European Commission

JRC TECHNICAL REPORTS

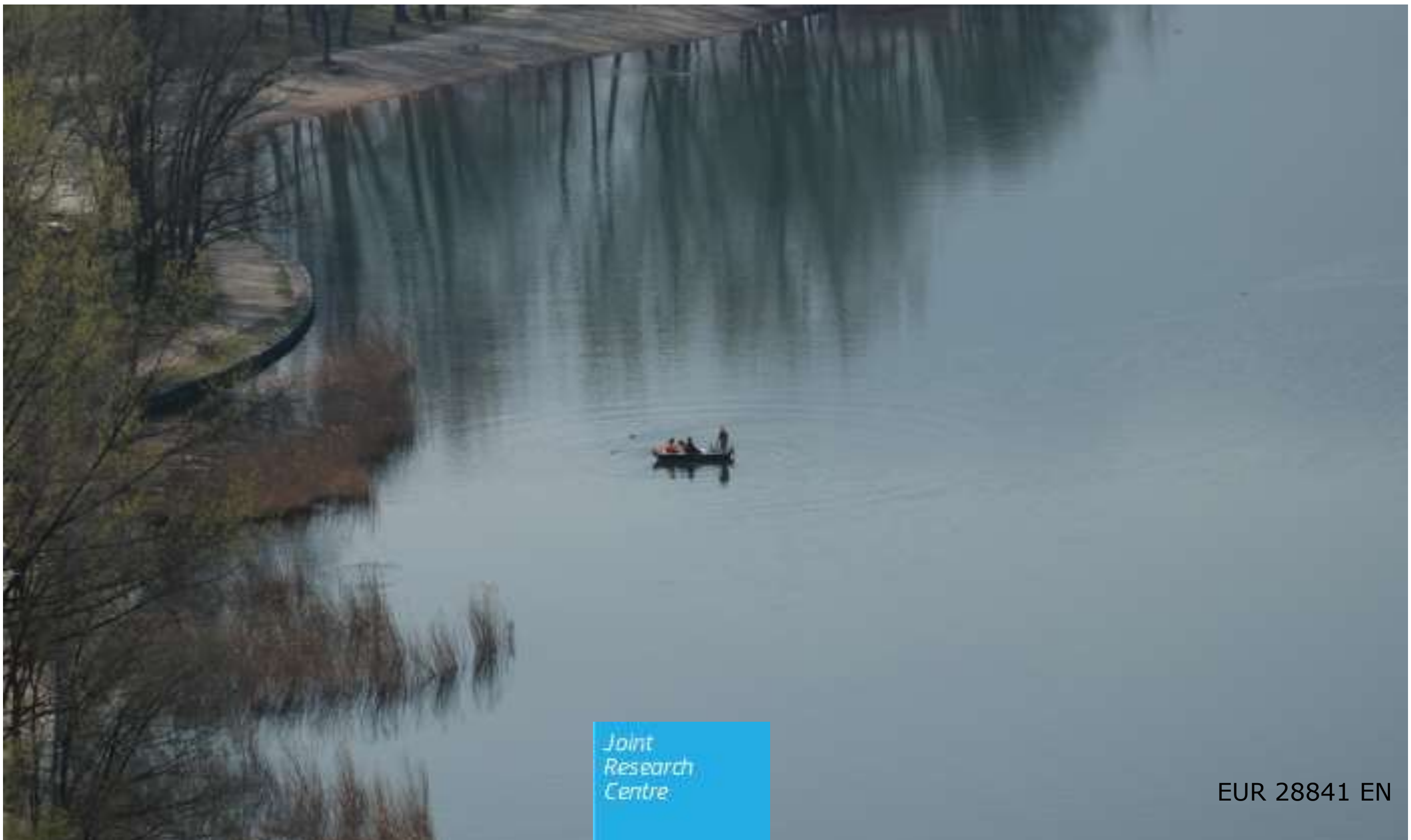
Intercalibration of the national classifications of ecological status for Central-Baltic Lakes

Biological Quality Element: Fish fauna

Part B and C

David Ritterbusch, Christine Argillier, Witold Białokoz, Janis Birzaks, Petr Blabolil, Jan Breine, Hanna Draszkiewicz-Mioduszewska, Nico Jaarsma, Ivan Karottki, Teet Krause, Jan Kubečka, Torben Lauridsen, Maxime Logez, Anthony Maire, Anu Palm, Graeme Peirson, Milan Říha, Jacek Szlakowski, Tomas Virbickas, Sandra Poikane

2018



Joint Research Centre

EUR 28841 EN

EU Science Hub
https://ec.europa.eu/jrc

JRC106889

EUR 28841 EN

PDF	ISBN 978-92-79-74611-6	ISSN 1831-9424	doi:10.2760/546291
Print	ISBN 978-92-79-74612-3	ISSN 1018-5593	doi:10.2760/016107

Luxembourg: Publications Office of the European Union, 2018

How to cite: RITTERBUSCH D, ARGILLIER C, ARLE J, BIALOKOZ W, BIRZAKS J, BLABOLIL P, BREINE J, DRASZKIEWICZ-MIODUSZEWSKA H, JAARSMA N, KAROTTKI I, KRAUSE T, KUBEČKA J, LAURIDSEN TL, LOGEZ M, MAIRE A, PALM A, PEIRSON G, RIHA M, SZLAKOWSKI J, VIRBICKAS T, POIKANE S, Water Framework Directive Intercalibration: Central-Baltic Lake Fish fauna ecological assessment methods;
Part B: Development of the intercalibration common metric; Part C: Intercalibration, EUR 28841 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-74611-6, doi:10.2760/546291, JRC106889.

Table of contents

Abstract

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 are 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).

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

This volume on intercalibration of the Lake Central Baltic Fish ecological assessment methods is split into three parts:

Part A, a document that provides an overview and detailed descriptions of fish-based lake ecological assessment methods;

Parts B describes the construction of a multiple pressure index in the Central-Baltic region;

Part C describes the procedure and results of the boundary harmonisation of national fish-based lake assessment systems.

Part B

Development of the intercalibration common metric

B.1 Introduction

At the second intercalibration meeting in October 2013, the IC options for the Central/Baltic Lake Fish Group were discussed. The GIG decided to develop a common index for the total anthropogenic pressure intensity (abbreviated TAPI-index). Our aim was to develop a pressure index which summarizes all (or most) pressures that possibly affect a lake into one final number. Additionally, the TAPI should provide a comparable estimation of the pressure intensity throughout the wide geographic range of the Central Baltic Intercalibration Group.

A similar intercalibration procedure was successfully used in Phase II by the NEA GIG and the Lake Fish Alpine group. The aim of the intercalibration process is comparing the levels of ecosystem alteration caused by pressures, but not comparing the pressure intensities themselves. Therefore, the ecological effects of pressures are essential part of the scoring in the TAPI index.

The TAPI development had three stages of development:

TAPI 1) initial characterization with the TAPI1 metrics (decided at the 2nd meeting, October 2013);

TAPI 2) addition of continuous eutrophication metrics and rejection of some TAPI1 metrics (e.g. pollution, decided at the 3rd meeting, June 2014);

TAPI 3) focus on calculations using minimum of pressures or mean of pressures and an IC dataset reduced to lakes > 50 ha (decided at the 4th meeting, January 2015).

The present document describes the final TAPI3. It is divided in three parts:

1) The contents of the common pressure table;
2) The procedure of scoring the individual metrics;
3) The combination of the metrics to a total pressure index and the selection of the 'best' one.

B.2 Common pressure table

First we compiled a table with the lakes of the intercalibration dataset and a comprehensive description and evaluation of potential human influences. In the following text, the descriptors of human influences are called metrics. The metrics belong to one of the pressure categories eutrophication, hydro-morphological alteration, biological influences or pollution. The table includes general information on the lake as well as the assessment results with the national fish-based systems. The following section provides a description of the contents of the common pressure table.

B.2.1 General lake information/Typology

MS (Member State)

LakeName (full name of the lake)

Icdat (IC data): a yes/no selection if this lake is included in the final intercalibration process. We selected lakes with areas between 50 and 10.000 ha, some lakes were excluded individually because of specialties making them incomparable.

origin: a distinction of the WFD categories natural, heavily modified water body (HMWB) and artificial water body (AWB).

LType0: a lake typology with polymictic vs stratified lakes (functional assignment - not based on thresholds for mean or max depth).

LType1: a typology with POLY (polymictic), STRAT (stratified) and DEEP lakes (strat. deeper 30 m), details in RITTERBUSCH et al. (2014)

LType2: a typology with a subdivision of the previous classification: POLY, STRAT, DEEP, RESV-POLY (polymictic reservoir), RESV-STRAT (stratified reservoir or deep stratified reservoirs), SPEC-flushed (special lake type flushed lake), SPEC-saline (special lake type with high salinity e.g. at shorelines) and others (free category for lakes that might by any reason be incomparable).

L-CB Type: An assignment of the intercalibration lake types used on Phase II for intercalibration of phytoplankton. Taken from the Technical Report (POIKANE 2009). Not all criteria might be correct in all assignments (e.g. alkalinity and mean depth, but not residence time). All lakes are natural lowland lakes with altitudes < 200 m:

> **1** is L-CB1: shallow, calcareous lakes (mean depth 3-15 m, alkalinity > 1 meq/l, water residence 1-10 years);
>
> **2** is L-CB2: very shallow, calcareous lakes (mean depth < 3 m, alkalinity > 1 meq/l, water residence 0.1-1 years);
>
> **3** is L-CB3: shallow, small, siliceous lakes (mean depth 3-15 m, alkalinity 0.2 - 1 meq/l, water residence 1-10 years);
>
> **0** is none of these types.

info special: descriptive information on specialties (e.g. high salinity), origin for AWB/HMWB or potential natural impacts on biological status.

info human: descriptive information on remarkable human influences currently affecting the lake status.

B.2.2 Eutrophication

Eutrophication is the most important pressure in the Central Baltic. Nearly all lakes are affected by some kind of nutrient surplus and this pressure affects the ecology of the whole lake in complex interactions. Four continuous measures and two discrete measures are used to assess this pressure. They all provide information on the trophic status/eutrophication and therefore not all of them are needed for calculation of the TAPI index.

year_eutro (year(s) of sampling for eutrophication data): informative

Chlo-a (Chlorophyll-a [µg/l]): mean summer epilimnetic (June - September), quantitative-continuous, for FR mean summer euphotic layer

TP_spring (total phosphorous in spring [µg/l]), mean of March/April or while water body is not stratified, quantitative-continuous

TP_summer (total phosphorous in summer [µg/l]), mean epilimnetic from June - September, quantitative-continuous, for FR mean summer euphotic layer.

LUNN_abs% (land use non-natural in the catchment area as percentage): quantitative-continuous, taken from the IRSTEA database. *Human activities in the catchment area usually are the main source of nutrients in lakes. The intensity of non-natural land-cover is a proxy for the eutrophication of tributaries and thus for the lake. The data is obtained with a GIS analysis by intersecting the lake catchment area with Corine Land Cover data of the year 2000. For many countries this data was already collected for the intercalibration phase II and is present in the IRSTEA database.*

TP_class (total phosphorous %; classified): Total phosphorous with type specific class boundaries. For many countries this data is present in the IRSTEA database. *There are no specific demands on the methodology of TP measurement and it will easily be possible to assign one of the five classes with existent data. The classification is based on German boundaries that appeared to be transferable (OGEWV 2011; LAWA 2014)*

LUNN_class (land use non-natural %; classified): This metric is a 5-step quantitative classification of LUNN_abs%.

TPlvl (trophic level): Classification in a national or international index of eutrophication. As an example, the German index accounts for TP spring, TP summer, Chlo-a and Secchi-depth. By combining multiple parameters, the indices might be more stable than TP only. The class boundaries depend on the depth/stratification of the lake. No standards for the data are given; the TPlvl classification is purely descriptive and has no quantitative thresholds.

Older TAPI1 metrics (grey columns in the pressure table):

dtTP (delta TP = trophic change): The difference of the mean TP concentration between reference conditions and current conditions (the TP surplus). This metric takes a specialty of trophic parameters into account: reference values deviate from 0 and there is a wide natural range. In some cases, the modeled TP background levels might be known and can be compared with the present TP level to get a true picture of eutrophication (and not of trophic status). No standards for the data or for calculations are given. Germany uses a modeling approach based on morphometric properties of the lake (LAWA 1998).

B.2.3 Hydromorphological alteration

Shoremod_class: shoreline modification in classes of percentages. It describes the direct alteration of the shoreline bank by humans. Modified structures can be marinas, walls, stony shores, footbridges, beaches, cattle troughs. *The data can be estimated with aerial photographs, e.g. Google Earth. In many cases, it is possible to virtually assign one of the chosen classes without time-consuming measurements. For many countries, this data is already present in the IRSTEA database. The class boundaries are adopted from the IC process.*

Lake use: Lake use is a metric for estimation of the direct impact of recreational and professional use of the water body. The categories are (which increasing impact on the lake ecology): Bathing; boating/sailing; boating/shipping; water skiing/diving and intense use in all categories. We adopted a 3-step classification from the IRSTEA database. Each category includes intense use by the aforementioned activities. The data is an expert's judgment based on investigations, field observations and experiences. *Lake use mainly affects the pelagic surface waters habitats. An effect on the lake ecology will take place at high intensities only, especially in big or deep lakes. It is important to carefully estimate the ecological effects of the use and assign the corresponding classes; e. g. a single diver is not a significant pressure in a big lake. For many countries lake use data is present in the IRSTEA database as a low/moderate/strong parameter.*

Habitat number: The metric assesses the reduction of habitats. To obtain the data, the number of habitats in undisturbed conditions is estimated and compared to the present number of habitats. Examples for natural habitats are: 1) Littoral: sand, gravel, stones, wood, submersed plants, floating leaved plants, reeds, inflow, outflow, 2) benthic with structures, benthic without structures but with oxygen, 3) the pelagic water body. We use a 5-step classification based on expert judgment (however, the missing habitats can be named, so this decision is traceable). ***Please note**: Human made habitats like beaches, stone packages or marinas increase the habitat number. They are not rated negative unless they are so extended that they reduce the number of natural habitats.*

Older TAPI1 metrics (grey columns in the pressure table):

dtwaterlvl: water level fluctuation/regulation. The metric compares the present water level with the expected situation without human impacts. It includes the total water level amplitude and also temporal deviations (e.g. water is retained in summer). The data requires knowledge on the current water levels and their development throughout the year as well as knowledge in the historical situation. If data is absent, expert knowledge is needed. Water level fluctuation might be 'natural' (= normal) in reservoirs.

Connect: The metric estimates the impact of human barriers on fish species migrating from/to the lake. The metric is not focused on long-distance migrators (salmon, eel) but is meant to assess conditions for species like lake trout, *Leuciscus spp*., bream or pikeperch which frequently spawn in tributaries or outflows. The classification is based on expert judgment as there is no common standard for estimation of barrier effects. *The connectivity is important for a limited number of fish species which usually have lower abundances. We want to assess the pressures affecting the lake ecology/whole fish community. Therefore, it is not possible to assign 'high' or 'extreme' to this pressure's intensity. **Please note**: the metric is applicable only for lakes that are fully connected in reference conditions.*

Popdens: population density: The metric population density is proposed as a proxy for use intensity (not for eutrophication). It refers to a 'catchment area' of human use, i.e. the range in which people come to the lake for recreation. This area must be estimated. *Maps of population densities might be present at the national agencies dealing with statistics of demography. Therefore, a quick assignment of the classes should be possible.* ***Please note****: this is NOT the metric population density in the catchment area used in the IRSTEA database. Examples: For Germany, the data was derived from statistical data of population density on the level of smaller administrative units (Landkreise). The geographical location of all lakes was checked individually and the few lakes near cities were raised one category above the mean of the Landkreis.*

Shoremod%: continuous values for the percentage of modified shoreline (basis for shoremod_class)

B.2.4 Biological influences

The biological pressures are somewhat critical as they directly change the fish community. The problem is that we do not want to assess the status of the fish community but of the lake ecology. Therefore, the intensity of biological pressures must be high enough to both change the fish community AND have notable secondary effects on the lake ecology.

Fishcatch: assesses the ecological effects of <u>selective fish removal</u> by commercial fisheries and/or angling. We use a 3-step classification based on expert judgment. ***Please note****: other potential effects of fishery and angling like stocking, disturbance, shoreline degradation or nutrient input are assessed with other metrics. For many countries, fish exploitation data is present in the IRSTEA database as a low/moderate/strong parameter. It has to be checked, if this classification considered the ecological effects*.

Stocknat: stocking of native species. This metric assesses the ecological effects of <u>selective fish input</u> by commercial fisheries and/or angling. It refers to the stocking of 'native' species, i.e. the species that would be present in an undisturbed condition. *The input itself is not a pressure if no ecological consequence is assumed, e.g. stocking of pike or pikeperch will rarely increase their abundance to an extent that the trophic interactions are significantly changed (LIT missing). We use a 3-step classification. The data is based on fisheries/anglers data of stocking and expert judgment of the ecological consequences. For many countries, stocking data is present in the IRSTEA database as a YES/NO parameter. Again, the ecological effects have to be approved*.

alienfish%W_class: percentage of weight of non-native fish. The metric assesses the percentage of introduced species in the scientific fish catches. For the difference between stocking and introduction see HUTCHINGS (2014). The estimation can be supported by statistics of commercial fisheries and anglers. We use a 5-step classification based on the experts assumption, that a weight-percentage of 16 % alien fish-species will have a significant impact on the ecology of the fish community, on other biological elements and therefore on the lake ecology (example for significant pressure).

Older TAPI1 metrics (grey columns in the pressure table):

alienfish_spn: the number of fish species absent in undisturbed conditions (true aliens and translocated species). *The data is based on the scientific fishing campaigns eventually supported by fisheries statistics or queries.*

alienfishspn_class: the number of fish species absent in undisturbed conditions (introduced species). Data as a 5-step classification based on the experts assumption, that the presence of 4/5 alien fish-species will have a significant impact on the ecology of the fish community, on other biological elements and therefore on the lake ecology (see 'significant pressure'). *If the alien species are known to be infertile, have low abundances and do not impact the lake ecology simply choose a lower category and make a note.*

alienfish_%W: continuous values for the percentage of introduced fish species in scientific catches

non-fish alien: The metric assesses the impact of non-fish aliens (like mussels, crustaceans, plants). I suggest a 3-step classification of the ecological effect based on an expert's evaluation. If aliens have adverse ecological effects, this will usually be known and an assignment to one of the classes will be possible.

B.2.5 Pressure pollution

This pressure group was completely removed in the TAPI2 approach. Reason is the dominance of high scores in all influences.

Chempoll (chemical pollution): This metric estimates the chemical pollution as defined by the criteria of the EC directive for environmental quality standards (2008/105/EC). The classification refers to Annex I of the directive. The information should be available from the reporting to EU by the corresponding national ministry of environment or by a person in charge of monitoring chemicals in the MS. In case no monitoring is available, expert judgment might be used.

Vispoll (visible pollution): The metric assesses the visible impairments of the fish community by urban discharge, industrial discharge and others. Examples are oil, wastewater, cooling water… I suggest a 3-step classification. The data can be obtained by expert's estimation during the fishing campaigns. For many countries this data is already present in the IRSTEA database as a YES/NO parameter 'urban/industrial discharge'.

Vistrash (visible trash): The metric estimates the amount of trash at the shoreline (plastics, cans…). It is a proxy for both pollution and lake use intensity. I suggest a 3-step classification. The data can be obtained by expert's estimation during the fishing campaigns.

Bioeffpoll (biological effects of pollution): The metric estimates the intensity of proved or supposed effects of pollution on biota (not only fish). Examples are shifts in sex ratio, lack of reproduction, reduced growth, infections or diseases). I suggest a 3-step classification. The information can be obtained during the fishing campaign (clues) or with specific investigations (proofs).

B.2.6 Information on the national assessment systems

LFI_EQR: EQR value of the national Lake Fish Indices (based on different systems!).

LFI_ESC: Ecological status class of the national Lake Fish Indices (based on different systems!).

YearAssess: Year of the fish sampling which provide the basis for the EQR and ESC calculations (informative).

Datatype: Methods used in fishing campaign (e.g. CEN, E, HYAC)

Exp_ESC: Experts estimation of the ecological status class provided by an expert of the MS (abiotic, not fish-based)

Exp_name: Experts name

ELFI_EQRMay14: EQR value of the European Lake Fish Index (ARGILLIER et al. 2013), as of May 2014

ELFI_ESCMay14: Corresponding ecological status class (ARGILLIER et al. 2013)

B.3 Scoring

B.3.1 General

The metrics are mostly scored on a 5-step WFD compliant scale. Metrics get a high score of 5 for low pressure intensity; a low score of 1 is assigned for very intense pressures. The class boundaries are usually set with a normal distribution in mind; narrow boundaries at the edges, extended ones in the middle. In our understanding the classes 5 and 1 should be rare. The score 5 represents a least disturbed condition, as true reference conditions might be absent for lakes > 50 ha in the Central Baltic. The score 1 is restricted to extreme pressures, e.g. a polytrophic urban water body with a few highly resistant fish species. This value should be very rare. In many cases the assignment of 5 classes to the pressure intensity was impossible or unwanted because of missing information. In this case, a 3-step classification close to the IBI concept is used (1/3/5 points). Table B.1 provides a general normative description of the pressure intensities.

Table B.1: General normative description of scoring the intensities of human influences in the TAPI.

Score	General explanation for 5-step assignment	General explanation for 3-step assignment
5	very low influence intensity - the influence is absent, negligible or will only have no effect on lake ecology / fish ecology	
4	minor influence intensity - the intensity is low and only minor effects on the lake ecology / fish ecology are observed or expected	-
3	Significant influence intensity - the intensity is assumed to be high enough to a) alter the fish abundance and/or b) alter the species composition and/or c) reduce the number of sensitive species and/or d) - reduce the reproductive success. The influence can affect the fish community both directly or indirectly via changing the lake ecology.	
2	High influence intensity - high enough to intensively change the above mentioned criteria for fish/lake ecology.	-
1	Extreme influence intensity - the influence should lead to a fish community with very high or very low abundances, strong dominance of single species, a very low number of fish species, the absence of sensitive species and the absence of reproduction for most species	

B.3.2 Class boundaries for the TAPI metrics

Table B.2: Class boundaries for scoring in the CB Lake Fish table of human influences. The setting for continuous metrics for eutrophication is described in the next chapter. The first part of the table shows the metrics used for the TAPI calculation, the second part shows the metrics where information is present, but which are not used for calculation of TAPIs.

TAPI metric	5 points - least disturbed	4 points - minor	3 points - major	2 points- strong	1 point extreme
Chlo-a	next section				
TP_spring	next section				
TP_summer	next section				
TP_class [µg/l]	POLY: ≤ 25 STRAT: ≤ 20 DEEP: ≤ 12	POLY: 26-50 STRAT: 21-40 DEEP: 13-25	POLY: 51-100 STRAT: 41-80 DEEP: 26-60	POLY: 101-300 STRAT: 81-240 DEEP: 61-130	POLY: > 300 STRAT: > 240 DEEP: > 130
LUNN_class	< 20	21-50	50-80	81-95	> 95
TPlvl	POLY: meso STRAT: low meso DEEP: oligo	POLY: low eutro STRAT: high meso DEEP: low meso	POLY: high eutro STRAT: low eutro DEEP: high meso	POLY: poly STRAT: high eutro DEEP: low eutro	POLY: hyper STRAT: poly DEEP: high eutro
Shoremod_class	≤ 10 %	11-30 %	31-50 %	51-70 %	> 70 %
lakeuse	Low (bath, boat, sail)	-	intense (motorboat, ships, dive)	-	very intense
habitatnr	natural/increased	all habitats	1-3 habitats missing	4-6 habitats missing	> 6 habitats missing
fishcatch	no/minor ecol. effects	-	significant ecol. effects	-	strong ecol. effects
stocknat	no/minor ecol. effects	-	input has ecol. effects	-	fish community mainly stocked
Alienfish%w_class	≤ 05 %	06-15 %	16-50 %	51-85 %	> 85 %

TAPI metric	5 points - least disturbed	4 points - minor	3 points - major	2 points- strong	1 point extreme
LUNN_abs%	Not applied				
dtTP [µg/l]	natural	POLY: + 25 STRAT: + 20 DEEP: + 15	POLY: + 75 STRAT: + 60 DEEP: + 45	POLY: + 250 STRAT: + 200 DEEP: + 120	POLY: +> 250 STRAT: +> 200 DEEP: +> 120
dtwaterlvl	natural	± 1 m	± 3 m	± 5 m	± > 5 m
connect	fully connected or barriers with fish passes	barriers down-/upstream	no passage down/upstream other with strong barriers	-	-
Popdens	< 100	101-200	201-500	> 500	central urban
Shoremod%	Not applied				
Alienfish_spn	Not applied				
Alienfishspn_class	0	1-3	4-5	6-7	> 7
Alienfish%w	Not applied				
non-fish alien	no or minor ecol. effect	-	significant ecol. effect	-	strong ecol. effect
chempoll	fits Annex I	-	fails 1 substance	-	fails > 1 substance
vispoll	no/minor	-	apparent	-	strong
vistrash	no/few	-	habitat destruction	-	plenty
bioeffpoll	no evidence	-	single proofs / reliable clues	-	multiple proofs

B.3.3 Classification of continuous metrics for eutrophication

The continuous metrics in the pressure table are the total phosphorous concentration in spring and in summer and the Chlorophyll-a concentration. For the calculation of a common index it was necessary to set class boundaries to the values and assign a score ranging from 1-5, similar to the rest of the metrics. The class boundaries were assigned in five different approaches.

