Documentation of the Equivalence of the Revised Phyto-See-Index to the Results of European Intercalibration

LAWA Project O 2.15

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1 Introduction

1.1 Objective and Task Description

Germany has introduced the Phyto-See-Index (Phyto Lake Index) with the editing status according to Mischke *et al.* (2008) in the program version PhytoSee 3.1 to the European Intercalibration (**IC**). The IC of the Phyto-See-Index relative to the methods of other nations has been carried out successfully in the Alpine **G**eographical **I**ntercalibration **G**roup (**GIG**) for lakes (WOLFRAM *et al.* 2014) and in the GIG for Central Europe and the Baltic States (PHILLIPS *et al.* 2014).

Per the Commission's Decisions of the European Council (EC 2008, 2013) the Phyto-See-Index (PSI) is a suitable method to implement the EC Water Framework Directive (EG 2000) for lakes in Germany using the quality element phytoplankton. The PSI has been modified in the previous years. Objectives of the modifications were – based on essentially enlarged and qualitatively enhanced data sets - a more sophisticated assessment of the national lake types, the improvement of the metric correlations to the stressors trophic status and total phosphorus and a consistent conception concerning the position of class boundaries (boundary setting protocol) following the LAWA-Trophieindex (LAWA Trophic Status Index; LAWA 2014).

Following the guidance published in March 2014 by the European Commission (EC 2014) new or modified assessment methods have to be reported to the EC. A document has to be provided demonstrating that the revised method still observes the criteria oft the "Intercalibration Guidance Document" (2011) and that compliance to the intercalibrated method is proven.

Essentially, the guidance (EC 2014) is being observed and the works are carried out in consultation with the German Federal Environmental Agency (UBA, contact person Dr. Jens Arle) and with professional support by the LAWA Expert Group "Lakes".

1.2 Description of the Phytoplankton Assessment Method Phyto-See-Index and Modifications since 2008

Table 1: Structure of the assessment method Phyto-See-Index (PSI).

Phyto-See-Index (PSI)			**= Multimetric Index**	
Metric	**Metric for**	**"Submetrics"**	**Average Determination**	**Short Description**
BM	biomass	- biovolume arithmetic mean during vegetation period - chlorophyll a arithmetic mean during vegetation period - chlorophyll a maximum during vegetation period	arithmetic mean	various parameters for trophic status characteristics
AK	algal classes: species composition, low determination level	lake type specific set of algal classes sensitive to stressor (4-6 algal classes)	arithmetic mean	biovolume or predominance (mean during vegetation period) of Bacillario-, Cyano- and Cryptophyceae, i. a.
PTSI	species composition, high determination level (predominantly species, rarely genus)	Trophic status index based on indicator taxa	weighted mean	weighted species-specific trophic values using biovolume classes and indicator quality (stenoecy)
Overall Index PSI		biomass algal classes PTSI	weighted mean	weighting factors are lake type specific and derived from correlation analyses using trophic stressors

chlorophyll a (including subtraction for phaeophytin), PTSI = Phytoplanktontaxa-Seenindex (Phytoplankton Taxa Lake Index)

Method Modifications relevant für IC:

The Phyto-See-Index (Phyto Lake Index) has to date been enhanced in the context of six projects (O9.08, O 9.09, O 4.10; O 8.12) supported and sponsored by the Länderarbeitsgemeinschaft Wasser (LAWA) (German Working Group of the Federal States on Water Issues http://www.lawa.de).

