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Interkalibrering av fiskbaserade bedömningar av ekologisk status i nordiska sjöar – resultat från en pilotstudie

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Summary

A Water Framework Directive for European water bodies is in effect since December 2000. The objective is to ensure at least good ecological status of all water bodies by 2015. The fish fauna and other biological quality elements should be monitored for assessment of whether the objective is achieved. Many national methods have been developed for assessment of ecological status in lakes, rivers and coastal waters. In December 2011, intercalibration of all European "monitoring systems" for ecological assessment of lakes, rivers and coastal waters is planned to be finalised. The aim is to ensure consistency and comparability between status assessments in similar water bodies, independent of member state affiliation. In a pilot study 2008-2009, Finnish and Swedish fish indices were applied to gillnet data (EN 14 757) from Finnish, Irish, Norwegian and Swedish lakes (89–305 lakes per member state). The Finnish and Swedish fish indices are based on four and eight metrics, respectively, describing different aspects of fish abundance and species composition. The index names EQR4 and EQR8 reflect their expressions as ecological quality ratios, with values between 0 and 1. The present dataset included only a few lakes within the seven "Northern intercalibration types", used for intercalibration of other biological elements during 2004-2007. Most of the lakes included in the study were, however, grouped into ten "Finnish lake types". Preliminary analyses revealed only weak or insignificant correlation between the Finnish and Swedish index values, within most lake types compared. The Finnish EQR4 failed to detect many impacted lakes from Ireland and Sweden, while the Swedish EQR8 appeared to be too conservative, especially for reference lakes with low species richness. Each of the fish indices responded nonlinearly to gradients of pH and total phosphorus, probably because the data set included a complex mixture of lakes with contrasting pressures (e.g. acidification and eutrophication). The Irish data set comprised many lakes with low proportions of native species. In contrast, native species made up 90–100 % of the fish biomass in the Finnish, Swedish and Norwegian lakes. In the upcoming intercalibration process, agreement is needed on which specific pressures are to be detected in which set of comparable lake types, and then some robust "Northern fish metrics" must be found for these pressure and lake type combinations.

Sammanfattning

EU.s ramdirektiv för vatten trädde i kraft i december 2000. Fiskfaunan är en av de biologiska kvalitetsfaktorer som ska övervakas, för att bedöma om målet minst god ekologisk status har uppnåtts år 2015. Sedan direktivet infördes har många nationella metoder utvecklats för bedömning av ekologisk status i sjöar, vattendrag och kustvatten. I december 2011 ska alla Europeiska metoder för bedömning av ekologisk status vara interkalibrerade. Syftet är att få konsekventa och jämförbara bedömningar av status i liknande vattenförekomster på olika sidor av nationsgränser. I en pilotstudie 2008-2009, beräknades finska och svenska fiskindex på data från provfiske med Nordiska översiktsnät (EN 14 757) i finska, irländska, norska och svenska sjöar (89–305 sjöar per land). De finska och svenska fiskindexen baseras på fyra respektive åtta fiskindikatorer, som beskriver olika aspekter av abundans och artsammansättning. Indexnamnen EQR4 och EQR8 speglar att de uttrycks som ekologiska kvalitetskvoter (ecological quality ratios) med värden mellan 0 och 1. Det aktuella datasetet inkluderade bara några få sjöar inom de ”nordiska interkalibreringstyper” som användes i interkalibrering av andra biologiska kvalitetsfaktorer under 2004-2007. Däremot kunde de flesta sjöar grupperas i någon av tio ”finska sjötyper”. Preliminära analyser uppvisade bara svaga korrelationer mellan finska och svenska indexvärden, inom de flesta jämförbara sjötyperna. Finska EQR4 misslyckades med att särskilja många av de påverkade sjöarna från Irland och Sverige, medan svenska EQR8 uppenbarligen var för konservativt, speciellt för referenssjöar med låg artrikedom. Båda fiskindexen uppvisade icke-linjär respons i gradienter av pH och totalfosfor. Det berodde sannolikt på att datasetet bestod av en komplex blandning av sjöar med kontrasterande påverkan (t.ex. försurning och eutrofiering). Det irländska datasetet innehöll många sjöar med låga andelar av inhemska fiskarter. I alla de finska och svenska sjöarna utgjordes istället fiskbiomassan till 90–100 % av inhemska arter, liksom i de flesta av de norska sjöarna. I den kommande interkalibreringsprocessen behövs enighet om vilka specifika typer av påverkan som ska kunna upptäckas i vilka jämförbara sjötyper. Några robusta “nordiska fiskindikatorer” bör identifieras för respektive kombination av påverkan och sjötyp.

Introduction

A Water Framework Directive for European water bodies is in effect since December 2000. The objective is to ensure at least good ecological status of all water bodies by 2015. The fish fauna and other biological quality elements should be monitored to verify that the objective is achieved (European Commission 2003a). The biological sampling methods should, when possible, follow European standards. Measured parameters should be indicative of species composition and abundance, and for fish the age structure should also be considered. The ecological status should be assessed as high, good, moderate, poor or bad, where high status means a biological community with no or minor deviation from type-specific reference conditions (European Commission 2003b). The typology admits that reference conditions may differ depending on geographical position, altitude, size, geology and, for lakes, depth.

Many methods have been developed for assessment of ecological status in lakes, rivers and coastal waters. Some assessment methods were developed in international cooperation, covering one or more biological quality element (e.g. Moss et al. 2003, Pont et al. 2006, 2007). More often the assessment methods differ between member states, e.g. for lake fish fauna in Finland and Sweden (Tammi et al. 2006a, b, Holmgren et al. 2007, Rask et al. 2010).

In December 2011, intercalibration of all European “monitoring systems” for ecological assessment of lakes, rivers and coastal waters is planned to be finalised (WG ECOSTAT 2009). The aim is to ensure consistency and comparability between status assessments in similar water bodies, independent of member state affiliation. The intercalibration exercise should focus on specific combinations of intercalibration type, biological quality element and pressure (or complex of pressures). The new guidance for the intercalibration process 2008-2011 was adopted at the WG Ecological Status (ECOSTAT) meeting 1-2 October 2009.

Some parts of the intercalibration process were completed during the first round 2004-2007 (Poikane 2008). However, fish in lakes was not officially included until a one-year pilot project started in October 2008. The pilot project is compiling a Pan-European database to develop common metrics to facilitate intercalibration of national methods, if they differ in data acquisition and numerical evaluation. Further preparatory work is being implemented within geographical intercalibration groups (GIG’s). The northern GIG includes partners from Finland, Ireland, Norway, Sweden and northern parts of the United Kingdom. The UK partners had no funding for practical contribution during the pilot project.

The present report summarises the work of the Northern GIG during the pilot study. There was no time to strictly follow procedures in the upcoming guidance for intercalibration. The analyses may rather serve as a first inventory of preconditions for a more formalised intercalibration during the following years. Preliminary results were discussed, considering differences in boundary setting procedure of national methods and types of pressure, as well as effects of low species richness and/or high proportion of non-native species. The discussion also aimed at commenting on possible future contribution to “the expected key elements” in the final intercalibration report (see WG ECOSTAT 2009).

General approach

The Northern GIG for lake fish was formalised in October 2008. The pilot study began with an exchange of country-specific information on fish sampling methods (i.e. any deviations from EN 14757) and status assessment methods (e.g. input data on fish and environment/typology, metrics and indices). All participating member states had fish data from sampling with gillnets, more or less according to the European standard (CEN 2005). Official methods for assessment of ecological status existed in Finland and Sweden, while methods were developing in Norway, Ireland and UK. The existing methods use multi-metric fish indices, EQR4 (Tammi et al. 2006a, b, Rask et al. 2010) and EQR8 (Holmgren et al. 2007), respectively. It was decided to compare the performance of Finnish and Swedish methods, on available fish data from Finnish, Irish, Norwegian and Swedish lakes.

Each Northern GIG partner had previously sent data sets with lake characteristics to the European fish database hosted and developed by Cemagref in France. Apart from the group-specific work, the partners independently sent pressure and fish data sets to Cemagref during the pilot study. For the Northern methods comparison, two reduced data sets were also compiled. Preliminary analyses were performed using fish metrics and indices, along with lake characteristics and pressure data extracted from the European database. Analyses were generally restricted to data available in April 2008, but in some cases later complementary lake descriptors and pressure data were included.

Differences in fish sampling methods

The partners from Finland, Ireland, Norway and Sweden used the European standard method (CEN 2005). This means that in recent years Nordic multi-mesh gillnets were set in a stratified random design in the benthic habitat. In lakes deeper than 10 m, the standard method includes larger pelagic gillnets, set at one or more spot in the deepest part of the lakes. The Finnish procedure deviates by using the smaller benthic gillnets for random sampling of the pelagic depth strata (Olin 2005). A similarly modified procedure is also used in Irish and Danish lakes (Kelly et al. 2007, Lauridsen et al. 2008). All comparisons in the present pilot study were restricted to data from benthic sampling.

For lakes smaller than 5 000 ha, the recommended sampling effort is 8–64 benthic gillnets, depending on lake area and maximum depth (Table 2 in CEN 2005). If the lake morphometry is poorly quantified, a default distribution of gillnets in different depth strata is recommended (Annex A in CEN 2005). Lake area and maximum depth were used to calculate the recommended total number of benthic gillnets in the northern GIG lakes, as well as the ratio between actually used and recommended number (net ratio, Table 1). The net ratio was generally highest in Swedish lakes, followed by Finnish lakes, and on average only about half the recommended effort was used in Irish and Norwegian lakes. A net ratio < 1 may be justified if the lake is close to a smaller category of lake area and maximum depth, or if the deepest part covers a very small proportion. The Irish sampling effort in recent years was, however, based on an active decision to reduce sampling effort in each depth stratum in an attempt to reduce fish mortalities (Kelly et al. 2007).