B.3.3.1 Approach LAWA: German national classification system

The classification of the continuous metrics Chlo-a, TP spring and TP summer was done by using the German national classification of trophic levels. The levels were scored different for the lake types polymictic and stratified (=strat+deep). The scoring is based on the following assumption:

Polymictic lakes: High = mesotrophic / good = eutro / moderate = poly / poor = hyper

Stratified lakes: High = oligotrophic / good = meso / moderate = eutro / poor = poly

The class boundaries were taken from tables in the corresponding German literature (LAWA 1998; LAWA 2014).

Metric	Lake Type	HG	GM	MP	PB	source
Chl-a (µg l^{-1})	POLY	10	33	110	325	LAWA 14
TPsp (µg l^{-1})	POLY	30	70	165	375	LAWA 14
Tpsum (µg l^{-1})	POLY	25	90	320	500	LAWA 98
Chloa (µg l^{-1})	STRAT+DEEP	3	10	33	110	LAWA 14
TPsp (µg l^{-1})	STRAT+DEEP	14	38	105	290	LAWA 14
Tpsum (µg l^{-1})	STRAT+DEEP	9	50	270	500	LAWA 98

B.3.3.2 Approach: relative class boundaries

The aim was to assign a 1/2/3/4/5 score based on an EQR value. In this approach, the score for the metrics was calculated as an EQR value using the minimum and the maximum for each metric. This was done separately for the types POLY, STRAT and DEEP. The EQR was then multiplied by 5 to get a 1-5 scale. This procedure implies that lakes in both HIGH and BAD status are present in the dataset. The min and max values in the dataset are (all values in µg l^{-1}):

	Chloa_min	Chloa_max	TPspring_min	TPspring_max	Tpsummer_min	Tpsummer_max
POLY	2.4	468.6	5	735	11	1364
STRAT	1.1	73.9	5	688	7	501
DEEP	0.7	71.8	5	155	4	79

Example for the scoring of Chl-a in DEEP lakes:

$$EQR_{Chloa} = (1-((Chloa-0.7)/(71.8-0.7)))*5$$

$$= (1- ((Chloa-0.7)/71.1))*5$$

Some Danish POLY lakes were excluded from the max determination because of extremely high values: Klejtrup Sø 2009 for Chlo-a, Tofte Sø for TP spring and summer.

B.3.3.3 Approach: Carlson's Trophic State Index (TSI)

The classification is based on CARLSONS TSI (CARLSON 1977). The values were calculated with equations in CARLSON & SIMPSON (1996). Boundaries were set at TSI 50 / 60 / 70 / 80 for polymictic lakes and at 40 / 50 / 60 / 70 for STRAT+DEEP lakes. The class boundaries for the annual mean values (all in (µg l^{-1}) of CARLSON are used for both spring and summer TP in the TAPI table.

		HG	GM	MP	PB
Chloa	POLY	7.2	20	56	154
TP	POLY	24	48	96	192
Chloa	STRAT+DEEP	2.6	7.2	20	56
TP	STRAT+DEEP	12	24	48	96

B.3.3.4 Approach: Vollenweider and Kerekes

The class boundaries are taken from VOLLENWEIDER & KEREKES (1982) with the class boundary set at the mean + one standard deviation of the upper class. The annual mean values are used for both spring and summer TP. We distinguished two lake types and assumed that:

Polymictic lakes: high = mesotrophic / good = eutro / moderate = lower hyper-eutro / poor = upper hyper-eutrophic

Stratified lakes: high = oligotrophic / good = meso / moderate = eutro / poor = lower hyper-eutro

		HG	GM	MP	PB
Chloa	POLY	7.5	31	100	150
TP	POLY	50	190	750	1200
Chloa	STRAT+DEEP	3.5	7.5	31	100
TP	STRAT+DEEP	13	50	190	750

B.3.3.5 Approach: IC results

The class boundaries for Chlo-a are taken from IC results (POIKANE 2009; POIKANE et al. 2014). The class boundary for TP is taken from a German surface water body regulation (OGEWV 2011) which implements both the WFD and the sub-directive (2000/60/EC 2000; 2008/105/EC 2008). Grey fields were set by D. Ritterbusch based on expert judgment, partially supported by PHILLIPS et al. (2008) and the previous results. Again, similar values are used for both TP spring and TP summer in the TAPI scoring.

		HG	GM	MP	PB
Chloa	POLY	11	21	52	215
TP	POLY	32	45	100	200
Chloa	STRAT+DEEP	6	10	26	104
TP	STRAT+DEEP	25	32	45	100

B.4 TAPI calculation and IC suitability criteria

The principle of intercalibration using a common pressure index is to translate the incomparable national Fish assessment results LFI into a comparable pressure index TAPI. The class boundaries are harmonized based on TAPI values and then re-translated into national LFI values. Therefore, a good correlation of the LFI to the TAPI is essential for the intercalibration process. The official intercalibration templates and the accompanying documents provide three criteria for suitability of the common TAPI. These criteria refer to the correlation of the TAPI to the national fish indices, comparing the values of TAPI-EQR and the LFI-EQR (BIRK et al. 2011; CIS 2011; NEMITZ et al. 2011):

1) The Pearson coefficient of correlation should be $R > 0.5$
2) The significance of this correlation should be $p < 0.05$
3) The slope of the regression line should be > 0.5

The GIG includes 12 MS. Slovakia participates as an observational member; Latvia has not yet developed a fish based system. UK has trialled the NL system, but decided to not participate in the process (G. Peirson, pers. comm. in March 2015). However, UK plans to test the compatibility of their class boundaries by application of the common pressure index. Poland has submitted data for two (!) fish systems based on different information on the fish communities (PC is the Polish system based on CEN 14757, PL is the Polish LFI based on fisheries statistics). The suitability of the TAPI will be tested for both, but only one will be included in the IC process.

At all, ten national systems are tested for correlation to the TAPI, with two of them being Polish.

Whoever compared the correlation of fish community traits to environmental parameters realizes that the above mentioned demands are quite challenging. We used a try-and-error approach to find the best TAPI. The steps were:

a) The calculation of a series of 62 different TAPI indices.
b) The decision to not use a subdivision into types <u>before</u> the identification of the best TAPI. This is based on intensive tests for the TAPI2 development. The analyses were not repeated for the TAPI3.
c) The analysis of the Pearson coefficients of correlation and their significances. The analysis of the slopes of the regression lines.
d) The selection of the best TAPI.
e) The test, if a subdivision into lake types improves slopes, correlations and significances <u>after</u> selecting the best TAPI.

B.4.1 Calculation of different TAPIs

The TAPI calculation is based on the common pressure table. Lakes without LFI-EQR values were removed (some datasets for BE, DE, DK and all data for LV). Lakes < 50 ha were also removed from the intercalibration dataset and those lakes which were assigned to be unsuitable for intercalibration by other reasons (ICdat = 0). Finally DE lakes without continuous data for eutrophication and Lake Klejtrup (DK) with Chlo-a > 1.000 were deleted from the dataset.

The TAPIs were calculated by combining pressure metrics to a total score. The metrics were assigned to pressure groups, e.g. TP and Chlo-a are assigned to the pressure group eutrophication. We decided to calculate the TAPI with mean values or minimum values of pressure groups (Silkeborg, January 2015). Some MS could not provide data for single pressure metrics, but at least one metric within each pressure group is present for all MS. A different number of metrics could skew the TAPIs and make them incomparable. The calculation of a pressure-based TAPI makes the index comparable for all MS.

Table B.3 provides an overview of the 62 TAPIs calculated by different metrics and combination procedures. All TAPIs were calculated as EQR values between 0 (high influences) and 1 (low influences). This is comparable to the EQR normalization of the WFD compliant biological assessment systems:

$TAPI_x = (score_x - min_x) / (max_x - min_x)$

Table B.3: Combinations of metrics for the calculation of 62 TAPIs (TAPI3, i.e. without lakes < 50 ha). nc: non continuous metrics, cont: continuous metrics (TPspring, TPsummer and Chlo-a), eutro: metrics for eutrophication, hymo: metrics for hydro-morphological alteration, bio: metrics for biological influences.

Nr	Description	Pressure	Metrics included	Combination	TAPI ID
1	Non-continuous metrics	Eutro	TP_class / Lunn_class	min of press	TAPI3_1a
2		Hymo	shoremod_class / lakeuse / habitatnr	mean of press	TAPI3_1b
		Bio	fishcatch / stocknative / alienfishW_class		
3	Non-continuous + TPlvl	Eutro	TP_class / Lunn_class / TPlvl	min of press	TAPI3_2a
4	*3 metrics for each pressure*	Hymo	shoremod_class / lakeuse / habitatnr	mean of press	TAPI3_2b
		Bio	fishcatch / stocknative / alienfishW_class		
5	Non-continuous, eutro weighted	Eutro	TP_class / Lunn_class (both 3* for total and 2* for min and mean)	min of press	TAPI3_3a
6	*Weight eutro = hymo + bio*	Hymo	shoremod_class / lakeuse / habitatnr	mean of press	TAPI3_3b
		Bio	fishcatch / stocknative / alienfishW_class		
7	Non-continuous, no LUNN	Diff	TP_class + mean of degra + mean of bio	mean of press	TAPI3_4
8	Non-continuous, no LUNN, 2*eutro	Diff	2*TP_class + mean of degra + mean of bio	mean of press	TAPI3_5
9	eutro only	Eutro	TP_class / Lunn_class	total mean	TAPI3_6a
10	eutro only + TPlvl	Eutro	TP_class / Lunn_class / TPlvl	total mean	TAPI3_6b
11	Non-continuous, all, no pollution	Eutro	TP_class / Lunn_class / TPlvl / dtTP	min of press	TAPI3_7a

Nr	Description	Pressure	Metrics included	Combination	TAPI ID
12		Hymo	shoremod_class / lakeuse / habitatnr / dtwaterlvl / connect / popdens	mean of press	TAPI3_7b
		Bio	fishcatch / stocknative / alienfishW_class / alienfishspn_class / non-fishalien		
13	continuous LAWA *(boundaries p. 13)*	Eutro	Chlo-a / TPspring / TPsummer / TP_class / Lunn_class	total	TAPI3_8a
14		Hymo	shoremod_class / lakeuse / habitatnr	min of press	TAPI3_8b
15		Bio	fishcatch / stocknative / alienfishW_class	mean of press	TAPI3_8c
16	continuous LAWA, eutro only	Eutro	Chlo-a, TPspring / TPsummer / TP_class / Lunn_class	total	TAPI3_8d
17	continuous LAWA + all non-continuous	Eutro	Chlo-a, TPspring / TPsummer / TP_class / Lunn_class / TPlvl / dtTP	total, no pollution	TAPI3_8e
18		Hymo	shoremod_class / lakeuse / habitatnr / dtwaterlvl / connect / popdens	total with poll.	TAPI3_8f
		Bio	fishcatch / stocknative / alienfishW_class		
		Pollution	Vispoll / vistrash / bioeffpoll		
19	continuous LAWA + hymo	Eutro	Chlo-a / TPspring / TPsummer	min of press	TAPI3_8g
20		Hymo	shoremod_class / lakeuse / habitatnr	mean of press	TAPI3_8h
21	continuous LAWA+ eutro non- continuous + hymo	Eutro 1	Chlo-a / TPspring / TPsummer	min of press	TAPI3_8i
22		Eutro 2	TP_class / Lunn_class / TPlvl	mean of press	TAPI3_8j
		Hymo	shoremod_class / lakeuse / habitatnr		
23	continuous relative *(boundaries p.* 14)	Eutro	Chlo-a / TPspring / TPsummer / TP_class / Lunn_class	total	TAPI3_9a
24		Hymo	shoremod_class / lakeuse / habitatnr	min of press	TAPI3_9b
25		Bio	fishcatch / stocknative / alienfishW_class	mean of press	TAPI3_9c

Nr	Description	Pressure	Metrics included	Combination	TAPI ID
26	continuous relative, eutro only	Eutro	Chlo-a, TPspring / TPsummer / TP_class / Lunn_class	total	TAPI3_9d
27	continuous relative, all non-continuous	Eutro	Chlo-a, TPspring / TPsummer / TP_class / Lunn_class / TPlvl / dtTP	total, no pollution	TAPI3_9e
28		Hymo	shoremod_class / lakeuse / habitatnr / dtwaterlvl / connect / popdens	total with poll.	TAPI3_9f
		Bio	fishcatch / stocknative / alienfishW_class		
		Pollution	Vispoll / vistrash / bioeffpoll		
29	continuous relative + hymo	Eutro	Chlo-a / TPspring / TPsummer	min of press	TAPI3_9g
30		Hymo	shoremod_class / lakeuse / habitatnr	mean of press	TAPI3_9h
31	continuous relative + eutro non-continuous + hymo	Eutro 1	Chlo-a / TPspring / TPsummer	min of press	TAPI3_9i
32		Eutro 2	TP_class / Lunn_class / TPlvl	mean of press	TAPI3_9j
		Hymo	shoremod_class / lakeuse / habitatnr		
33	continuous TSI *(boundaries p. 14)*	Eutro	Chlo-a / TPspring / TPsummer / TP_class / Lunn_class	total	TAPI3_10a
34		Hymo	shoremod_class / lakeuse / habitatnr	min of press	TAPI3_10b
35		Bio	fishcatch / stocknative / alienfishW_class	mean of press	TAPI3_10c
36	continuous TSI, eutro only	Eutro	Chlo-a, TPspring / TPsummer / TP_class / Lunn_class	total	TAPI3_10d
37	continuous TSI, all non-continuous	Eutro	Chlo-a, TPspring / TPsummer / TP_class / Lunn_class / TPlvl / dtTP	total, no pollution	TAPI3_10e
38		Hymo	shoremod_class / lakeuse / habitatnr / dtwaterlvl / connect / popdens	total with poll.	TAPI3_10f
		Bio	fishcatch / stocknative / alienfishW_class		
		Pollution	Vispoll / vistrash / bioeffpoll		

Nr	Description	Pressure	Metrics included	Combination	TAPI ID
39	continuous TSI + hymo	Eutro	Chlo-a / TPspring / TPsummer	min of press	TAPI3_10g
40		Hymo	shoremod_class / lakeuse / habitatnr	mean of press	TAPI3_10h
41	continuous TSI + eutro non-continuous + hymo	Eutro 1	Chlo-a / TPspring / TPsummer	min of press	TAPI3_10i
42		Eutro 2	TP_class / Lunn_class / TPlvl	mean of press	TAPI3_10j
		Hymo	shoremod_class / lakeuse / habitatnr		
43	continuous Vollenw. & Kerekes (boundaries p. 14)	Eutro	Chlo-a / TPspring / TPsummer / TP_class / Lunn_class	total	TAPI3_11a
44		Hymo	shoremod_class / lakeuse / habitatnr	min of press	TAPI3_11b
45		Bio	fishcatch / stocknative / alienfishW_class	mean of press	TAPI3_11c
46	continuous VW, eutro only	Eutro	Chlo-a, TPspring / TPsummer / TP_class / Lunn_class	total	TAPI3_11d
47	continuous VW, all non-continuous	Eutro	Chlo-a, TPspring / TPsummer / TP_class / Lunn_class / TPlvl / dtTP	total, no pollution	TAPI3_11e
48		Hymo	shoremod_class / lakeuse / habitatnr / dtwaterlvl / connect / popdens	total with poll.	TAPI3_11f
		Bio	fishcatch / stocknative / alienfishW_class		
		Pollution	Vispoll / vistrash / bioeffpoll		
49	continuous VW + hymo	Eutro	Chlo-a / TPspring / TPsummer	min of press	TAPI3_11g
50		Hymo	shoremod_class / lakeuse / habitatnr	mean of press	TAPI3_11h
51	continuous VW + eutro non-continuous + hymo	Eutro 1	Chlo-a / TPspring / TPsummer	min of press	TAPI3_11i
52		Eutro 2	TP_class / Lunn_class / TPlvl	mean of press	TAPI3_11j
		Hymo	shoremod_class / lakeuse / habitatnr		

Nr	Description	Pressure	Metrics included	Combination	TAPI ID
53	continuous IC *(boundaries p. 15*)	Eutro	Chlo-a / TPspring / TPsummer / TP_class / Lunn_class	total	TAPI3_12a
54		Hymo	shoremod_class / lakeuse / habitatnr	min of press	TAPI3_12b
55		Bio	fishcatch / stocknative / alienfishW_class	mean of press	TAPI3_12c
56	continuous IC, eutro only	Eutro	Chlo-a, TPspring / TPsummer / TP_class / Lunn_class	total	TAPI3_12d
57	continuous IC, all non-continuous	Eutro	Chlo-a, TPspring / TPsummer / TP_class / Lunn_class / TPlvl / dtTP	total, no pollution	TAPI3_12e
58		Hymo	shoremod_class / lakeuse / habitatnr / dtwaterlvl / connect / popdens	total with poll.	TAPI3_12f
		Bio	fishcatch / stocknative / alienfishW_class		
		Pollution	Vispoll / vistrash / bioeffpoll		
59	continuous IC + hymo	Eutro	Chlo-a / TPspring / TPsummer	min of press	TAPI3_12g
60		Hymo	shoremod_class / lakeuse / habitatnr	mean of press	TAPI3_12h
61	continuous IC + eutro non-continuous + hymo	Eutro 1	Chlo-a / TPspring / TPsummer	min of press	TAPI3_12i
62		Eutro 2	TP_class / Lunn_class / TPlvl	mean of press	TAPI3_12j
		Hymo	shoremod_class / lakeuse / habitatnr		

B.4.2 Explanation of the TAPI calculation

Table B.3 is difficult to understand. As an example, TAPI3_12i is explained in detail using data of the German Lake Sacrow, a lake close to the Institute of the GIG leader. Table B.3 shows:

Nr	Description	Pressure	Metrics included	Combination	TAPI ID
61	**continuous IC + eutro non-continuous + hymo**	Eutro 1	Chlo-a / TPspring / TPsummer	**min of press**	**TAPI3_12i**
62		Eutro 2	TP_class / Lunn_class / TPlvl	mean of press	TAPI3_12j
		Hymo	shoremod_class / lakeuse / habitatnr		

TAPI3_12i is index number 61 and consists of three pressure groups:

1) Eutro 1 - Continuous eutrophication metrics: Chlo-a / TPspring / TPsummer
2) Eutro 2 - Non-continuous eutrophication metrics: TP_class / Lunn_class / TPlvl
3) Hymo - Hydromorphological metrics: shoremod_class / lakeuse / habitatnr

TAPI3_12**i** combines the minima of the three pressure groups (see column 'combination'). The next index Nr. 62 (TAPI3_12**j**) would combine mean scores of the same three pressure groups. In the following example, the TAPI3_12**i** is calculated.

Lake Sacrow is a deep stratified lake. The three continuous values for eutrophication are classified and scored according to approach Nr. 5 (p. 15, class boundaries for stratified and deep lakes repeated below):

		HG	GM	MP	PB
Chloa	STRAT+DEEP	6	10	26	104
TP	STRAT+DEEP	25	32	45	100

The other metrics are scored directly by using the preset of the TAPI table. The original data of the pressure-metrics for Lake Sacrow is shown in Table B.4, column 'TAPI-value'. The column 'score' shows the score assigned to the corresponding pressure. The column 'min of pressure' shows the minimum score within each of the three pressure groups. The high TP value for spring corresponds to the lowest possible score of 1 (bad) within the group of continuous eutrophication metrics. The minimum score of the pressure group 'classified eutrophication metrics' is 2, the minimum in the Hymo-group is 3. TAPI3_12i is based on the sum of the minimum values of three pressures; which actually is 6. The minimum achievable sum for three pressures is $min_x = 3$ (3 pressures, 1 point each) and the maximum is $max_x = 15$ (3 pressures, 5 points each). The calculation of the EQR is shown at the right of table B.4.

Table B.4: Example for the calculation of TAPIs: the score for TAPI3_12i using data for Lake Sacrow (DE)

Metric	TAPI-value	Score	Min of Pressure
Chlo-a µg/l	7	4	
TPspring µg/l	142	1	
TPsummer µg/l	35	3	1
TP_class µg/l	POLY: 101-300 STRAT: 81-240 DEEP: 61-130	2	
Lunn_class %	21-50	4	
TPlvl	POLY: poly STRAT: high eutro DEEP: low eutro	2	2
shoremod_class %	≤ 10	5	
lakeuse	Low (bath, boat, sail)	5	
habitatnr	1-3 habitats missing	3	3

TAPI3_12i

$= (score_x - min_x)/(max_x - min_x)$

$= (1+2+3-3)/(15-3)$

$= 3/12$

$= 0.25$

B.4.3 Number of Pearson coefficients > 0.5

The first decisive point for TAPI selection is the Pearson correlation to the national LFI indices. As shown in Table B.5 nearly all TAPIs correlate significantly to the national LFI of all MS except BE and FR. The highest means of the Pearson coefficients are obtained with the TAPI3_12-series (a, c, e, f, h, j in Table B.5). The Pearson coefficients were calculated with the PEARSON function of Microsoft Excel.

Table B.5: Pearson coefficients R for the correlation of national LFI indices and 62 ways of calculating TAPIs (TAPI3, without lakes < 50 ha). Green cells show coefficients above 0.5; column n indicates the number of significant correlations (PL systems counted once), mean R is the mean without BE and FR, and only the higher value for PL.

TAPI ID	BE	CZ	DE	DK	EE	FR	LT	NL	PC	PL	n > 0.5	mean R
TAPI3_1a	0.31	0.68	0.54	0.78	0.65	-0.62	0.62	0.44	0.79	0.78	6	0.64
TAPI3_1b	0.18	0.65	0.51	0.68	0.67	-0.57	0.64	0.61	0.76	0.78	7	0.65
TAPI3_2a	0.31	0.68	0.59	0.80	0.65	-0.62	0.64	0.48	0.79	0.78	6	0.66
TAPI3_2b	0.12	0.65	0.58	0.65	0.67	-0.57	0.69	0.67	0.77	0.78	7	0.67
TAPI3_3a	0.24	0.65	0.54	0.72	0.65	-0.38	0.60	0.48	0.78	0.78	6	0.63
TAPI3_3b	0.13	0.63	0.50	0.63	0.68	-0.27	0.63	0.67	0.76	0.77	7	0.64
TAPI3_4	0.16	0.60	0.58	0.66	0.64	-0.39	0.53	0.67	0.77	0.78	7	0.64
TAPI3_5	0.07	0.55	0.57	0.61	0.63	0.03	0.49	0.73	0.78	0.74	6	0.62
TAPI3_6a	0.00	0.54	0.45	0.54	0.50	0.63	0.60	0.75	0.66	0.50	7	0.58
TAPI3_6b	-0.10	0.52	0.54	0.52	0.57	0.72	0.66	0.77	0.69	0.50	8	0.61
TAPI3_7a	0.36	0.60	0.58	0.80	0.63	-0.42	0.67	0.50	0.79	0.78	7	0.65
TAPI3_7b	0.31	0.61	0.57	0.62	0.69	-0.02	0.68	0.65	0.78	0.78	7	0.66
TAPI3_8a	0.19	0.69	0.61	0.75	0.66	-0.26	0.67	0.63	0.79	0.82	7	0.69

