Intercalibration of revised classification method for lake macrophytes in France - Alpine Geographical Intercalibration Group

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GIG: Alpine Geographical Intercalibration Group
Member State: France
BQE: macrophytes
Water category: lake
Common intercalibration types: L-AL3 and L-AL4

1. Introduction

As part of the Water Framework Directive, France developed its own method to assess ecological status of lakes regarding macrophyte communities. This method was intercalibrated in 2011 together with four other Member States (Austria, Germany, Italy and Slovenia) from the Alpine Geographical Intercalibration Group (GIG).
Since the intercalibration exercise was carried out, the French assessment method has been further developed.
This document addresses the intercalibration of the revised "new" French classification method for macrophytes in alpine lakes, following the procedure described in the CIS Guidance Document No. 30 (European-Commission, 2015). The results show that the revised "new" assessment method fits the intercalibrated "old" method for common types L-AL3 and L-AL4 within the Alpine GIG.

2. Description of national assessment methods

The French assessment method for macrophytes in lakes is called "Macrophyte Index for Lakes" (IBML). It estimates all the pressures linked or associated with the degradation of the trophic level (eutrophication, HYMO, general degradation, etc.) of lakes with a water level fluctuation of less than two meters (Boutry *et al.*, 2015). Both intercalibrated "old" method and revised "new" method have the same assessment concept.

2.1. Method and required BQE parameters

The French intercalibrated "old" assessment method includes one metric based on abundance of indicator taxa and composition (trophic level indicating species and stenoecy coefficient).

The revised "new" method uses the same metric as the intercalibrated "old" method.

2.2. Sampling and data processing

Full sampling strategy and method of calculation are detailed in Annex A.2 in Pall *et al.*, 2014. Macrophyte communities are surveyed according to the French standard for macrophytes in lake (AFNOR, 2022) on several observation units, each consisting of one section of shore and three profiles perpendicular to the shore (see figure A.1 in Pall *et al.*, 2014). These observation units are located by applying the Jensen's method (geometric positioning, see Jensen, 1977) and selected so that the main types of riparian zone around the lake are represented. Four types of riparian zone are available, based on the description of the vegetation structures and/or anthropic alterations of the shore: three types of shore correspond to natural habitats or habitats not significantly modified by human pressure, a

fourth type indicates extensive human modification of the lake (see table A.15 in Pall *et al.*, 2014). Macrophytes are sampled using a rake or a grapnel on three observation units at least. The surveyed compartment stretches from the entire littoral of each transect down to the vegetation limit.
On each observation unit, four trophic scores (one for the shore and three for the profiles) are calculated based on the relative abundance of about 300 indicator taxa with their own specific value and stenoecy coefficient. Specific values and stenoecy coefficients of indicator species are specified in table A.20 of the intercalibration technical report (Pall *et al*., 2014). A mean score is then calculated for shore samplings on one hand and profile samplings on the other hand, weighted by the proportion of a given riparian zone type around the lake. The final trophic score at the lake scale is given by the mean of the two weighted scores.

Both intercalibrated "old" and revised "new" methods use the same sampling and data processing. Nevertheless, during the intercalibration exercise, the surveys on the sections of shore (littoral zone surveys) and the weighting of scores by the riparian zone types (description of the vegetation structures and/or anthropic alteration of the shore) were not taken into account in the intercalibrated "old" method. The results were given at a transect scale (a combination of perpendicular profiles, data grouped by depth zones). Final ecological quality ratios (EQRs) were not bounded (likely > 1) in the intercalibrated "old" method.

The revised "new" method uses macrophytes data collected in the littoral zone surveys and perpendicular profiles, weighted by the proportion of the four riparian zone types (Boutry *et al.*, 2015). The revised "new" method uses normalised EQR (bounded from 0 to 1).

2.3. National reference conditions

Reference lakes are those listed in a national circular on least disturbed condition sites (Ministère de l'Écologie et du Développement Durable, 2004), mostly based on the land use data of the catchment area and the chemical/physicochemical data of the lake. Regarding the macrophyte communities, only the presence of invasive aquatic species is taken into account.