- Fine-tuning of the Phyto-See-Index, LAWA-Project O 9.08 (MISCHKE *et al.* 2009)
- Adaptation of the Phyto-See-Index, LAWA-Project O 9.09 (MISCHKE *et al.* 2010)
- Ecological assessment of natural lakes and HMWB & AWB using phytoplankton, LAWA-Project O 4.10 (RIEDMÜLLER *et al.* 2013a)
- Extension of the assessment possibilities for lakes pursuant to the EC-WRRL for the biological element phytoplankton (effects of food chain, trophic classification and quality management), LAWA-Project O 8.12 (RIEDMÜLLER *et al.* 2015).
- Trophic assessment of lakes, GEP for HMWB, physico-chemical supporting quality elements, LAWA-Project LFP 2016. Modification of PSI in the alpine module (i. a.). Revision of the assessment tool PhytoSee to version 7.0. In progress.

Objective of the Revisions:

- Improvement of stressor sensitivity

- Establishing of a consistent conception concerning the position of the class boundaries (boundary setting protocol) following the – likewise revised – German Trophic Status Index acc. to LAWA (2014).

- Adjustment to the by now substantially improved data set (in terms of extent/taxonomic quality)

All German lake types relevant for IC as well as all metrics and submetrics specified in Table 1 are affected by the modifications.

In the submitted version the assessment results of the intercalibrated PhytoSee version 3.1 (MISCHKE & BÖHMER 2008) are compared to the results of the revised PhytoSee version 7.0 from Mischke *et al.* (2016a).

A final documentation of the updated Phyto-See-Index is available in the form of the manual "Handbuch für die Seenbewertung mittels Plankton" in German and English language (Method description of the assessment of lakes and reservoirs with Phytoplankton and the Phyto-See-Index in Germany) (MISCHKE *et al.* 2016b/c).

2 Check of Equivalence of the Revised PSI

Essentially, the testing criteria from the manual of the European Commission (EC 2014) on "Procedure to fit new or updated classification methods to results of the completed intercalibration" are used below.

Completed Intercalibration Exercises

In the **G**eographical **I**ntercalibration **G**roups (GIG)

- Central Europe and Baltic States (Central/Baltic GIG)

- Alps (Alpine GIG)

the phytoplankton assessment method developed in Germany has been intercalibrated for the IC lake types

- L-CB1 and 2 (L-CB: Lake Central/Baltic)

- L-AL3 and 4 (L-AL: Lake Alpine).

The completed intercalibration, in which phytoplankton experts from Germany were involved, has been documented in the Technical Reports:

WOLFRAM, G., BUZZI, F., DOKULIL, M., FRIEDL, M., **HOEHN, E.**, LAPLACE-TREYTURE, C., MENAY, M., MARCHETTO, A., MORABITO, G., REICHMANN, M., REMEC-REKAR, S., **RIEDMÜLLER, U.**, URBANIC, G. (2014): Alpine Lake Phytoplankton, ecological assessment methods. Water Framework Directive Intercalibration Technical Report. JRC Technical Reports. Edited by Sandra Poikane. 71 p.

PHILLIPS, G., FREE, G., KAROTTKI, I., LAPLACE-TREYTURE, C., MAILEHT, K., **MISCHKE, U.**, OTT, I., PASZTALENIEC, A., PORTIELJE, R., SØNDERGAARD, M., TRODD, W., VAN WICHELEN, J. (2014): Central Balthic Lake Phytoplankton ecological assessment methods. Water Framework Directive Intercalibration Technical Report. JRC Technical Reports. Edited by Sandra Poikane. 184 p.

2.1 WFD Compliance Checking

The single metrics of the German PSI have been adjusted and in particular submetrics have been replaced to enhance the correlations to the stressors (generally total phosphorus). The fundamental structure of the method has, however, not been changed.

For this reason the observation of the compliance criteria as to the EC WFD is not affected. The revised method can thus be regarded to be "WFD compliant". In the publications WOLFRAM *et al.* (2014) und PHILLIPS *et al.* (2014) the nine testing criteria and how to comply are displayed (in Table 3.1 in each case). They are thus not depicted here.

2.2 Selection of a Qualified Data Set

Since the IC types do not conform one-to-one to the German lake types (see RIEDMÜLLER *et al.* 2013b) regarding type criteria, they have to be filtered and sorted by the criteria of the IC types (see Table 2).