TAPI ID	BE	CZ	DE	DK	EE	FR	LT	NL	PC	PL	n > 0.5	mean R
TAPI3_8b	0.31	0.64	0.57	0.81	0.64	-0.75	0.64	0.45	0.78	0.79	6	0.65
TAPI3_8c	0.28	0.69	0.60	0.78	0.65	-0.60	0.67	0.61	0.77	0.81	7	0.69
TAPI3_8d	0.14	0.61	0.59	0.66	0.54	0.61	0.63	0.71	0.72	0.68	8	0.64
TAPI3_8e	0.16	0.65	0.60	0.69	0.69	-0.26	0.69	0.64	0.80	0.82	7	0.68
TAPI3_8f	0.14	0.66	0.60	0.69	0.72	-0.26	0.69	0.64	0.78	0.82	7	0.69
TAPI3_8g	0.06	0.51	0.56	0.84	0.55	-0.63	0.66	0.59	0.70	0.74	7	0.64
TAPI3_8h	0.16	0.63	0.62	0.78	0.62	-0.32	0.64	0.67	0.71	0.81	7	0.68
TAPI3_8i	0.02	0.58	0.61	0.81	0.56	-0.37	0.69	0.67	0.77	0.77	7	0.67
TAPI3_8j	0.06	0.62	0.62	0.69	0.65	0.15	0.68	0.75	0.76	0.81	7	0.69
TAPI3_9a	0.26	0.72	0.59	0.75	0.66	-0.46	0.55	0.59	0.74	0.80	7	0.67
TAPI3_9b	0.31	0.71	0.56	0.79	0.65	-0.64	0.61	0.44	0.78	0.81	6	0.65
TAPI3_9c	0.29	0.74	0.57	0.78	0.65	-0.65	0.58	0.57	0.74	0.81	7	0.67
TAPI3_9d	0.18	0.57	0.54	0.60	0.54	0.61	0.47	0.66	0.53	0.46	7	0.56
TAPI3_9e	0.23	0.70	0.59	0.67	0.69	-0.43	0.62	0.61	0.76	0.80	7	0.67
TAPI3_9f	0.20	0.71	0.59	0.67	0.72	-0.44	0.62	0.61	0.75	0.80	7	0.68
TAPI3_9g	0.05	0.52	0.52	0.85	0.48	-0.64	0.40	0.48	0.54	0.59	4	0.55
TAPI3_9h	0.11	0.62	0.55	0.77	0.57	-0.54	0.36	0.58	0.58	0.73	6	0.60
TAPI3_9i	0.02	0.62	0.58	0.80	0.54	-0.38	0.55	0.61	0.66	0.69	7	0.63
TAPI3_9j	0.02	0.65	0.60	0.66	0.66	0.03	0.59	0.72	0.69	0.76	7	0.66
TAPI3_10a	0.15	0.73	0.64	0.72	0.66	-0.22	0.62	0.67	0.80	0.82	7	0.70
TAPI3_10b	0.33	0.72	0.62	0.85	0.63	-0.72	0.65	0.45	0.81	0.80	6	0.67
TAPI3_10c	0.28	0.73	0.63	0.74	0.66	-0.57	0.63	0.65	0.78	0.82	7	0.69
TAPI3_10d	0.14	0.67	0.62	0.62	0.55	0.40	0.58	0.71	0.73	0.70	7	0.64
TAPI3_10e	0.14	0.69	0.62	0.66	0.69	-0.21	0.65	0.67	0.81	0.82	7	0.69
TAPI3_10f	0.11	0.69	0.62	0.66	0.72	-0.22	0.65	0.67	0.80	0.82	7	0.69
TAPI3_10g	0.04	0.60	0.60	0.84	0.59	-0.58	0.63	0.66	0.75	0.78	7	0.67
TAPI3_10h	0.21	0.72	0.67	0.74	0.62	-0.28	0.58	0.72	0.74	0.84	7	0.70
TAPI3_10i	0.01	0.60	0.62	0.79	0.58	-0.29	0.65	0.72	0.78	0.78	7	0.68
TAPI3_10j	0.10	0.67	0.64	0.66	0.65	0.09	0.64	0.76	0.77	0.82	7	0.69
TAPI3_11a	0.19	0.73	0.65	0.75	0.62	-0.35	0.59	0.64	0.79	0.81	7	0.69
TAPI3_11b	0.31	0.64	0.58	0.81	0.63	-0.68	0.64	0.45	0.77	0.79	6	0.65
TAPI3_11c	0.26	0.72	0.63	0.77	0.62	-0.64	0.61	0.61	0.76	0.80	7	0.68
TAPI3_11d	0.12	0.68	0.64	0.66	0.43	0.47	0.53	0.73	0.69	0.61	6	0.62
TAPI3_11e	0.17	0.68	0.63	0.68	0.66	-0.33	0.65	0.65	0.80	0.81	7	0.68
TAPI3_11f	0.14	0.69	0.63	0.68	0.69	-0.33	0.65	0.65	0.78	0.81	7	0.68
TAPI3_11g	0.05	0.48	0.61	0.86	0.58	-0.53	0.67	0.62	0.70	0.73	6	0.65
TAPI3_11h	0.11	0.70	0.66	0.77	0.53	-0.42	0.51	0.69	0.68	0.79	7	0.66
TAPI3_11i	0.02	0.58	0.64	0.83	0.60	-0.27	0.68	0.71	0.78	0.77	7	0.69

TAPI ID	BE	CZ	DE	DK	EE	FR	LT	NL	PC	PL	n > 0.5	mean R
TAPI3_11j	0.03	0.67	0.66	0.68	0.61	0.07	0.63	0.76	0.75	0.79	7	0.68
TAPI3_12a	0.21	0.71	0.62	0.75	0.68	-0.17	0.67	0.69	0.81	0.83	7	0.71
TAPI3_12b	0.35	0.72	0.58	0.83	0.66	-0.65	0.67	0.45	0.82	0.79	6	0.67
TAPI3_12c	0.32	0.72	0.61	0.77	0.67	-0.60	0.68	0.66	0.79	0.82	7	0.71
TAPI3_12d	0.21	0.65	0.60	0.67	0.58	0.57	0.64	0.76	0.75	0.71	8	0.66
TAPI3_12e	0.19	0.68	0.61	0.69	0.70	-0.17	0.68	0.69	0.81	0.83	7	0.70
TAPI3_12f	0.16	0.68	0.61	0.69	0.73	-0.18	0.68	0.69	0.80	0.83	7	0.70
TAPI3_12g	0.06	0.61	0.56	0.84	0.60	-0.37	0.68	0.71	0.75	0.76	7	0.68
TAPI3_12h	0.27	0.71	0.64	0.78	0.63	-0.24	0.65	0.78	0.77	0.84	7	0.72
TAPI3_12i	0.03	0.61	0.59	0.80	0.60	-0.03	0.70	0.75	0.77	0.77	7	0.69
TAPI3_12j	0.15	0.66	0.62	0.69	0.66	0.23	0.68	0.79	0.78	0.82	7	0.70

B.4.4 Slopes of regression lines

Other decisive aspects for the TAPI selection are the slopes of the regression lines between TAPI and the national LFI scores. For application of the official IC templates, they have to be within the range of 0.5 and 1.5 (Birk et al. 2011; Nemitz et al. 2011). This assures the comparability of the relationship which is needed to harmonize the class boundaries. The slopes refer to the dependence of the TAPI (y-axis) from the national LFI-EQR values (x-axis) which is not intuitive. Table B.6 shows the slopes of the regression lines, green cells indicate slopes within the required range. The slopes were calculated with the SLOPE function of Microsoft Excel. CZ, DE, EE, NL and both Polish systems have high numbers of potential regressions within the acceptable range; the number is lower for DK and LT. The highest number of regressions with slopes within the requested range is seven; a value provided by the ID codes d, g, and i of the TAPI3_12-series. These codes are not within the selection of maximum mean Pearson coefficients (a, c, e, f, h, j). In order to intercalibrate as many MS as possible, we decided to apply the TAPI3_12i and accept a minor decrease of the mean Pearson coefficient.

Table B.6: Slopes of the regression lines of 62 TAPI3s (y-axis) and the national LFI indices (x-axis). Green cells show slopes between 0.5 and 1.5; n indicates the number of slopes in this range (PL systems counted once).

TAPI ID	BE	CZ	DE	DK	EE	FR	LT	NL	PC	PL	n slope
TAPI3_1a	0.26	0.69	0.81	0.36	1.26	-0.29	0.43	0.53	1.01	0.92	5
TAPI3_1b	0.11	0.51	0.55	0.22	0.87	-0.15	0.28	0.50	0.73	0.73	5
TAPI3_2a	0.26	0.69	0.88	0.39	1.26	-0.29	0.45	0.57	1.04	0.92	5
TAPI3_2b	0.07	0.50	0.62	0.24	0.89	-0.15	0.29	0.52	0.73	0.73	4
TAPI3_3a	0.18	0.72	0.89	0.39	1.11	-0.12	0.49	0.54	0.90	0.80	5
TAPI3_3b	0.08	0.54	0.64	0.28	0.82	-0.05	0.36	0.56	0.70	0.65	5
TAPI3_4	0.08	0.52	0.67	0.22	0.88	-0.11	0.22	0.55	0.68	0.79	5
TAPI3_5	0.04	0.56	0.83	0.28	0.83	0.01	0.27	0.63	0.63	0.74	5
TAPI3_6a	0.01	2.55	3.68	1.84	2.72	1.02	2.45	2.96	2.50	1.64	1
TAPI3_6b	-0.43	2.46	4.57	2.06	2.95	1.10	2.59	3.17	2.53	1.64	1

TAPI ID	BE	CZ	DE	DK	EE	FR	LT	NL	PC	PL	n slope
TAPI3_7a	0.37	0.56	0.89	0.39	1.16	-0.18	0.47	0.42	1.02	0.92	4
TAPI3_7b	0.15	0.38	0.58	0.19	0.58	0.00	0.26	0.36	0.56	0.64	3
TAPI3_8a	0.11	0.47	0.61	0.23	0.81	-0.05	0.26	0.45	0.64	0.69	3
TAPI3_8b	0.26	0.55	0.78	0.36	1.30	-0.39	0.41	0.54	0.99	0.93	5
TAPI3_8c	0.15	0.48	0.56	0.20	0.85	-0.19	0.22	0.44	0.69	0.75	3
TAPI3_8d	0.12	0.55	0.94	0.40	0.63	0.16	0.45	0.55	0.50	0.46	5
TAPI3_8e	0.09	0.40	0.65	0.23	0.65	-0.04	0.29	0.32	0.60	0.62	3
TAPI3_8f	0.06	0.38	0.54	0.19	0.62	-0.04	0.24	0.26	0.65	0.62	3
TAPI3_8g	0.07	0.40	1.05	0.51	0.84	-0.42	0.44	0.58	0.64	0.69	5
TAPI3_8h	0.13	0.45	0.79	0.29	0.73	-0.09	0.26	0.52	0.58	0.69	4
TAPI3_8i	0.02	0.53	1.14	0.54	0.77	-0.15	0.54	0.60	0.63	0.61	7
TAPI3_8j	0.05	0.50	0.91	0.37	0.73	0.03	0.39	0.61	0.60	0.60	5
TAPI3_9a	0.12	0.55	0.57	0.15	0.71	-0.08	0.18	0.40	0.56	0.66	4
TAPI3_9b	0.26	0.77	0.87	0.35	1.26	-0.31	0.43	0.53	1.02	1.01	5
TAPI3_9c	0.14	0.52	0.52	0.14	0.78	-0.20	0.16	0.40	0.63	0.75	4
TAPI3_9d	0.11	0.69	0.85	0.23	0.39	0.11	0.27	0.44	0.34	0.29	2
TAPI3_9e	0.10	0.45	0.62	0.18	0.57	-0.06	0.23	0.29	0.54	0.59	3
TAPI3_9f	0.08	0.42	0.52	0.15	0.56	-0.05	0.20	0.24	0.60	0.59	3
TAPI3_9g	0.06	0.64	1.03	0.37	0.65	-0.41	0.27	0.51	0.55	0.63	5
TAPI3_9h	0.08	0.57	0.71	0.16	0.53	-0.13	0.10	0.41	0.44	0.60	4
TAPI3_9i	0.02	0.69	1.12	0.44	0.64	-0.14	0.42	0.56	0.57	0.57	5
TAPI3_9j	0.02	0.59	0.85	0.28	0.60	0.00	0.29	0.54	0.51	0.53	5
TAPI3_10a	0.10	0.57	0.76	0.26	0.88	-0.06	0.30	0.50	0.72	0.74	4
TAPI3_10b	0.33	0.68	0.94	0.40	1.32	-0.41	0.42	0.53	1.02	0.97	5
TAPI3_10c	0.16	0.54	0.67	0.22	0.90	-0.19	0.25	0.48	0.73	0.79	4
TAPI3_10d	0.16	0.75	1.28	0.47	0.78	0.15	0.53	0.67	0.65	0.57	6
TAPI3_10e	0.08	0.46	0.75	0.25	0.69	-0.04	0.31	0.35	0.67	0.67	3
TAPI3_10f	0.06	0.43	0.62	0.21	0.66	-0.04	0.26	0.29	0.71	0.67	3
TAPI3_10g	0.05	0.58	1.30	0.61	0.93	-0.39	0.51	0.76	0.71	0.78	7
TAPI3_10h	0.20	0.62	1.07	0.34	0.86	-0.10	0.32	0.64	0.70	0.80	5
TAPI3_10i	0.01	0.65	1.31	0.60	0.83	-0.13	0.58	0.73	0.68	0.67	7
TAPI3_10j	0.10	0.62	1.10	0.40	0.82	0.03	0.43	0.69	0.68	0.67	5
TAPI3_11a	0.11	0.49	0.65	0.21	0.74	-0.07	0.24	0.45	0.63	0.67	3
TAPI3_11b	0.26	0.55	0.82	0.36	1.30	-0.37	0.43	0.54	0.97	0.94	5
TAPI3_11c	0.14	0.49	0.58	0.19	0.80	-0.20	0.20	0.44	0.68	0.73	3
TAPI3_11d	0.10	0.58	1.02	0.37	0.48	0.13	0.40	0.54	0.48	0.42	3
TAPI3_11e	0.08	0.41	0.67	0.22	0.60	-0.05	0.27	0.31	0.60	0.60	3
TAPI3_11f	0.06	0.39	0.56	0.18	0.58	-0.05	0.23	0.26	0.65	0.60	3

TAPI ID	BE	CZ	DE	DK	EE	FR	LT	NL	PC	PL	n slope
TAPI3_11g	0.08	0.37	1.13	0.56	0.91	-0.39	0.51	0.63	0.65	0.69	6
TAPI3_11h	0.09	0.48	0.86	0.26	0.60	-0.12	0.21	0.51	0.56	0.65	4
TAPI3_11i	0.03	0.51	1.19	0.57	0.82	-0.13	0.58	0.64	0.64	0.61	7
TAPI3_11j	0.03	0.52	0.96	0.35	0.65	0.01	0.36	0.60	0.59	0.57	5
TAPI3_12a	0.16	0.58	0.80	0.29	0.92	-0.03	0.36	0.55	0.77	0.79	5
TAPI3_12b	0.36	0.71	0.95	0.41	1.36	-0.29	0.45	0.54	1.06	0.96	5
TAPI3_12c	0.20	0.55	0.70	0.25	0.93	-0.17	0.29	0.52	0.77	0.83	5
TAPI3_12d	0.27	0.78	1.38	0.54	0.87	0.19	0.65	0.80	0.75	0.69	7
TAPI3_12e	0.12	0.47	0.78	0.27	0.72	-0.03	0.35	0.38	0.71	0.72	3
TAPI3_12f	0.09	0.44	0.65	0.23	0.69	-0.02	0.30	0.32	0.74	0.72	3
TAPI3_12g	0.09	0.62	1.33	0.64	1.10	-0.22	0.65	0.84	0.80	0.87	7
TAPI3_12h	0.29	0.64	1.16	0.39	0.93	-0.06	0.42	0.77	0.79	0.91	5
TAPI3_12i	0.04	0.68	1.33	0.63	0.94	-0.01	0.68	0.78	0.74	0.73	7
TAPI3_12j	0.16	0.63	1.15	0.43	0.87	0.05	0.50	0.78	0.73	0.74	5

B.4.5 Significances of correlations

The significances of the correlation coefficients were extensively tested for the development of the previous index TAPI2. The analyses have shown that coefficients > 0.5 are always significant in our dataset and significances seem to be uncritical for decision. Therefore, the significances are only shown for the final TAPI3_12i (

Table B.7). All correlations with Pearson R > 0.5 are significant on the required level of $p < 0.05$.

Table B.7: Statistical descriptors the correlation of national LFI and TAPI3_12i.

	Pearson R	Significance p
BE	0.026	0.9463
CZ	0.612	0.0042
DE	0.580	0.0000
DK	0.794	0.0000
EE	0.605	0.0000
FR	-0.021	0.9601
LT	0.696	0.0000
NL	0.744	0.0000
PC	0.769	0.0000
PL	0.766	0.0000

The descriptors in

Table B.7 were calculated using the program BIAS (10.09). Minor (!) differences to the results of the Excel calculations in Table B.5 occur.

B.4.6 Final TAPI selection and discussion

The national fish systems and the numerous TAPIs show a high number of good correlations. This indicates that the metrics included are representative for the pressures affecting the lakes throughout the geographical range and that the index calculation as an EQR value is a suitable way of combining the metrics. The results clearly show the reaction the fish systems of many MS to pressures. Most fish-based systems show good correlations to both single pressure indices (eutrophication, TAPI-codes in green letters in Table B.5) and even better correlations to multi-pressure indices.

The suitability criteria for intercalibration are coefficient of correlation, significance of correlation and the slope of the regression line. With respect to the coefficient of correlation, no restrictions can be observed for most MS except BE and FR. The FR-system correlates significantly to most TAPIs that are exclusively based on eutrophication metrics. This reflects the aims of the French system (ARGILLIER et al. 2013). For the other MS, the coefficients of correlation to TAPIs based solely on eutrophication are usually poorer if compared to TAPIs based on multiple pressures.

The slope of the regression is the more critical criterion. However, we found TAPIs that allow intercalibrating seven MS in terms of correlation and slope.

The selected TAPI3_12i fulfils the criteria for correlation and slope for: CZ, DE, DK, EE, LT, NL, and PL (both Polish systems).

For FR, the TAPI3_6 fulfills the acceptance criteria for both significance and slope. Unfortunately, no other MS has acceptable slopes for this specific TAPI.

B.5 Suitability of a typology

After having chosen the final TAPI3_12i version, we did additional tests to check if a typology improves the number of intercalibratable MS. The area typology with a distinction of lake-areas below and above 50 ha was not done as we reduced our dataset to lakes > 50 ha prior to the analysis. The subdivision into special vs. normal lakes was not done because most special lakes were removed from the intercalibration dataset by decision of the national representatives. The following types of lakes were separated and the coefficients of correlation and the slopes of the regression lines to the TAPI3_12i were calculated:

- Natural lakes vs. AWB/HMWB (the latter summarized as AHM)
- Polymictic lakes vs. stratified lakes
- The POLY / STRAT / DEEP typology
- The L-CB1 / L-CB2 / L-CB3 typology (na is not assigned)

As a first step we analyzed the number of lakes in each group (Table B.8). We decided that type-specific datasets with a lake number below 4 would not be intercalibratable because of too much uncertainty. The subdivision into types reduces the number of intercalibratable lakes; e. g, the polymictic Czech reservoirs, the German AHM and others would be skipped. With regard to the low number of lakes within these types, this reduction of datasets would be acceptable.

Table B.8: Number of lakes in the IC dataset for different typologies. Empty cells show no lakes of the corresponding type.

MS	Total	natural	AHM	polym.	strat.	POLY	STRAT	DEEP	LCB1	LCB2	LCB3	na
BE	9		9	9		9			6	1	2	
CZ	20		20	4	16	4	7	9	3	3	14	
DE	78	77	1	41	37	41	24	13	48	15		15
DK	34	34		34		34				34		
EE	48	48		32	16	32	16		17	31		
FR	8	8		6	2	6	2				8	
LT	80	78	2	32	48	32	34	14	45	29		6
NL	26		26	21	5	21	5		6	20		
PC	32	27	5	13	19	13	10	9	26	6		
PL	58	58		21	37	21	16	21	49	9		

In a second step, we compared the Pearson coefficients before and after a subdivision into different lake types (Table B.9). The red cells in the table show the R < 0.5. They indicate that the BE and the FR systems are not intercalibratable with the TAPI3_12i - independent of the typology used. The POLY/STRAT/DEEP typology reduces the set of intercalibratable lakes for CZ, DE and LT and thus seems to be inappropriate for the improvement of intercalibration success. No typology convincingly increases the R values in comparison to the total dataset.

Table B.9: Pearson R coefficients for the correlation of the national LFI and the TAPI3_12i with and without the separation into different lake types. Empty cells show less than 5 lakes in the group, red cells show R < 0.5. Mean shows the group mean for CZ, DE, DK, EE, LT, NL, PC.

MS	Total	Natural	AHM	polym.	strat.	POLY	STRAT	DEEP	LCB1	LCB2	LCB3
BE	0.03		0.03	0.03		0.03			-0.11		
CZ	0.61		0.61		0.78		0.18	0.99			0.79
DE	0.59	0.57		0.73	0.48	0.73	0.40	0.58	0.50	0.65	
DK	0.80	0.80		0.80		0.80				0.80	
EE	0.60	0.60		0.53	0.78	0.53	0.78		0.75	0.54	
FR	-0.03	-0.03		-0.10		-0.10					-0.03
LT	0.70	0.69		0.69	0.67	0.69	0.72	0.43	0.68	0.66	
NL	0.75		0.75	0.79	0.69	0.79	0.69		0.79	0.81	
PC	0.77	0.74	0.53	0.88	0.73	0.88	0.75	0.70	0.76	0.92	
PL	0.77	0.77		0.84	0.63	0.84	0.63	0.63	0.70	0.91	
mean	**0.69**		**0.66**		**0.71**			**0.66**			**0.72**

In a third step, we analyzed the slopes of the regression lines (Table B.10). The red cells are unacceptable slopes and show that the use of a typology would make some EE and some PL lakes non-intercalibratable.

Table B.10: Slopes of the regression of the national LFI and the TAPI3_12i with and without the separation into different lake types. Empty cells show less than 5 lakes in the group and/or R < 0.5. Red cells show slopes outside the range 0.5 to 1.5.

MS	Total	Natural	AHM	polym.	strat.	POLY	STRAT	DEEP	LCB1	LCB2	LCB3
BE											
CZ	0.68		0.68		0.70			0.97			0.75
DE	1.33	1.27		1.40		1.40		1.23	1.17	1.32	
DK	0.63	0.63		0.63		0.63				0.63	
EE	0.94	0.94		0.77	1.52	0.77	1.52		1.49	0.77	
FR											
LT	0.68	0.68		0.59	0.78	0.59	0.83		0.82	0.58	
NL	0.78		0.78	0.92	0.82	0.92	0.82		0.97	0.90	
PC	0.74	0.70	0.45	0.70	0.76	0.70	0.83	0.79	0.73	0.77	
PL	0.73	0.73		0.75	0.64	0.75	0.59	0.68	0.71	0.68	

To summarise, a typology seems to be inappropriate for intercalibration using the TAPI index. The number of lakes in the subsets is small and the subdivision does not increase the number of intercalibratable lakes. A typology does not increase the coefficients of correlation and does not shift slopes of regressions into the acceptable range.

Part C
Intercalibration

C.1 Introduction

The Central Baltic intercalibration group consists of eleven active member states (and Slovakia as purely observational participant). Ten of the active MS have developed fish based systems to assess the ecological status of lakes. Many, but not all systems are based on fish data obtained with standardized multimesh gillnetting (EN 14757 2005).

"The intercalibration process is aimed at ensuring comparability of the classification results of the WFD assessment methods developed by the Member States for the biological quality elements. The essence of intercalibration is to ensure that the high-good and the good-moderate class-boundary in all Member States' assessment methods correspond to comparable levels of ecosystem alteration" (CIS 2011).

To reach this goal, the following steps of intercalibration are proposed by the guidance for Phase II (CIS 2011):

1. Check the preconditions: WFD compliance check, intercalibration feasibility check
2. Establish a common database
3. Choose the intercalibration option
4. Develop an intercalibration common metric
5. Compare the class boundaries and adjust them, if necessary
6. Describe the reference community based on abiotic reference sites (benchmarking)
7. Describe moderate BQE community

Step 1 is a preparation of the intercalibration process. The national systems of the member states of the Central Baltic GIG are described in Part A of the document with compliance and feasibility check.

The establishment of a common database (step 2) was one of the first actions in the European LakeFish intercalibration. The common database is hosted at the IRSTEA and was/is used in the intercalibration process, the WISER project, the MARS project and other projects to come.

At the 2nd CB LakeFish meeting the GIG discussed the options for the intercalibration process (step 3). All three options proposed by the Phase II guidance have special challenges. **IC Option 1** is the choice for similar assessment methods based on similar sampling strategies. It equals a mere harmonization of the class boundaries. Although this would be the most straightforward option, it cannot be used for the CB LakeFish Intercalibration. All MS have developed national methods which differ considerably concerning fish sampling, metrics, calculation and class boundaries. In 2010, efforts were made to develop a common method for MS applying the CEN 14757 multimesh standard or slightly modified sampling. A common system was drafted, but after having developed common fish metrics and a common index calculation it turned out that both metrics and class boundaries were not directly transferable between the MS. The common lake fish system gave reasonable results only for few MS. The main reason is probably the huge biogeographical range of the GIG.

IC option 3 is applied if data acquisition in the MS is comparable, but different assessment systems are used. In this case, intercalibration is done by direct comparison, i.e. the application of systems to the data of other MS. The harmonization of class boundaries can be supported by the use of a common metric. A common metric can be a metric already present in all systems, a newly developed metric or a combination of metrics. This option could have been used for those MS who use similar data acquisition (EN 14757). However, the GIG decided to avoid options that exclude MS from intercalibration (in this case BE and NL). Option 3 has other disadvantages. There is no common metric already used in all assessment systems. A common system consisting of four common metrics was developed in Phase II but comparisons of national assessment results showed that there was no 'one for all' solution. No biological metric fulfilled the demands on the correlations to the national systems given by the IC guidance (CIS 2011), not even for neighboured MS using similar fishing methods. The application of the German system to other MS' fish data also showed an insufficient transferability. This indicates that both direct comparison and biological common metrics are of limited use in the CB LakeFish intercalibration and thus option 3 cannot be used in the Central Baltic intercalibration.

IC option 2 is used if both data acquisition and assessment systems differ. In this case, intercalibration is based on the comparison of the national assessment results with a common metric. This option allows including all MS in the CB LakeFish intercalibration process. The problems of using a biological fish common metric were mentioned above. Therefore we decided to use **IC option 2 with the use of a non-biological common metric**, i.e. a **total anthropogenic pressure index** (TAPI). We compiled a comprehensive table with pressure information. A total of 26 parameters in the pressure groups eutrophication, hydro-morphological pressures, biological pressures and pollution are included. All the pressure intensities were classified and got either 1/2/3/4/5 or 1/3/5 points (5 being reference-like conditions). We made several tests to combine these parameters to a total pressure index. The aim was achieving the highest possible number of significant correlations to the EQR values of the national systems. The TAPI provides the possibility to intercalibrate a satisfying number of MS, but not all. Details about the TAPI are described in Part B of the document.

The steps 1-4 are described in other parts of the document. The present part C focuses on a short repetition of the TAPI and then continues with the class boundary harmonisation, i.e. the intercalibration process. Finally, a description of fish communities characterising the different status classes is added.