Differences between assessment methods

The national methods of Finland and Sweden are summarised in Annex I and II, respectively. Differences are found in several aspects, in addition to using different numbers of metrics in the final fish indices. For example, all observed species are used for calculation of the Finnish metrics for relative abundance and biomass, while only the species native in the country are used in the Swedish counterparts. Finnish reference

Table 1. Recommended sampling effort (number of benthic gillnets) and ratio between actual and recommended sampling effort in lakes of the Northern GIG countries.

MS	N lakes of < 5 000 ha	Recommended sampling effort			Net ratio (actual / recommended)		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
Finland	93	30.2	8	64	0.76	0.21	2.50
Norway	138	22.8	8	56	0.46	0.06	1.00
Rep. of Ireland	84	25.5	8	64	0.48	0.17	0.75
ROI / NI	3	26.7	8	56	0.54	0.50	0.63
Sweden	303	24.2	8	64	0.93	0.50	2.00

values and class-boundaries were derived from catch data including sampling with benthic, meta-limnetic and surface gillnets, while only benthic gillnets were used for the Swedish system. Finnish reference values and class-boundaries were calculated from groups of type-specific (Figure A.I.1 in Annex I) reference lakes, while lake-specific reference values of Swedish metrics were calculated using regression models with lake characteristics. Observed metric values were expressed as standardised residuals and then converted to probabilities of belonging to a distribution of least impacted lakes. Class-boundaries were only set for the final index, i.e. the mean of metric probabilities. The good-moderate boundary was set at equal risk of miss-classification of least impacted (high-good status) and more impacted (moderate-bad status) lakes, respectively. Reference conditions in Finnish lakes are based mainly on existing information of land use and nutrient concentrations and judged by the environmental authorities. Any differences in deriving reference conditions cannot be fully evaluated at the present stage. There were, however, considerable differences in testing metric response to pressures, as well as in boundary setting procedures. Finnish metrics were selected based on their response to eutrophication, which is considered the main pressure in their lakes (Tammi et al. 2003). The Swedish index aimed at detecting mixed pressures, as well as specific pressure from acidification or eutrophication. The Finnish procedures for boundary setting and calculation of ecological quality ratios followed the previous guidance of the European commission (2003b) quite well. The Swedish index rather relies on procedures described for development of the European fish index in rivers (Pont et al. 2006; 2007).

Material and methods

Fish data from 640 lakes were selected for the present pilot exercise (Figure 1), covering four member states, each represented by 89–305 lakes. The Irish data set included all lakes sampled with the standard method for fish during 2005-2008.

The Finnish selection of lakes had the most even geographical distribution in relation to the total area of the country. It consisted of one year results of lakes sampled during 1996-2008. The aim was to include the same number of reference and impacted lakes (50+50), and to include lakes from ten different Finnish lake types. About one third of the lakes were from monitoring and research projects on acidification (Tammi et al. 2004) and eutrophication (Olin 2005). The rest of the Finnish lakes were WFD-related monitoring sites, including sites of surveillance monitoring as well as lakes monitored for the effects of diffuse nutrient loading on fish status. As the monitoring is conducted in cooperation with the environmental authorities, the water quality and pressure data were fairly well available for all lakes.

The Norwegian dataset consisted of one year results of lakes sampled during 1995-2008. Most of the lakes (n = 81 or 56 %) were from the national monitoring programme on acidification (SFT 2003). These lakes were generally selected in 1995 in connection with the “Northern European Lake Survey 1995” (Henriksen et al. 1998,

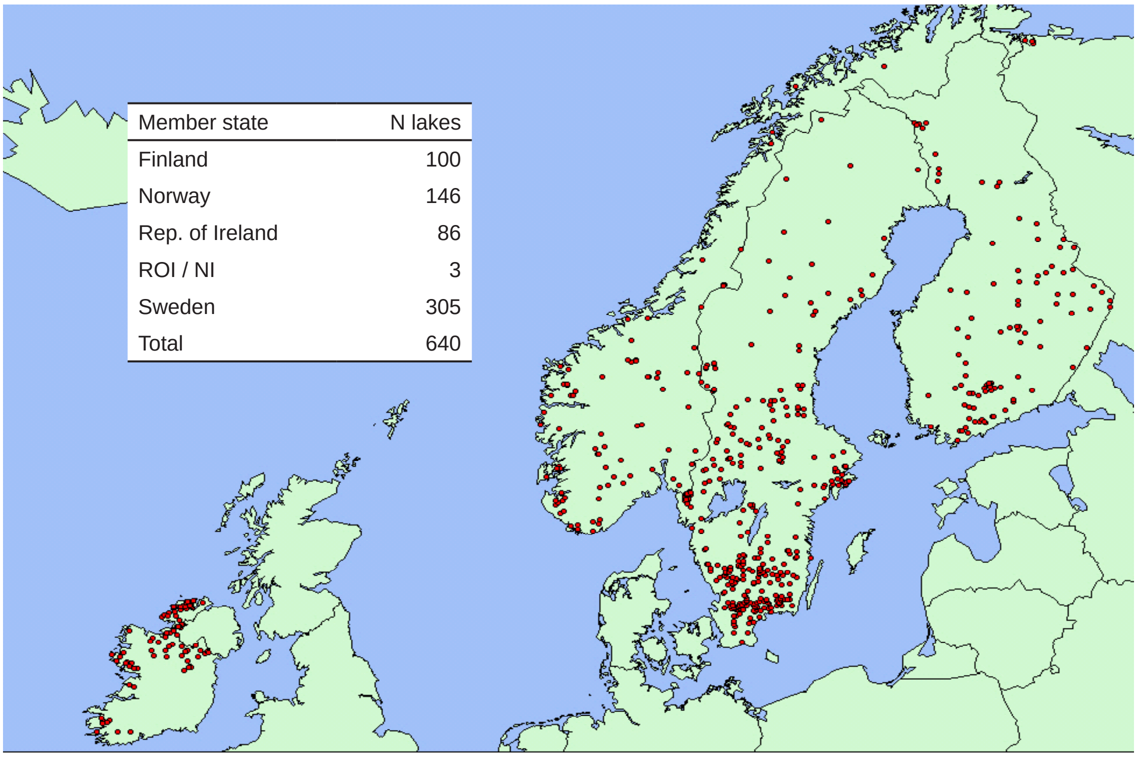

Figure 1. Distribution of lakes with fish data used in the Northern GIG pilot exercise. Three lakes are situated at the border between the Republic of Ireland and Northern Ireland (ROI/NI).

Rask et al. 2000, Tammi et al. 2003). These localities had a minimum size of 4 ha, and they were randomly chosen. They followed a certain geographical distribution to fulfil requirements regarding amount of precipitation, climatic conditions and biogeography (i.e. different fish communities). It was also required that the lakes would have a gradient in terms of acid-sensitivity, having relatively low values for ionic strength (< 50 µS/cm) and ANC (< 50 µeq/L). Thus, non-acid reference lakes in low-polluted areas were also selected. The study lakes were not affected by hydro power regulation, liming, industrial pollution (point source) and were not located close to heavily affected agricultural land. The maximum size of the monitoring sites size was 1 000 ha. The rest of the monitoring lakes were mainly from a study carried out in River Enningdal watershed in southeastern Norway, where the effects of acidification and liming on fish communities have been studied in recent years, total of 56 sites (cf. Hesthagen et al. 2007).

The Swedish dataset is a subset of 3 205 lakes in the National register of survey test-fishing (NORS, www.fiskeriverket.se). Lakes were selected if time series sampling occurred during 1994-2007. The selection was further based on availability of water chemistry data at the national data host (http://info1.ma.slu.se), such as pH, alkalinity, total phosphorus concentration and water colour. The resulting dataset was heavily aggregated in the southern highlands, where many lakes are regularly limed to mitigate effects of acidification.

This study was based on reduced fish data sets, as compared with that delivered to the European fish data base. The data templates included only the minimum data input for metrics and indices according to Finnish and Swedish assessment methods, respectively (Annex III). Calculations of fish metrics and indices were made independently by the Swedish and Finnish partners, respectively, for each combination of lake and sampling event that the partners wanted to include. Results (see variables in Annex III) were then compiled by matching two data files based on key variables for each lake and fishing date (e.g. the first date if gillnets were set on two or more consecutive nights). For analyses in this report, only the last sampling year per lake was included.

The final fish data set was created in SPSS 15.0, by matching original data from excel-files. Fish data were matched with lake characteristics and pressure data extracted from the European fish data base. No decision was made in advance concerning common intercalibration types or suitable pressures for intercalibration. Whenever possible, the lakes were classified as Northern lake types (Table 2) and as Finnish lake types (Figure A.I.1 in Annex I).

The outcome of Finnish and Swedish assessment methods were compared using two different methods. First, overall relationships between values of fish indices were explored, within northern lake types comprising at least 20 lakes each, and within Finnish lakes types where at least two countries contributed ten or more lakes each. Pearson's correlation and R^2-values of linear regression were used as measures of similarity between the fish indices. Secondly, country-specific distributions of status classes derived by each method were compared graphically with distributions of reference and impacted lakes, according to national pre-classification.

Scatterplots, bars and boxplots were used to illustrate variation within and between countries in some lake characteristics and pressure variables, as well as for index response in gradients of total phosphorus and pH. Loess fit was used to illustrate non-linear relationships between paired observations. The default of 50 % of the data points was used to calculate a local smoother, for drawing a fit line using iterative weighted least squares. Boxplots and scatterplots were likewise used to explore some additional issues, e.g. 1) confounding effects of low species richness on performance of the Swedish fish index EQR8 in reference lakes, and 2) effects of high proportion of non-native species on values of some fish metrics in the Swedish assessment method (Annex II).

Table 2. Description of Northern lake types, used in previous intercalibration of phytoplankton (modified from Table 2.51 in Poikane (2008)).