Table 2: IC lake types and German phytoplankton lake types, in which the IC-lakes were chosen following the selective IC type criteria.

IC Lake Type	IC Type Criteria*	German Phytoplankton Lake Type
L-CB1	mean depth 3-15 m, < 200 m asl, retention time 1-10 years	10.1
		13
L-CB2	mean depth < 3 m, < 200 m asl, retention time 0,1-1 year	11.2
L-AL4	mean depth 3-15 m, 200-800 m asl	2
		3
L-AL3	mean depth > 15 m, 50-800 m asl	4

*alkalinity > 1 meq/l – calcareous, lake surface area > 50 ha

From the existing national "Datenbank für Phytoplankton, Trophieparameter und Nährstoffe in Seen" (data base for phytoplankton, trophic parameters and nutrients in lakes) lake years have been selected complying to the following criteria:

a) Comparable sampling and assessment method

b) Selection of lakes corresponding to the IC types relevant for Germany

c) Index output specified as "reliable assessment"

Ad a) Exclusive use of more recent years of investigation: from 2009 (CB) or 2005 (AL), respectively

Ad b) Conformance to the criteria in Table 2 (mean depth, altitude, occasionally retention time)

Ad c) ≥ 4 sampling dates per year/vegetation period, ≥ 4 indicator taxa (annual mean) for determination of the species-based index PTSI → reliable assessment

Table 3: IC lake types and number of selected lake years and lakes in the qualified data set.

IC Lake Type	Number of Lake Years	Number of Lakes
L-CB1	194	54 (type 13) + 77 (type 10.1)
L-CB2	109	81 (type 11.2)
L-AL3	43	17 (type 4)
L-AL4	74	15 (type 2) + 9 (type 3)

2.3 Testing Procedure

(summarised from EC 2014)

Test Step 1:

The correlation between the ecological quality ratios (EQR) of the previous and the new method has to be verified using the suitable national data set. If, respectively, the correlation or the regression coefficient is higher than 0.8 (linear fit) the equivalence is achieved. Furthermore, the class boundaries high/good and good/moderate have to be compared. If the new method results in a more stringent assessment, this is accepted in either case. If the assessment is less stringent, test step 2 has to be conducted.

Test Step 2:

This step becomes necessary when one of the comparison criteria in Figure 1 (bottom right, framed red) is not met, e. g. if the correlation (R^2) is < 0.8. In this case the steps for newly developed methods given in the IC instruction have to be followed. The methods are different, depending on how the IC problem has been solved in the individual GIGs. Furthermore, the use of alternative methods is allowed to simplify the problem, if appropriate.

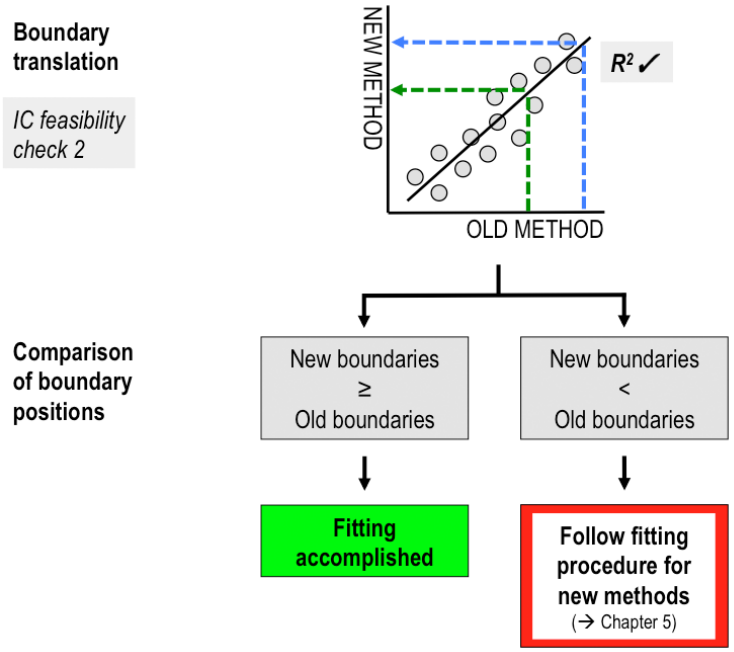

Figure 1: Workflow, from EC (2014).