C.2 Preparatory Work

C.2.1 Correlations of the common metric TAPI3_12i and the national LFI values

The suitability of a TAPI is described by its relation to the national fish indices: coefficient of correlation (should be > 0.5), significance of correlation (< 0.05) and slope of regression (0.5 < x < 1.5). The TAPI we selected is coded as TAPI3_12i. This index is based on three minimum values of a) three measured and classified eutrophication parameters (Chlo-a / TPspring / TPsummer); b) three classified eutrophication parameters (TP_class / Lunn_class / TPlvl) and three classified hydromorphological parameters (shoremod_class / lakeuse / habitatnr). All three minimum values are combined using an EQR calculation procedure. Please refer to the TAPI description in part B for details. The TAPi3_12i fulfils the prerequisites for intercalibration for seven member states (Figure C.1 shows the regression lines, Polish systems are shown in the next figure).

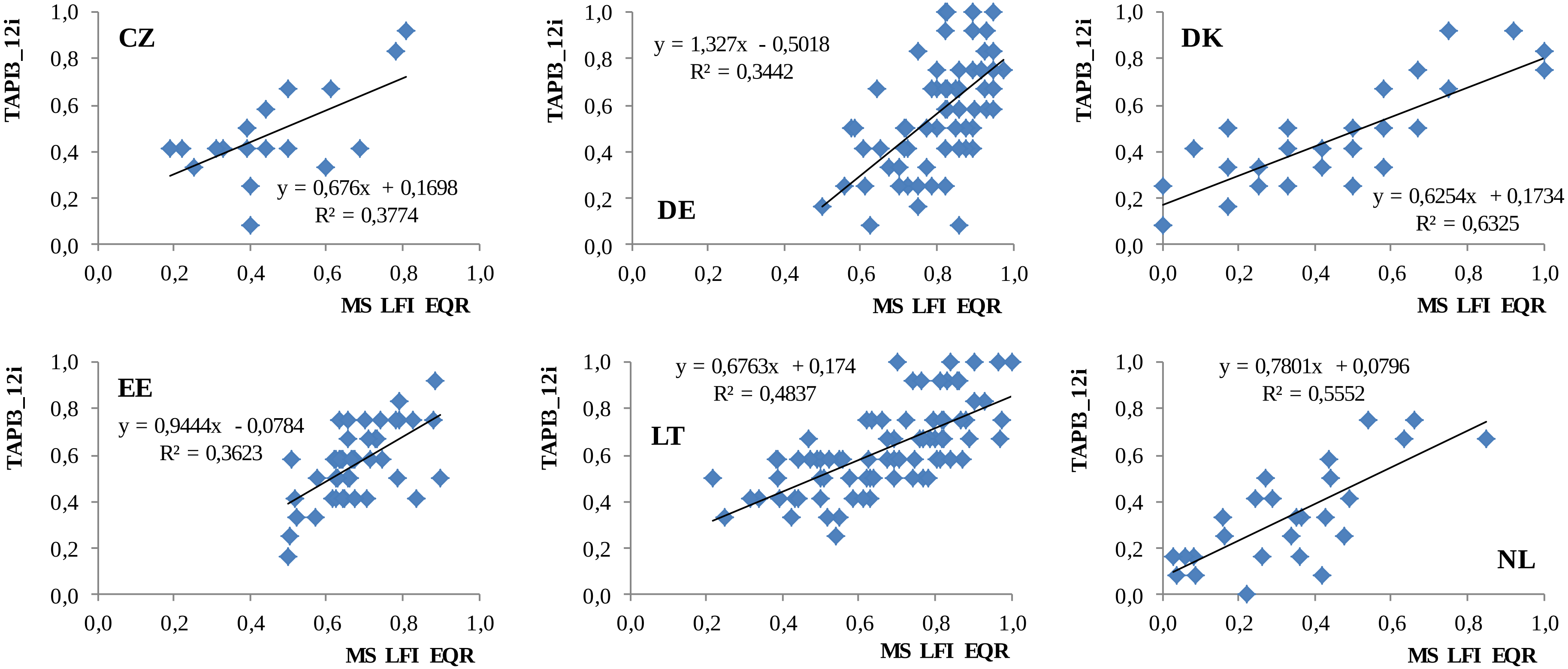


Figure C.1: Regressions for the national fish indices and the common metric six MS fulfilling the acceptance criteria. MS LFI EQR: ecological quality ratio of the lake fish index of the member state; TAPI3_12j: total anthropogenic pressure index (common metric). Please note that the TAPI values are plotted at the Y-axis.

C.2.2 Intra-calibration: Poland

Poland has two national systems to assess the ecological status of lakes with fish. The LFI+ is based on the evaluation of fishery data, which is often present and offers a good possibility to evaluate the lakes status based on profound and long term data (which additionally is comparably easy to obtain). During the last decade, the fish sampling based on the European standard multimesh-method (EN 14757 2005) became more and more established. Poland decided to apply this method and has developed the LFI-CEN, an additional system to evaluate these data.

Poland has expressed the wish to get both systems intercalibrated, i.e. harmonized with the other European systems. In the intercalibration process, the class boundaries of all systems are used for adjusting the national class boundaries; the average represents the common understanding. Therefore, only one class boundary can be considered for Poland. This requires a national harmonisation of the two Polish class boundaries in advance. The harmonization is done similar to the intercalibration: 1) both systems are related to a common pressure index, 2) the class boundaries for both systems are translated to pressure index values, 3) the mean of both pressure index values is the new threshold for the common class boundary transition, 4) the common class boundary transition is re-translated into the system. Because of its high coefficients of correlation we use the same TAPI3_12i for the Polish harmonization that we will use for the intercalibration (Table C.2). The process is greatly eased by the fact that both Polish systems correlate highly with the TAPI3_12i, the regressions are very similar and the class boundaries of both systems are the same.

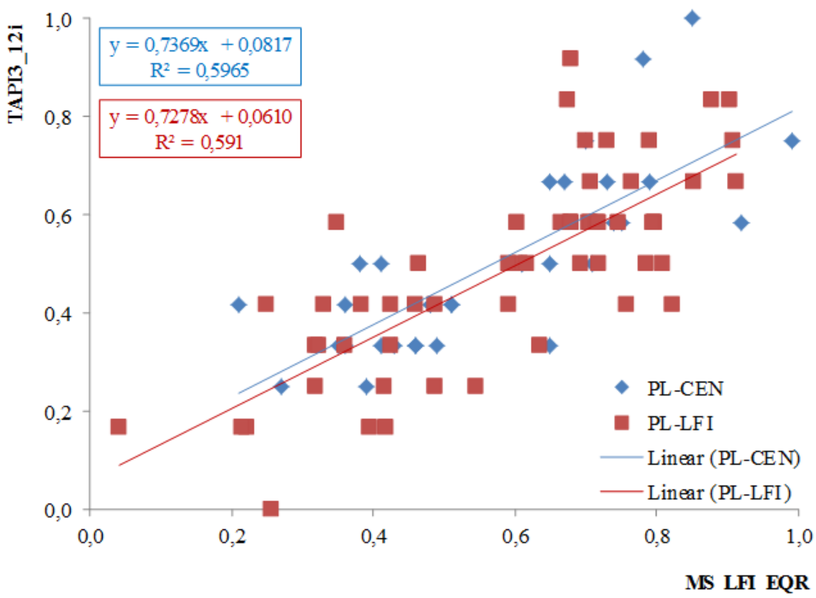


Figure C.2: Regression lines for the two Polish systems and the TAPI3_12i.

The harmonization of the Polish class boundaries includes the calculations of…

- the TAPI3_12i equivalent to the original class boundaries of the CEN system: TAPICEN = 0.7369*BoundCEN+0.0817
- the TAPI3_12i equivalent to the original class boundaries of the LFI system: TAPILFI = 0.7278*BoundLFI+0.0610

- a mean TAPI3_12i for both approaches: TAPImean = (TAPICEN + TAPILFI)/2
- the harmonized class boundaries for the CEN system: CENharm = (TAPImean - 0.0817)/0.7369
- the harmonized class boundaries for the LFI system: LFIharm = (TAPImean - 0.061)/0.7278

The results are shown in Table C.1. The harmonized class boundaries are close to each other. The analysis shows that the relations of the two Polish systems to pressures are almost the same. It also shows that the evaluation of the ecological status is very similar in terms of status classes assigned to pressure intensities. For the intercalibration process, the **Polish CEN system** will be used with the harmonized new class boundaries (coded PCIC in the following text, Polish CEN system for IC). The PCIC is a proxy for the mean Polish opinion on the class boundaries. It needs to be re-translated into the original Polish systems PL-CEN and PL-LFI after intercalibration.

Table C.1: Details for the class boundary harmonisation of two Polish systems.

Boundary	Original	$TAPI_{CEN}$	$TAPI_{LFI}$	$TAPI_{mean}$	CENharm	LFIharm
H/G	0.75	0.634	0.607	0.621	0.731	0.769
G/M	0.45	0.413	0.389	0.401	0.433	0.467
M/P	0.25	0.266	0.243	0.254	0.234	0.266
P/B	0.10	0.155	0.134	0.145	0.085	0.115

C.2.3 Types or no types

We use no typology in the Central Baltic LakeFish intercalibration. The subdivision into types proved to be useful for many groups and BQE (Poikane 2009). In our case, different subdivisions did not improve the 'intercalibrateability' but reduced it. This can be explained. Generally, a typology is essential for fish based lake assessment methods. Fish communities and their reactions to anthropogenic pressures differ considerably between types. A typology allows use of a type specific set of metrics and to score them differently. A typology is useful for a common anthropogenic pressure index, too. Comparable intensities of certain pressures may have different ecological effects, dependent on the lake type. While relating an anthropogenic pressure index TAPI to national lake fish indices two possibilities exist for considering type-specific differences: a) use one TAPI and separate into types for the analysis of the correlations or b) use a type-specific TAPI calculation and analyse all types together. The first possibility is required if biological common metrics are used. For anthropogenic pressure indices, the second possibility can be applied. In this case, a type specific scoring of the pressures allows the calculation of type specific pressure indices. We use a type-specific scoring for eutrophication and habitat related metrics. Not only the TAPI but also the national LFI are type-specific: All national systems included in the intercalibration with the TAPI common metric use typologies to account for type-specific differences in the fish reaction and to be able to score them correspondingly. We decided to intercalibrate independent of lake type as we already compare type-specific LFI with type-specific pressure indices.

Despite this decision, the effects of different typologies were intensively tested. We analysed the correlations of three versions of a previous pressure index TAPI2 with the national LFI values (no details in the present document). We found no obvious differences of the coefficient of correlation and slopes of the regression. Additionally, we analysed the effect of typologies on correlations and slopes of the final TAPI3_12i and the national LFI indices. Using a typology does not increase the number of intercalibrateable lakes or MS. The coefficients of correlation are not increased and there are no lakes or MS included because of more intercalibrateable slopes of the regression. On the contrary, some combinations of MS-type would be removed from the intercalibration dataset because of insufficient number of lakes, low coefficients of correlation or slopes out of the acceptable range. We think that using no typology is justified both from the theoretical scientific background and from a pragmatic approach of the highest possible number of intercalibrateable MS and lakes.

The rejection of a typology allows us to include AWB and HMWB in the intercalibration process. We principally think that comparable levels of anthropogenic pressures should lead to a comparable assignment of status classes, independent on the origin of the water body. These water bodies are treated like natural lakes with a corresponding intensity of anthropogenic pressures and an expected fish based score. However, the values intercalibrated with this approach reflect **ecological status classes and not ecological potential**. Ecological status classes describe the effects of all anthropogenic impacts including those which are obligatory constraints in AWB or HMWB. The assignment of ecological potential is not discussed in this group.

There are some aspects that can't be clarified, mainly because of data restrictions. The lake types are unevenly distributed in the dataset. Some types are generally rare; e.g. L-CB3. Lakes of this type exist in FR and CZ (and a small number in BE). It is questionable if L-CB3 lakes at the opposite geographical edges of the GIG are comparable. The more frequent lake types can be distributed unevenly within specific MS, e.g. L-CB1 are absent in DK and rare in NL. It is possible that the typology has minor influences on the correlations because the datasets of MS are dominated by one type.

C.3 Steps of intercalibration and initial situation in the CB Lake Fish GIG

The principle of option 2 of intercalibration is to relate the national systems to a common metric. For all class boundaries, the corresponding metric values are calculated. The mean of the metric values is a parameter for the mean of the national understanding of class boundaries. This mean is re-translated into the adapted (new) national class boundaries, thus assuring that all national boundaries are close to the common mean (there are certain deviation limits accepted). Details of the procedure were established in Phase II including the possibility of a standardized application. Excel-templates for a homogenous performance of the mathematical procedures of class boundary harmonisation are developed and available at https://www.uni-due.de/aquatic_ecology/publications/birk.shtml#intercalibration (NEMITZ et al. 2011). Background information and user manuals for the use of the templates are also available (WILLBY & BIRK 2010; BIRK et al. 2011) and can be found in the IC guidance (CIS 2011). Therefore, we had the possibility to exactly follow an established procedure of intercalibration. The following chapters describe the principles steps of intercalibration and the concrete results. The Central Baltic Lake Fish intercalibration is based on a total anthropogenic pressure index used as a common metric. We used the IC template IC_opt2_sub for diverging regression lines. The tables and the figures are copied from the official template or from an own template which exactly copies all steps of the original template (but allows to add figures). The similarity of the results obtained by official and our own template was checked for all values.

C.3.1 Step 1: Initial national class boundaries

As starting point, an overview of all participating MS and their national class boundaries is required. The class boundaries of the MS before intercalibration were extracted from the system descriptions, approved by the national experts and specified in the template (Table C.2). The class boundaries begin with the reference HIGH=1 and descend towards 0. The H/G value in the table is the maximum value for a GOOD lake (i.e. the highest EQR for good). For six MS, the class boundaries and national datasets are taken 'as they are': CZ, DE, DK, EE, LT und NL. Poland participates with its CEN-system and harmonized national class boundaries (PCIC).

Table C.2: Original class boundaries of the member states before the class boundary harmonisation.

National method	CZ	DE	DK	EE	LT	NL	PCIC
Ref	1.000	1.000	1.000	1.000	1.000	1.000	1.000
H/G	0.900	0.980	0.800	0.800	0.864	0.800	0.731
G/M	0.745	0.800	0.600	0.600	0.604	0.600	0.433
M/P	0.495	0.600	0.450	0.400	0.364	0.400	0.234
P/B	0.245	0.400	0.250	0.200	0.174	0.200	0.085

C.3.2 Step 2: TAPI values corresponding to the national class boundaries

In the second step, the national datasets for TAPI3_12i and the corresponding LFI values are inserted in the official templates. The regressions are calculated automatically as well as the TAPI-equivalents to the national class boundaries. If a biological common metric is used, the values of the common metric are adjusted by the values of benchmark sites which represent an agreement of sites with comparable pressure intensities. We use an anthropogenic pressure index which is based on comparable measures of pressures. The TAPI index itself is a benchmarking procedure. Therefore, the selection of benchmarking sites is not applied, which is practically done by manually setting the offset to zero (row 10 in the [calc]-sheet of the template). The TAPI values corresponding to the national class boundaries are shown in *Table C.3*.

Table C.3: TAPI3_12i values for the national class boundaries.

National Method	CZ	DE	DK	EE	LT	NL	PCIC	harm line
CM_Max +Offset	0.846	0.825	0.799	0.866	0.850	0.860	0.819	0.838
CM_H/G +Offset	0.778	0.799	0.674	0.677	0.758	0.704	0.620	0.716
CM_G/M +Offset	0.673	0.560	0.549	0.488	0.583	0.548	0.401	0.543
CM_M/P +Offset	0.504	0.294	0.455	0.299	0.420	0.392	0.254	0.374
CM_P/B +Offset	0.335	0.029	0.330	0.111	0.292	0.236	0.144	0.211

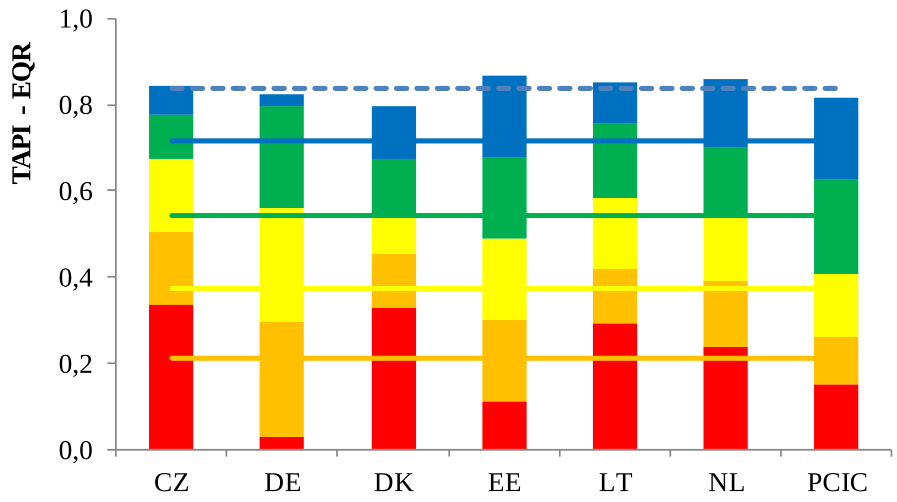


Figure C.3: TAPI3_12i equivalents to the national class boundaries - initial situation with harmonization lines.

The total mean of the TAPI values for the class boundaries is the **harmonization line** used to adjust the national class boundary. It is the mean of the lower boundary of the corresponding class (Table C.3, yellow column). The harmonization line is not recalculated if the class boundaries are modified during the IC process. The intercalibration is a harmonization with the initial mean and not with an evolving mean.

A visual comparison of the national class boundaries can be done using Figure C.3. For the H/G boundary it can be seen that CZ and DE are too strict in comparison to the harmonization line while DK and PCIC are too relaxed (compare transition of blue and green with the blue line). For the G/M boundary only two major deviations occur, CZ is too strict and PCIC too relaxed (compare green-yellow transitions with green line).

C.3.3 Step 3: Raw boundary bias

For each MS and each class boundary, the deviation of the states' TAPI values from the total mean is calculated (the raw boundary bias). *Table C.4* shows the values of the raw boundary bias. As an example, the raw bias of the Czech H/G boundary is 0.778-0.717 = 0.061 (compare to Table C.3). It is important to keep in mind that these values refer to the TAPI values, not to the national fish systems. The intercalibration templates are designed to adjust the H/G and the G/M boundary. All following statements focus on these two boundaries.

Table C.4: Raw boundary bias of the class boundaries.

National Method	CZ	DE	DK	EE	LT	NL	PCIC
H/G bias	0.062	0.083	-0.042	-0.039	0.043	-0.012	-0.095
G/M bias	0.130	0.017	0.006	-0.055	0.039	0.005	-0.142

C.3.4 Step 4: Class widths

There are certain limits of acceptable deviation of the national class boundaries from the harmonization line. The limits of deviation are dependent on the corresponding class widths (the bigger the class, the bigger is the allowed deviation). The width is the upper boundary of the class minus the lower boundary, e.g. the Czech GOOD class has a width of 0.778-0.673 =

0.105 units (data in Table C.3). Please note again that the TAPI EQR values are used, not the EQR values of the original fish-systems. The class widths are shown in Table C.5.

Table C.5: Class widths as TAPI ranges.

National Method	CZ	DE	DK	EE	LT	NL	PCIC
H width to Max	0.068	0.027	0.125	0.189	0.092	0.156	0.198
G width	0.105	0.239	0.125	0.189	0.176	0.156	0.220
M width	0.169	0.265	0.094	0.189	0.162	0.156	0.146

C.3.5 Step 5: Boundary bias in class equivalents

As mentioned, the allowed deviation is dependent on the class widths. This is measured by dividing the raw boundary bias by the class width. This relative measure is called the **boundary bias in class equivalents**. It is a measure of intercalibration success and should be in the range of -0.25 to 0.25. The data for the initial situation in the Lake Fish CB GIG are shown in Table C.6. The values are calculated as raw boundary bias (Table C.4) divided by class width (Table C.5), e.g. for the Czech GOOD/MODERATE class boundary 0.130/0.169 = 0.77 (the values in the preceding tables sometimes leads to rounding errors).

Table C.6: Starting situation of the CB LakeFish intercalibration: the boundary bias in class equivalents. Bold red letters show bias outside the range of acceptability. Background colours indicate the class relevant for class width (blue = high, green = good, yellow = moderate).

National Method	CZ	DE	DK	EE	LT	NL	PCIC
H/G bias/CW	**0.596**	**0.347**	**-0.336**	-0.204	0.242	-0.077	**-0.481**
G/M bias/CW	**0.771**	0.064	0.060	**-0.290**	0.243	0.030	**-0.648**

The boundary bias is the raw bias divided by the class width **of the class intersected by the harmonization line**. Figure C.4 is used for explanation, in this case the adjustment of the G/M boundary (green-yellow) needs to be harmonized by

- column B) raising the lower boundary of GOOD if the green harmonization line intersects the GOOD class
- column C) lowering the upper value of the MODERATE class if the green harmonization line intersects the MODERATE class

As an effect, the G/M boundary bias is calculated with the GOOD width class for some MS and with the MODERATE width for others (Table C.6). The effect is very similar, but the values used for calculation of the boundary bias in class equivalents and thus the allowed deviations differ.

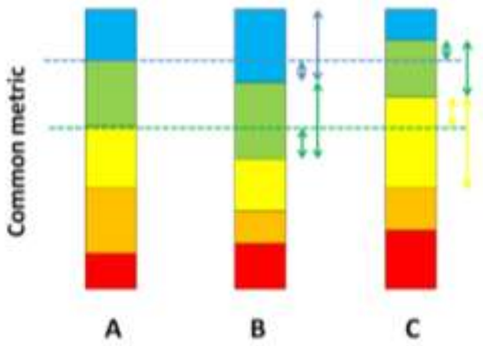
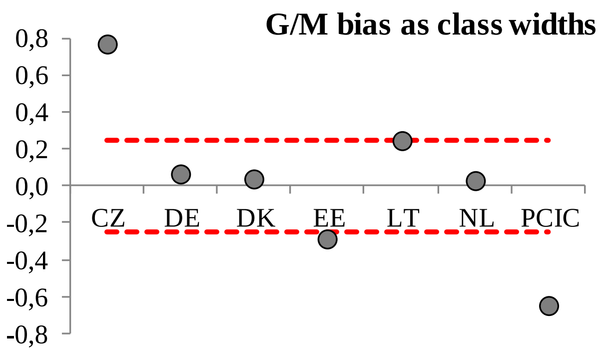


Figure C.4: National classification schemes (A, B, C) intersected by the average boundary positions derived in intercalibration ("harmonisation line" - broken blue and green lines). Small arrows depict the distance of relevant national boundary to the harmonisation guideline. Large arrows define relevant national class width. The relation of small to large arrow-lengths specifies the boundary bias in class equivalents (figure and description copied from Birk *et al. (2011)).*

The criterion for successful class boundary harmonization is a **boundary bias in class equivalents between -0.25 and 0.25.** At the start of intercalibration the following MS deviated from this threshold and therefore need to adjust their class boundaries (Figure C.5):

- G/M class boundary: CZ (too strict), EE and PCIC (too relaxed)
- H/G class boundary: CZ and DE (too strict), DK and PCIC (too relaxed)



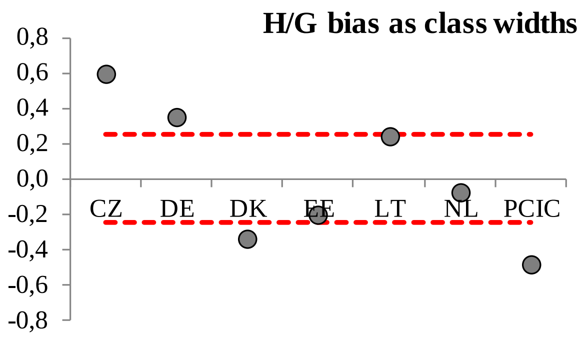


Figure C.5: Boundary bias in class equivalents; initial situation in the GIG. Red lines show -0.25 and 0.25.

C.4 CB Lake Fish Class boundary adjustment

The practical adjustment of the class boundaries is done by first adjusting the G/M boundary and then the H/G boundary for each MS. The harmonization line is not changed anymore and remains the mean of the initial situation. Therefore, the class boundary adjustment can be done separately for each MS. Figure C.6 shows the starting situation of the TAPIs corresponding to the national class boundaries at the left side (repeats Figure C.3). At the right side, the TAPIs corresponding to intercalibrated class boundaries are shown.

The needs for class boundary adjustment were indicated by red numbers in Table C.6. The adjustment was done by a stepwise reduction or increase of the national class boundaries for 0.001 digits until the boundary bias in class equivalents was within the range of -0.25 to 0.25. Therefore, Figure C.3 shows the minimal acceptable change to achieve class harmony according to the official procedure. It is possible to get closer to the common mean, but this decision has to be left to the MS official instances. While it is required to implement increased class boundaries as results of the IC process, the lowering of class boundaries is not obligatory. The following minimal changes are proposed to achieve an acceptable class boundary deviation according to the official criteria:

- No class boundary adjustment is required for Lithuania and the Netherlands.
- A small increase of the G/M boundary is required for Estonia. The intercalibrated value is 0.611 (instead of 0.600).
- A small increase of the H/G boundary is required for Denmark. The intercalibrated value is 0.824 (instead of 0.800).
- A decrease of the H/G boundary can be suggested for Germany. The intercalibrated value is 0.956 (instead of 0.980).

