculated for $EQR_{LEAFPACS}$ as follows:

   If the value of $EQR_{LEAFPACS}$ is < 0.20, $^{S}EQR_{LEAFPACS}$ should be assigned a value of "0". If the value of $EQR_{LEAFPACS}$ is > 1.05, $^{S}EQR_{LEAFPACS}$ should be assigned a value of "1". Otherwise, $^{S}EQR_{LEAFPACS}$ should be calculated using the following equations:

   If $EQR_{LEAFPACS}$ ≥ 0.8: $^{S}EQR_{LEAFPACS}$ = ([$EQR_{LEAFPACS}$ - 0.8] ÷ [1.05 - 0.8]) x 0.2 + 0.8,

   If $EQR_{LEAFPACS}$ ≥ 0.66: $^{S}EQR_{LEAFPACS}$ = ([$EQR_{LEAFPACS}$ – 0.66] ÷ [0.8 - 0.66]) x 0.2 + 0.6

   If $EQR_{LEAFPACS}$ ≥ 0.51: $^{S}EQR_{LEAFPACS}$ = ([$EQR_{LEAFPACS}$ – 0.51] ÷ [0.66 - 0.51]) x 0.2 + 0.4

   If $EQ_{LEAFPACS}$ ≥ 0.35: $^{S}EQR_{LEAFPACS}$ = ([$EQR_{LEAFPACS}$ – 0.35] ÷ [0.51 - 0.35]) x 0.2 + 0.2

   If $EQR_{LEAFPACS}$ < 0.35: $^{S}EQR_{LEAFPACS}$ = ([$EQR_{LEAFPACS}$ – 0.20] ÷ [0.35 - 0.20]) x 0.2

b. the value of $^{S}EQR_{LEAFPACS}$ for surveys carried out between July and September should be used. If surveys have been carried out in more than one year the mean value of $^{S}EQR_{LEAFPACS}$ should be used.

The value of $^{S}EQR_{LEAFPACS}$ should then be assigned to an ecological status class according to the Table below.

$^{S}EQR_{LEAFPACS}$	Status
0.80 - 1.0	High
0.60 - 0.79	Good
0.40 - 0.59	Moderate
0.20 - 0.39	Poor
0 - 0.20	Bad

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

Putative reference sites were identified at a type-specific level initially from their biology, using individual species-pressure relationships indicated by empirical analysis, historical macrophyte records and expert opinion. Finally all reference sites remaining were checked against available land cover, total P and chlorophyll data. Within-type regressions between pressures and biological metrics were used to identify sites where deviating biology was related to increased pressure. Any such outliers or sites with known hydromorphological modifications were then removed.

Individual metrics were modelled using environmental variables to determine their expected value at reference sites. These expected values are used to calculate an EQR for each metric. A multimetric EQR is then calculated based on the national combination rules. The H/G boundary corresponds to the lower 5^{th} percentile of the multimetric EQR in reference sites and is interpreted as representing the lower limit of undisturbed status of the quality element. The GM boundary is based on the interval between the median EQR of the national reference site dataset and the HG boundary and is approximately equivalent to the lower 1%tile of the reference site multimetric EQR. This point is interpreted to represent the limit of slight change in the quality element since there is some but minimal overlap with the natural variation in the population of reference sites Below this the EQR range is divided equally to form the MP and PB boundaries.

How well do these indicators correlate with pressure indicators?

The relationship between LMNI and Total P (annual mean) in the UK dataset is summarised in Figure A.8 below. Since this is an internally validated model (LMNI is calibrated from the mean TP values for each species in lakes where they are recorded) the highly significant relationship that is observed (r^2 = 0.62) is to be expected. However, LMNI also performs extremely well if applied to a completely independent dataset composed of the combined N-GIG and CB-GIG lake datasets (r^2 = 0.5) and in this dataset is only fractionally worse than the internally calibrated ICCM that was based on this data.