The testing is based on IC lake type specific comparisons of results from PhytoSee version 3.1 (MISCHKE *et al.* 2008) and version 7.0 (MISCHKE *et al.* 2016b).

2.4 Test Step 1 and Documentation of Modifications

2.4.1 Regression Testing

The equivalence of the new method is achieved when the regression coefficient R^2 of a linear fit between assessment results of the new (PhytoSee version 7.0) and the intercalibrated method (PhytoSee version 3.1) is higher than 0.8.

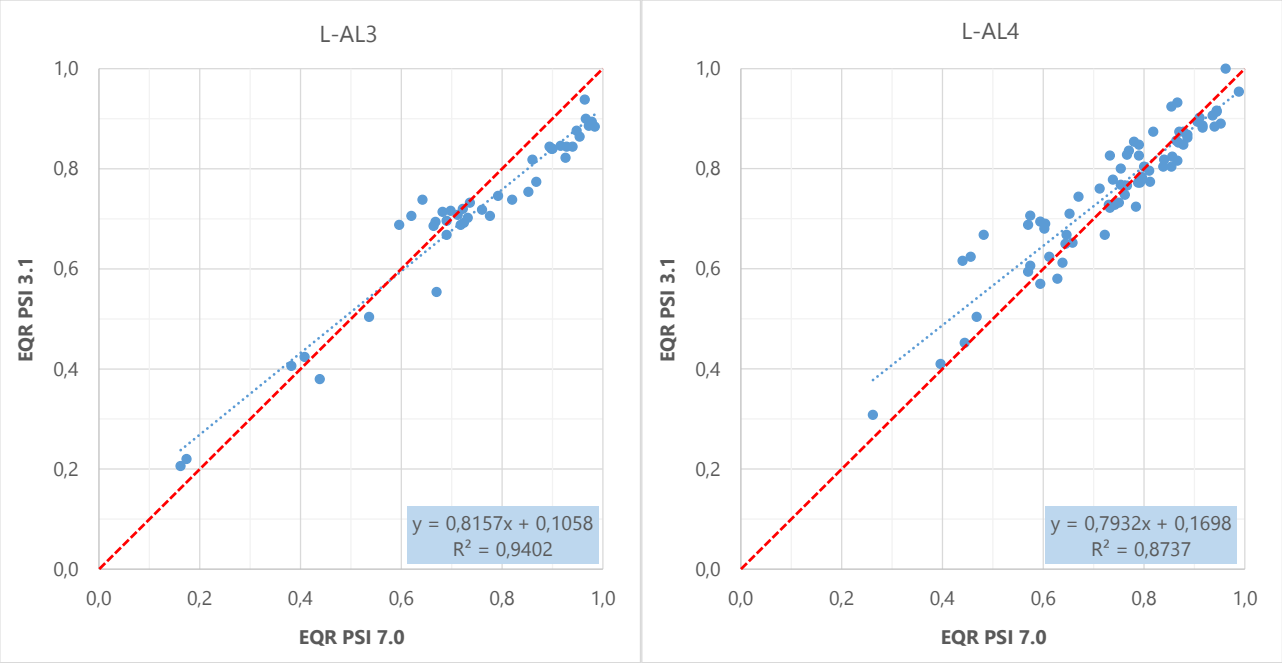

Figure 2: Comparison of the assessment results from PhytoSee 7.0 and 3.1 for IC types in the Alpine Region.