2.4. National boundary setting

In both intercalibrated "old" and revised "new" methods, the reference value is given by the median of French macrophytes indices of reference lakes identified according to the pressure criteria. The high-good class boundary is defined as the 75th percentile from the distribution of the reference lakes. The boundaries of the four remaining classes (good, moderate, poor, bad) are given by the equidistant division of the continuum.

In the intercalibrated "old" method the reference value was calculated from samples collected between late July and early August 2008 on 12 observations units (transects) from three reference lakes (lac de Barterand - FRDL45 -, lac du Grand Maclu - FRDL30 - and grand lac d'Etival - FRDL19). The high-good intercalibrated "old" boundary was 0.92, expressed as EQR (see Table 1). During the intercalibration exercise, the comparison of Member Sate's assessment methods showed that the good-moderate boundary for France had to be more precautionary and was then adjusted from 0.69 to 0.72, expressed as EQRs.
In the revised "new" method, the high-good boundary is 0.80 and the good-moderate boundary is 0.60, also expressed as EQRs.

Table 1: National class boundaries of intercalibrated "old" and revised "new" classification methods for alpine lake macrophytes in France

Class	Class boundaries of the intercalibrated "old" method (in EQR)	Class boundaries of the revised "new" method (in EQR)
High	0.92 - 1	0.80 - 1
Good	0.72 - 0.92	0.60 – 0.80
Moderate	0.46 – 0.72	0.40 – 0.60
Poor	0.23 – 0.46	0.20 – 0.40
Bad	0 – 0.23	0 – 0.20

3. WFD compliance checking

The revised "new" assessment method fulfils all the WFD compliance criteria listed in the CIS Guidance Document No. 14, page 92 (European-Commission, 2011) as shown in Table 2.

Table 2: List of the WFD compliance criteria and the WFD compliance checking process and results.

Compliance criteria	Compliance checking conclusion
Ecological status is classified by one **of five classes** (high, good, moderate, poor and bad).	Yes, see Table 1 for class boundaries.
High, good and moderate ecological status are set in line with the WFD's **normative definitions** (**Boundary setting procedure**).	Yes.
All relevant parameters indicative of the biological quality element are covered (see Table 1 in the IC Guidance). A **combination rule** to combine parameter assessment into BQE assessment has to be defined. If parameters are missing, Member States need to demonstrate that the method is sufficiently indicative of the status of the QE as a whole.	Yes, French assessment method considers taxonomic composition and abundance of macrophytes and has defined a combination rule for these two parameters.
Assessment is adapted to **intercalibration common types** that are defined in line with the typological requirements of the WFD and approved by WG ECOSTAT.	Yes, IBML is appropriate for L-AL3 and L-AL4 lake types.
The water body is assessed against **type-specific near-natural reference conditions**.	Yes, reference lakes are selected following a national circular on least disturbed condition sites. Reference sites correspond to whole lakes.
Assessment results are expressed as **EQRs**.	Yes.
Sampling procedure allows for **representative** information about water body quality/ecological status in **space and time**.	Yes.

All data relevant for assessing the biological **parameters** specified in the WFD's normative definitions are covered by the **sampling procedure**.	Yes, sampling includes species composition and abundance parameters.
Selected taxonomic level achieves adequate **confidence and precision** in classification.	Yes, work at the species level.

4. Intercalibration feasibility checking

4.1. Typology

The intercalibrated "old" method was relevant for both L-AL3 and L-AL4 Alpine lake types, whose characteristics are described in Table 3. The revised "new" method is appropriate for the same Alpine lake types L-AL3 and L-AL4 and intercalibration is thus feasible regarding the common intercalibration types.

Table 3: Characteristics of Alpine lake types

Common intercalibration type	Type characteristics
L-AL3	Altitude 50 - 800 m Mean depth > 15 m Mean alkalinity > 1meq/l Surface area > 0.5 km²
L-AL4	Altitude 200 – 800 m Mean depth 3 – 15 m Mean alkalinity > 1meq/l Surface area > 0.5 km²

4.2. Pressures addressed

The revised "new" method addresses the same pressures than those in the Alpine GIG intercalibration exercise: eutrophication and general degradation (Table 4).