The system of the Czech Republic requires a more detailed analysis. As can be seen in Figure C.6 (left) the deviation of the national class boundaries is systematic. The Czech class boundaries are too strict in comparison to the total mean. This leads to conflicts with the widths of the corresponding classes. Changing only the H/G and the G/M boundaries would lead to a very narrow range of the MODERATE class. Therefore, we propose to move the M/P and the P/B closer to the common mean before the 'normal' intercalibration of the H/G and the G/M boundary. The adjustment of the lower class was done by a graphical evaluation (Figure C.6). The adjustment of the H/G and the G/M boundaries was done using the official procedure of minimizing the boundary bias in class equivalents.

- A proposal for intercalibrated class boundaries for the Czech Republic is
  - H/G: 0.870 (instead of 0.900)
  - G/M: 0.619 (instead of 0.745)
  - M/P: 0.350 (instead of 0.495)
  - P/B: 0.150 (instead of 0.245)

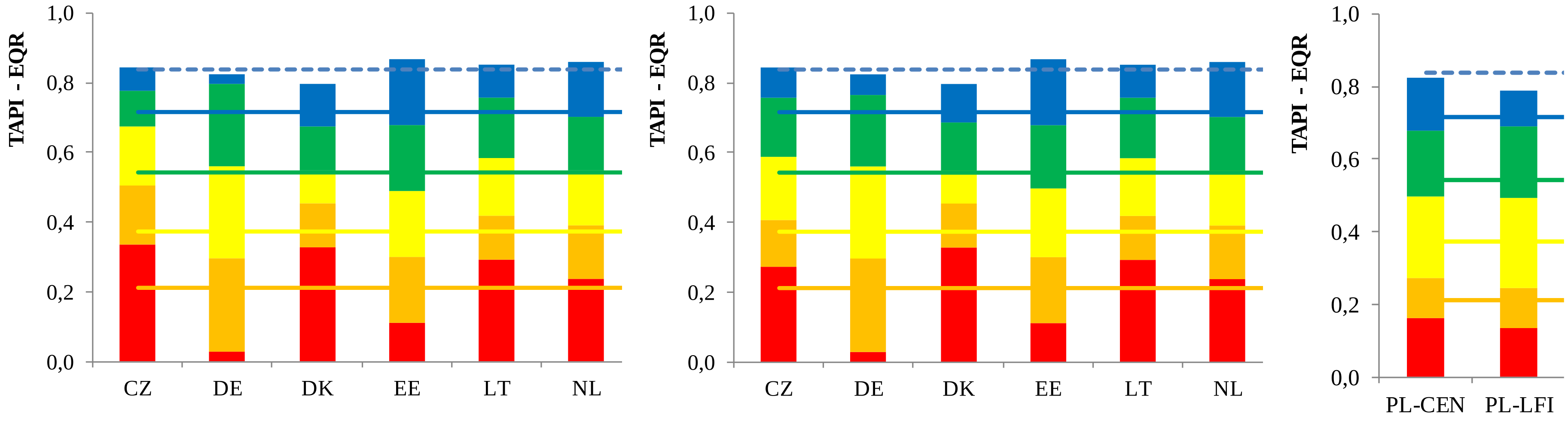


Figure C.6: TAPI3_12i equivalents to the national class boundaries. Left: initial situation (Figure C.3 repeated); middle: with intercalibrated H/G and G/M class boundaries, right: with intercalibrated H/G and G/M class boundaries for the two Polish systems.

For Poland, the class boundaries of the two systems were averaged to represent a mean Polish opinion about pressure intensities belonging to status class transitions. One Polish system with averaged class boundaries was included in the class boundary harmonization (coded PCIC).

The Polish class boundaries before the Polish harmonization were identical for both systems. However, the correlations of the TAPI and the fish-systems were not identical. For the same TAPI values, the regression of the CEN system scores slightly lower fish EQR values, i.e. the CEN system was stricter then the LFI system (Figure C.2). Therefore, the harmonized transitions for the stricter CEN system are lower than the original ones (lower = more relaxed). The LFI system initially was a little bit more relaxed and the harmonized class boundaries are higher than the original ones.

Please note: a low TAPI is a high pressure, but a low class boundary of a fish EQR is a relaxed system. The PCIC was used to determine an averaged vote for Poland for the GIG understanding of class transitions. However, it does not represent a Polish system. We adjusted the class boundaries for the two Polish systems to the harmonization line (Figure C.6). This was done with a template that exactly repeats the mathematical procedures of the official template. We expect that the boundaries of the strict PL-CEN should be lower than those of the PL-LFI but both will have to be increased in comparison to the initial class boundaries. The minimal required adjustments to reach a boundary bias between -0.25 and 0.25 class boundaries are:

- H/G: 0.804 for PL-CEN and 0.866 for PL-LFI (instead of 0.75)
- G/M: 0.577 for PL-CEN and 0.595 for PL-LFI (instead of 0.45)

C.5 Conclusion: Proposal of adjusted class boundaries

The present document implies no official obligation but provides a suggestion for national class boundaries that would represent an intercalibrated condition. A proposal for intercalibrated class boundaries for the member states is shown in *Table C.7*. The proposal represents the possibility to adjust the national class boundaries to a mean understanding of the assignment of ecological status classes to pressure intensities (i.e. to become intercalibrated). The procedure to achieve the intercalibrated class boundaries follows exactly the prerequisites of the WFD and uses the official templates established in Phase II. The class boundaries in *Table C.7* show the minimum required changes to achieve compliance with the criteria for successful intercalibration given by the IC guidance (CIS 2011) and the official IC template and manuals (Birk et al. 2011; Nemitz et al. 2011).

Table C.7: Proposal of intercalibrated class boundaries for the Central Baltic LakeFish GIG. Bold numbers indicate a modification in comparison to the pre-intercalibration value: red shows raised boundaries and green lowered ones.

	CZ	DE	DK	EE	LT	NL	PL-CEN	PL-LFI
H/G	**0.870**	**0.956**	**0.824**	0.800	0.864	0.800	**0.804**	**0.866**
G/M	**0.619**	0.800	0.600	**0.611**	0.604	0.600	**0.557**	**0.595**
M/P	**0.350**	0.600	0.450	0.400	0.364	0.400	0.250	0.250
P/B	**0.150**	0.400	0.250	0.200	0.174	0.200	0.100	0.100

The implementation of the suggested class boundaries into the national fish indices can only be done by the national representatives. It is not required to lower class boundaries, like proposed for CZ and DE. Additionally, there is no guideline on the transfer of ecological status classes (our results) into the ecological potential of AWB and HMWB. These kinds of water bodies are frequent or dominant in some MS participating in the intercalibration process. Except for CZ, no proposals for the adjustment of M/P or P/B class boundaries are made at this place, although major deviations occur.

C.6 Addition: class boundaries for identity to the common mean

It is possible to adjust the national class boundaries until the TAPI values corresponding to the class boundaries are identical to the pre-intercalibration (TAPI) harmonization line. The national class boundaries that exactly fit the common mean are shown in Table C.8. They might serve as an orientation in case a member state wishes to adjust the class boundaries as close as possible to the initial common mean (the previous results in Table C.7 show the minimal adjustment required). Please note that in Table C.8 all class boundaries are adjusted (and not only the H/G and G/M boundaries).

Table C.8: Class boundaries corresponding to the pre-intercalibration (TAPI) harmonization line (all class boundaries).

	CZ	DE	DK	EE	LT	NL	PL-CEN	PL-LFI
H/G	0.808	0.918	0.868	0.841	0.802	0.816	0.853	0.899
G/M	0.552	0.787	0.591	0.658	0.545	0.594	0.619	0.662
M/P	0.302	0.660	0.322	0.479	0.296	0.378	0.389	0.430
P/B	0.061	0.537	0.061	0.306	0.054	0.169	0.168	0.206

C.7 Member states not intercalibrated

C.7.1 Belgium

The Belgian fish-based index for reservoirs and lakes is explained in part A (system descriptions p. 20-25; see also Breine et al. (2015)). There are several issues causing problems for the intercalibration:

1. Lack of data. Only nine lakes from the dataset were conform the required characteristics. The ratio cases to independent variable should be 20:1 (lowest ratio 5:1) to allow a regression.
2. Total phosphorous data were not always available; making is rather difficult to calculate the complete TAPI.
3. The used technique (fyke nets and electric fishing) catches different fish than the multimesh gillnets.

However, the developed index responds to the criteria stipulated in the Water Framework Directive. Its selected metrics are relevant allowing for an appropriate assessment of anthropogenic impacts on the fish communities. In addition these metrics assess different aspects of the ecological functions of reservoirs (and lakes) for fishes, and that they are not redundant.

C.7.2 United Kingdom

The UK has provided all data required for calculation of the TAPI indices as well as preliminary assessment results of the adopted Dutch fish assessment system. Principally, all requirements for intercalibration are fulfilled (significant correlation with a Pearson correlation > 0.5 and a slope between 0.5 and 1.5). However, the UK fish assessment is still under development and the data consists of a low number of lakes that partially were sampled twice or have areas < 50 ha. Additionally, some pressure and fishing information was outdated. The UK representative decided to not participate in the intercalibration process with a preliminary system based on few data. The data collection in UK is proceeding and alternative fish stock assessment methods are tested. Most probably, it will be possible to intercalibrate a future UK fish assessment system by using the TAPI index developed here. The class boundaries of any future UK assessment system need to be adjusted to the present harmonization lines, i.e. the future UK system will not influence the existing results.

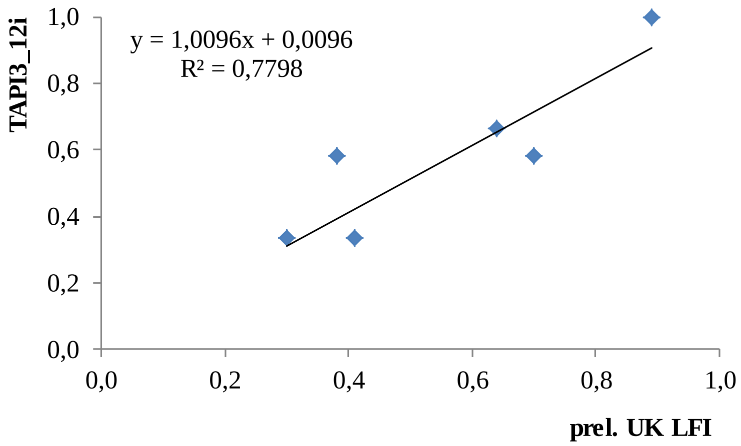


Figure C.7: Regression of the TAPI3_12i pressure index and preliminary fish assessment results with the adopted Dutch method for lakes in the UK.

C.7.3 Latvia

Latvia has submitted all pressure information needed to calculate the intercalibration common pressure index TAP3_12i. As soon as a national fish system is developed, it will be possible to correlate the fish index to the common pressure index. The Latvian system can be intercalibrated if a significant correlation with a Pearson coefficient > 0.5 exists and the slope of the regression is between 0.5 and 1.5. If this is not the case, other TAPI versions can be checked for the possibility to apply a satellite intercalibration. The Latvian class boundaries need to be adjusted to the present harmonization lines, i.e. the future Latvian system will not influence the existing results.

C.8 Changes of fish communities and their assignment to status classes

C.8.1 Czech Republic

Fish are probably the most sensitive indicators to anthropogenic changes in the environment and are used since the first Index of biotic integrity was developed by (KARR 1981). On one hand fish are sensitive to a variety of natural and disturbance factors (KARR 1981; KARR et al. 1986); on the other hand, fish can have their own impact on biological processes in water ecosystems (CARPENTER et al. 1985), each species to a different degree. Fish lifespan is on average rather longer comparable to other biological elements required by WFD. Therefore, they may integrate long-term changes. Concurrently, they are sensitive to acute harmful events in ecosystem. The integration of historical changes can be detected in fish community composition and condition of individual fish. Fish usually belong to several trophic levels and are mobile organisms and thus show an integrative view of the ecosystem (LINDEMANN 1942, KARR 1981). In a relatively small country such as the Czech Republic, fish species have the same chance of occurrence due to natural distribution or from anthropogenic stocking, but the environmental factors and stressors determine the population structure.

The “**High**” class should represent the reference status for Czech water bodies, close to the ecosystem without any anthropogenic stressors. The main anthropogenic stressor in the Czech Republic is eutrophication. In natural conditions the trophic status would be oligo- to mesothrophic due to natural low nutrient load (HEJZLAR et al. 2003). In this condition only limited abundance and biomass of fish would occur (~ 50-150 kg/ha). The species composition would be dominated by species characteristic for low productivity in water such as Salmonidae. The littoral would support submerged and immersed vegetation providing refugee for invertebrates as well as spawning substrate for phytophilous species (e.g. rudd). The natural reproduction would be present every year, but might by poor under condition of natural strong fish predation pressure. Species hybrids as well as fish with morphological anomalies would be absent or extremely rare. The species typical for eutrophic conditions (e.g. common bream and ruffe) would play only a minor role or be completely missing from the community. Therefore, low species richness is typical under such conditions. The pelagic community would be very limited due to low productivity in open water and perch would occur more often than typical zooplanctivorous Cyprinidae fish. Currently, none of the sampled waterbody in the Czech Republic belong to this class (based on the original class boundaries). We have historical records of small natural lakes being in that class, but all fish species went extinct from these localities after acidification (VRBA et al. 2000).

Slight changes from the “High” class are required for a reservoir to be classified in the “**Good**” ecological class. The fish community is stable and reflects water productivity. The fish abundance and biomass is only a bit higher due to increased nutrients. Benthic habitats should still have higher biomass than pelagic habitat. Similarly, the species composition is slightly altered. The species typical for nutrients-rich waters still have small populations and sensitive species can stagnate or show minor population decreases. However, sensitive species are still present in the community. Fluctuation in year-class strength is allowed, but the absence of natural reproduction should not extend more seasons since this can result in the collapse of species populations. One example is the Nyrsko reservoir located in the Bohemian Forest. Built mainly for drinking water storage, its long term total phosphorus concentration in the dam part of the reservoir is 0.007 mg/l and 0.012 mg/l in the inflowing river, angling, bathing and other in lake water use is prohibited, and the percentage of agricultural use in its catchment is 16.2%. Only native species were detected during sampling. Water level fluctuated slightly due to hydropower generation with year amplitude < 2m. Although historical unpublished data records identified high populations of Salmonidae species, none of the species were detected. The reason for their extinction was mainly the increase in water level fluctuations, a new dam in the tributary restricting natural reproduction and stocking of northern pike. The dominant fish species are perch and roach, rudd population is relative high and stable.

The "**Moderate**" class differs moderately from the "High". Fish abundance and biomass is relative high reflecting higher production in open water. The omnivorous/zooplanctivorous Cyprinidae species play high role in the community. However, specialised species should also be present. The occurrence of sensitive species indicating presence of suitable habitats (e.g. developed littoral and absence of oxygen deficit in hypolimnion of stratified reservoirs) gives information about an ecological status that is not bad. Hybrids, especially of Cyprinids species such as bream and roach are not rare. Non-native species are often found too, however the stocked fish should not play a major role in the system. Species richness is usually relative high. Lucina reservoir is a good example. The long term concentration of total phosphorus in the dam part is 0.034 mg/l and 0.038 mg/l in the inflowing river, the agriculture use in the catchment area reaches 29.3 %. The water level fluctuation is similar to Nyrsko (year amplitude < 2m). The fish biomass in the benthic and pelagic habitat is nearly equal. The dominant species was roach.

Whole section taken from the system description provided by CZ.

C.8.2 Germany

The German fish based system for the assessment of the ecological status of lakes was developed with the aim to provide an integrative assessment of the combined effects of all kinds of pressures. Specific reactions of the fish community or certain species to specific pressures have been shown, e.g. the total biomass of fish is known to correlate with trophic level and the abundance of certain shoreline species is related to littoral habitat destruction. However, the analysis of German data has shown that pressures intensities are highly correlated and that it is therefore impossible to separate their effects on the fish community. An additional limitation is set by the methodology of fish sampling, which is exclusively based on EN 14757 (2005). Multimesh gillnetting is selective with respect to species inventory and size range. The method does not allow the quantitative assessment of small, big, rare or sensitive species that could indicate the effects of specific pressures. The German assessment system uses the more abundant species and certain combinations of them. The metrics are comparable but not identical for all types of lakes. The class boundaries are type-specific and the biological transitions gradual; therefore the description has to remain a little vague. Many changes of fish community traits occur as a consequence of anthropogenic impacts, but only those relevant for the assessment system are described here.

The **reference** conditions of the fish community can be derived from the situation in least disturbed lakes. These lakes have no or minor impacts of eutrophication, shoreline degradation and lake use, please refer to RITTERBUSCH et al. (2014) for details. Some descriptors of the fish community in least disturbed conditions are shown in Table C.9. The reference fish communities in the different types have many similarities. A handful of species is present in virtually every lake (obligatory species): perch, roach, ruffe, bream, rudd and pike. Perch and roach are the most abundant species, followed by ruffe in number and bream in weight. The transition of a **High to Good s**tatus is characterised by a gradual increase of total catch and increasing percentages of insensitive bottom-dwelling species (ruffe, bream, white bream). Perch abundance is higher in clear water with high structural diversity and therefore decreases from High to Good while increasing stocks of pikeperch can be found in turbid waters. In a **Moderate** status the total catch is strongly increased. One or more obligatory species might be absent. Benthic and benthivorous species strongly dominate, reaching more than 70-90 % in the catch with benthic nets. Thus, the fish community reaction shows a clear response to increased nutrient availability and a reduced availability of littoral habitats.

Literature for changes of the fish community with increasing pressure

Increase of abundance and biomass (JEPPESEN et al. 2005; SØNDERGAARD et al. 2005; LAUNOIS et al. 2011b; ARGILLIER et al. 2013; BRUCET et al. 2013)

Increasing percentage or abundance of bream, roach, cyprinids or benthivorous (PERSSON & GREENBERG 1990; PERSSON et al. 1991; HELMINEN et al. 2000; JEPPESEN et al. 2000; DIEKMANN et al. 2005)

Decrease of littoral species (BELPAIRE et al. 2000; JEPPESEN et al. 2005)

Decrease of perch (PERSSON et al. 1991; HELMINEN et al. 2000; OLIN et al. 2002; MEHNER et al. 2005)

Increase of ruffe and pikeperch (PERSSON et al. 1991; BARTHELMES 2000; JEPPESEN et al. 2000; GARCIA et al. 2006)

Table C.9: Species-specific descriptors of type-specific fish communities (RITTERBUSCH et al. 2014). For each species, the type-specific percentage of occurrence (%TSO), the percentage by number and by weight in catches with benthic nets are given (%NB, %WB). The data are sorted by %TSO followed by %NB.

POLY				STRAT				DEEP			
Species	**%TSO**	**%NB**	**%WB**	**Species**	**%TSO**	**%NB**	**%WB**	**Species**	**%TSO**	**%NB**	**%WB**
Perch	100	41.1	24.9	Perch	100	58.0	38.7	Perch	100	42.6	35.1
Roach	100	28.1	28.1	Roach	100	31.9	33.9	Roach	100	33.2	26.6
Ruffe	100	9.8	1.9	Ruffe	100	3.5	0.5	Vendace	100	8.6	5.6
Bream	100	7.0	25.2	Bream	100	1.9	9.2	Ruffe	100	6.7	1.8
W. Bream	100	4.3	5.6	Rudd	100	1.6	3.4	Bleak	100	3.7	1.1
Rudd	100	0.4	2.0	Pike	100	0.5	10.9	Rudd	100	1.8	7.8
Pike	100	0.1	2.9	Tench	80	0.3	0.7	Pike	100	0.6	7.6
Pikeperch	83	1.5	3.1	W. Bream	60	0.9	0.5	Tench	100	0.4	5.0
Bleak	78	7.1	1.8	Vendace	60	0.3	0.3	W. Bream	100	0.5	0.5
Tench	78	< 0.1	0.3	Bleak	53	0.8	0.3	Bream	100	0.3	4.6
Belica	61	0.1	< 0.1					Smelt	60	1.2	0.2
Gudgeon	51	0.4	0.1					Whitefish	60	0.1	2.5
								Burbot	60	0.1	0.9

C.8.3 Denmark

Following a European standard the Danish lakes are generally small and shallow with median values of 0.17 km^2 and 1.8 m, respectively. In total 116 L-CB2 lakes and 45 L-CB1 lakes were used for development of the fish index. A total of 31 fish species were registered in the lakes, and based on the gill net catches, number of species per lake varied between 1 and 11 species, which is relatively few. Eleven species were found in one single lake. More than 50 % of the lakes contained only 3-6 species and the most common number is 5 species, registered in 22 % of the investigated lakes. The most common species are perch, roach, pike, rudd and bream, registered in 90, 87, 68, 54 and 50 % of the lakes, respectively.

Planktivores and piscivores are well represented in all the lakes. In the Central-Baltic GIG there has been a general discussion on the use of indicator species. In Danish lakes indicator species have not been used in the index as lakes are generally small, compared to lake size in other member states. The smaller size means less habitats and consequently less species and probability of occurrence of indicator species and/or sensitive species. Besides, many of the Danish lakes are isolated or parts of small stream systems, limiting dispersal possibilities.

Fish communities can be dependent on several stressors. Based on Søndergaard et al. (2003), the common stressor in Danish systems is eutrophication. However, due to the small systems and e.g. limited dispersal possibilities, absence of certain species can be caused by other reasons but eutrophication.

Based on the given conditions the Danish index is based on 4 metrics: 1) NPUE (number per unit effort) as total catch per net; 2) percentage piscivores >10 cm, measured as biomass of perch, pike and pikeperch of the total catch; 3) percentage roach and bream, measured as biomass of roach, bream and roach/bream hybrids of the total catch; 4) Mean individual biomass of the total catch (BPUE/NPUE).

NPUE values are positively correlated with eutrophication due to increasing productivity. The increase is particularly due to increasing numbers of smaller sized roach and perch and to some extent number of breams. Number of pikes is normally negatively correlated to increasing eutrophication.

The percentage of large piscivores is negatively correlated to eutrophication, primarily because of increased dominance of the planktivores; this despite the above mentioned increasing number of small sized perch with increasing eutrophication.

In contrast the percentage biomass of roach, bream and the hybrids of roach and bream is positively correlated to eutrophication. Not necessarily because fish are becoming larger, but because of increasing numbers of small sized roach and breams. However, large sized breams do occur in eutrophicated systems, thus contributing to the positive correlation with eutrophication.

Overall the individual fish size, measured as biomass, is negatively correlated with eutrophication. Basically because the size of both the two dominating fish species in Danish lakes, perch and roach, decreases in average biomass with increased eutrophication. However, in general other species, except the pike, decreases in average biomass too with increased eutrophication.

C.8.4 Estonia

The Estonian system to assess lake quality on the basis of fish assemblage follows the principles of succession from coregonids over percids to cyprinids as dominating families changing alongside the enlargement in the load of nutrients in water (Colby et al.,1972; Svärdson, 1976; Leach et al., 1977; Reshetnikov 1980; Moss 1998). Our system consists of the following metrics: the share of percids in a lake, the species richness, the share of mesh sizes with fish, the abundance corrected with the share of non-piscivorous fish alongside with the shoreline index, and the occurrence of rudd. With sample fishing 24 fish species of seven families were caught with the burbot, spined loach, whitefish, vendace, dace, chub, ide, asp, nine-spined stickleback, carp, and gudgeon being rare.

The least affected lakes, hence of **high status**, had less than 40 individuals per Nordic gillnet, the share of piscivores exceeded 40 % consisting mostly of the perch, whereas the share of piscivorous percids (Holmgren et al., 2007) exceeded 30 % on average with percids outweighing cyprinids. Of percids the perch outnumbered the ruffe by 20 times, whereas the pikeperch was uncommon or absent. In total nine cyprinid species were caught from this type of lakes averaging at 3.1 cyprinid species per lake. Neither of cyprinid species was obligatory or caught only from the lakes of high status and the numbers of individuals per species (Palm et al, 2012) were about 6 per Nordic gillnet. The whitefish, vendace, and burbot inhabited the largest of small lakes in Estonia Lake Saadjärv. The whitefish was caught only from the lake of high status.

In fish assemblages that estimated the lake to be in **good status** percids were less in total weight as compared with cyprinids. The share of piscivores was 30 % on an average as was the share of percids. The pike was more frequent compared with the pikeperch. The vast majority of small Estonian lakes over 50 ha in area was assessed to be in good status and on approximately half of them the pikeperch is fished. In two deeper lakes of this status the burbot was fished. The numbers of cyprinid individuals per cyprinid species in a Nordic gillnet averaged at 13, the mean numbers of cyprinid species per lake were 4.2. Different from the lakes of high status the sunbleak inhabited these lakes, but commonly lower in numbers compared with the bream, roach, white bream, and bleak.

Moderate status of a lake was characterised by low total weight of percids compared with cyprinids (the ratio stayed below 0.4). The share of piscivores was less than 20 % (somewhat higher when dominant piscivore was pikeperch). The share of percids stayed below 20 % and the share of piscivorous percids below 10 % with perch outnumbering ruffe by 6 times. The numbers of cyprinid individuals per cyprinid species averaged at 28 per Nordic gillnet. Of cyprinids the tench, Prussian carp, and crucian carp were uncommon or absent, whereas the sunbleak could outnumber both the roach and the bleak. The pikeperch was common in these lakes.

Lakes assessed to be in **poor or bad status** were less than 50 ha in area, either closed or have long water retention time. In these lakes the share of percids (commonly only the perch) was less than 10 %. Whenever percids were absent of the lake it was assessed to be in bad status of ecological quality.