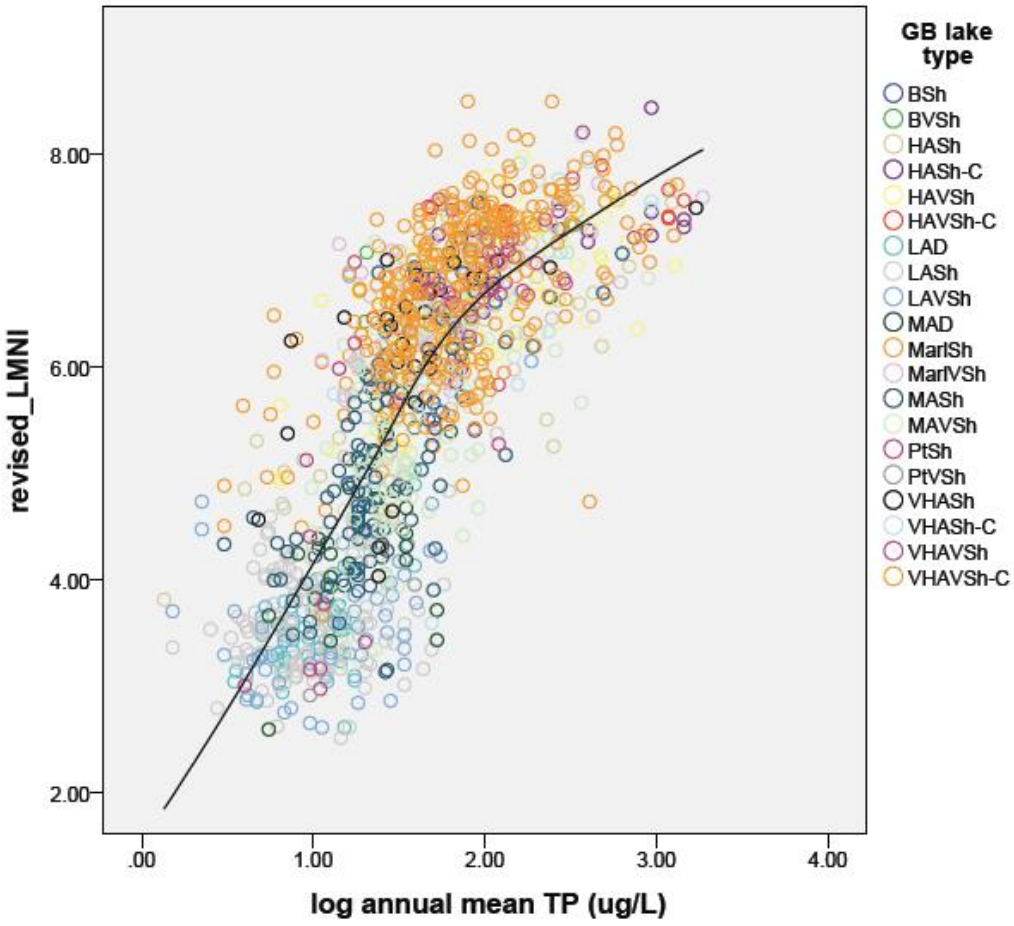

Figure A.8 Global relationship between LMNI and lake Total P (annual mean) in UK lakes dataset (n=1359, relationhip based on lakes containing >4 taxa).

Further reading

Hornung, M et.al. (1995) The sensitivity of surface waters of Great Britain to acidification predicted from catchment characteristics. Environmental Pollution 87, 207-214

Willby, N.J., Pitt, J & Phillips G. L. (2009) The ecological classification of UK lakes using aquatic macrophytes. Environment Agency, Science Report SC010080/SR

Appendix 1 UK Species list

Table A.49 List of lake macrophyte taxa and associated information for the calculation of the values for the parameters