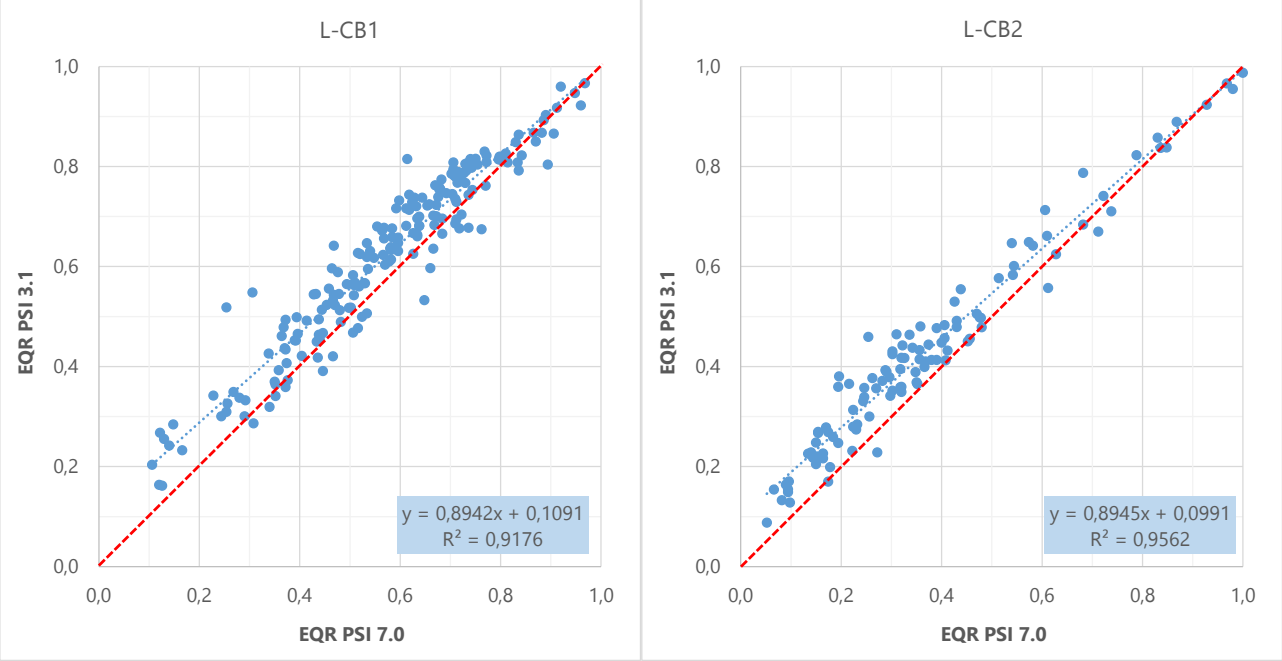

Figure 3: Comparison of the assessment results from PhytoSee 7.0 and 3.1 for IC types in the Central European/Baltic Region (= North German Lowlands).

All regression coefficients R^2 are higher than 0.8. Thus, according to this criterion the methods are considered to be equivalent.

2.4.2 Comparison of the Class Boundaries

Table 4: Comparison of the class boundaries high/good (H/G) and good/moderate (G/M) for the PSI using the previous and the new method. (Formulas of the linear curve fittings for previous (x) and new method (y) taken from Figure 2 and Figure 3).

Comparison of Class Boundaries of PSI and EQR values					
L-AL3	previous boundary	new boundary	deviation	ecological status class difference	comparison result
H/G	0.80	0.76	-0.04	-0.21	less stringent
G/M	0.60	0.60	-0.005	-0.02	less stringent
formula	y = 0.8157x + 0.1058				
L-AL4	previous boundary	new boundary	deviation	ecological status class difference	comparison result
H/G	0.80	0.80	0.004	0.02	more stringent
G/M	0.60	0.65	0.05	0.23	more stringent
formula	y = 0.7932x + 0.1698				
L-CB1	previous boundary	new boundary	deviation	ecological status class difference	comparison result
H/G	0.80	0.82	0.02	0.12	more stringent
G/M	0.60	0.65	0.05	0.23	more stringent
formula	y = 0.8942x + 0.1091				
L-CB2	previous boundary	new boundary	deviation	ecological status class difference	comparison result
H/G	0.80	0.81	0.01	0.07	more stringent
G/M	0.60	0.64	0.04	0.18	more stringent
formula	y = 0.8945x + 0.0991				