The relationships between the three pressure indicators identified in the intercalibration exercise (Secchi depth, total phosphorus and chlorophyll a concentrations) and the EQRs of the revised "new" method are significant (table 1).

Table 4: Correlation between the pressure variables and the EQR values of the revised "new" method in macrophytes-relevant lakes using the complete French dataset

Pressure	Pressure indicators	Strength of relationship with revised "new" method
Eutrophication and general degradation	Secchi depth	R^2= 0.30 / p-value = 8.10e-07
	Total phosphorus (in log)	R^2= 0.24 / p-value = 3.04e-05
	Chlorophyll a (in log)	R^2= 0.12 / p-value = 0.004

The Organization for Economic Cooperation and Development (OECD) has defined four trophic categories (OCDE, 1982), from oligotrophic to hypereutrophic, based on Secchi depth, total

phosphorus and chlorophyll a concentrations. According to this trophic status assessment, oligotrophic lakes are associated with high EQR values whereas hypereutrophic lakes are associated with lower EQR values (Figure 1).

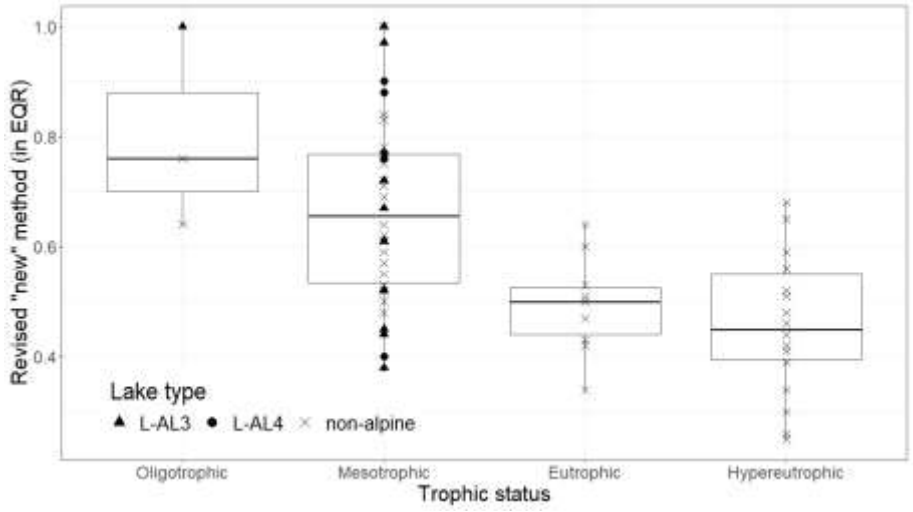

Figure 1: Distribution of the EQRs of the revised "new" method in the four trophic status defined by the OECD

4.3. Assessment concept

The revised “new” method follows the same assessment concept as the intercalibrated “old” method: same sampling strategy and same data processing (species composition and abundance index). The main improvements of the revised “new” method are:

- littoral zone surveys are included;
- trophic scores are weighted by the proportion of four riparian zone types (description of the vegetation structures and/or anthropic alterations of the shore);
- normalised EQRs (bounded from 0 to 1) are used.

4.4. Conclusion on the intercalibration feasibility

The fitting of the updated classification method to the results of the completed Alpine GIG intercalibration exercise is feasible regarding typology, pressure addressed and assessment concepts.

5. Compliance with the completed intercalibration exercise

5.1. Dataset collected

The fitting procedure of the revised “new” French classification method for macrophytes is carried out using a dataset from eight French lakes (Table 5) where macrophyte communities are considered a relevant biological quality element to assess ecological status (as defined in a national decree, Ministère de la Transition Ecologique, 2022).