Type	Lake characterisation	Altitude (m above sea level)	Mean depth (m)	Geology alkalinity (meq/l)	Colour (mg Pt/l)	Lake size (km^2)
L-N1	Lowland, shallow, siliceous (moderate alkalinity) clear, large	< 200 m	3–15	0.2–1	< 30	> 0.5
L-N2a	Lowland, shallow, siliceous (low alkalinity) clear, large	< 200 m	3–15	< 0.2	< 30	> 0.5
L-N2b	Lowland, deep, siliceous (low alkalinity) clear, large	< 200 m	> 15	< 0.2	< 30	> 0.5
L-N3a	Lowland, shallow, siliceous (low alkalinit), organic (humic) large	< 200 m	3–15	< 0.2	30–90	> 0.5
L-N5a	Mid-altitude, shallow, siliceous (low alkalinity) clear, large	200-800 m	3–15	< 0.2	< 30	> 0.5
L-N6a	Mid-altitude, shallow siliceous (low alkalinity), organic (humic) large	200-800 m	3–15	< 0.2	30–90	> 0.5
L-N8a	Lowland, shallow, siliceous (moderate alkalinity), organic (humic), large	< 200 m	3–15	0.2–1	30–90	> 0.5

Results

Lake characteristics and pressures

Most of the study lakes did not belong to any of the previously defined Northern lake types, and only one type (L-N5a) was represented by at least ten lakes each in more than two countries (Table 3). Some lakes had missing values for essential lake characteristics, but most of the lakes were too small, too shallow, too humic, or otherwise different from the seven northern lake types. In contrast, all but 42 lakes were classified into one of the Finnish lake types (Figure A.I.1), and six types were common in more than one country. The number of lakes with valid lake types were further reduced in lakes pre-classified as reference or impacted lakes.

Swedish lakes covered wide ranges in lake characteristics, e.g. from low to high values of humic content and alkalinity (Figure 2a). Norwegian lakes generally had low values in both gradients. Finnish lakes usually had moderate to high humic content and low to moderate alkalinity. Finally, most Irish lakes had low to moderate humic content, but moderate to high alkalinity. The data set revealed a contrasting pattern of pressures, with an overall positive correlation between total phosphorus concentration and pH ($r = 0.352$, $P < 0.001$, $N = 589$ lakes, Figure 2b). Data on land use were not available for the Irish lakes, but the Fennoscandian lakes generally had a rather low proportion of agricultural land in their catchments compared to the boundary suggested for reference lakes in the European fish data base (Figure 3). At any proportion of agricultural land, total phosphorus concentrations appeared to be highest in Finland, intermediate in Sweden and lowest in Norway. Catchments of most Fennoscandian lakes were dominated by forests and other more or less natural land (Figure 4). High proportions of natural land often coincided with low or negative alkalinity, implying high sensitivity to acidification.

Many of the northern GIG lakes had missing data for several pressures categorised in the European fish data base (Table 4). Among lakes with classified pressure, the majority were generally considered to have insignificant pressure. An outstanding exception was “Bio- and/or chemical manipulation”, reflected by high numbers of Swedish and Norwegian lakes with regular liming against negative effects of acidification.

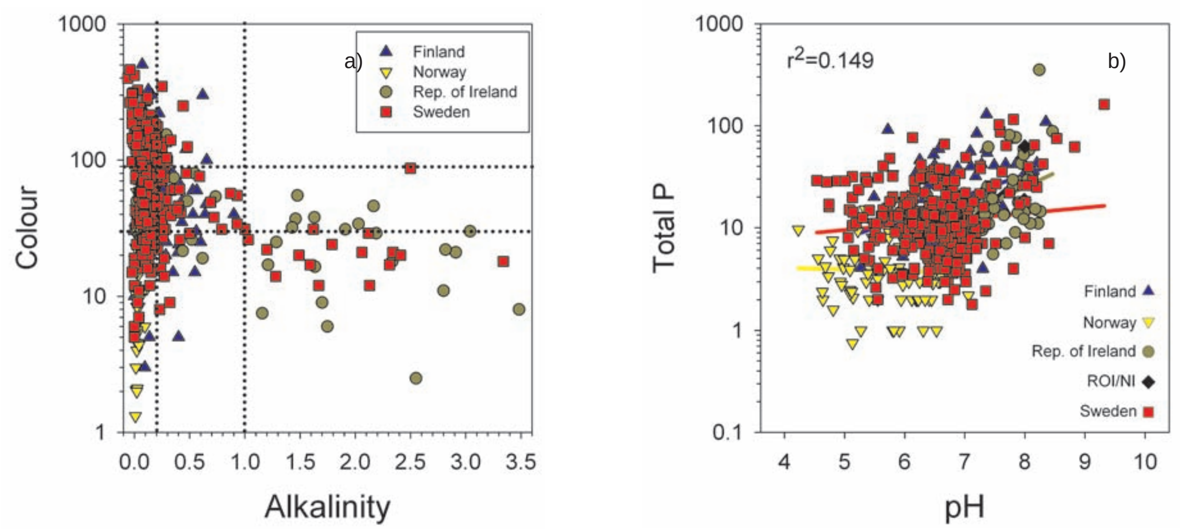

Figure 2. Variation in some lake characteristics and pressures within northern GIG lakes.
a) water colour (mg Pt/L, log scale) and alkalinity (or acidity, meq/L), paired data from 100 Finnish, 41 Norwegian, 58 Irish and 305 Swedish lakes. b) total phosphorus concentration (µg/L, log scale), paired data from 94 Finnish, 80 Norwegian, 61 Irish, 3 Irish/Northern Ireland and 304 Swedish lakes. Reference lines in a) delimit low, moderate, and high values according to the northern typology in Table 1. In b) the overall relationship is indicated by linear and loess fits, respectively.

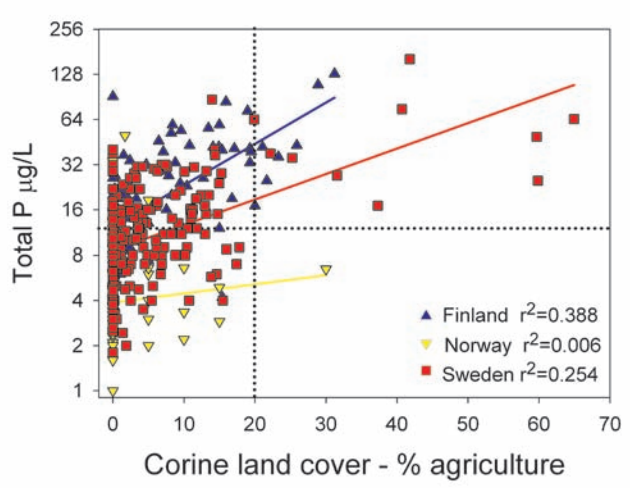

Figure 3. Total phosphorus concentration (µg/L, log scale) in relation to percent agricultural land in the catchments. Horizontal and vertical reference lines are set at 12 µg/L and 20 %, i.e. boundaries suggested for reference lakes in the European fish data base. Paired data from 93 Finnish, 80 Norwegian and 214 Swedish lakes.

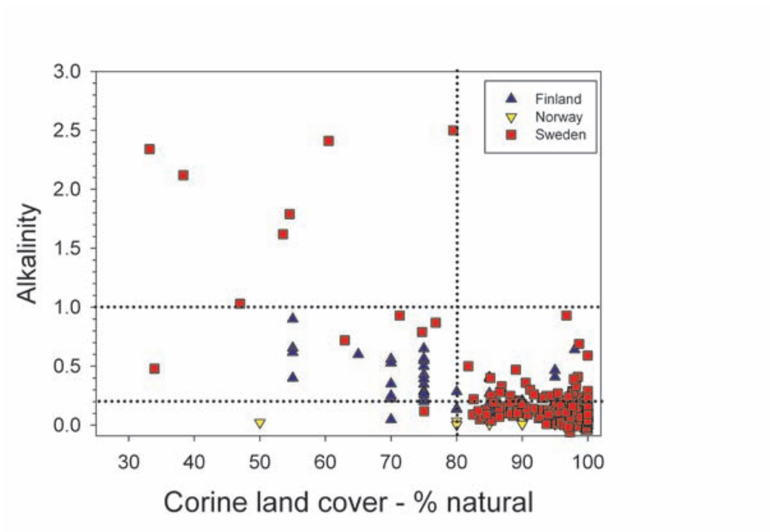

Figure 4. Alkalinity (meq/L) in relation to percent natural land in the catcment. Horizontal reference lines are set at 0.2 and 1, delimiting lakes of low, moderate and high alkalinity. The vertical reference line is set at 80 %, i.e. boundary suggested for reference lakes in the European fish data base. Paired data from 93 Finnish, 42 Norwegian and 214 Swedish lakes.

Table 3. Number of lakes classified as Northern and Finnish lake types, respectively. Within countries, types with at least ten lakes are highlighted in yellow. The total number of lakes within types, are similarly highlighted, whenever two or more countries contributed at least ten lakes each. The number of lakes within types is further divided dependent on pre-classified status as reference or impacted.

Lake type		Finland	Norway	Rep. of Ireland	ROI / NI	Sweden	Total	Reference/impacted		
								Missing	I	R
Northern lake type	L-N1	1		1		2	4		3	1
	L-N2a	3	3	1		3	10		3	7
	L-N2b	1	2			2	5		2	3
	L-N3a	8		5		21	34	1	21	12
	L-N5a		21			10	31	9	8	14
	L-N6a		3			26	29	2	17	10
	L-N8a	6		4		5	15	2	11	2
	Valid	19	29	11	0	69	128	14	65	49
	Missing	81	117	75	3	236	512	110	289	113
	Total	100	146	86	3	305	640	124	354	162
Finnish lake type	1	19	96	15		36	166	70	42	54
	2	15	29	23	1	60	128	42	58	28
	3	11	1	3	1	11	27	13	14	0
	4	1		1		1	3	1	1	1
	5	3					3	3	0	0
	6	16	19	3		38	76	36	34	6
	7	2		7		12	21	7	14	0
	8	11		19		41	71	17	44	10
	9	12		8		61	81	17	61	3
	12	10	1	7		4	22	11	11	0
	Valid	100	146	86	2	264	598	217	279	102
	Missing				1	41	42	5	26	11
	Total	100	146	86	3	305	640	222	305	113

Table 4. Categorised pressures in the European fish data base. The 640 northern GIG lakes are distributed between numbers with missing data, and numbers with significant or insignificant pressure.