For the IC types **L-AL4, L-CB1 and 2** the revisions of the method led to consistently more stringent assessments (see Table 4). According to EC (2014) the modifications are thus **accepted**.

For the IC type **L-AL3** the H/G boundary and also the G/M boundary are less stringent using the new method. For the H/G boundary the difference is -0.21, i. e. one-fifth of an ecological status class unit (Table 4). The G/M boundary is only slightly lower. According to EC (2014) the modifications are thus **not accepted** for this lake type.

Conclusion: Taking into account the ideas about the position of the reference trophic status and the ecological status classes, the assessment for the IC type L-AL3 in the previous method had been too stringent or not optimally calibrated for some metrics, respectively. Within the German system the modifications appear conclusive and should not be "back-fitted" to an old, less reasonable status of the procedures. Since the important G/M boundary is just slightly different, it has been decided to deviate from the categoric procedure in EC (2014). Following discussion in the LAWA Group of Experts "Lakes" and the German Federal Environmental Agency (represented by Dr. Jens Arle) the step 2 of the IC instruction shall not be applied in this case.

In the chapter below reasons for an adequate equivalence of the assessment of IC type L-AL3 to the intercalibrated method and in the context of the intercalibration exercise are presented.

2.4.3 Ecological Status Assessment in the IC Types

In the data sets of the IC types the assessment using ecological status classes demonstrates that the new method leads to an increasing or at least constant number of lake years evaluated moderate to poor. Even in the less stringent evaluated IC type L-AL3 no additional year statistically achieves the "good" ecological status class. Offsets appear mainly within the "high/good" group, where using the new method three additional years are assessed as "high".