Column 1	Column 2	Column 3	Column 4	Column 5
Macrophyte taxa	**Lake macrophyte nutrient index score**	**Number of functional group**	**Taxa indicated as filamentous algal taxa ("F")**	**Included in CBGIG**
Alisma gramineum	7.65	13		
Apium inundatum	4.32	7		Y
Aponogeton distachyos	8.88	16		
Azolla filiculoides	7.25	1		
Baldellia ranunculoides	3.97	13		Y
Batrachospermum sp.	1.56			
Butomus umbellatus	7.97	13		Y
Callitriche brutia var. brutia	2.26	6		Y
Callitriche brutia var. hamulata	4.08	6		
Callitriche hermaphroditica	8.08	5		Y
Callitriche obtusangula	9.34	6		Y
Callitriche platycarpa	9.50	6		Y
Callitriche sp.	7.11	6		Y
Callitriche stagnalis	6.38	6		Y
Callitriche truncata	8.28	6		Y
Ceratophyllum demersum	7.99	5		Y
Ceratophyllum submersum	6.78	5		Y
Chara aculeolata	3.49	2		Y
Chara aspera	4.19	2		Y
Chara baltica	5.83	2		Y
Chara canescens	4.73	2		Y
Chara connivens	5.60	2		Y
Chara contraria var. contraria	5.06	2		Y
Chara contraria var. hispidula	6.41	2		Y
Chara curta	4.14	2		Y
Chara globularis	6.86	2		Y
Chara hispida	3.95	2		Y
Chara intermedia	5.04	2		Y
Chara rudis	3.93	2		Y
Chara sp.	5.57	2		Y
Chara virgata	4.29	2		Y

Column 1	Column 2	Column 3	Column 4	Column 5
Macrophyte taxa	Lake macrophyte nutrient index score	Number of functional group	Taxa indicated as filamentous algal taxa ("F")	Included in CBGIG
Chara virgata var. annulata	4.07	2		Y
Chara vulgaris	5.56	2		Y
Crassula helmsii	5.57	5		Y
Damasonium alisma	6.19	13		
Elatine hexandra	3.81	11		Y
Elatine hydropiper	5.34	11		Y
Eleocharis acicularis	8.68	4		Y
Eleocharis multicaulis	3.03	4		Y
Eleogiton fluitans	2.03	15		Y
Elodea callitrichoides	7.64	5		
Elodea canadensis	7.45	5		Y
Elodea nuttallii	6.19	5		Y
Eriocaulon aquaticum	1.47	4		
Filamentous algae	6.70		F	Y
Fontinalis antipyretica	4.19	3		Y
Fontinalis squamosa	3.09	3		Y
Groenlandia densa	5.35	5		
Hippuris vulgaris	5.23	7		Y
Hottonia palustris	6.29	7		Y
Hydrocharis morsus-ranae	6.51	8		Y
Hydrodictyon reticulatum	8.42		F	
Hypericum elodes	3.56	11		Y
Isoetes echinospora	2.47	4		Y
Isoetes lacustris	2.22	4		Y
Isoetes sp.	2.22	4		Y
Juncus bulbosus	2.42	4		Y
Lagarosiphon major	3.51	5		Y
Lemna gibba	7.66	1		Y
Lemna minor	8.52	1		Y
Lemna minuta	10.00	1		Y
Lemna trisulca	7.96	1		Y
Leptodyction riparium	8.71	3		
Limosella aquatica	3.80	11		Y
Littorella uniflora	3.73	4		Y
Lobelia dortmanna	2.16	4		Y