Pressure	Missing data	Significant pressure	Insignificant pressure
Natural land use < 80 %	194	53	393
Population density > 10 / km^2	241	32	367
Natural acidification	269	7	364
Catchment impounded by upstream barriers	334	12	294
Lack of connectivity (downstream)	330	36	274
Significant water level fluctuation	40	6	594
Shoreline (bank) modified	345	11	284
Urban and/or industrial discharge	345	12	283
In-lake activities	345	4	291
Stocking	345	14	281
Bio &/or chemical manipulation	40	227	373
Exploitation of fish population by fishery	337	7	296

Comparison of national assessment tools

The values of Finnish EQR4 and Swedish EQR8 were positively correlated ($r = 0.421$, $P < 0.001$, $N = 596$ lakes). The linear relationships were, however, weak or insignificant within most lake types compared (Figure 5). The best relationship was for Northern lake type L-N6a ($r = 0.694$, $P = 0.001$, $N = 20$), but still the linear fit explained less than half of the variance. This lake type was unfortunately not common in any country except for Sweden. Within Finnish lake types, the highest correlation was in type 3 ($r = 0.586$, $P = 0.001$, $N = 27$ lakes), including 1-11 lakes from each country.

The distribution of status classes differed considerably, depending on whether lake status was pre-classified or assessed using fish indices EQR4 or EQR8 (Figure 6). The Finnish EQR4 failed to detect most of the impacted lakes in Ireland and Sweden, possibly related to other pressures than eutrophication, e.g. exotic species or acidification and liming. On the other hand most Irish and Norwegian lakes attained poor or bad status using the Swedish EQR8, indicating that assessments were too conservative. The inconsistency between assessment methods was similarly revealed by stacked bars of status classes using the contrasting method (Figure 7). Few lakes actually achieved the same ecological status with both national methods. Using Finnish EQR4, most lakes were assessed as high to moderate ecological status. With Swedish EQR8, most lakes were grouped into good to poor status, indicating a systematic difference in definitions of reference conditions and in boundary setting procedures.

Index values of Finnish EQR4 were generally higher than that of Swedish EQR8, at comparable levels of pressure (Figure 8). Both of the national fish indices responded nonlinearly to the total phosphorus gradient, and similar responses to the pH gradient were probably explained by the contrasting but correlated pressures in the data set. Using EQR4, the Finnish, Irish and Swedish lakes responded similarly, with decreasing values in the upper parts of both gradients (Figure 9). Norwegian lakes achieved relatively low values of both fish indices, with no or positive responses to increasing total phosphorus and pH. Swedish lakes tended to have higher EQR8-values, along both pressure gradients, compared to lakes from the other countries. The Irish lakes had very low values of EQR8, with no response at all to increasing levels of total phosphorus or pH. The country-specific index responses indicated differences in the main pressures, perhaps in combination with different natural conditions.

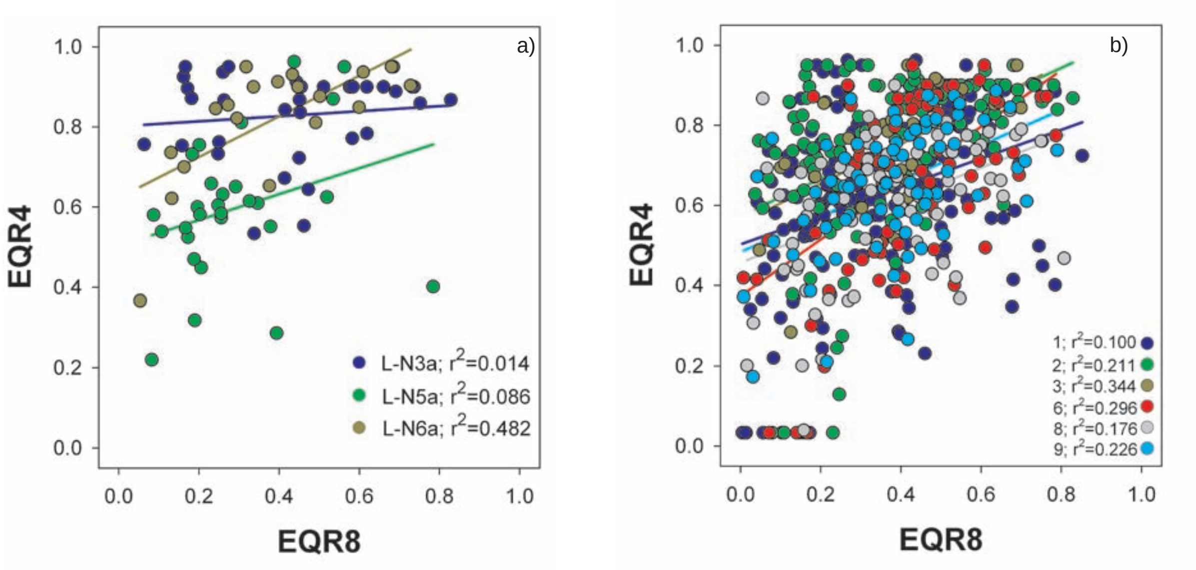

Figure 5. Relationships between values of Finnish EQR4 and Swedish EQR8, within a) three northern lake types and b) six Finnish lake types. Number of paired observations as in Table 2, except for northern types L-N3a (33) and L-N6a (20), and Finnish type 9 (80).

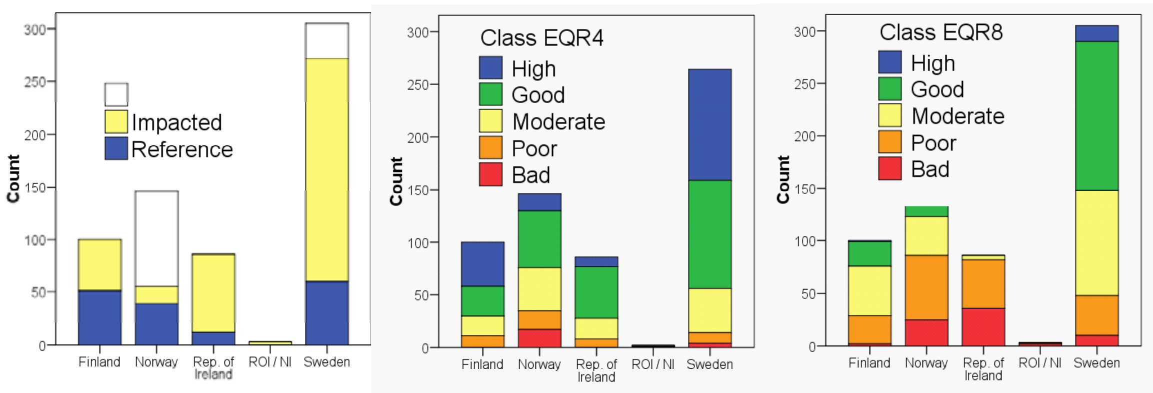

Figure 6. Distribution of northern GIG lakes, depending on pre-classified impact or reference status (N = 640, including lakes with unknown status), and ecological status using Finnish EQR4 (N = 598) and Swedish EQR8 (N = 639), respectively.

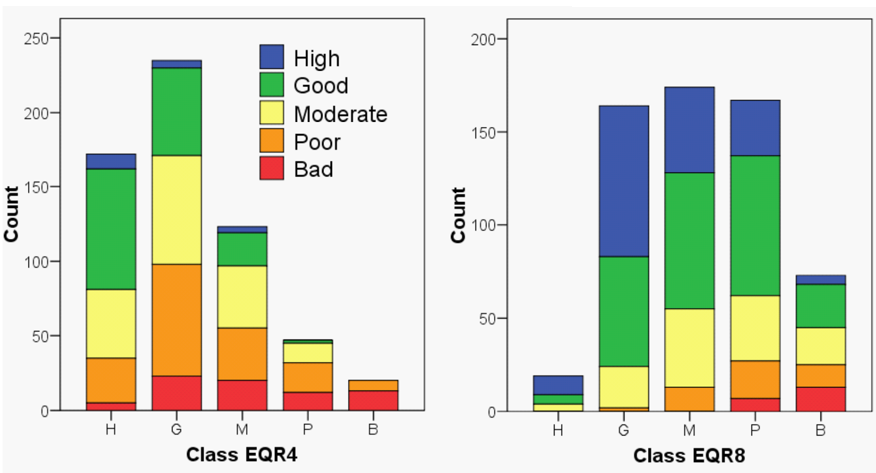

Figure 7. Distribution of status classes by the contrasting method, within status classes using Finnish EQR4 (left panel) and Swedish EQR8 (right panel). N = 596 lakes with paired observations.