Table 5: Lakes used in the fitting procedure of the revised "new" method

Lake name	Lake code	Lake national code
Aiguebelette	FRDL61	AIG73
Lac d'Annecy	FRDL66	ANN74
Lac de Barterand	FRDL45	BAR01
Bourget	FRDL60	BOU73
Lac de Chalain	FRDL22	CHA39
L'Entonnoir-bouverans	FRDL8	ENT25
Grand lac Etival	FRDL19	ETI39
Paladru	FRDL81	PAL38

All the lakes are located in the Alps within the French hydro ecological area n°5. The use of ecoregions defined by the WFD is not feasible since only one lake is located in the WDF ecoregion n°4. The dataset consists of 84 observation units (transects) based on 18 field campaigns that took place between 2008 and 2016, and is considered a qualified national dataset since:

- it sufficiently covers the geographical area in which the common types L-AL3 and L-AL4 are located in France (see Figure 2);
- it encompasses the complete ecological quality gradient ranging from high to poor ecological status, as shown in Figure 3 by the dashed lines representing the high-good and the good-moderate class boundaries;
- it is accompanied with non-biological and biological data to conduct pressure- impact analyses: Secchi depth, total phosphorus and chlorophyll a (see Table 6).

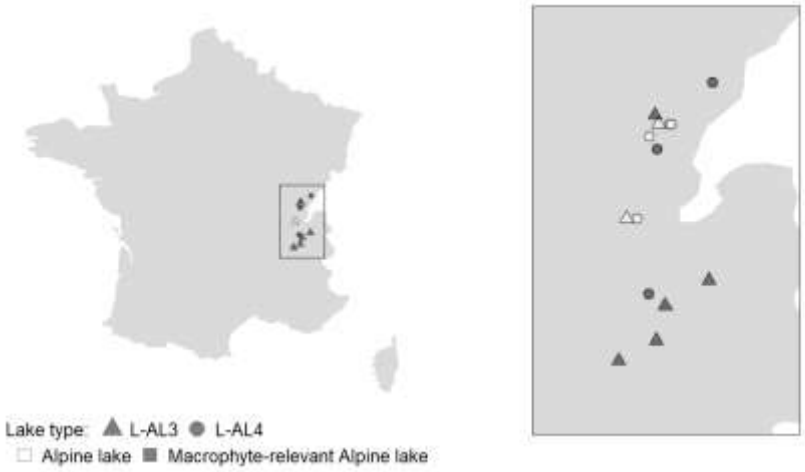

Figure 2: Geographical areas of lake type L-AL3 (represented by circles) and L-AL4 (represented by triangles) in France. Alpine lakes that are relevant for macrophyte communities are shown as black symbols and other alpine lakes are shown as white symbols.

Table 6: Number of non-biological and biological data for each lake type

Lake type	Number of lake-transects		
	Biological data	Physico-chemical data	Pressure data
L-AL3	120	5 lakes	5 lakes
L-AL4	60	3 lakes	3 lakes

5.2. Relationship between intercalibrated “old” and revised “new” methods

The EQRs of the intercalibrated “old” method are strongly correlated with the EQRs of the revised “new” method (R^2=0.81, see Figure 3).