Column 1	Column 2	Column 3	Column 4	Column 5
Macrophyte taxa	Lake macrophyte nutrient index score	Number of functional group	Taxa indicated as filamentous algal taxa ("F")	Included in CBGIG
Ludwigia palustris	3.82	11		Y
Luronium natans	3.52	13		Y
Lythrum portula	4.31	11		Y
Menyanthes trifoliata	5.17	10		Y
Myriophyllum alterniflorum	2.66	7		Y
Myriophyllum aquaticum	6.87	7		
Myriophyllum spicatum	6.23	7		Y
Myriophyllum verticillatum	5.32	7		Y
Najas flexilis	2.89	14		Y
Najas marina	5.24	14		Y
Nitella confervacea	3.28	2		Y
Nitella flexilis agg.	5.19	2		Y
Nitella gracilis	3.56	2		Y
Nitella mucronata	5.67	2		Y
Nitella opaca	2.36	2		Y
Nitella sp.	4.66	2		Y
Nitella translucens	2.73	2		Y
Nitellopsis obtusa	5.23	2		Y
Nuphar lutea	7.47	12		Y
Nuphar pumila	4.82	12		Y
Nuphar x spenneriana	3.65	12		Y
Nymphaea alba	6.84	12		Y
Nymphoides peltata	6.75	10		Y
Persicaria amphibia	8.25	10		Y
Pilularia globulifera	3.59	4		Y
Potamogeton alpinus	4.48	16		Y
Potamogeton berchtoldii	6.58	14		Y
Potamogeton coloratus	3.46	16		Y
Potamogeton compressus	5.18	14		Y
Potamogeton crispus	7.50	17		Y
Potamogeton epihydrus	1.00	16		
Potamogeton filiformis	3.68	15		Y
Potamogeton friesii	4.71	14		Y
Potamogeton gramineus	2.85	16		Y
Potamogeton lucens	4.37	17		Y

Column 1	Column 2	Column 3	Column 4	Column 5
Macrophyte taxa	Lake macrophyte nutrient index score	Number of functional group	Taxa indicated as filamentous algal taxa ("F")	Included in CBGIG
Potamogeton natans	4.71	16		Y
Potamogeton obtusifolius	6.97	14		Y
Potamogeton pectinatus	7.19	15		Y
Potamogeton perfoliatus	4.42	17		Y
Potamogeton polygonifolius	2.39	16		Y
Potamogeton praelongus	3.92	17		Y
Potamogeton pusillus	7.54	14		Y
Potamogeton rutilus	5.49	14		Y
Potamogeton trichoides	5.79	14		Y
Potamogeton x cooperi	4.93	17		
Potamogeton x griffithii	2.57	16		
Potamogeton x lintonii	7.21	14		
Potamogeton x nitens	3.48	17		Y
Potamogeton x salicifolius	5.89	17		
Potamogeton x sparganifolius	3.71	16		Y
Potamogeton x suecicus	4.62	15		Y
Potamogeton x zizii	4.04	16		Y
Ranunculus (sub sect. Batrachian) sp.	5.31	18		
Ranunculus aquatilis agg.	6.30	18		Y
Ranunculus aquatilis var diffusus	4.20	18		
Ranunculus aquatilis var. aquatilis.	5.81	18		Y
Ranunculus circinatus	8.70	5		Y
Ranunculus fluitans	5.65	18		
Ranunculus hederaceus	8.33	11		Y
Ranunculus lingua	6.79	10		Y
Ranunculus omiophyllus	5.51	11		Y
Ranunculus peltatus subsp. baudotii	6.48	18		Y
Ranunculus peltatus subsp. peltatus	6.49	18		Y
Ranunculus penicillatus subsp. penicillatus	4.21	18		

Column 1	Column 2	Column 3	Column 4	Column 5
Macrophyte taxa	Lake macrophyte nutrient index score	Number of functional group	Taxa indicated as filamentous algal taxa ("F")	Included in CBGIG
Ranunculus penicillatus subsp. pseudofluitans	6.68	18		
Riccia fluitans	6.35	1		Y
Ricciocarpus natans	5.32	1		Y
Ruppia cirrhosa	7.03	15		Y
Ruppia maritima	7.85	15		Y
Ruppia sp.	8.08	15		
Sagittaria sagittifolia	6.01	12		Y
Sparganium angustifolium	2.52	13		Y
Sparganium emersum	6.06	13		Y
Sparganium natans	2.79	13		Y
Sphagnum (aquatic indet.)	2.74	3		Y
Spirodela polyrhiza	9.62	1		Y
Stratiotes aloides	6.20	8		Y
Subularia aquatica	1.80	4		Y
Tolypella glomerata	5.32	2		Y
Ulva (Enteromorpha) flexuosa	9.05		F	
Utricularia australis	2.87	9		Y
Utricularia intermedia sens.lat.	1.61	9		Y
Utricularia minor	2.36	9		Y
Utricularia ochroleuca	1.04	9		Y
Utricularia sp.	3.34	9		Y
Utricularia stygia	1.30	9		Y
Utricularia vulgaris	4.24	9		Y
Zannichellia palustris	8.69	15		Y

Appendix 2 Worked example

The following data were obtained from a GB lake survey.