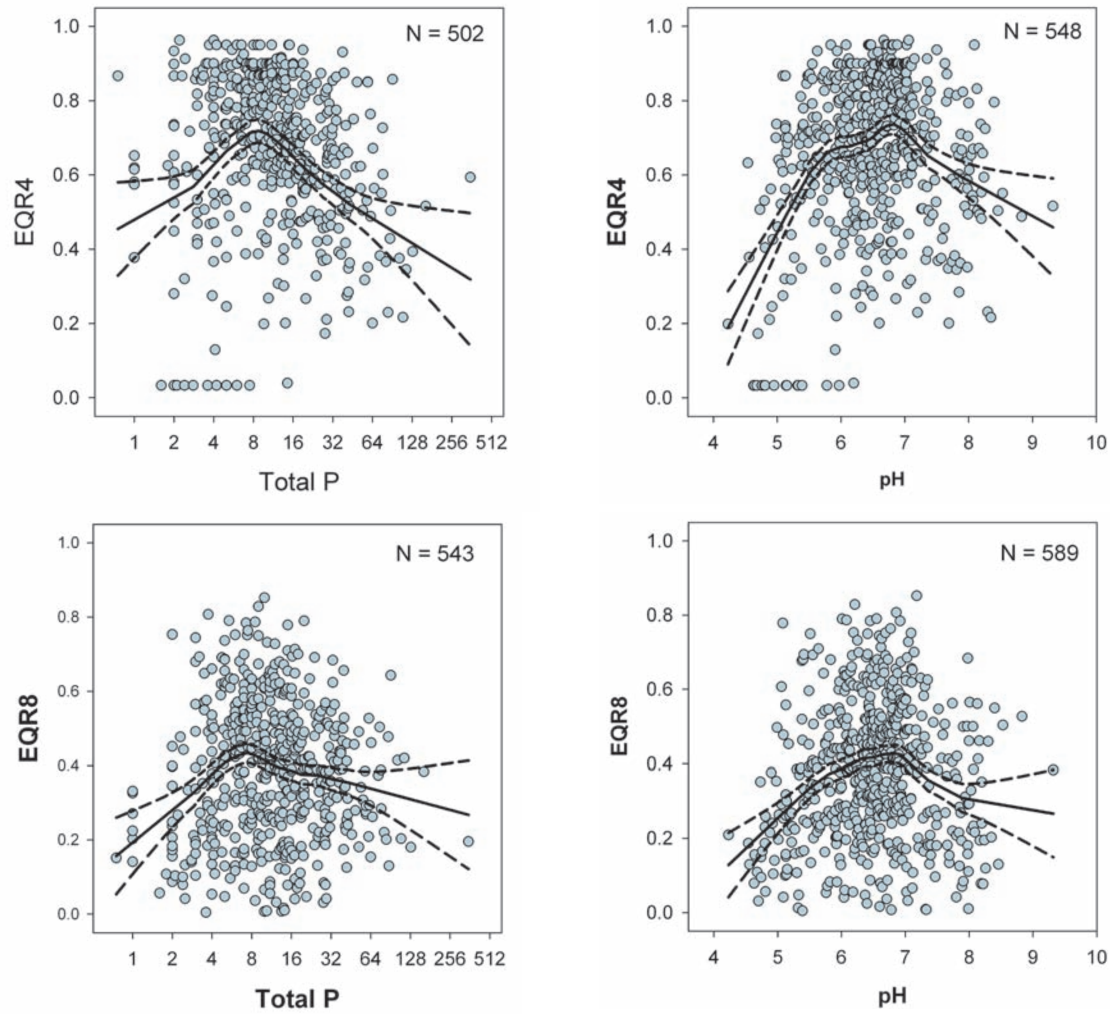

Figure 8. Overall response of Finnish EQR4 (upper panels) and Swedish EQR8 (lower panels) to total phosphorus concentration (μg/Lt, log scale, left panels) and pH (right panels). Nonlinear responses indicated by Loess fit (solid lines) and upper and lower limits of 99 % confidence intervals (dashed lines).

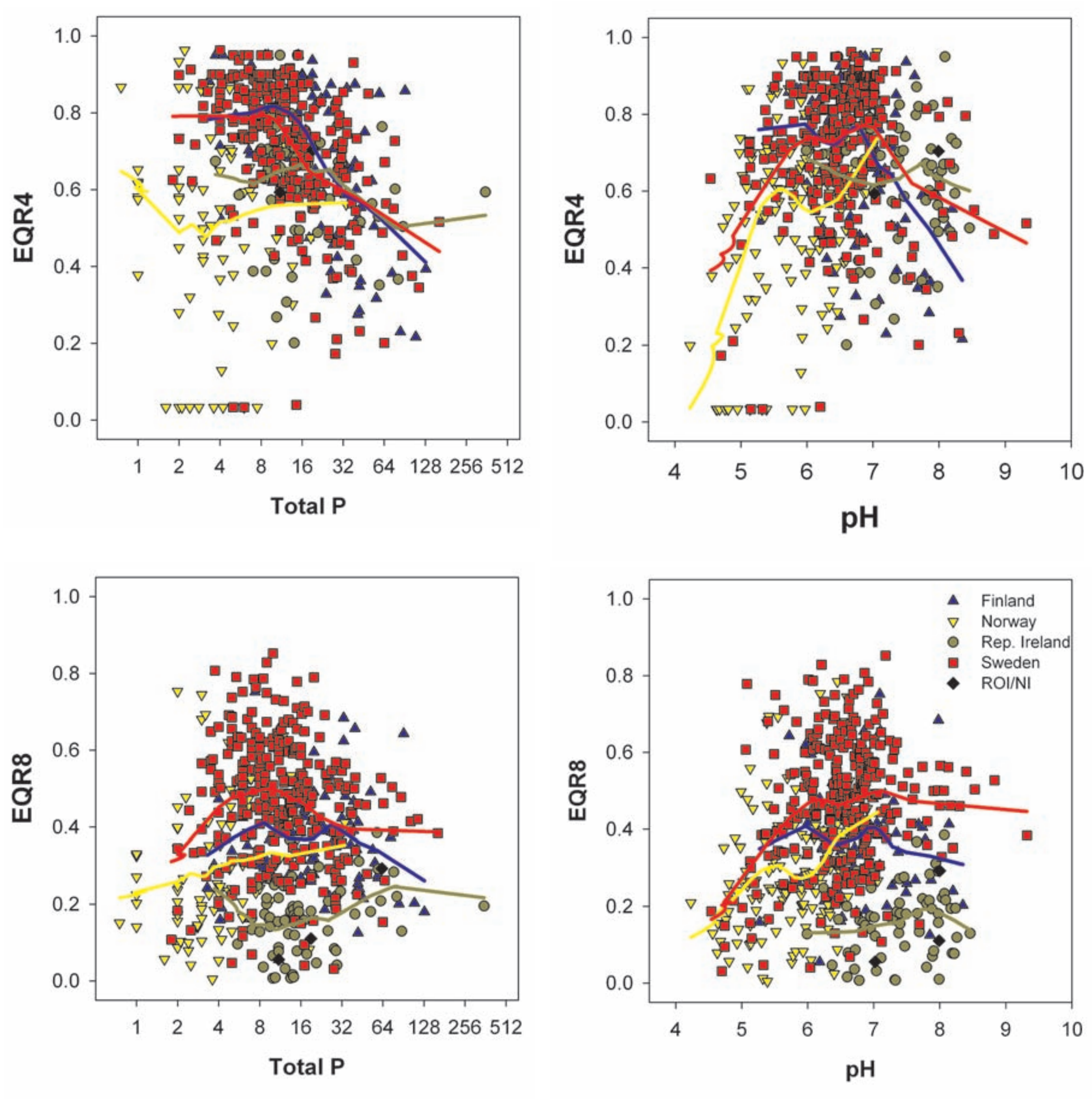

Figure 9. Within countries response of Finnish EQR4 (upper panels) and Swedish EQR8 (lower panels) to total phosphorus concentration (µg/L, log scale, left panels) and pH (right panels). Nonlinear responses indicated by Loess fit.

Additional issues

Norwegian lakes generally had lower fish species richness than lakes from the other countries. For example, 87 of the Norwegian lakes had zero or one fish species, compared to only 2, 12 and 17 of the Finnish, Irish and Swedish lakes. The Swedish index was clearly influenced by low species richness (Figure 10). For lakes with only one fish species, most index values were below the good-moderate boundary, independent of impact or reference status.

Native fish species made up 90–100 % of the fish biomass in the Finnish and Swedish lakes, and in most of the Norwegian lakes. In contrast, the Irish data set included many lakes with fish communities dominated by non-native species. Lakes with low proportion of native fish species got extremely low values of some metrics used for the Swedish EQR8 (Figure 11).

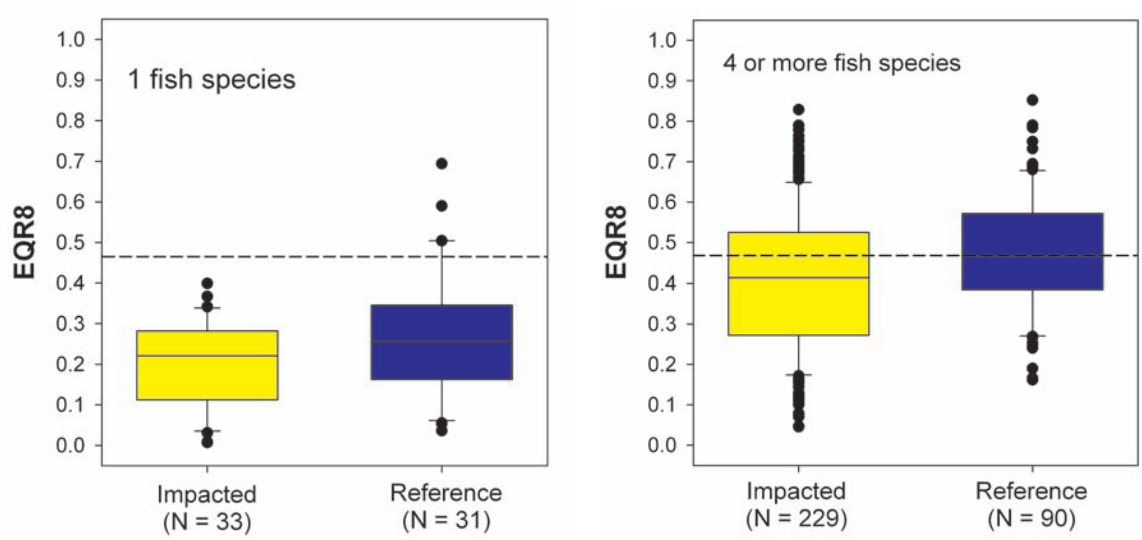

Figure 10. Distribution of Swedish EQR8 values within impacted and reference lakes, depending on fish species richness. The horizontal reference line is the boundary between good and moderate ecological status.