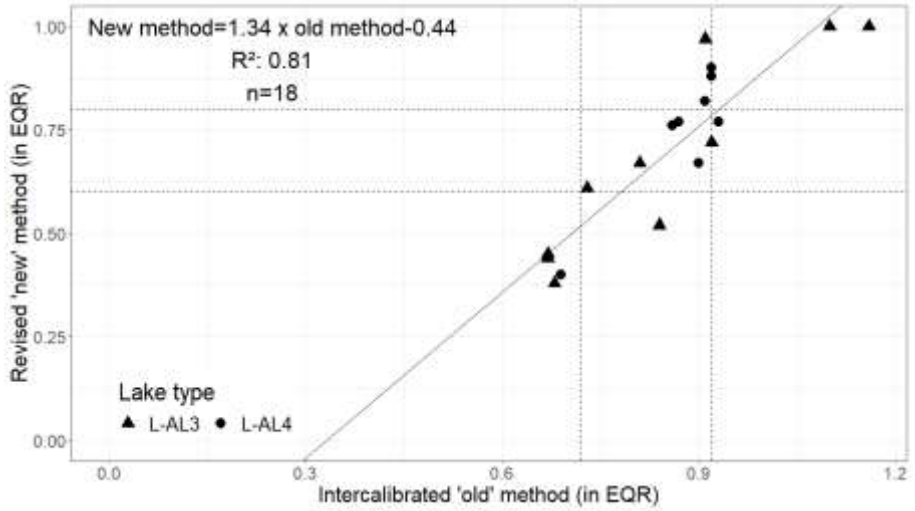

Figure 3: Correlation between the EQRs of the intercalibrated “old” method (x-axis) and the revised “new” method (y-axis) for macrophytes in lakes using the French dataset. The dashed lines represent the intercalibrated high-good and good-moderate class boundaries (respectively 0.92 and 0.72 for the intercalibrated “old” method and 0.80 and 0.60 for the revised “new” method, expressed as EQRs).

5.3. Comparison of two methods’ boundaries

The high-good and good-moderate boundaries of the intercalibrated “old” method were translated into EQR-values of the revised “new” method using the following ordinary least squares equation (see Figure 3):

New method EQR = 1.34 * Old method boundary EQR - 0.44 (R^2=0.81, p-value < 0.001)

The old and new methods’ boundaries are summarised in Table 7.

Table 7: Position of old and new methods’ boundaries on the EQR scale of the revised “new” method

Boundary	**Intercalibrated “old” method (in EQR)**	**Translated boundary (in EQR)**	**Revised “new” method (in EQR)**
High-good	0.92	0.79	0.80
Good-moderate	0.72	0.52	0.60

The intercalibrated “old” high-good boundary at EQR scale of the revised “new” method (0.79) is lower than the respective translated boundary of the revised “new” method (0.80). The intercalibrated “old” good-moderate boundary at EQR scale of the revised “new” method (0.52) is lower than the respective boundary of the revised “new” method (0.60). **This implies that the boundaries of the revised “new” method are more precautionary than the translated boundaries of the intercalibrated “old” method and can therefore be kept as is**.

Thus, the revised “new” French assessment method for macrophytes in lakes within the Alpine GIG is in accordance with the completed intercalibration exercise.

6. Description of boundary setting procedure and biological communities

The ecological status in lake is based on lakes whose "taxonomic composition corresponds totally or nearly totally to undisturbed conditions" (European Parliament and Council, 2000). French reference lakes are listed in a national circular (Ministère de l'Écologie et du Développement Durable, 2004). The reference value corresponds to the median IBML score of those reference lakes and the high-good class boundary is as the 75th percentile from the distribution of the scores. The other class boundaries (good-moderate and moderate-poor) are given by the equidistant division of the continuum.

The normative definition for each ecological status in lakes, as defined in the WFD Annex V table 1.2.2, is given in Table 8 along with its interpretation in the French assessment method for macrophytes in lakes.

Table 8: Comparison of the French assessment method for macrophyte with the WFD (Annex V) normative definitions

Ecological status	Normative definition (WFD)	Interpretation	EQR
High	"The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic [...] abundance. [...]"	Vegetation density. IBML score and species composition correspond totally or nearly totally to undisturbed conditions.	> 0.80
Good	"There are slight changes in the composition and abundance of macrophytic [...] taxa compared to the type-specific communities. [...]	Vegetation density. IBML score and species composition differ slightly from undisturbed conditions.	0.60 – 0.80
Moderate	"The composition of macrophytic [...] taxa differ moderately from the type-specific communities and are significantly more distorted than those observed at good quality. Moderate changes in the average macrophytic [...] abundance are evident. [...]"	Vegetation density. IBML score and species composition deviate moderately from undisturbed conditions.	0.40 – 0.60
Poor	Macrophyte "communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions".	Vegetation density. IBML score and species composition deviate substantially from undisturbed conditions.	0.20 – 0.40
Bad	"Large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent".	Very low macrophytes abundances or lack of macrophytes without natural reasons.	≤ 0.20

The taxonomic composition of IBML includes:

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

Phanerogams, bryophytes, pteridophytes and charophytes are determined at species level. Unicellular organisms (algae excepted charophytes) are determined at genius level. A full list of indicator species taken into account in both intercalibrated "old" and revised "new" methods is available in intercalibration technical report for Alpine Lake Macrophyte (Pall *et al.*, 2014, Table A.20).

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