REFERENCES

Holmgren K., Kinnerbäck A., Pakkasmaa S., Berquist B.& Beier U. 2007. Bedömningsgrunder för fiskfaunans status i sjöar - utveckling och tillämpning av EQR8. Fiskeriverket Informerar 2007: 3, 54 lk.

Leach J.H., Johnson M.G., Kelso J.R.M., Hartmann J., Hümann W. & Entz B. 1977. Responses of percid fishes and their habitats to eutrophication. J. Fish. Res. Board Canada, 34, 10, 1964-1971.

Moss B. 1998. Ecology of fresh waters. Blackwell Sci. Ldt. Oxford, 531 lk.

Palm, A., Krause, T., Järvalt, A., Silm, M. (2012). Cyprinids in Estonian small lakes: comparison between main water bodies Balwois Proceedings, 5, 1-9.

Reshetnikov Yu.S. 1980. Ecology and classification of coregonid fish. Nauka, Moscow, 300 lk (in Russian).

Svärdson G. 1976. Interspecific population dominance in fish communities of Scandinavian lakes. Report of thr Institute of Freshwater Research Drottingholm 56, 144-171.

C.8.5 Lithuania

Polymictic lakes (L-CB2)

Shift from High to Good status is mainly characterized by decrease in the relative abundance of perch (by approximately 20% compared to reference conditions) and an increase in the relative biomass of benthivorous species (by approximately 15% compared to reference conditions). All obligatory species are present, non-native and translocated species are absent.

At the Good/Moderate boundary the relative biomass of benthivorous species is up to 30% higher compared to reference conditions, there is a significant increase in the relative biomass of degradation resistant species silver bream (compared to reference conditions). Some obligatory species are absent. Non-native and/or translocated species might be present, but contribute to less than 1% of the total biomass.

At Moderate/Poor boundary the share of biomass of benthivorous fish is by 60% higher and relative abundance of perch is by 60% lower than that at reference conditions. Approximately 30% of obligatory species (including stenotermic ones) are absent. If present, non-native and/or translocated species contribute to more than 5% of the total biomass.

At Poor/Bad boundary relative abundance of perch is by 90% less compared to that at reference conditions. More than 50% of obligatory species are absent. If present, non-native and/or translocated species contribute to more than 15% of the total biomass.

Stratified lakes (L-CB1)

Shift from High to Good status is characterized by approximately 10% decrease in the relative biomass of perch and stenotermic fish and corresponding increase in the relative biomass of benthivorous species. All type specific obligatory species are present, non-native and translocated species are absent.

At the Good/Moderate boundary the relative biomass of perch and stenotermic fish are up to 25% lower and that of benthivorous species is approximately 25% higher compared to reference conditions. There is a significant decrease in the average weight of individuals of roach (compared to reference conditions). Some obligatory species are absent. Non-native and/or translocated species might be present, but contribute to less than 1% of the total biomass.

At Moderate/Poor boundary the share of biomass of benthivorous fish is by 60% higher and that of perch is by 70% lower than that at reference conditions. Approximately 30% of obligatory species (including stenotermic ones) are absent. If present, non-native and/or translocated species contribute to more than 5% of the total biomass.

At Poor/Bad boundary relative abundance of perch is by 90% less compared to that at reference conditions. More than 50% of obligatory species are absent. If present, non-native and/or translocated species contribute to more than 10% of the total biomass.

C.8.6 The Netherlands

Since the Netherlands is a delta, the rivers (Rhine and Meuse) and the sea have largely formed the landscape. Most of the country is flat and lies at or just below sea level, this is where most of the natural lakes are found. The lakes are usually very shallow, less than 3 metres deep. There are lakes with predominantly inorganic sediments, sand or clay, which was deposited by the sea, and lakes with organic sediment that has accumulated over long periods in marshes and peat bogs. Depending on the sediment and the influence of the rivers, most lakes used to be mesotrophic or eutrophic clear lakes. In reference conditions large areas of these lakes were overgrown with submerged vegetation. This is not the case for the deeper lakes or deeper parts of the shallow lakes. Also there might have been some lakes that were turbid due to natural conditions (e.g. nutrient rich, slightly brackish ground water).

Depending on dimensions, trophic status, water clarity and depth profile, the following reference conditions might have occurred:

- Oligotrophic, clear lakes: rare, mainly smaller lakes in the coastal dune area or some ground water fed peat lakes;
- Meso-eutrophic clear lakes: largely overgrown with pondweeds and charophytes, this would be the most common situation for lakes over 50 ha;
- Eutrophic turbid lakes: e.g. lakes with clay bottoms that are fed by nutrient rich surface- or ground water. Little vegetation.

Apart from the trophic status of the lake, probably even more important for the fish community was the seasonal water level fluctuation. Since the land is very flat, a water level fluctuation of about 0,5-1 meter, caused inundation of large areas around the lakes in winter (floodplains). During wet winters the lake area might have increased 3-fold. Around the lakes large areas with reedbelts and marshes would occur. In spring these would still be inundated and were ideal spawning grounds for fish, especially for phytophilic species. In summer the fish retreated to the lake, where submerged vegetation gave structure and shelter.

The fish communities of the meso-eutrophic lakes would be expected to have a large proportion of phytophilic species like rudd, pike, tench, crucian carp, weatherfish (see Figure C.8 and Table C.10 for species list). These were probably dominant. In the deeper, less vegetated areas of the lake, dominance of eurytopic species like roach, perch and bream would be expected. This is what is still seen in e.g. lakes with large seasonal water level fluctuations in the Danube Delta, even though they are already quite heavily eutrophicated.

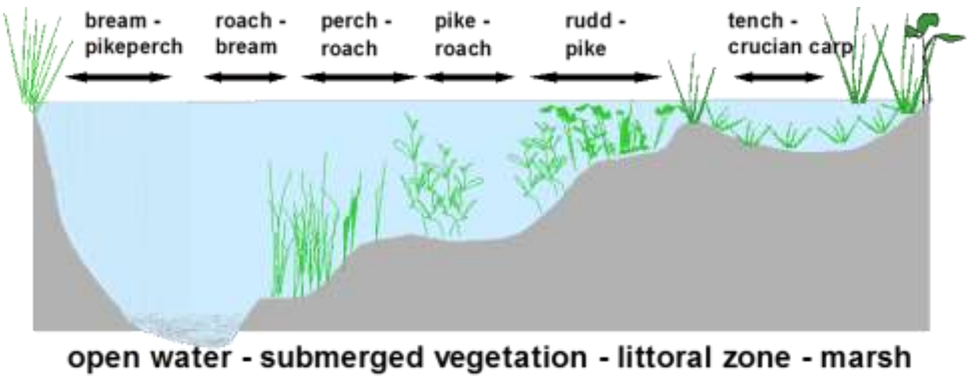


Figure C.8: Fish communities in shallow Dutch lakes.

Class boundary setting: The H/G class boundary is based on expert judgement, since there are no data on reference conditions available. The best we have are data on the (eutrophicated) lakes in the Danube Delta, which still have more or less natural water level fluctuations. Further, restoration of natural water level fluctuations for larger lakes in the Netherlands is not considered possible for economic reasons. Therefore the relevance of this class boundary is limited.

The G/M and M/P class boundaries are based on observed shifts in fish communities. The theoretical background is:

- G/M: change from dominance of phytophilic to dominance of eurytopic as a result of water level regulation causing disappearance of floodplain areas and marshes and thus loss of spawning areas and habitat for juveniles of phytophilic fish;
- M/P: change from dominance of perch/roach to dominance of bream as a result of eutrophication and the consequential disappearance of submerged vegetation, shift of the lake status from macrophyte to phytoplankton dominated system

Class boundary setting was based on fish data collected in lakes in the Netherlands, Poland and the Danube Delta (Romania). For these lakes eutrophication status and water level fluctuation was used to determine status with regards to reference conditions.

Table C.10: Species list for freshwater lake fishes and their guilds (FAME).

Dutch name	Scientific name	Phytophilic species / Low oxygen tolerant	Trofical guild	Degree of rheophily	Migration guild	Tolerance for habitat degradation
Aal	Anguilla anguilla		BENT/PISC	EURY	LMC	INTE
Alver	Alburnus alburnus		OMNI	EURY	SM	TOLE
Baars	Perca fluviatilis		BENT/PISC	EURY	SM	TOLE
Bittervoorn	Rhodeus sericeus	PHYT	HERB	LI	SM	INTOL
Blankvoorn	Rutilus rutilus		OMNI	EURY	SM	TOLE
Brasem	Abramis brama		OMNI	EURY	IM	TOLE
Driedoornige stekelbaars	Gasterosteus aculeatus		OMNI	EURY	SM	TOLE
Giebel	Carassius gibelio	PHYT	OMNI	EURY	SM	TOLE
Grote modderkruiper	Misgurnus fossilis	PHYT/OXY	BENT	LI	SM	INTOL
Karper	Cyprinus carpio		OMNI	EURY	SM	INTE
Kleine modderkruiper	Cobitis taenia	PHYT	BENT	EURY	SM	INTE
Kolblei	Blicca bjoerkna		OMNI	EURY	SM	TOLE
Kroeskarper	Carassius carassius	PHYT/OXY	OMNI	LI	SM	TOLE
Kwabaal	Lota lota		PISC	EURY	IM	INTE
Meerval	Silurus glanis		PISC	EURY	SM	INTE
Pos	Gymnocephalus cernuus		BENT	EURY	SM	TOLE
Rivierdonderpad	Cottus gobio		INSV	RH	SM	INTOL
Riviergrondel	Gobio gobio		BENT	RH	SM	INTE
Ruisvoorn	Scardinius erythrophthalmus	PHYT	OMNI	LI	SM	INTE
Snoek	Esox lucius	PHYT	PISC	EURY	SM	INTOL
Snoekbaars	Sander lucioperca		PISC	EURY	SM	INTE
Spiering	Osmerus eperlanus		PISC	LI	SM	INTE
Tiendoornige stekelbaars	Pungitius pungitius	PHYT	OMNI	LI	SM	INTE
Vetje	Leucaspius delineatus	PHYT	OMNI	LI	SM	INTE
Winde	Leuciscus idus		OMNI	RH	IM	INTE

Species characteristics: PHYT + phytophilic; BENT = benthivorous; OMNI = omnivorous; PISC = Piscivorous; EURY = eurytopic; LI = limnophilic; RH = rheophilic; SM = Short distance migratory species; IM = intermediate distance migratory species; LMC = long distance migratory species; INTOL = intolerant; TOLE = tolerant; INTE = intermediate.

C.8.7 Poland

Biological meaning of H–G–M classes (provided by Witold Białokoz, Łucjan Chybowski)

Fish are good indicator of water ecosystems health. They live in almost all aquatic ecosystems, creating characteristic fish assemblages. Different species have specific habitat requirements and are sensitive to its changes. Changes in the environment state translate directly to ichthyofauna composition and structure. And vice versa, the ichthyofauna composition and structure is direct indicator of the environment state. Examples of such relations, succession of species and groups of species due to changes in the environment are described by Colby et al. (1972), Hartmann (1977, 1979), Leach et al. (1977), Zdanowski (1995). Bnińska (1985, 1991), LEOPOLD et al. (1986) and MICKIEWICZ et al. (2003) utilised the above regularities for evaluation the degree of lakes transformation in Poland. Commercial catches, which reflect ichthyofauna state in examined lakes, have distinctly shown on negative changes in lakes environment with profound consequences for ichthyofauna structure and abundance.

In general, together with deterioration of the ecological status of lakes (within the type) the share of expansive small-bodied and with stunted growth cyprinid fishes as well as pikeperch have increased, while the share of perch and littoral fishes (tench, pike, rudd) and large bream and roach in total catches of these species have declined.

Polish methods of lakes status assessment (LFI+ and LFI-EN) on the basis of the above regularities assumed that in accordance with the environmental preferences of fish species, the share of pike, tench, perch, rudd, large bream, large bream in total bream catches, large roach and large roach in total roach catches are indicators of positive changes, whereas the share of pikeperch, crucian carp, white bream, bleak, ruffe, small bream and small roach are negative indicators. These assumptions have been confirmed by correlation and regression analysis with pressure indices such as combined TSI Carlson index, the Secchi disk transparency, phosphorus and chlorophyll concentrations, and the TAPI indices. Metrics regressed with multiple regression have been used to build multimetric LFI indices.

Preliminary class boundaries for LFI indices for lakes with different ecological status are as follows:

HIGH:	0.71-1.00
GOOD:	0.46-0.70
MODERATE:	0.26-0.45
POOR:	0.11-0.25
BAD:	0.00-0.10

Average metrics values with their standard deviations are given in the tables below.

Table C.11: Average metric values with standard deviations for polymictic lakes depending on the lake ecological status.

Metric	Ecological status according to LFI-EN											
	Reference		Very good		Good		Moderate		Poor		Bad	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Bream %	12.3	2.0	12.3	2.0	20.0	10.9	19.6	10.6				
White bream %	2.4	1.5	2.4	1.5	7.4	6.4	11.5	7.6				
Roach %	20.3	4.4	20.3	4.4	27.4	12.7	29.7	11.5				
Rudd %	3.7	5.0	3.7	5.0	1.3	1.0	0.0	0.0				
Bleak %	2.6	3.7	2.6	3.7	7.2	6.3	11.9	7.7				
Perch %	37.5	2.6	37.5	2.6	19.6	9.5	8.0	3.3				
Ruffe %	0.2	0.1	0.2	0.1	3.3	2.5	4.3	1.7				
Pike-perch %	5.7	8.0	5.7	8.0	3.3	4.3	9.7	11.5				

The data in Table C.11 indicates that together with deterioration of the ecological status of polymictic lakes the share of rudd and perch decline, whilst an increase in the share of bream, white bream, roach, ruffe and pike-perch is observed.

Table C.12: Average metric values with standard deviations for stratified lakes depending on the lake ecological status.

Metric	Ecological status											
	Reference		Very good		Good		Moderate		Poor		Bad	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Tench %	4.4	2.8	1.9	2.8	0.6	1.1	0.3	0.6	0.3			
Bream %	2.9	3.8	4.3	4.1	6.8	3.9	11.0	7.7	6.7			
White bream %	5.5	3.3	4.6	2.6	5.1	3.3	8.2	3.6	6.2			
Roach %	19.6	5.3	21.3	4.8	32.0	18.3	28.6	7.9	41.1			
Rudd %	17.0	5.4	9.6	8.6	4.3	4.1	1.4	2.6	0.2			
Bleak %	2.1	2.2	1.6	1.5	3.9	4.2	8.6	3.6	19.4			
Perch %	36.4	5.6	44.8	10.5	36.4	9.5	30.3	13.6	16.2			
Ruffe %	1.4	1.6	1.2	1.0	3.1	1.3	4.8	2.3	5.4			

The data in Table C.12 indicates that together with deterioration of the ecological status of stratified lakes, the share of tench, rudd and perch declines, whilst an increase in the share of bream, white bream, roach, bleak and ruffe is observed.

Table C.13: Average metric values with standard deviations for stratified lakes depending on the lake ecological status.

Metric	Ecological status according to LFI+											
	Reference		Very good		Good		Moderate		Poor		Bad	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Pike-perch %	0.0	0.1	2.8	5.8	3.7	6.0	15.2	12.6	25.7	11.7	52.8	
Pike %	26.4	3.9	21.3	10.9	14.4	6.6	5.3	5.9	10.2	2.8	18.1	
Tench %	35.4	13.1	8.2	4.3	9.2	8.8	1.4	1.0	1.2	1.6	0.1	
Crucian carp %	1.6	1.5	0.4	0.7	3.5	3.8	3.3	4.5	10.6	12.1	16.4	
Perch %	5.4	1.6	7.2	3.8	6.3	1.7	1.3	1.2	1.0	0.2	1.7	
Share of large roach in total roach %	28.6	15.5	54.9	34.4	30.0	30.0	28.5	36.8	2.1	2.9	0.0	

The Data in Table C.13 indicates that together with deterioration of the ecological status of polymictic lakes, the share of pike, tench, perch and large roach decline, whilst an increase in the share of pike-perch and crucian carp is observed.

Table C.14: Average metric values with standard deviations for stratified lakes depending on the lake ecological status.

Metric	Ecological status according to LFI+											
	Reference		Very good		Good		Moderate		Poor		Bad	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Pike-perch %	0.0	0.0	0.5	1.3	3.7	7.1	11.1	12.9	27.3			
Tench %	8.0	7.2	6.0	5.2	4.8	4.8	3.2	2.6	1.6			
Crucian carp %	0.4	0.9	0.1	0.2	0.7	1.1	0.2	0.2	0.0			
Perch %	10.2	6.2	10.4	5.8	6.4	3.8	3.0	2.3	1.5			
large bream %	8.0	5.3	9.7	7.8	6.8	5.2	2.7	2.6	8.9			
small bream %	4.4	3.1	10.5	8.6	19.4	13.3	46.0	29.4	49.8			
share of large bream in total bream %	64.5	11.7	52.5	19.3	31.7	22.4	11.4	13.3	15.2			
large roach %	9.2	5.6	9.0	5.1	4.6	3.8	1.3	1.9	0.6			
White bream %	2.3	1.9	1.5	2.8	5.5	7.9	6.3	6.2	4.9			

The data in Table C.14 indicates that together with deterioration of the ecological status of stratified lakes the share of tench, perch, large bream, the share of large bream and large roach in catches decline, whilst an increase in the share of pike-perch, crucian carp, small bream and white bream is observed.

In both methods of evaluation in stratified as well as polymictic lakes detected changes in the ichthyofauna composition follow biological assumptions: together with deterioration of the ecological status of lakes, from reference and very good, through good and moderate the share of “positive” species decline and “negative” once increase. It is true that there is a considerable metric values dispersion in specific lakes, but due to multimetric character of the indices, fluctuations of metrics maintain desirable trends and allow for the correct calculation of LFI indices.

Transformation of an LFI index, which in fact is a biological index, into EQR with the range value 0-1 rise doubts. The Water Framework Directive requires only a very rough framework for the ecological status of lakes:

High status: Species composition and abundance correspond totally or nearly totally to undisturbed conditions. All the type-specific sensitive species are present. The age structures of the fish communities show little sign of anthropogenic disturbance and are not indicative of a failure in the reproduction or development of a particular species

Good status: There are slight changes in species composition and abundance from the type-specific communities attributable to anthropogenic impacts on physicochemical or hydromorphological quality elements.The age structures of the fish communities show signs of disturbance attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements, and, in a few instances, are indicative of a failure in the reproduction or development of a particular species, to the extent that some age classes may be missing.

Moderate status: The composition and abundance of fish species differ moderately from the type-specific communities attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements. The age structure of the fish communities shows major signs of disturbance, attributable to anthropogenic impacts.

Both Polish methods meet the WFD requirements very well, as they fully take advantages from the changes in the composition and abundances of ichthyofauna assemblages specific for lake types. In our opinion separation of classes of ecological status of lakes with high accuracy is neither necessary or possible to meet the WFD requirements. More important is the comparability of ratings and this can be ensured in the intercalibration process.

C.9 Summary and conclusions

In the Central-Baltic Fish Intercalibration exercise:

- Nine countries participated in the intercalibration with 10 finalised fish-based lake assessment methods (Belgium-Flanders, Czech Republic, Denmark, Estonia, France, Germany, Lithuania, the Netherlands, Poland (two assessment systems);
- Intercalibration "Option 2" was used - indirect comparison of assessment methods using a common metric;
- IC common metric (TAPI = Total Anthropogenic pressure Index) was developed specifically for this IC exercise comprising eutrophication and hydromorphological parameters;
- All systems showed sufficiently strong correlations with common index, except FR and BE-FL assessment systems;
- The comparability analysis showed considerable boundary disagreement, so the boundary adjustment was needed for several countries which brought all boundaries in the harmonization band;
- French system was intercalibrated via additional indirect intercalibration procedure;
- The final results include EQRs of CZ, DK, EE, FR, DE, LT, NL and PL (2 systems) lake fish-based assessment systems;
- BE system was evaluated as WFD-compliant and therefore included in the EC Decision Annex part 2 (ecological assessment methods WFD compliant, not possible to intercalibrate due to valid reasons)

References

2000/60/EC (2000): Directive 2000/60/EC of the European Parliament and the Council of 23 October 2000 establishing a framework for Community action in the field of water policy vom 22.12.2000. Official Journal of the European Communities Vol 43, L 327 Seiten 1-73 ff.

2008/105/EC (2008): Directive 2008/105/EG of the European Parliament and of the Council on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council vom 16.12.2008. Abl. L 348 Seiten 84-97 ff.

ARGILLIER, C., S. CAUSSÉ, M. GEVREY, S. PÉDRON, J. BORTOLI, S. BRUCET, M. EMMRICH, E. JEPPESEN, T. LAURIDSEN, T. MEHNER, M. OLIN, M. RASK, P. VOLTA, I. J. WINFIELD, F. KELLY, T. KRAUSE, A. PALM & K. HOLMGREN (2013): Development of a fish-based index to assess the eutrophication status of European lakes. Hydrobiologia 704: 193-211.

BARTHELMES, D. (2000): Zur Trophieindikation durch Fische in norddeutschen Seen. Gewässerökologie Norddeutschlands 4: 123-131.

BELPAIRE, C., R. SMOLDERS, I. V. AUWEELE, D. ERCKEN, J. BREINE, G. VAN THUYNE & F. OLLEVIER (2000): An index of biotic integrity characterizing fish populations and the ecological quality of Flandrian water bodies. Hydrobiologia 434: 17-33.

BIAS 10.09 (2014): Biometrische Analyse von Stichproben. H. Ackermann, epsilon-Verlag. Abrufbar unter letzter eigener Zugriff am

BIRK, S., N. WILLBY & D. NEMITZ (2011): User's Manual of the Intercalibration Spreadsheets.

BREINE, J., G. V. THUYNE & L. D. BRUYN (2015): Development of a fish-based index combining data from different type of gear. A case study of reservoirs in Flanders (Belgium). Belgian Journal of Zoology 145: 17-39.

BRUCET, S., S. PÉDRON, T. MEHNER, T. L. LAURIDSEN, C. ARGILLIER, I. J. WINFIELD, P. VOLTA, M. EMMRICH, T. HESTHAGEN, K. HOLMGREN, L. BENEJAM, F. KELLY, T. KRAUSE, A. PALM, M. RASK & E. JEPPESEN (2013): Fish diversity in European lakes: geographical factors dominate over anthropogenic pressures. Freshwater Biology 58: 1779-1793.

CARLSON, R. & J. SIMPSON (1996): A Coordinator's Guide to Volunteer Lake Monitoring Methods. Ed.: North American Lake Management Society.

CARLSON, R. E. (1977): A trophic state index for lakes. Limnology and Oceanography 22: 361-369.

CARPENTER, S. R., J. F. KITCHELL & J. R. HODGSON (1985): Cascading Trophic Interactions and Lake Productivity. BioScience 35: 634-639.

CIS (2011): Guidance document on the Intercalibration Process 2008-2011. ECOSTAT 14, Implementation Strategy for the Water Framework Directive (2000/60/EC) - Guidance Document.

DIEKMANN, M., U. BRÄMICK, R. LEMCKE & T. MEHNER (2005): Habitat-specific fishing revealed distinct indicator species in German lowland lake fish communities. Journal of Applied Ecology 42: 901-909.

EN 14757 (2005): European Standard: Water quality - Sampling of fish with multi-mesh gillnets vom 27.06.05. ICS 13.060.70; 65.150.

GARCIA, X.-F., M. DIEKMANN, U. BRAMICK, R. LEMCKE & T. MEHNER (2006): Correlations between type indicator fish species and lake productivity in German lowland lakes. Journal of Fish Biology 68: 1144-1157.

HEJZLAR, J., J. MATĚNA, J. KOMÁRKOVÁ & J. KUBEČKA (2003): Typology and reference status standing water bodies: The introductory study for implementation of Water Framework Directive in the Czech Republic (in Czech). Biology Centre of the AS CR, v.v.i. Institute of Hydrobiology.

HELMINEN, H., J. KARJALAINEN, M. KURKILAHTI, M. RASK & J. SARVALA (2000): Eutrophication and fish biodiversity in Finnish lakes. Verhandlungen der Internationalen Vereinigung für Limnologie 27: 194-199.

HUTCHINGS, J. A. (2014): Unintentional selection, unanticipated insights: introductions, stocking and the evolutionary ecology of fishes. Journal of Fish Biology 85: 1907-1926.

JEPPESEN, E., J. P. JENSEN, M. SØNDERGAARD, T. LAURIDSEN & F. LANDKILDEHUS (2000): Trophic structure, species richness, and biodiversity in Danish lakes: changes along phosphorus gradient. Freshwater Biology 45: 201-218.

JEPPESEN, E., M. SØNDERGAARD, J. P. JENSEN, K. E. HAVENS, O. ANNEVILLE, L. CARVALHO, M. F. COVENEY, R. DENEKE, M. T. DOKULIL, B. FOY, D. GERDEAUX, S. E. HAMPTON, S. HILT, K. KANGUR, J. KÖHLER, E. LAMMENS, T. L. LAURIDSEN, M. MANCA, M. R. MIRACLE, B. MOSS, P. NOGES, G. PERSSON, G. PHILLIPS, R. PORTIELJE, S. ROMO, C. L. SCHELSKE, D. STRAILE, I. TATRAI, E. WILLEN & M. WINDER (2005): Lake responses to reduced nutrient loading - an analysis of contemporary long-term data from 35 case studies. Freshwater Biology 50: 1747-1771.

KARR, J. R. (1981): Assessment of Biotic Integrity Using Fish Communities. Fisheries 6: 21-27.