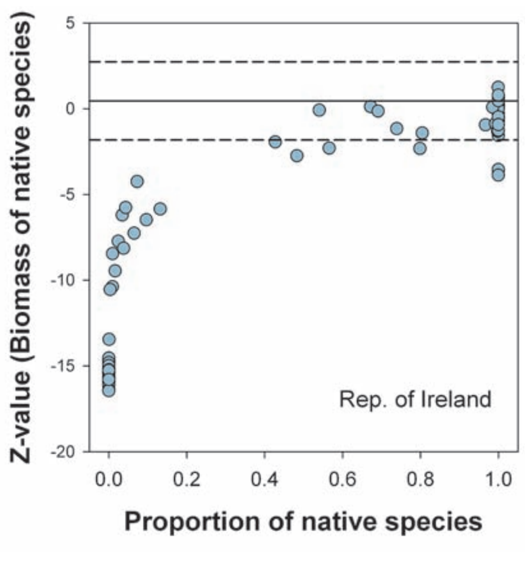

Figure 11. Example of standardised fish metric (Z-values) response to biomass proportion of native fish species in 86 Irish lakes. Horizontal reference lines are set at the reference value ± 2 standard deviations.

Discussion

Data compilation experiences

For many reasons, it would have been better to postpone the northern GIG analyses, until all fish and lake data were available and quality assured in the European data base. Other European projects previously stressed the need for proper relational databases (e.g. Beier et al. 2007a, Moe et al. 2008). The time schedule of the pilot study, however, necessitated preliminary analyses to be done before the central database was ready for use. Inconsistent lake identities (i.e. misspelled or duplicate lake names) prevented a fully automatic matching of the northern fish dataset with that of lake characteristics and pressures. A more time-consuming lake-by-lake matching was sometimes applied, which might have introduced some errors in the combined data set.

Another annoying problem was a high frequency of missing values in certain lake characteristics and pressures, preventing some lakes with fish samples to be used in all analyses and illustrations. Typology data needed for estimation of reference values differed somewhat between Finnish and Swedish assessment methods (Annex I and II). Complete lake characteristics enabled calculations of the Finnish EQR4 for 598 lakes and the Swedish EQR8 for 639 lakes, out of 640 lakes included in this study. Missing values for pressure variables further reduced the number of paired observations to different degrees. Fish sampling was never ensured in all lakes in the first intercalibration register (Noges et al. 2005), or in the lakes finally used in the first intercalibration of other biological quality elements (Poikane 2008). The present data set was primarily a compilation of available samples from 1994-2008, more or less independent of what other lake-specific data could be easily accessed.

Comparability of assessments and pressures

The present analyses revealed only a weak or insignificant correlation between the Finnish and Swedish index values, within most lake types compared. Low consistency between the methods was earlier indicated, when applying both indices to smaller sets of Finnish and Swedish lakes (Sairanen et al. 2008, unpublished material). Some of the differences could be traced to low performance of the Swedish fish index in Northern Sweden (Holmgren 2007). Differences were also related to different metrics selected for multi-metric indices, related to testing sensitivity against different pressures (Annex I and II). Both fish indices aimed at detecting a response to eutrophication, measured as total phosphorus concentrations and assumed to be positively related to agricultural land use. This study revealed country-specific relationships between total phosphorus concentration and proportion of agricultural land. At a certain level of agricultural land use the total phosphorus concentration was generally highest for Finnish and lowest for Norwegian lakes. A corresponding pattern also appeared in the Northern European lake Survey 1995 (Henriksen et al. 1998). This is probably due to differences in terrestrial relief and bedrock and soil properties between the countries, and may have been affected also by the different fertilization practices of the countries. In the present study, a complex mixture of contrasting pressures was most probably the reason for nonlinear index responses to gradients of total phosphorus and pH. However, in the parts of the gradients where fish community responses are expected (pH 4 to 7 and total phosphorous concentrations 20 to 200 µg/l), the EQR values related to these parameters were, in fact, linear. Still, to elucidate responses to certain pressures, any contrasting pressures should be handled separately. Procedures also differed in definition of reference conditions and in setting boundaries between status classes. Similar differences were found between Finnish and Swedish assessment methods, when comparing national fish indices for rivers (Beier et al. 2007b).

Different from the Swedish method, the Finnish reference values and class boundaries are calculated from data including both benthic and pelagic gillnets. Thus, as in this study only benthic data were used, the classification results according to the Finnish system may be biased. According to limited data of Sairanen et al. (2008), benthic gillnets give slightly higher total biomass (BPUE) and numbers of fish (NPUE), but lower biomass proportion of cyprinids, compared to data including benthic and pelagic gillnets. Classifications using the Finnish method without pelagic data, as in this study, may thus be too conservative.

Additional experience of the data exchange

The inclusion of novel comparisons with Norwegian and Irish lakes high-lighted additional problems of low index performance, related to low species richness and/or high proportions of non-native fish species. More than half of the Norwegian lakes had only one species, which contributed to low performance of the Swedish EQR8. Most of the Irish lakes were considered impacted because of non-native species. This provided an excellent opportunity to test metric response to exotic species, which was not possible in the original Swedish data set (Holmgren et al. 2007). At a high proportion of non-native species in Irish lakes, the relative biomass and abundance of native species were extremely low in relation to estimates of lake-specific reference values. A peculiar fact was that some of the most frequently occurring fish species in Fennoscandian lakes were not native in Ireland, e.g. perch (*Perca fluviatilis*), roach (*Rutilus rutilus*) and pike (*Esox lucius*). Probably the only truly native fish species in Ireland are euryhaline species, e.g. Arctic char (*Salvelinus alpinus*), salmon (*Salmo salar*), brown trout (*Salmo trutta*), three-spined stickleback (*Gasterosteus aculeatus*), eel (*Angulla anguilla*), flounder (*Platichthys flesus*) and pollan (*Coregonus autumnatis*) (Kelly et al. 2007).

Concluding remarks

The present pilot study did not aim at covering all of the "expected key elements" in the final intercalibration report (WG ECOSTAT 2009), i.e. 1) national assessment methods, 2) common intercalibration types, 3) data bases, 4) intercalibration option used, 5) reference conditions/benchmarking, 6) boundary comparison/setting, and 7) boundary EQR values established for the type/quality element/pressure combination of common metrics and/or each national WFD assessment method. Instead of following a predefined step-by-step procedure, this study was an overview of existing assessment methods and data. The northern fish group definitely has some advantages compared with that of fish groups of other GIG's, e.g. two assessment methods and existing fish data from a relatively high number of lakes sampled with standardised gillnets. Still a lot of questions remain to be solved, including decisions on common intercalibration types and intercalibration options, as well as all work on harmonisation of reference conditions and boundaries between status classes. Development of new Nordic metrics and indices might be considered. This would, among other things, solve the problem with different boundary setting procedures of the present national methods. With a common assessment system the intercalibration exercise can concentrate on the harmonisation of reference conditions and class boundary setting, which is the preferred option in the intercalibration process (WG ECOSTAT 2009).

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Annex I

Summary of the Finnish assessment criteria – EQR4

Most of the data is from standard gillnet test fishing. This is most crucial because the calculations for the EQR4 tool are based on sampling with Nordic gillnets. Electrofishing has been conducted in the littoral of some regulated lakes but not used for classification yet. All available data (including previous study or restoration projects, catch statistics of local fishermen, fishery inquiries) is used for the metrics “indicator species”. In many cases, the gillnet data is still the only available data.

Finnish lakes are categorised into 12 lake types based on physical-chemical and geographic properties (Figure A.I.1). For the metrics calculated from the gillnet data, reference values (RV) and class boundaries (CB) are based on the data of type-specific reference lakes (n = 133). Preliminary class boundaries have been calculated for 10 lake types (in some metrics, nearest lake types are combined due to lack of data) and used in classification. For lake type “lakes with low retention time”, the existing boundaries are adapted from the nearest lake types. Lake type “high altitude lakes” can not yet be classified. Lake type “Naturally eutrophic and high calcium lakes” is lacking reference sites and “best left” sites (n = 13) are used for calculating RVs and CBs.

The ecological classification by the metric “indicator species” is defined as expert judgement based on presence, absence/extinction of certain indicator species (Table A.I.1). This metric is the same for all lake types. However, for lakes <200 ha the criteria are less demanding.

The sensitivity of seven metrics were tested: “number of fish species”, “indicator species”, “total biomass of fish”, “total number of individuals”, “species diversity”, “biomass proportion of cyprinids” and “biomass proportion of piscivorous percids”. Reproduction of sensitive fishes is not yet tested due to lack of data. Four metrics were found to be sensitive to eutrophication pressure, which is at present the main problem in Finnish lakes. These metrics are “indicator species”, “total biomass of fish (totBPUE)”, “total number of individuals (totNPUE)” and “biomass proportion of cyprinids”. They are used for official classification of Finnish lakes (EQR4).

The reference value (RV) is the median value of the gillnet data of the type-specific reference lake group. EQR-value is calculated by dividing the observed value with the reference value if the values of the metrics decrease with human impact. When the values of the metrics increase with human impact, EQR-value is calculated by dividing the reference value with the observed value. “Total biomass of fish” and “total number of individuals”, are bidirectional metrics: both exceptionally high and low values decrease the classification. Low values do not affect the classification unless there is environmental pressure that decreases the fish abundance.