The values below represent the cover determined from a single survey covering a minimum of four sectors of a lake.

Taxon identified as present in the lake	% cover in sampled area	Lake macrophyte nutrient index score	Number of functional group
Chara aspera	10	4.19	2

Elodea canadensis	1	7.45	5
Hippuris vulgaris	5	5.23	7
Nitellopsis obtusa	2	5.23	2
Nymphaea alba	10	6.84	12
Potamogeton obtusifolius	5	6.97	14

In addition, the following environmental data were obtained:

Variable	Value
Lake altitude (H)	15 metres
Mean depth (D)	2.7 metres
Area (S)	3.1 hectares
Reference alkalinity (Alk)	1700 µeq L^{-1}
weighted Freshwater Sensitivity Class (wFSC)	4.1

LMNI

The observed value of LMNI is calculated as follows:

1. Sum LMNI scores for all taxa = 35.91
2. Divide this value by the number of taxa present (6) = 5.99

The reference value is calculated using the equation in section 3.2. This results in a reference value for LMNI of 4.73.

EQR_{LMNI} = (5.99 – (4.73 + 5)) / (4.73 – (4.73 + 5)) = 0.75.

Functional diversity (NFG)

The observed number of functional groups (NFG) for this lake is 5 (*Chara aspera* and *Nitellopsis obtusa* are in group 2, *Potamogeton obtusifolius* group 14, *Nymphaea alba* group 12, *Hippuris vulgaris* group 7 and *Elodea canadensis* group 5).

The reference value is calculated using the equation in section 3.2. This results in a reference value for NFG of 5.89.

EQR_{NFG} = observed NFG / reference NFG = 0.85

Number of taxa (NTAXA)

The observed number of taxa (NTAXA) is 6.

The reference value is calculated using the equation in section 3.2. This results in a reference value for NTAXA of 9.41.

EQR_{NTAXA} = observed value of NTAXA / reference value for NTAXA = 0.64

Mean percent cover (COV)

The observed value for COV is calculated as follows:

1. Sum % cover values for all taxa = 33
2. Divide this value by the number of taxa present (6) = 5.5

A reference value for COV of 8.2 applies to those lakes where data is collected by the recommended method.

$$EQR_{COV} = \surd 5.5 \div \surd 8.2 = 0.82$$

Relative cover of algae (ALG)

As the relative cover of filamentous algae is < 0.05, $EQR_{ALG} = 1.00$

Combining metrics

The complete results for this lake are, therefore, as follows:

Parameter	Observed value	Reference value	EQR
LMNI	5.99	4.73	0.75
NFG	5.00	5.89	0.85
NTAXA	6.00	9.41	0.64
COV	5.50	8.20	0.82
ALG	0.0	0.05	1.00

EQR_{LMNI} is larger than the lowest of EQR_{NFG} and EQR_{NTAXA} (0.64) so the diversity adjusted ecological quality ratio for LMNI is given by:

$$^{A}EQR_{LMNI} = [(0.75 + (0.64 \times 0.5)] \div 1.5 = 0.71$$

The value of $^{A}EQR_{LMNI}$ (0.71) is less than the values of EQR_{COV} (0.82) and EQR_{ALG} (1.00) and is therefore taken as the value for $EQR_{LEAFPACS}$. This value is then standardised according to the formula in Section 3.5 such that:

$$^{S}EQR_{LEAFPACS} = ([0.71 - 0.66] \div [0.8 - 0.66]) \times 0.2 + 0.6 = 0.67$$

$^{S}EQR_{LEAFPACS}$ values in the range 0.6 to 0.8 are assigned to Good Ecological status (section 3.5). Therefore the status of this water body based on its macrophyte assemblage would be Good.

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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 Central Baltic Lake Macrophyte IC group.

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