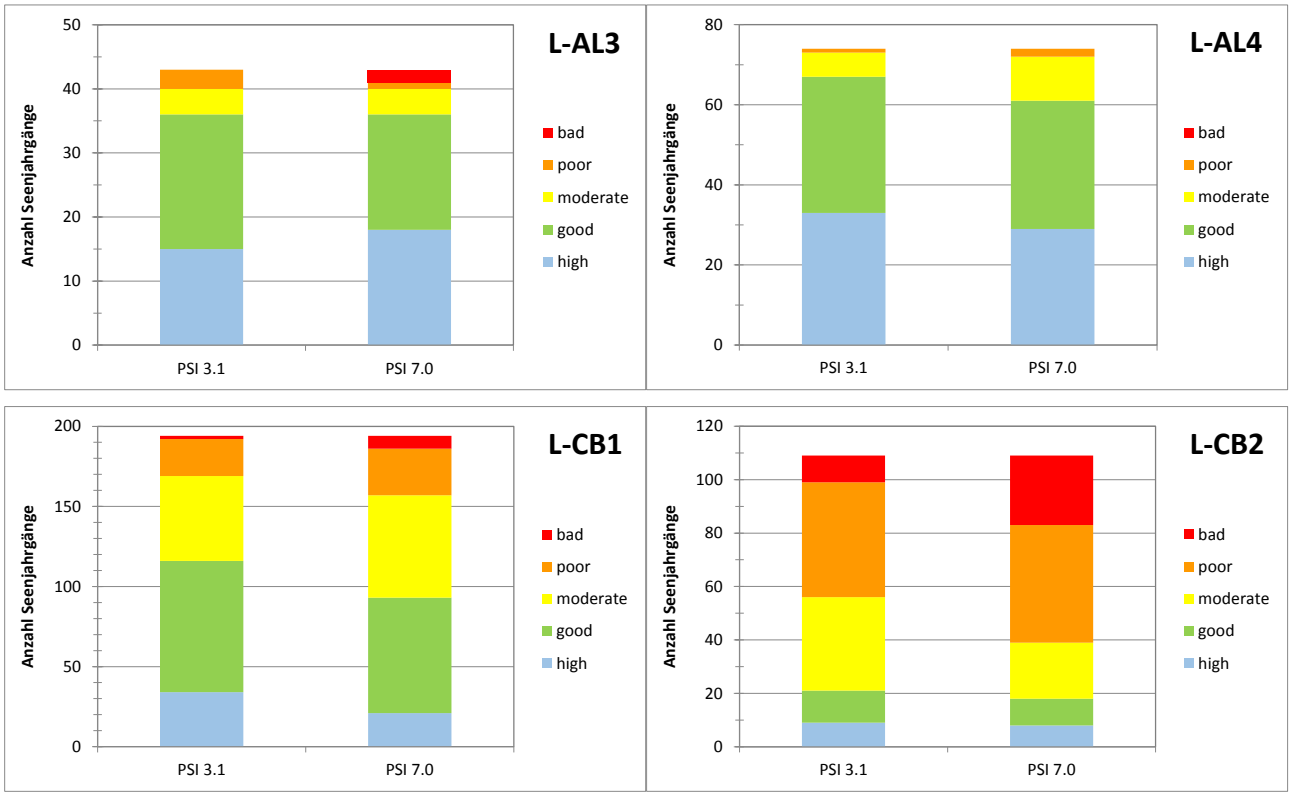

Figure 4: Shift of the ecological status assessment in the IC types using PhytoSee 3.1 vs. 7.0.

Summary: For the currently less stringent evaluated IC type L-AL3 nary shift towards a favourable assessment occurs at the G/M boundary. For the remaining IC types the ecological status classes "high" and "good" occur less frequent using the new method, correspondant to the more stringent assessment.

2.4.4 Considerations Based on the IC Exercise of the Type L-AL3 in the Alpine GIG

In the Alpine GIG (see WOLFRAM *et al.* 2014) three methods from four member states were intercalibrated: from Austria and Slovenia (AT/SI), Germany (GE) and Italy (IT). Option 3 was applied to assess a common data set containing 173 lake years (of type L-AL3) using the three basically very similar structured national methods. For assessment all methods use total biovolume, chlorophyll a concentrations and an indicator-based species index requiring 4-6 sampling dates during the vegetation period. Only the German method additionally contains the algal classes metric. For each lake year the arithmetic mean of the three assessments was calculated as a "pseudo-common-metric" (PCM), which is used for the comparisons with the national assessment results.

The methods displayed a high degree of consistency with one another and with the PCM, and comparison criteria were met well (WOLFRAM *et al.* 2014). For the IC type L-AL3 discussed here, AT/SI and

GE evaluated nearly identical compared to the PCM (**before** normalisation of the EQR values) and, in comparison to the PCM, somewhat more stringent. The IT method evaluated somewhat less stringent. The now revised German method especially for the H/G boundary approximates the Italian method. The G/M boundary remains nearly unchanged close to the AT method boundary. A violation of the comparison criteria is not to be expected.

3 Conclusion and Summary

Germany has introduced the Phyto-See-Index (Phyto Lake Index) with the editing status according to Mischke *et al.* (2008) in the program version PhytoSee 3.1 to the European Intercalibration (**IC**). The IC of the Phyto-See-Index relative to the methods of other nations has been carried out successfully in the Alpine **G**eographical **I**ntercalibration **G**roup (**GIG**) for lakes as well as in the GIG for Central Europe and the Baltic States.