KARR, J. R., K. D. FAUSCH, P. L. ANGERMEIER, P. R. YANT & I. J. SCHLOSSER (1986): Assessing biological integrity in running waters - A method and its rationale. Illinois Natural History Survey, Champaign.

KILGOUR, B. W. & L. W. STANFIELD (2006): Hindcasting reference conditions in streams. Landscape influences on stream habitats and biological assemblages, Symposium: 623-639.

LAUNOIS, L., J. VESLOT, P. IRZ & C. ARGILLIER (2011a): Development of a fish-based index (FBI) of biotic integrity for French lakes using the hindcasting approach. Ecological Indicators 11: 1572-1583.

LAUNOIS, L., J. VESLOT, P. IRZ & C. ARGILLIER (2011b): Selecting fish-based metrics responding to human pressures in French natural lakes and reservoirs: towards the development of a fish-based index (FBI) for French lakes. Ecology of Freshwater Fish 20: 120-132.

LAWA (1998): Gewässerbewertung - stehende Gewässer. Vorläufige Richtlinie für eine Erstbewertung von natürlich entstandenen Seen nach trophischen Kriterien. Länderarbeitsgemeinschaft Wasser.

LAWA (2014): Trophieklassifikation von Seen: Trophieindex nach LAWA - Handbuch -. LBH Freiberg & IGB Berlin.

LINDEMANN, R. L. (1942): The trophic-dynamic aspect of ecology. Ecology 23: 399-417.

MEHNER, T., M. DIEKMANN, U. BRÄMICK & R. LEMCKE (2005): Composition of fish communities in German lakes as related to lake morphology, trophic state, shore structure and human-use intensity. Freshwater Biology 50: 70-85.

NEMITZ, D., N. WILLBY & S. BIRK 2011 Intercalibration Excel Template Sheets (v1.24). Abrufbar unter https://www.uni-due.de/aquatic_ecology/publications/birk.shtml#intercalibration, letzter eigener Zugriff am 09.01.15.

OGEWV (2011): Verordnung zum Schutz der Oberflächengewässer vom 20.07.2011. BGBl. Teil I Nr. 37 Seiten 1429 ff.

OLIN, M., M. RASK, J. RUUHIJARVI, M. KURKILAHTI, P. ALA-OPAS & O. YLONEN (2002): Fish community structure in mesotrophic and eutrophic lakes of southern Finland: the relative abundances of percids and cyprinids along a trophic gradient. Journal of Fish Biology 60: 593-612.

PERSSON, L. & L. A. GREENBERG (1990): Juvenile competitive bottlenecks: The perch (*Perca fluviatilis*)-roach (*Rutilus rutilus*) interaction. Ecology 71: 44- 56.

PERSSON, L., S. DIEHL, L. JOHANSSON, G. ANDERSSON & S. F. HAMRIN (1991): Shifts in fish communities along the productivity gradient of temperate lakes - patterns and the importance of size-structured interactions. Journal of Fish Biology 38: 281-293.

PHILLIPS, G., O. P. PIETILÄINEN, L. CARVALHO, A. SOLIMINI, A. LYCHE SOLHEIM & A. C. CARDOSO (2008): Chlorophyll–nutrient relationships of different lake types using a large European dataset. Aquatic Ecology 42: 213-226.

POIKANE, S. (2009): Water Framework Directive intercalibration technical report - Part 2: Lakes. Joint Research Center.

POIKANE, S., R. PORTIELJE, M. VAN DEN BERG, G. PHILLIPS, S. BRUCET, L. CARVALHO, U. MISCHKE, I. OTT, H. SOSZKA & J. VAN WICHELEN (2014): Defining ecologically relevant water quality targets for lakes in Europe. Journal of Applied Ecology: n/a-n/a.

RITTERBUSCH, D., U. BRÄMICK & T. MEHNER (2014): A typology for fish-based assessment of the ecological status of lowland lakes with description of the reference fish communities. Limnologica - Ecology and Management of Inland Waters 49: 18-25.

SØNDERGAARD, M., E. JEPPESEN, J. P. JENSEN & S. L. AMSINCK (2005): Water Framework Directive: ecological classification of Danish lakes. Journal of Applied Ecology 42: 616-629.

VOLLENWEIDER, R. A. & J. J. KEREKES (1982): Appendix 1: Background and summary results of the OECD cooperative programme on eutrophicaton. In: R. A. Vollenweider & L. J. Janus (Eds.), The OECD Cooperative Programme on Eutrophication, pp. A1-A59. National Water Research Institute, Ontario.

VRBA, J., J. KOPÁČEK & J. FOTT (2000): Long-term limnological research of the Bohemian Forest lakes and their recent status. Silva Gabreta 4: 7-28.

WILLBY, N. & S. BIRK (2010): A case study of three techniques for assessing comparability of national methods of ecological classification.

Annex to Part B

Comments on metrics

Pressure acidification (1 metric): Acidification is an important pressure in many European countries, especially in Scandinavian countries. In the Central Baltic GIG, acidification is of minor (if any) relevance and restricted to a few water bodies like mining lakes or peat bogs. Only one acidified lake was present in the common IC database. Therefore, this pressure is not taken into account.

Critical aspects of pressures included in the TAPI:

TP: All existing assessment systems address eutrophication as the most important human pressure and all of them have used TP as a measure. But none differentiates between anthropogenic and natural shares of TP (as far as I know). The natural background level of nutrients is so variable that type-specific approaches are erroneous. **Stocked fish and aliens**: many MS consider these to be components of the fish community which can show pressures but are not a pressure themselves. In the CB GIG, stocking has negligible effects on the lake ecology in most cases (UK is an exception).

Pressures not included in the TAPI and some comments:

Population density in the catchment area: is frequently used as a proxy for eutrophication. Human activities in the catchment area are the main source of nutrients in lakes. However, for pop density it seems not suitable to refer to the catchment. Especially in lowland lakes catchment areas can be huge compared to lake areas and often are very diverse. It is doubtful that same values for this driving force will have comparable impacts on a European scale, e.g. because of different quality of sewage treatment. The metric would be quite different for isolated vs. connected lakes. Many CB representatives argue that lake fish assessment should focus on the lake, not on the catchment area or connected rivers. Therefore we focus on metrics with a more direct relation to eutrophication. *Strictly speaking, similar arguments apply for the land use in the catchment area.*

Aquaculture: aquaculture is a method of fisheries management and might influence the lake ecology, e.g. via nutrient input or escaping fish. In contrast to commercial fishing and angling, the effects are affecting the fish community indirectly. I suggest that the impact of aquaculture is already accounted for in other metrics (like TP or alien species surplus).

Cormorants eat abundant fish of small to intermediate size in benthic/pelagic habitats. In lakes > 50 ha, their presence can change the fish community to a situation indicating a better status: decreased total abundance, fewer cyprinids, more big fish, more predators, higher percentage of shoreline species. Therefore cormorants should not be included in a list of pressures that negatively affect the lake ecology as indicated by the fish community. Please note: This is a statement referring to the total lake ecology, not to the impact of cormorants on fish communities and fisheries.

Biomanipulation is usually done by changing the fish community directly using catch and stocking measures. It aims at improving the ecological status and will lead to fish communities that would be typical for 'better' lakes. Therefore, biomanipulation cannot be included in a list of negative pressures. Similar arguments are valid for chemical manipulation.

Annex to Part C

Part 1. Changes of fish communities and their assignment to status classes

The Central Baltic GIG has a wide geographical range. Comparing the situation in the member states, heterogeneous fish communities with respect to species inventory and composition can be found. However, some common reactions of fish to anthropogenic pressures can be identified.

The total fish abundance is one example. It tends to increase with increasing degradation, mostly because of a positive correlation of fish abundance and trophic status (HELMINEN et al. 2000; SØNDERGAARD et al. 2005; ARGILLIER et al. 2013; BRUCET et al. 2013). Metrics for the total fish abundance (standardized or non-standardized catches in number or weight) are used in the LFI of CZ, DE, DK, EE, and FR. Cyprinids tend to profit from a certain degree of degradation. Increasing percentages of the whole taxonomic group or of specific species like common bream, white bream, and roach are well described in literature (PERSSON et al. 1991; BARTHELMES 2000; HELMINEN et al. 2000; JEPPESEN et al. 2000; DEGERMAN et al. 2001; OLIN et al. 2002; MEHNER et al. 2004; MEHNER et al. 2005b; GARCIA et al. 2006). Cyprinid metrics used in the systems of CZ, DE, DK, LT, NL, and PL. The European perch is a common indicator of degradation, too. Generally, perch abundance is dependent from trophic status and structural diversity, having a peak in mesotrophic conditions (PERSSON et al. 1991; HELMINEN et al. 2000; OLIN et al. 2002; MEHNER et al. 2005a). The metric is used in the systems of CZ, DE, EE, LT, NL, and PL.

Despite the fact that some comparable reactions of the fish communities can be observed throughout the GIG, it is not possible to unify them to a common assignment of fish-changes belonging to status classes. This requires a more or less quantitative description. The species inventory differs considerably, even between neighbored member states, making many species-specific metrics inadequate. For the more widespread species, the starting points of assessment (i. e. the values belonging to reference conditions), are too different within the huge geographical range of the GIG. Similar observations were made in the intercalibration process of the Northern GIG (OLIN et al. 2014). During Phase II of the Intercalibration, efforts were made to develop a common Central Baltic fish-based assessment system or at least to find a common biological metric. Neither such system nor a common metric working for more than two-three member states could be found. At all, it was not possible to provide a valid GIG-wide description of the changes of the fish communities corresponding to the ecological status. Therefore, the following descriptions refer to the national situations with a special focus on the metrics of the individual member states.

Literature

ARGILLIER, C., S. CAUSSÉ, M. GEVREY, S. PÉDRON, J. BORTOLI, S. BRUCET, M. EMMRICH, E. JEPPESEN, T. LAURIDSEN, T. MEHNER, M. OLIN, M. RASK, P. VOLTA, I. J. WINFIELD, F. KELLY, T. KRAUSE, A. PALM & K. HOLMGREN (2013): Development of a fish-based index to assess the eutrophication status of European lakes. Hydrobiologia 704: 193-211.

BARTHELMES, D. (2000): Zur Trophieindikation durch Fische in norddeutschen Seen. Gewässerökologie Norddeutschlands 4: 123-131.

BRUCET, S., S. PÉDRON, T. MEHNER, T. L. LAURIDSEN, C. ARGILLIER, I. J. WINFIELD, P. VOLTA, M. EMMRICH, T. HESTHAGEN, K. HOLMGREN, L. BENEJAM, F. KELLY, T. KRAUSE, A. PALM, M. RASK & E. JEPPESEN

(2013): Fish diversity in European lakes: geographical factors dominate over anthropogenic pressures. Freshwater Biology 58: 1779-1793.

DEGERMAN, E., J. HAMMAR, P. NYBERG & G. SVARDSON (2001): Human impact on the fish diversity in the four largest lakes of Sweden. Ambio 30: 522-528.

GARCIA, X.-F., M. DIEKMANN, U. BRAMICK, R. LEMCKE & T. MEHNER (2006): Correlations between type indicator fish species and lake productivity in German lowland lakes. Journal of Fish Biology 68: 1144-1157.

HELMINEN, H., J. KARJALAINEN, M. KURKILAHTI, M. RASK & J. SARVALA (2000): Eutrophication and fish biodiversity in Finnish lakes. Verhandlungen der Internationalen Vereinigung für Limnologie 27: 194-199.

JEPPESEN, E., J. P. JENSEN, M. SØNDERGAARD, T. LAURIDSEN & F. LANDKILDEHUS (2000): Trophic structure, species richness, and biodiversity in Danish lakes: changes along phosphorus gradient. Freshwater Biology 45: 201-218.

MEHNER, T., M. DIEKMANN, U. BRÄMICK & R. LEMCKE (2005a): Composition of fish communities in German lakes as related to lake morphology, trophic state, shore structure and human-use intensity. Freshwater Biology 50: 70-85.

MEHNER, T., M. DIEKMANN, X.-F. GARCIA, U. BRÄMICK & R. LEMCKE (2004): Ökologische Bewertung von Seen anhand der Fischfauna. Berichte des IGB 21: 202.

MEHNER, T., M. DIEKMANN, X.-F. GARCIA, U. BRÄMICK & R. LEMCKE (2005b): Möglichkeiten und Grenzen der Bewertung der ökologischen Qualität von Seen anhand der Fischfauna. In: C. K. Feld, S. Rödiger, M. Sommerhäuser & G. Friedrich (Eds.), Typologie, Bewertung, Management von Oberflächengewässern, pp. 137-150. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.

OLIN, M., M. RASK, J. RUUHIJARVI, M. KURKILAHTI, P. ALA-OPAS & O. YLONEN (2002): Fish community structure in mesotrophic and eutrophic lakes of southern Finland: the relative abundances of percids and cyprinids along a trophic gradient. Journal of Fish Biology 60: 593-612.

OLIN, M., K. HOLMGREN, M. RASK, M. ALLEN, L. CONNOR, A. DUGUID, W. DUNCAN, A. HARRISON, T. HESTHAGEN, F. KELLY, A. KINNERBÄCK, R. ROSELL & R. SAKSGÅRD (2014): Water Framework Directive Intercalibration Technical Report - Northern Lake Fish fauna ecological assessment methods. JRC Technical Reports, Ed.: S. Poikane.

PERSSON, L., S. DIEHL, L. JOHANSSON, G. ANDERSSON & S. F. HAMRIN (1991): Shifts in fish communities along the productivity gradient of temperate lakes - patterns and the importance of size-structured interactions. Journal of Fish Biology 38: 281-293.

SØNDERGAARD, M., E. JEPPESEN, J. P. JENSEN & S. L. AMSINCK (2005): Water Framework Directive: ecological classification of Danish lakes. Journal of Applied Ecology 42: 616-629.

Part 2. Czech Republic: reasons for strong deviations of original CZ status boundaries

The deviation of original CZ class boundaries from other systems is caused by slightly different approach in metrics selection, class boundaries settings and in our opinion high level of anthropogenic stressors. The main difference between Czech and other countries involved into intercalibration is in consideration of negative impacts of eutrophication (the main stressor). Most of the Czech water bodies included in the intercalibration process are deep and thermally stratified reservoirs with high nutrient load. High nutrient load and resulting high algae production cause very negative effect in these reservoirs as water column below the thermocline is unsuitable for fish and other biota due oxygen depletion. In our opinion this is an extremely negative impact and it causes absence of cold water living fish in most of the reservoirs and as such decrease their ecological status (it decreases biodiversity and creates troublesome anoxic water masses). Therefore, we included also metrics reflecting this situation.

The original EQR class boundaries settings were based on expert judgment using linear model of the relationship between a proxy of eutrophication and each metric as the best solution for interim classification of reservoir ecological potential. We are ready to apply class boundaries suggested by the Central-Baltic Lake Fish Geographical Intercalibration Group and to correct this part of methodology. The new class boundaries would still provide reasonable classification of our reservoirs.

The Czech participation was involved during whole process of intercalibration by the Central-Baltic Lake Fish Geographical Intercalibration Group. The data used for intercalibration were properly collected and covered all type of stressors as well as natural characteristic of intercalibrated reservoirs. The extent of any possible data errors should be fully comparable to the datasets from other member states.

Part 3. Poland: reasons for strong deviations of original PL status boundaries

Changes in the environment state translate directly to the ichthyofauna composition and structure. And vice versa, the ichthyofauna composition and structure is direct indicator of the environment state. Examples of such relations, succession of species and groups of species due to changes in the environment are described by Colby et al. (1972), Hartmann (1977, 1979), Leach et al. (1977), and in Poland by Bnińska (1985, 1991), Leopold et al. (1986), Zdanowski (1995) and Mickiewicz et al. (2003). In general, together with deterioration of the ecological status of lakes (within the type) the share of expansive small-bodied and with stunted growth cyprinid fishes as well as pikeperch have increased, while the share of perch and littoral fishes (tench, pike, rudd) and large bream and roach in total catches of these species have declined.

Polish methods of lakes status assessment (LFI+ and LFI-EN) based on the above regularities assumed that in accordance with the environmental preferences of fish species, the share of pike, tench, perch, rudd, large bream, large bream in total bream catches, large roach and large roach in total roach catches are indicators of positive changes, whereas the share of pikeperch, crucian carp, white bream, bleak, ruffe, small bream and small roach are negative indicators.

These assumptions have been confirmed by correlation and regression analysis with pressure indices such as combined TSI Carlson index, the Secchi disk transparency, phosphorus and chlorophyll concentrations, and the TAPI indices. Metrics regressed with multiple regression have been used to built multimetric LFI indices. Preliminary class boundaries for LFI indices for lakes with different ecological status were as below:

H/G	**0.71**
G/M	**0.46**
M/P	0.25
P/B	0.10

Average metrics values with their standard deviations are given in the tables below.

Table B.1 Average metric values with standard deviations for polymictic lakes depending on the lake ecological status.

Metric	Ecological status according to LFI-EN											
	Reference		Very good		Good		Moderate		Poor		Bad	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Bream %	12,3	2,0	12,3	2,0	20,0	10,9	19,6	10,6				
White bream %	2,4	1,5	2,4	1,5	7,4	6,4	11,5	7,6				
Roach %	20,3	4,4	20,3	4,4	27,4	12,7	29,7	11,5				
Rudd %	3,7	5,0	3,7	5,0	1,3	1,0	0,0	0,0				
Bleak %	2,6	3,7	2,6	3,7	7,2	6,3	11,9	7,7				
Perch %	37,5	2,6	37,5	2,6	19,6	9,5	8,0	3,3				
Ruffe %	0,2	0,1	0,2	0,1	3,3	2,5	4,3	1,7				
Pike-perch %	5,7	8,0	5,7	8,0	3,3	4,3	9,7	11,5				

Data indicate that together with deterioration of the ecological status of polymictic lakes the share of rudd and perch decline, whilst an increase in the share of bream, white bream, roach, ruffe and pike-perch is observed.

Table B.2 Average metric values with standard deviations for stratified lakes depending on the lake ecological status.

Metric	Ecological status according to LFI-EN											
	Reference		Very good		Good		Moderate		Poor		Bad	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Tench %	4,4	2,8	1,9	2,8	0,6	1,1	0,3	0,6	0,3			
Bream %	2,9	3,8	4,3	4,1	6,8	3,9	11,0	7,7	6,7			
White bream %	5,5	3,3	4,6	2,6	5,1	3,3	8,2	3,6	6,2			
Roach %	19,6	5,3	21,3	4,8	32,0	18,3	28,6	7,9	41,1			
Rudd %	17,0	5,4	9,6	8,6	4,3	4,1	1,4	2,6	0,2			
Bleak %	2,1	2,2	1,6	1,5	3,9	4,2	8,6	3,6	19,4			
Perch %	36,4	5,6	44,8	10,5	36,4	9,5	30,3	13,6	16,2			
Ruffe %	1,4	1,6	1,2	1,0	3,1	1,3	4,8	2,3	5,4			

Data indicate that together with deterioration of the ecological status of stratified lakes, the share of tench, rudd and perch declines, whilst an increase in the share of bream, white bream, roach, bleak and ruffe is observed.

Table B.3 Average metric values with standard deviations for polymictic lakes depending on lake ecological status.

Metric	Ecological status according to LFI+											
	Reference		Very good		Good		Moderate		Poor		Bad	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Pike-perch %	0,0	0,1	2,8	5,8	3,7	6,0	15,2	12,6	25,7	11,7	52,8	
Pike %	26,4	3,9	21,3	10,9	14,4	6,6	5,3	5,9	10,2	2,8	18,1	
Tench %	35,4	13,1	8,2	4,3	9,2	8,8	1,4	1,0	1,2	1,6	0,1	
Crucian carp %	1,6	1,5	0,4	0,7	3,5	3,8	3,3	4,5	10,6	12,1	16,4	
Perch %	5,4	1,6	7,2	3,8	6,3	1,7	1,3	1,2	1,0	0,2	1,7	
Share of large roach in total roach %	28,6	15,5	54,9	34,4	30,0	30,0	28,5	36,8	2,1	2,9	0,0	

Data indicate that together with deterioration of the ecological status of polymictic lakes, the share of pike, tench, perch and large roach decline, whilst an increase in the share of pike-perch and crucian carp is observed.

Table B.4 Average metric values with standard deviations for stratified lakes depending on the lake ecological status.

Metric	Ecological status according to LFI+											
	Reference		Very good		Good		Moderate		Poor		Bad	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Pike-perch %	0,0	0,0	0,5	1,3	3,7	7,1	11,1	12,9	27,3			
Tench %	8,0	7,2	6,0	5,2	4,8	4,8	3,2	2,6	1,6			
Crucian carp %	0,4	0,9	0,1	0,2	0,7	1,1	0,2	0,2	0,0			
Perch %	10,2	6,2	10,4	5,8	6,4	3,8	3,0	2,3	1,5			
large bream %	8,0	5,3	9,7	7,8	6,8	5,2	2,7	2,6	8,9			
small bream %	4,4	3,1	10,5	8,6	19,4	13,3	46,0	29,4	49,8			
share of large bream in total bream %	64,5	11,7	52,5	19,3	31,7	22,4	11,4	13,3	15,2			
large roach %	9,2	5,6	9,0	5,1	4,6	3,8	1,3	1,9	0,6			
White bream %	2,3	1,9	1,5	2,8	5,5	7,9	6,3	6,2	4,9			

Data indicate that together with deterioration of the ecological status of stratified lakes the share of tench, perch, large bream, the share of large bream and large roach in catches decline, whilst an increase in the share of pike-perch, crucian carp, small bream and white bream is observed.

In both methods of evaluation detected changes in the ichthyofauna composition that follow biological assumptions: together with deterioration of the ecological status of lakes, from reference and very good, through good and moderate, the share of "positive" species decline and "negative" ones increase. However, these changes do not occur abruptly. The relations are rather smooth and strongly correlated with pressure indicators. It is also hard to determine which ichthyofauna assemblage is worse to the extent that qualifies the lake to lower ecological status. Therefore, for the Polish methods we adopted temporarily such classes division, which in any case did not differ from normative definitions contained in the Water Framework Directive (WFD, Annex V). This means that ichthyofauna of lakes evaluated with Polish methods as High, in the opinion of experts was actually fully characteristic for the type of lake, with a very high proportion of the sensitive species. Fish fauna of lakes assessed as Good was changed only slightly.

As it was already mentioned, classes division was introduced temporarily and it was not an official division. During the intercalibration exercises, when data from many countries were used, class boundaries have been harmonized which resulted in the rise of H/G and G/M class boundaries.

	PL-EN	PL-LFI
H/G	**0.804**	**0.866**
G/M	**0.557**	**0.595**
M/P	0.250	0.250
P/B	0.100	0.100

The increase of boundary values (of 0.10 to 0.15) does not raise our opposition, although in our opinion separation of classes with high accuracy is neither necessary or possible to meet the WFD requirements. More important is the comparability of ratings and this was obtained in the intercalibration process. When new class boundaries were applied to evaluation of the ecological status of lakes, it was found that the composition and structure of the fish fauna still lies within a normative, but very capacious definitions of High, Good, and Moderate classes, included in the Water Framework Directive.

Literature

Bnińska M. 1985 – The possibilities of improving catchable fish stocks in lakes undergoing eutrophication – J. Fish Biol. 27 (suppl. A): 253-261.

Bnińska M. 1991 – Fisheries - In: Cyprinid Fishes. Systematics, biology and exploitation. Chapman & Hall Fish and Fisheries Series 3, London, New York, Tokyo, Melbourne, Madras: 572-589.

Bnińska M., Wołos A. 1998 – Effectiveness of coregonid management versus environment quality - Arch. Pol. Fish. 6(2): 295-314.

Carlson R. E 1977 - A trophic state index for lakes. Limnology and oceanography. 22: 361-369.

Colby P.J., Spangler G.R., Hurley D.A., McCombie A.M. 1972 - Effects of eutrophication on salmonid communities in oligotrophic lakes – J. Fish .Res. Bd. Can. 29: 975-983.

Hartmann J. 1977. - Fischereiliche Veranderungen in kulturbedingt eutrophierenden Seen. Schweitz. Z. Hydrol. 39 2: 243-254.

Hartmann J. 1979. - Unterschiedliche Adaptionsfahigkeit der Fische an Eutrophierung. Schweitz. Z. Hydrol. 41, 2: 374-382.

Leach J.H., Johnson M.G., Kelso J.R., Hartmann J., Numann W., Entz B. 1977 - Responses of percid fishes and their habitats to eutrophication - J. Fish. Res. Bd. Can. 34: 1964-1971.

Leopold M., Bnińska M., Nowak W. 1986 - Commercial fish catches as an index of lake eutrophication - Arch. Hydrobiol. 106(4): 513-524.

Mickiewicz M., Wołos A., Leopold M. 2003 – Effectiveness of fisheries management in eutrophic lakes near Mrągowo (north-eastern Poland) – Arch. Pol. Fish. 11(1): 123-139.

Wołos A., Zdanowski B., Wierzchowska M. 2009 - Long-term changes in commercial fish catches in Lake Mamry Północne (north-eastern Poland) on the background of physical, chemical, and biological data. Arch. Pol. Fish. 17: 195-210.

Part 4. Reasons for Belgium not to be intercalibrated

The Belgian fish-based index for reservoirs and lakes is explained in part A (system descriptions p. 20-25; see also Breine et al. (2015)). There are several issues causing problems for the intercalibration:

1) Lack of data. Only nine lakes from the dataset were conform the required characteristics. The ratio cases to independent variable should be 20:1 (lowest ratio 5:1) to allow a regression.
2) Total phosphorous data were not always available; making is rather difficult to calculate the complete TAPI.
3) The used technique (fyke nets and electric fishing) catches different fish than the multimesh gillnets.