To calculate the class boundaries, EQR-values were calculated for each reference lake. For most lake types, the EQR-values of each type-specific reference lake group produced the EQR-distribution from where the class boundaries were calculated. The high/good boundary was decided to be the 25th percentile from the EQR-distribution of the reference lakes. Other boundaries were set to even distances from high/good boundary to theoretical/observed type-specific min/max-value. In the lake type “Naturally eutrophic and high calcium lakes” the H/G boundary is the median value of the “best left” sites. For small totBPUEs or totNPUEs, the G/M boundary is the observed minimum, type-specific value in the reference data.

EQR-values from different metrics have different ranges and should be scaled to range from 0 to 1. This is done by comparing the observed value to the class boundaries (Table A.I.2) and selecting the corresponding EQR-value (“point value”: 0.1, 0.3, 0.5, 0.7 or 0.9) – this system was used in the official Finnish classification based on integrated approach of all biological quality elements. (another option in EQR calculations would have been to use certain equations to produce continuous and more “accurate” scaled EQR-values)

The fish based classification (EQR4) is the median of the EQR-values of the four metrics.

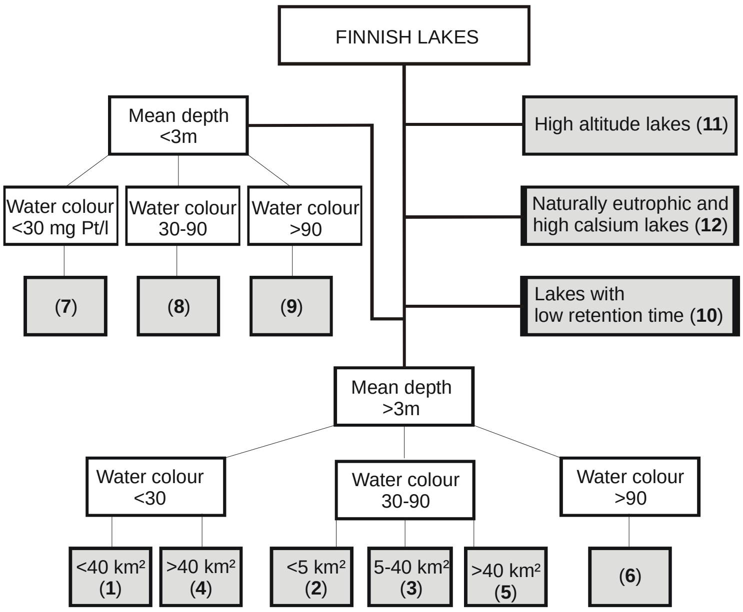

Figure A.I.1. Finnish lake typology.

Table A.I.1. Criteria for EQR according to indicator species. Documented extinction of indicator species decrease classification to next lower class. Stocking of indicators does not increase classification.

EQR	Criteria, >200 ha lakes	Criteria, <200 ha lakes
0.9	Natural population: *S. alpinus, C. lavaretus, P. phoxinus, B. barbatula, T. quadricornis* >1 species → 0.05 extra points for each	As in >200 ha lakes
0.7	Natural population: *L. lota, S. trutta, C. albula, T. thymallus, C. gobio, C. poecilopus, P. pungitius* >1 species → 0.05 extra points for each	Normal population structure of *P. fluviatilis, E. lucius* and/or *R. rutilus*
0.5	Normal population structure of *P. fluviatilis, E. lucius* and/or *R. rutilus*	Abnormal population structure of *P. fluviatilis, E. lucius* and/or *R. rutilus*
0.1	Abnormal population structure of *P. fluviatilis, E. lucius* and/or *R. rutilus*	Very abnormal population structure of *P. fluviatilis, E. lucius* and/or *R. rutilus*

Table A.1.2. The reference values (RV) and class boundaries (H/G = high/good, etc.) for 3 metrics.

Metrics	Type	RV	H/G	G/M	M/P	P/B
Total biomass (low BPUEs) g /gillnet night	1	863	259	194	130	65
	2	898	227	170	113	57
	3&5	596	384	288	192	96
	4	895	614	460	307	153
	6	715	236	177	118	59
	7	1628	937	703	469	234
	8	1552	1001	751	501	250
	9	997	661	495	330	165
	12	2224	588	441	294	147
Total biomass (high BPUEs) g /gillnet night	1	863	1240	1493	1874	2518
	2	898	1229	1475	1843	2457
	3 & 5	596	841	1024	1308	1812
	4	895	987	1231	1634	2431
	6	715	822	973	1193	1540
	7	1628	2327	2673	3138	3801
	8	1552	2003	2363	2880	3688
	9	997	1456	1834	2478	3816
	12	2224	2224	2653	3288	4323
Total number (low NPUEs) ind. /gillnet night	1	32.9	14.9	11.2	7.5	3.7
	2	38.0	10.6	7.9	5.3	2.6
	3 & 5	30.8	18.6	14.0	9.3	4.7
	4	38.6	24.1	18.1	12.1	6.0
	6	25.9	8.5	6.4	4.3	2.1
	7	54.8	34.4	25.8	17.2	8.6
	8	53.4	51.3	38.5	25.7	12.8
	9	35.3	29.9	22.4	14.9	7.5
	12	94.5	29.9	22.4	15.0	7.5
Total number (high NPUEs) ind. /gillnet night	1	32.9	48.3	59.7	78.0	112.7
	2	38.0	51.4	63.2	82.0	116.8
	3 & 5	30.8	38.6	47.3	68.8	85.3
	4	38.6	47.5	60.3	82.2	129.5
	6	25.9	31.0	37.8	48.5	67.4
	7	54.8	88.6	106.7	134.1	180.6
	8	53.4	84.4	98.4	118.0	147.3
	9	35.3	44.7	57.7	81.5	138.3
	12	94.5	94.4	114.1	144.2	195.8
Cyprinid biomass proportion %	1	35.9	53.9	60.9	70.0	82.4
	2	49.9	59.1	65.9	74.3	85.3
	3&5	37.5	44.9	52.1	62.0	76.6
	4	40.5	45.8	52.9	62.8	77.1
	6	37.1	58.7	65.4	74.0	85.0
	7 & 8 & 9	50.5	65.3	71.5	79.0	88.3
	12	55.3	55.3	62.2	71.2	83.2

Annex II

Summary of the Swedish assessment criteria – EQR8

This assessment tool (EQR8, based on eight fish metrics) has many similarities with a previous Swedish multi-metric fish index. Both are calculated from standardised sampling with Nordic gillnets. They have several metrics in common, e.g. the number of native fish species and relative measures of abundance and biomass. Both methods consider metrics to depend on factors like altitude, lake area and maximum depth. The observed values were therefore evaluated in relation to lake-specific reference values. The previous fish index was developed using all available data to estimate typical rather than reference values. Now the latest sampling event in each lake was used, and reference lakes were selected based on low values in acidity (pH > 6), nutrients (total phosphorus < 20 µg/l) and land use (agriculture < 25 % and built-up area < 1 % of the catchments). Limed lakes were also excluded from the reference data set. The selected lakes were assumed to be a mixture of high and good status. From a total number of 1 157 lakes with standardised fish sampling, only 508 lakes could be classified by the reference filter. The final data set included 116 reference lakes, 168 lakes were disturbed as well as 224 limed lakes that initially passed the reference filter.

The index development started, by testing the response of 16 candidate metrics to the impact of acidity or nutrients. Several metrics responded in the same directions in both acidic and limed lakes. The outcome was used to select the most relevant and non-redundant metrics for a new multimetric index. The performance of old and new indices were compared. Both indices worked better for distinction between acidic and reference conditions, than for detecting nutrient pressure. The new index was, however, somewhat better than the old one for separation between nutrient rich and reference lakes.

Short guide for practical use of EQR8

This section summarises the prerequisites of using EQR8, and how to calculate metric values, reference values and all steps until suggested boundaries for classification of index values. The Institute of Freshwater Research will do all calculations for Swedish fish sampling data delivered in the format required by the National Register of Survey test-fishing (NORS).

Prerequisites of status assessment using EQR8

1. The lake should have natural conditions suitable for fish, an assumption based on historical data or expert judgement using knowledge from conditions in similar lakes.
2. Data from standardised time series sampling with Nordic gillnets (EN-14 757).
3. Data on altitude, lake area, maximum depth, annual mean in air temperature, and location below (0) or above (1) the highest coast line after deglaciation (HC).

4. Assessments should be treated with caution if environmental factors are not within the intervals found in the reference lakes used for calibration; altitude 10 – 894 m above sea level, lake area 2 – 4 236 ha, maximum depth 1 – 65 m, annual mean in air temperature -2 – 8 °C.

Included fish metrics

EQR8 uses observed values in eight metrics. All of them are primarily calculated from the benthic catch in a standardised test-fishing event. If any more species is caught in pelagic nets, it will, however, be included in the number of native fish species. Some metrics need identification of native species or species in the family Cyprinidae. The essential information is found in the section "Fish species found in Swedish freshwaters". The eight metrics are;

1. Number of native fish species.
2. Simpson's Dn (diversity index based on number of individuals): calculated as $1 / (\Sigma P_i^2)$, where P_i = numerical proportion of species i, and the sum is taken for all species in the catch.
3. Simpson's Dw (diversity index based on biomass): calculated as $1 / (\Sigma P_i^2)$, where P_i = biomass proportion of species i, and the sum is taken for all species in the catch.
4. Relative biomass of native fish species: total biomass (g) of all native species, divided by number of nets.
5. Relative abundance of native fish species: total number of individuals of all native species, divided by number of nets.
6. Mean mass: biomass of all species (g) divided by the number of individuals.
7. Proportion of piscivorous percids (based on biomass in the total catch): The proportion of potentially piscivorous perch is 0 at fish length less than 120 mm and 1 at length above 180 mm. At intermediate length the proportion is calculated as 1 – ((180 – length) / 60). Individual mass of perch (g) is estimated as a · length (mm)^b, where a = $3.377 \cdot 10^{-6}$, and b = 3.205. Each individual mass is multiplied with the length-specific proportion piscivorous perch. The sum of the products is the biomass of piscivorous perch, which is then added to any biomass of pikeperch. Finally, the total sum of piscivorous percids is divided by the total biomass of all species in the catch.
8. Ratio perch / cyprinids (based on biomass): total biomass of perch divided with total biomass of all native cyprinids.