The Phyto-See-Index has been modified in the previous years. Objectives of the modifications were – based on essentially enlarged and consistently acquired data sets - a more sophisticated assessment of the national lake types, the improvement of the metric correlations to the stressors trophic status and total phosphorus and the establishing of a consistent conception concerning the position of the class boundaries (boundary setting protocol) following the revised LAWA-Trophieindex (LAWA Trophic Status Index; LAWA 2014). The up-to-date tool version is PhytoSee 7.0 (MISCHKE *et al.* 2016a).

Following the guidance published in March 2014 by the European Commission (EC 2014) new or modified assessment methods have to be reported to the EC. It has to be demonstrated that the revised method features "equivalence" to the intercalibrated method. The works reported here were carried out in consultation with the German Federal Environmental Agency (contact person Dr. Jens Arle) and with professional support by the LAWA Expert Group "Lakes".

The nine criteria for compliance with the EC WFD are still met for the revised method since the basic structure of the PSI has not been modified.

For the four IC lake types relevant for Germany

- L-CB1 and 2 (L-CB: Lake Central/Baltic)

- L-AL3 and 4 (L-AL: Lake Alpine)

appropriate data sets compliant with the given criteria were selected from the national lake data base for phytoplankton. Test step 1 was conducted following the IC guidance using regression testing and a boundary class comparison of the new (PhytoSee version 7.0) to the intercalibrated method (PhytoSee version 3.1).

Results of Test Step 1:

Regression testing: The equivalence of the new method is achieved when the regression coefficient of a linear fit between assessment results of the new and the intercalibrated method is higher than 0.8. Since the four regression coefficients of the IC types show values substantially higher than 0.8 (0.87 to 0.96), the methods are considered to be equivalent in this regard.

Comparison of class boundaries: For the IC types L-AL4, L-CB1 and 2 the revisions of the method led to consistently more stringent assessments. According to the guidance the modifications are accepted. In contrast, for the IC type L-AL3 the H/G boundary and also the G/M boundary are less stringent using the new method. For the H/G boundary the difference is -0.21, i. e. one-fifth of an ecological status class unit. The G/M boundary is only slightly lower. According to the IC guidance

the modifications are thus not accepted for this lake type, and like for new methods test step 2 should be conducted. Since the important G/M boundary is just slightly different, it has been decided to deviate from the categoric procedure in EC (2014) and step 2 was not applied. Instead of that the equivalence was shown with the concluding differences in trophic class assessment as well as in the context of the intercalibration exercise in the Alpine GIG (see below).

Results of the Ecological Status Assessment of Lake Years in the Data Set:

- In the IC types L-AL4, L-CB1 and 2 the ecological quality classes "moderate" to "bad" occur more frequently using the new method, correspondent to the more stringent assessment.

- For the less stringent evaluated IC type L-AL3 (deep Alpine lakes) nary shift towards a higher number of years evaluated as "good" occurs at the G/M boundary using the new method. Only at the H/G boundary a 20% increase in lake years evaluated as "high" occurs. The assessment difference is thus regarded to be tolerable and virtually equivalent.

Appraisal of Equivalence Based on the IC Results for Type L-AL3 in the Alpine GIG (WOLFRAM *et al.* 2014):

The three methods (AT/SI, GE, IT) displayed a high degree of consistency with one another and with the "pseudo-common-metric" (PCM), and the stipulated comparison criteria were met well. The AT/SI and "old" GE method assess the IC type L-AL3 nearly identical and, in comparison to the PCM, somewhat more stringent. The IT method evaluates somewhat less stringent. In a further comparison for the H/G boundary, the revised German method would approximate the Italian method. The G/M boundary remains nearly unchanged close to the AT method boundary. A violation of the comparison criteria is not to be expected.

Final conclusion: Using different methods and approaches it has been demonstrated that the revised Phyto-See-Index (PhytoSee version 7.0) with its modifications of assessment standards can be considered to be equivalent to the intercalibrated method (PhytoSee version 3.1).

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