However, the developed index responds to the criteria stipulated in the Water Framework Directive. Its selected metrics are relevant allowing for an appropriate assessment of anthropogenic impacts on the fish communities. In addition these metrics assess different aspects of the ecological functions of reservoirs (and lakes) for fishes, and that they are not redundant.

Intercalibration will be possible if more lakes with the required characteristics are monitored. This can also include extra surveys in the lakes already used in this exercise. Multi-mesh gillnets can be used but this involves the development of a new fish-based index.

Part 5. Member states indirectly intercalibrated - FRANCE

In this section, the characteristics of the fish index used to assess the eutrophication status of French lakes are described, and explanations of why the intercalibration of this index was not performed are given. A biological description of the class boundaries is also provided.

The fish index used for France was developed at the European scale, on the basis of a dataset consisting of 454 lakes located in 10 European countries (WISER project N° 226273; Argillier *et al.*, 2013). All the details regarding the index development are fully described in the document "CBLakeFish_DocA_Systems" of the final CB intercalibration report, and only the main features are summarized hereafter.

Also called the European Lake Fish Index (ELFI), this multi-metric index was built to respond to eutrophication, which was measured through two pressure variables: the total phosphorus and the proportion of non-natural land-uses in the lake catchment. The ELFI aggregates three biological metrics: the number of individuals caught per unit effort (CPUE), the biomass of individuals caught per unit effort (BPUE), and the number of individuals of omnivorous species per unit effort (CPUE_OMNI). CPUE and BPUE bring complementary information on fish abundance in the lake. CPUE_OMNI is a metric in relation with the trophic composition of the fish community, and omnivorous species are known to be less sensitive than specialist species from a functional point of view. These metrics thus reflect the abundance, the species composition and the species sensitivity of the lake fish community. In addition, all these three metrics significantly and positively responded to eutrophication.

Hindcasting modelling was used to estimate the values of the three metrics in reference conditions (i.e. for very low level of human disturbances), given that not enough reference lakes were available to build a more classical 'reference sites approach'. This modelling procedure consisted in relating each metric to environmental variables and stressors through predictive models (Kilgour & Stanfield, 2006). The metric reference values were then obtained by artificially reducing the values of the stressors in the models. The Ecological Quality Ratio (EQR) of each metric was defined as the difference between the observed and the reference values of the metric. The EQR of the three metrics were finally averaged to build the multi-metric index. The values of the index were divided into five classes of ecological status. The index value corresponding to the 25% percentile of the "reference or weakly disturbed" lakes was used to define the High/Good boundary. Following the recommendation of the commission expert, we applied a piecewise procedure to mathematically shift the High/Good boundary to a fixed value of 0.8 in order to make this index comparable with the indices used by the other member states.

The multi-metric index showed a significant relationship to eutrophication, which was assessed through a composite stressor index combining the two pressure variables previously defined, as recommended by the commission expert. This step considerably improved the robustness of the index-pressure relationship (R^2 = 0.42, p-value < 0.001; Figure B.1).

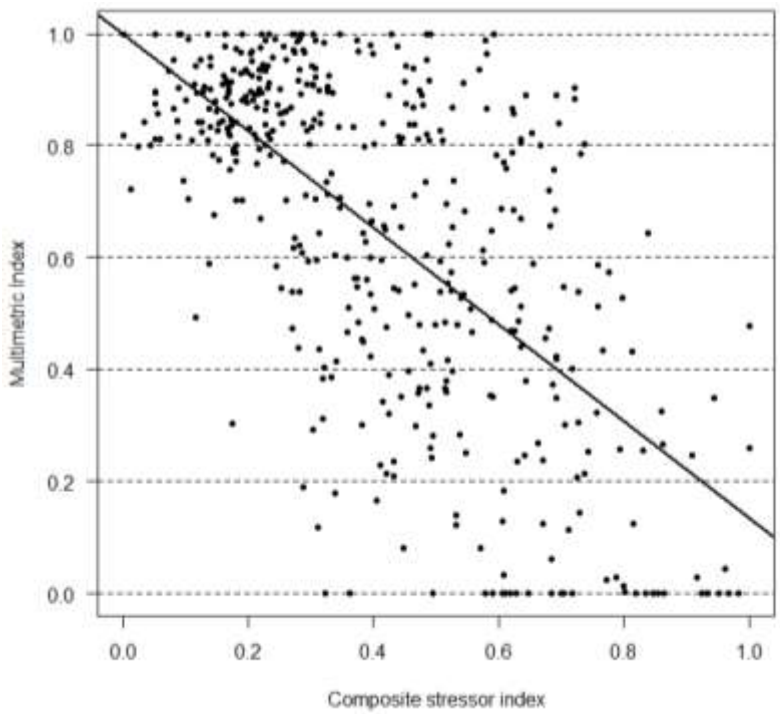


Figure B.1 Relationship between the composite stressor index and the multimetric index resulting from the mean of the three selected metrics. Horizontal dashed lines indicate the ecological class boundaries

These results demonstrate that the ELFI fulfills all the criteria for WFD compliance. However, and despite the efforts that were undertaken to improve the ELFI, none of them has enabled the participation to the CB intercalibration exercise for the French fish index. Several aspects may explain this outcome.

First, the French fish index was built to respond to eutrophication, and not to another type of stressor, owing to the fact that eutrophication is considered as the most impacting stressor for natural lakes in France (Launois *et al.*, 2011). Consequently, the French index did not show good relationships to the other stressors considered for the intercalibration exercise, such as hydro-morphological alterations or the proportion of invasive species. Indeed, eutrophication only represents one third of the pressure assessed at the GIG scale, and the common pressure index (TAPI) was thus not relevant for French lakes.

Second, French lakes are all LCB-3 type, ant this type is very minority at the scale of the GIG. Even though all types (LCB-1, -2 and -3) were included in the intercalibration exercise, no certainties can be provided on the possibility of intercalibrating a national dataset exclusively made up of LCB-3 lakes with the other national datasets essentially made up of LCB-1 and LCB-2 lakes. In addition, French lakes are located at the western margin of the geographical area of the GIG and present very different climatic features (Figure B.2.a). Several of these lakes are also much larger than the other CB lakes (Figure B.2.b). These original features imply that fish communities of these lakes may be driven by different relationships to stressors. Alkalinity in addition to temperature is likely to influence productivity, which may also make the French assessment method incomparable to other national methods.

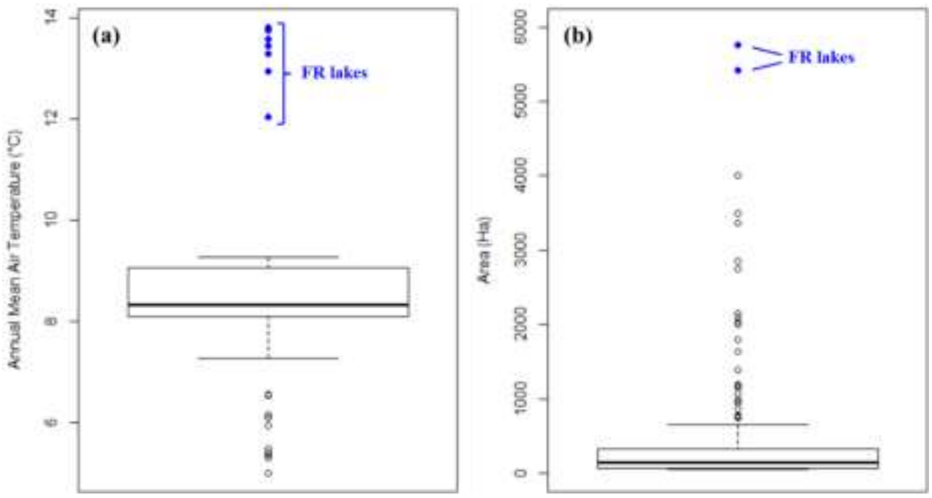


Figure B.2 Boxplots of (a) annual mean air temperatures and (b) areas for all CB lakes. French lakes are shown in blue.

Last but not least, only eight French lakes belong to the Central-Baltic GIG, which represents a very small dataset to identify significant and robust statistical relationships. This obligatory methodological issue has greatly limited our ability to improve the fish index, and therefore has strongly impacted the intercalibration exercise for France. For instance, the fact that changes in the index or stressor values for just one or two lakes may result in totally different relationships well illustrates the statistical problem that we have faced.

Given these fundamental differences between French and other CB lakes and the previously detailed statistical issue, it was not possible to intercalibrate the French fish index with other national CB indices during the common intercalibration exercise.

Nevertheless, following the recommendations of the commission expert, we have explored an indirect intercalibration procedure. To do so, we have considered the lakes in common between the IC dataset and the one used to develop the ELFI. This has resulted in a subset of 116 European lakes essentially located in France, Germany or Denmark.

First, we have calculated the values of the composite stressor index of eutrophication corresponding to the values of the ELFI class boundaries through the regression line (Figure B.3). The values obtained are given in the Table B.5.

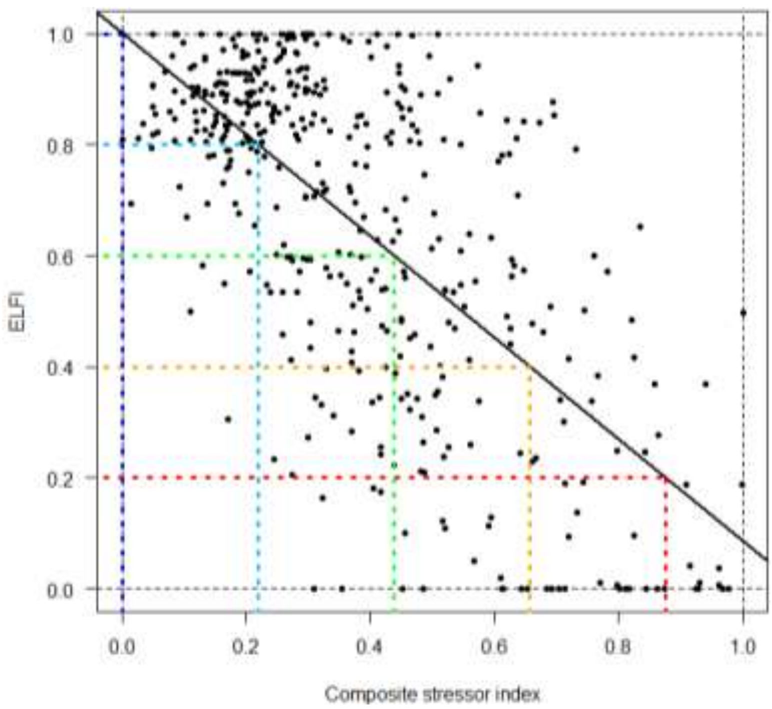


Figure B.3 Relationship between the composite stressor index and the ELFI for the whole dataset of 454 European lakes. The dashed lines correspond to the conversion of the values of the ELFI boundary classes into values of the composite stressor index for the bad (red), poor (orange), moderate (orange), good (green), high (light blue) classes, and for the maximum observed (dark blue).

Table B.5 Values of the ELFI, the composite stressor index, the TAPI (version 3_12i), the harmonization lines of the IC procedure, the harmonization bias, the class width and the harmonization bias in class equivalents corresponding to the ELFI boundary classes. While the ELFI is negatively correlated to the composite stressor index, the ELFI is positively correlated to the TAPI.

Boundary classes	**ELFI**	**Composite stressor index**	**TAPI**	**GIG harmonization line**	**Harmonization bias**	**Class width**	**Harmonization bias in class equivalents**
Max	1.0	0.001	0.965	0.838	0.127	-	-
High/Good	0.8	0.220	0.815	0.716	0.099	0.149	**0.665**
Good/ Moderate	0.6	0.438	0.666	0.543	0.123	0.149	**0.823**
Moderate/ Poor	0.4	0.657	0.517	0.374	0.143	0.149	0.955
Poor/Bad	0.2	0.876	0.367	0.211	0.156	0.149	1.046

Second, we have found a good relationship between the TAPI used in the IC procedure and the composite stressor index ($\rho_{Spearman}$ = -0.735, R^2 = 0.58) (Figure B.4). The previously calculated values of the composite stressor index corresponding to the ELFI class boundaries were translated into TAPI values, which are indicated in Table C 19. We have then followed the same procedure than the one done during the intercalibration exercise by computing the biases between these values and the harmonization lines of the GIG (see the document "CBLakeFish_DocC_IC" of the final CB intercalibration report for the full details of this procedure). We finally obtained the harmonization biases in class equivalents by dividing the harmonization biases by the class widths (Table C19). For the intercalibration procedure, the most important values are those of the High/Good and Good/Moderate boundary classes. While they have to be lower than 0.25 (in absolute value), these values were of 0.665 and 0.823, respectively. We have consequently proposed new values for the ELFI class boundaries that allowed harmonization biases in class equivalents lower than 0.25 (Table B.6), which were also converted into TAPI values following the reverse procedure (Figure B.5).

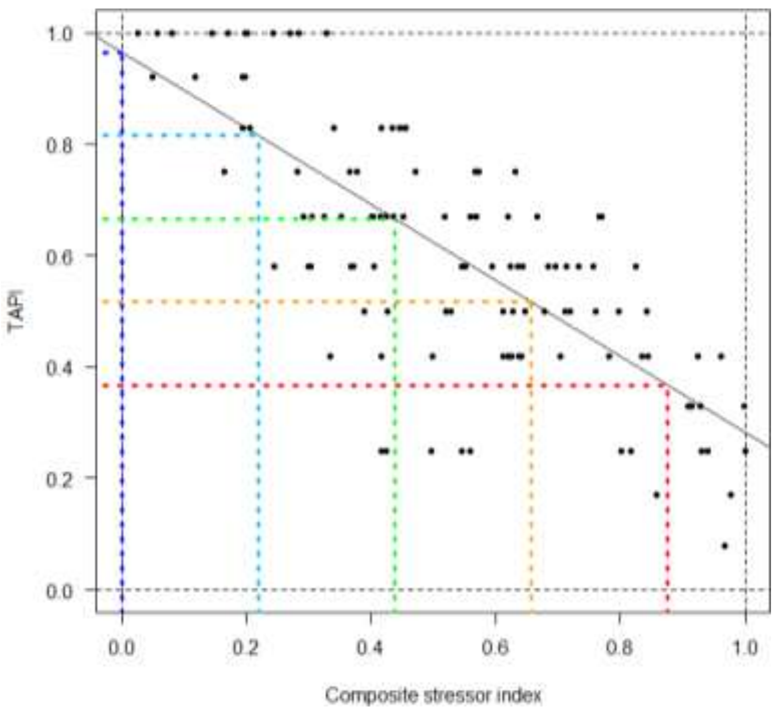


Figure B.4 Relationship between the TAPI and the composite stressor index for the common dataset of 116 European lakes. The dashed lines correspond to the conversion of the values of the ELFI boundary classes into values of the TAPI through the composite stressor index for the bad (red), poor (orange), moderate (orange), good (green), high (light blue) classes, and for the maximum observed (dark blue).

Table B.6 New values of the French class boundaries and their corresponding values of TAPI, harmonization line, harmonization bias, class width and harmonization bias in class *equivalents.*

Boundary classes	**New French boundary**	**TAPI**	**GIG harmonization line**	**Harmonization bias**	**Class width**	**Harmonization bias in class equivalents**
Max	1.000	0.965	0.838	0.127	-	-
High/Good	0.733	0.765	0.716	0.049	0.199	0.247
Good/Moderate	0.494	0.587	0.543	0.044	0.179	0.245
Moderate/Poor	0.350	0.479	0.374	0.105	0.108	0.979
Poor/Bad	0.175	0.349	0.211	0.138	0.131	1.052

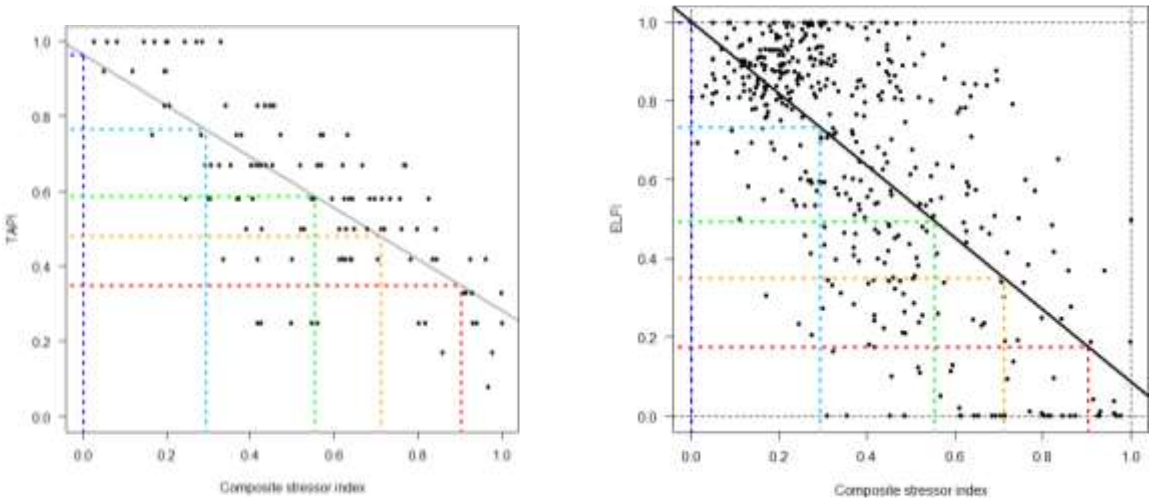


Figure B.5 Relationship between the TAPI and the composite stressor index (left) and between the ELFI and the composite stressor index (right). The dashed lines correspond to the conversion of the values of the new ELFI boundary classes into values of the TAPI through the composite stressor index for the bad (red), poor (orange), moderate (orange), good (green), high (light blue) classes, and for the maximum observed (dark blue).

We were thus able to indirectly intercalibrate the French assessment method with the other CB GIG methods, which has resulted in changes in the values of the French class boundaries. The new values of the class boundaries are: **0.733** for the **H/G boundary**, **0.494** for the **G/M boundary**, **0.350** for the **M/P boundary**, and **0.175** for the **P/B boundary** (Table B.6).

The small number of lakes in the French dataset was also restricting to provide a general biological description of the class boundaries. Nevertheless, some generalities were identified regarding the composition of the fish communities.

The “**High**” class consists of very slightly disturbed lakes, which are characterized by the possible occurrence of some sensitive species such as *Telestes souffia*, *Barbatula barbatula* and *Phoxinus phoxinus*, as well as a low proportion of omnivorous individuals.

The previously listed sensitive species were not found in the lakes belonging to the “**Good**” class (neither in the lower classes), and this ecological class was also characterized by higher abundances of several omnivorous species such as *Squalius cephalus* and *Scardinius* *erythrophthalmus*. A decrease of both abundance and biomass of several salmonid species (e.g. *Salmo trutta*, *Salvelinus umbla*) was also noted between the "**High**" and "**Good**" classes.

The limit between the "**Good**" and "**Moderate**" classes seems to be well marked with a great increase in abundances of many generalist and omnivorous species such as *Rutilus rutilus*, *Perca fluviatis* and *Abramis brama*. The proportion of cyprinid species seems also to be much higher in lakes belonging to the "**Moderate"** class than lakes of the two higher classes.

Literature

Argillier C, Caussé S, Gevrey M, Pédron S, De Bortoli J, Brucet S, Emmrich M, Jeppesen E, Lauridsen T, Mehner T, *et al.* 2013. Development of a fish-based index to assess the eutrophication status of European lakes. *Hydrobiologia* **704**: 193-211.

Launois L, Veslot J, Irz P, Argillier C. 2011. Development of a fish-based index (FBI) of biotic integrity for French lakes using the hindcasting approach. *Ecological Indicators* **11**: 1572-1583.

Kilgour BW, Stanfield LW. 2006. Hindcasting reference conditions in streams. In 'Landscape influences on stream habitats and biological assemblages'. *American Fisheries Society* **48**: 623-639.

Part 6. Czech Republic – role of reservoir data in ecological status assessment

In the Czech Republic we do not have any natural lakes with fish communities eligible for ecological status assessment (the largest natural lake in the country has an area 18 ha only and no fish live in Czech natural lakes). Under the absence of natural lakes, the Czech assessment system could be developed using data from reservoirs only and of course, the system was in turn applied also only to reservoirs ecological potential assessment.

Reservoirs are heavily modified water bodies created by humans but they share many important ecological characteristics with lakes. These similarities result in comparable fish communities as well as ecological driving processes and main stressors. The fish species pool available in Czech reservoirs is comparable to natural lakes in neighboring countries. Of course, reservoirs possess a few specific characteristics which had to be considered during assessment development (as e.g. higher level fluctuation, specific gradients in fish distributions induced by reservoir morphology and so on) and these specific characteristics and indicators reflecting them are in detail described in the methodology of Czech assessment. But the principle of fish community assessment is similar for both ecological status and potential and effect of specific hydromorphological conditions is lower in comparison to the main stressor – eutrophication (this stressor is also considered as crucial by other members of the intercalibration group). Therefore, we believe that Czech reservoir ecological potential can be intercalibrated together with ecological status of natural lakes within the Central-Baltic Lake Fish Geographical Intercalibration Group showing similar ecological quality both types of waterbodies.

List of abbreviations and definitions

%N - percentage of total number of fish catch

%NB - the percentage by number in catches with benthic nets

%TSO - type-specific percentage of occurrence

%WB - the percentage by weight in catches with benthic nets

alienfish%W_class - percentage of weight of non-native fish

alienfish_%W - the percentage of introduced fish species in scientific catches

alienfish_spn - the number of fish species absent in undisturbed conditions

alienfishspn_class - the number of introduced species (expressed as class)

AWB – artificial water bodies

Bioeffpoll - biological effects of pollution

BQE – Biological Quality Element

CB - Central – Baltic region

Chempoll - chemical pollution

Chlo-a - Chlorophyll-a

CIS – Common Implementation Strategy

CPUE - Catch Per Unit Effort

CZ - Czech Republic

DE – Germany

DEEP - stratified, deep lake type

DK – Denmark

dtTP - trophic change, the difference of the mean TP concentration between reference conditions and current conditions

EE – Estonia

ELFI - European Lake Fish Index

ELFI_EQR - EQR value of the European Lake Fish Index (ARGILLIER et al. 2013)

ELFI_ESC - Corresponding ecological status class

EQR – Ecological Quality Ratio

Exp_ESC: Experts estimation of the ecological status class provided by an expert of the MS (abiotic, not fish-based

Fishcatch: assesses the ecological effects of selective fish removal by commercial fisheries and/or angling

FR - France

GIG - Geographical Intercalibration region

GM - boundary between good and moderate ecological status class

HG - boundary between high and good ecological status class

HMWB - heavily modified water bodies

IBI - index of biotic integrity

IC - Intercalibration of ecological assessment systems

LAWA - German national classification system (based on phosphorus, chlorophyll-a and Secchi depth)

L-CB1 – Central-Balti lake type 1: shallow, calcareous lakes (mean depth 3-15 m, alkalinity > 1 meq/l, water residence 1-10 years)

L-CB2 - Central-Balti lake type 2: very shallow, calcareous lakes (mean depth < 3 m, alkalinity > 1 meq/l, water residence 0.1-1 years)

L-CB3 -Central-Balti lake type 3: shallow, small, siliceous lakes (mean depth 3-15 m, alkalinity 0.2 - 1 meq/l, water residence 1-10 years)

LFI - Lake Fish Index: systems to assess the ecological status of lakes based on **fish** community data

LFI EN national fish assessment system based on gillnet sampling

LFI_EQR: EQR value of the national Lake Fish Indices (based on different systems!).

LFI_ESC: Ecological status class of the national Lake Fish Indices (based on different systems!).

LFI+ national fish assessment system of Poland based on fisheries statistics

LT – Lithuania

LUNN_abs% - land use non-natural in the catchment area as percentage

LUNN_class - land use non-natural % (expressed in classes)

LV – Latvia

MP boundary between moderate and poor ecological status class

MS Member state

NL – the Netherlands

non-fish alien: The metric assesses the impact of non-fish aliens (like mussels, crustaceans, plants). I

NPUE: number per unit of effort

PB boundary between poor and bad ecological status class

PL – Poland

POLY - Polymictic lake type

Popdens - population density in a ‘catchment area’ of human use

RESV-POLY - polymictic reservoir

RESV-STRAT - stratified reservoir or deep stratified reservoirs

Shoremod_class: shoreline modification in classes of percentages

SPEC-flushed - special lake type flushed lake

SPEC-saline - special lake type with high salinity e.g. at shorelines

Stocknat - stocking of native species.

STRAT - stratified lake type

TAPI index - total anthropogenic pressure intensity index

TP - total phosphorus

TP_class (total phosphorous %; classified): Total phosphorous with type specific class boundaries.

TPlvl - trophic level (classification in a national or international index of eutrophication)

TSI - Trophic State Index

UK – United Kingdom

Vispoll (visible pollution)

Vistrash (visible trash)

W - weight

WFD – Water Framework Directive

YearAssess: Year of the fish sampling which provide the basis for the EQR and ESC calculations (informative).

List of figures

List of tables

KJ-NA-28841-EN-N

The European Commission's science and knowledge service

Joint Research Centre

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

EU Science Hub
ec.europa.eu/jrc

@EU_ScienceHub

EU Science Hub - Joint Research Centre

Joint Research Centre

EU Science Hub

Publications Office

doi:10.2760/546291
ISBN 978-92-79-74611-6