Procedure from metric values to combined index (EQR8)

1. Transformation of some environmental factors: The altitude is transformed as $\log_{10}(x+1)$, and $\log_{10}(x)$ is used for lake area and maximum depth.
2. Estimation of reference values: Use linear regression models, $Y = a + b_1 \cdot X_1 + \ldots + b_n \cdot X_n$, where a is intercept and b_1 - b_n are coefficients of regression for environmental factors ($X_1 – X_n$) according to Table A.II.1.
3. Transformation of some observed metric values: Metrics 4-5 are transformed as $\log_{10}(x+1)$ and $\log_{10}(x)$ is used for metrics 6 and 8.
4. Calculation of deviations from reference values (residuals): The residual of each metric is calculated as observed (or transformed) value minus reference value.
5. Calculation of standardised residuals (Z-values): Transformation to Z-values is achieved by division with the metric-specific standard deviation (SD) of residuals (SD_{resid}) in the reference data set (see Table A.II.1).

6. Transformation to probabilities (P-values) in the distribution of reference values: Get a two-tailed P-value for each Z-value, by using any statistical software (eg. SPSS where P = 2 . CDF. NORMAL(-ABS(Z-value),0,1).

7. Calculation of the combined fish index: Calculate EQR8 as mean value of P-values for the 3-8 metrics that can be calculated from a given catch.

Table A.II.1. Intercept and coefficients of regression for calculation of reference values, and standard deviation (SD_{resid}) needed for transformation to Z-values.

		Altitude	Lake area	Maximum depth	Annual ait temp.	HC	
Metric	intercept	$lg_{10}(x+1)$	$lg_{10}(x)$	$lg_{10}(x)$	(°C)	(0 or 1)	SD_{resid}
1. Number of native fish species	-0.410		2.534		0.347	-0.916	1.538
2. Simpson's D (numbers)	2.537	-0.460	0.380				0.570
3. Simpson's D (biomass)	1.223		0.345		0.153		0.753
4. Relative biomass of native species	3.666	-0.202	0.121	-0.394			0.202
5. Relativt number of native species	2.171	-0.397	0.081	-0.262	0.044		0.241
6. Mean mass (from total catch)	1.181	0.307			-0.038		0.235
7. Biomass proportion of piscivorous percids	0.057			0.198			0.175
8. Ratio perch / cyprinids (biomass)	1.223				-0.186		0.472

Classification of ecological status

Use the following class boundaries for values of EQR8:

Status	EQR8
High	> 0.72
Good	> 0.46 och < 0.72
Moderate	> 0.30 och < 0.46
Poor	> 0.15 och < 0.30
Bad	< 0.15

Guide for interpretation of low metric values

The signs of metric Z-values (+ or -) can be used for evaluation of which possible pressures might be the reason for low index values. The table below summarises which metrics responded significantly with positive (+) or negative residuals (-), dependent on acidity or high nutrient levels, respectively:

Metric	Acidity	Nutrients
1. Number of native fish species	-	+
2. Simpson's D (numbers)	-	
3. Simpson's D (biomass)	-	+
4. Relative biomass of native species	-	+
5. Relativt number of native species	-	+
6. Mean mass (from total catch)		+
7. Biomass proportion of piscivorous percids	+	
8. Ratio perch / cyprinids (biomass)		-

Fish species found in Swedish freshwaters

Fish species considered to be native in Sweden are denoted with X, as well as fish species occurring in lakes within the National Register of Survey test-fishing (NORS).

Family	Scientific name	English name	Native	NORS
Petromyzontidae	*Petromyzon marinus*	Sea lamprey	X	
	Lampetra fluviatilis	River lamprey	X	X
	Lampetra planeri	Brook lamprey	X	
Acipenseridae	*Acipenser oxyrinchus*	Sturgeon	extinct	
Anguillidae	*Anguilla anguilla*	Eel	X	X
Clupeidae	*Alosa fallax*	Twaite shad	X	
Cyprinidae	*Abramis ballerus*	Zope	X	X
	Abramis bjoerkna	White bream	X	X
	Abramis brama	Bream	X	X
	Abramis vimba	Vimba	X	X
	Alburnus alburnus	Bleak	X	X
	Aspius aspius	Asp	X	X
	Carassius carassius	Crucian carp	X	X
	Cyprinus carpio	Carp		X
	Gobio gobio	Gudgeon	X	X
	Leucaspius delineatus	Belica	X	X
	Leuciscus idus	Ide	X	X
	Leuciscus leuciscus	Dace	X	X
	Pelecus cultratus	Ziege	X	
	Phoxinus phoxinus	European minnow	X	X
	Rutilus rutilus	Roach	X	X
.	*Scardinius erythrophthalmus*	Rudd	X	X
	Squalius cephalus	Chub	X	X
	Tinca tinca	Tench	X	X
Cobitidae	*Cobitis taenia*	Spined loach	X	X
Balitoridae	*Barbatula barbatula*	Stone loach	X	
Siluridae	*Silurus glanis*	Wels	X	X
Esocidae	*Esox lucius*	Northern pike	X	X
Salmonidae	*Oncorhynchus clarki*	Cuttroat trout		
	Oncorhynchus mykiss	Rainbow trout		X
	Oncorhynchus nerka	Sockeye salmon		X
	Salmo salar	Atlantic salmon	X	X
	Salmo trutta	Brown trout	X	X
	Salvelinus alpinus	Arctic char	X	X
	Salvelinus fontinalis	Brook trout		X
	Salvelinus namaycush	Lake trout		X
	Salvelinus umbla		X	X
	Thymallus thymallus	Grayling	X	X

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Family	Scientific name	English name	Native	NORS
Coregonidae	*Coregonus albula*	Vendace	X	X
	Coregonus sp.	Whitefish	X	X
	Coregonus maraena		X	
	Coregonus maxillaris		X	
	Coregonus megalops	Lacustrine fluvial whitefish	X	
	Coregonus nilssoni		X	
	Coregonus pallasii		X	
	Coregonus peled	Peled	X	
	Coregonus trybomi		X	
	Coregonus widegreni	Valaam whitefish	X	
Osmeridae	*Osmerus eperlanomarinus*		X	
	Osmerus eperlanus	Smelt	X	X
Lotidae	*Lota lota*	Burbot	X	X
Gasterosteidae	*Gasterosteus aculeatus*	Three-spined sticklback	X	X
	Pungitius pungitius	Nine-spined stickleback	X	X
Cottidae	*Cottus gobio*	Bullhead	X	X
	Cottus koshewnikowi	Siberian bullhead	X	
	Cottus poecilopus	Alpine bullhead	X	X
	Triglopsis quadricornis	Fourhorn sculpin	X	X
Percidae	*Perca fluviatilis*	Eurasian perch	X	X
	Sander lucioperca	Pikeperch	X	X
	Gymnocephalus cernua	Ruffe	X	X
Pleuronectidae	*Platichthys flesus*	Flounder	X	X

Annex III

Fish data sets for comparison of national methods

Data for Finnish EQR4

Data were delivered to Mikko Olin, as one excel-sheet with one row per lake and fishing date. Data was sorted in one column each for the following fish data and lake criteria:

Fish data:

- date of fishing
- total CPUE weight (g / Nordic gillnet night)
- total CPUE number of individuals (ind. / Nordic gillnet night)
- weight proportion (%) of cyprinids (of the total catch)
- list of all naturally reproducing fish species (besides stocked species)

Lake criteria:

- name
- reference/impacted
- longitude (WGS84)
- latitude (WGS84)
- altitude
- lake area
- mean depth (< or > 3 m)
- colour
- hydraulic retention time (< or > one week)
- information whether the lake is naturally eutrophic (e.g. TP > 30 µg/l) or not.

The results file included additional columns for Finnish lake type, EQR-values for each metric, the index EQR4 and the ecological status class.

Data for Swedish EQR8

Data were delivered to Anders Kinnerbäck, in one excel-file with three separate data sheets (Table A.III.1). They comprised; 1) a “Lake” sheet with one row per lake, 2) a “Catch” sheet with one row per lake, fishing date and fish species, and 3) a “Perch lengths” sheet with one row per lake, fishing date and individual or size group of perch.

The results file was delivered as one excel-sheet with one row per lake and fishing date. Columns included variables from the “Lake sheet”. New columns comprised the eight fish metrics (Annex II) expressed as observed, reference, Z- and P-values, respectively, the index EQR8, the ecological status class and probability for each of five possible status classes. These probabilities were calculated assuming a general uncertainty of ±0.07 for the EQR8-value.

Table A.III.1. Variables requested in the data template for calculation of Swedish EQR8.

Variable	Description	Lake	Catch	Perch lengths
MS	Member state	X		
Lake name	Name of the lake	X	X	X
Latitude	Latitude (WGS84)	X	X	X
Longitude	Longitude (WGS84)	X	X	X
Altitude	Altitude (m above sea level)	X		
Area	Lake area (ha)	X		
Maxdepth	Maximum depth (m)	X		
Air temp	Annual mean air temperature	X		
Highest coastline	Position above or below the highest coastline	X		
Fishing date	Date for setting the first gillnets		X	X
Method	EN14757 for all lakes and fishing dates		X	
Net type	Nordic for all lakes and fishing dates		X	
N of gillnets	Number of benthic gillnets		X	
Species sci	Scientific name of fish species		X	
Native	Native in the country (yes or no)		X	
NPUE	Number fish per benthic gillnet		X	
WPUE	Biomass (g) fish per benthic gillnet		X	
Length	Individual length of perch (mm)			X
Lnumber	Number of perch in the length class of interval data			X

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