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# Water Framework Directive Intercalibration Technical Report

## Alpine Lake Fish fauna ecological assessment methods

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# Introduction

The European Water Framework Directive (WFD) requires the national classifications of good ecological status to be harmonised through an intercalibration exercise. In this exercise, significant differences in status classification among Member States are harmonized by comparing and, if necessary, adjusting the good status boundaries of the national assessment methods.

Intercalibration is performed for rivers, lakes, coastal and transitional waters, focusing on selected types of water bodies (intercalibration types), anthropogenic pressures and Biological Quality Elements. Intercalibration exercises were carried out in Geographical Intercalibration Groups - larger geographical units including Member States with similar water body types - and followed the procedure described in the WFD Common Implementation Strategy Guidance document on the intercalibration process (European Commission, 2011).

In a first phase, the intercalibration exercise started in 2003 and extended until 2008. The results from this exercise were agreed on by Member States and then published in a Commission Decision, consequently becoming legally binding (EC, 2008). A second intercalibration phase extended from 2009 to 2012, and the results from this exercise were agreed on by Member States and laid down in a new Commission Decision (EC, 2013) repealing the previous decision. Member States should apply the results of the intercalibration exercise to their national classification systems in order to set the boundaries between high and good status and between good and moderate status for all their national types.

Annex 1 to this Decision sets out the results of the intercalibration exercise for which intercalibration is successfully achieved, within the limits of what is technically feasible at this point in time. The Technical report on the Water Framework Directive intercalibration describes in detail how the intercalibration exercise has been carried out for the water categories and biological quality elements included in that Annex.

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

# Contents



## Annexes

# 1. Introduction

In the Alpine Fish Geographical Intercalibration Group (GIG):

- Four Member States (Austria, France, Germany and Italy) submitted their lake fish-based assessment methods;
- After evaluation of the IC feasibility, 3 methods were included in the current IC exercise: AT, DE and IT (as FR method has different assessment concept);
- Intercalibration "Option 3" was used - direct comparison of assessment methods using a common dataset via application of all assessment methods to all data available;
- The comparability analysis show that methods give a closely similar assessment (in agreement to comparability criteria defined in the IC Guidance), so no boundary adjustment was needed, still IT and DE boundaries were slight adapted for a better comparison and for improving the assessment results;
- The final results include EQRs of German, Austrian and Italian lake fish-based assessment systems for 2 common types: LAL-3 and L-AL4.

# 2. Description of national assessment methods

In the Alpine Fish GIG, four countries participated in the intercalibration with finalised fish-based lake assessment methods (for detailed description see Annex A):

- Austria: ALFI (Austrian lake fish index): A multimetric index to assess the ecological status of alpine lakes based on fish fauna;
- Germany: DELAFI_SITE - national fish assessment method for southern German alpine lakes;
- Italy – Italian Lake Fish Index (I-LFI) national fish assessment method for lakes (only for natural lakes);
- France – Multimetric index based on fish fauna for the assessment of subalpine lakes.

## 2.1. Methods and required BQE parameters

The assessments systems of Austria, Germany (alpine) and Italy meet the requirements (species composition, abundance and age structure) of the WFD (see Table 2.1). Length frequency is used instead of age structure:

- Austria: The present version of the Austrian assessment method includes eight metrics and covers all requirements (species composition, abundance, age structure) of the WFD;

- Germany: The present version of the German assessment method covers with 9 metrics all requirements (species composition, abundance, age structure is assessed by successful reproduction) of the WFD;
- Italy: The present version of the Italian assessment method includes five metrics and covers all requirements (species composition, abundance, age structure) of the WFD;
- France: The assessment method of France includes two metrics. In the French assessment system age structure is not reflected..

*Table 2.1 Overview of the metrics included in the national fish-based lake assessment methods (for more details see Annex A)*

| MS | Taxonomic composition | Abundance | Age structure |
|---|---|---|---|
| AT | Abundance Index (AI) of type specific species; Proportion of AI alien species; AI of small-bodied species; AI of sensitive species; AI of migrating spawners; AI of spawning guilds | Abundance Index (AI) included in all metrics<br>Fish biomass (hydroacoustics) | Length frequency of sentinel species |
| IT | Total number of guiding species;<br>% of guiding + accompanying species whose the reproductive success is verified during sampling ;<br>Reduction % of the number of guiding + accompanying species<br>% presence of alien species of the total number of species; | Number and percentage are included in metrics | Population structure of guiding species |
| DE | Sentinel species number: scores the number of species that are sentinel species in reference condition but absent today;<br>Type species number: likewise;<br>Side species number: likewise;<br>Sentinel species abundance: scores the number of species that are sentinel species in reference condition but type or side species today;<br>Habitat preferences: scores the number of habitat preferences that exist in reference condition but are missing today (preferences are littoral, benthic, epilimnetic, hypolimnetic).<br>Spawning preferences: likewise (preferences are lithophilic, psammophilic, phyto-lithophilic, phytophilic) | Species numbers and abundance classes are included in metrics | Reproduction of potentially stocked species: is a downgrading metric. For a selection of species it has to be checked if the species is stocked and if it reproduces naturally. Species which persist by stocking only are treated as |

| | | | |
|---|---|---|---|
| | Abundance of habitat preferences: scores the distribution of abundance classes within the habitat preferences (e.g. littoral species are sentinel in reference condition, but side today)<br>Abundance of spawning preferences: likewise | | if they were absent. |
| FR | Number of omnivorous individuals caught per unit effort (OMNI) | Number of individuals caught per unit effort (CPUE) | |

Following combination rule of metrics are used :

- AT : Unweighted average of all metric scores;
- IT : The final EQR is calculated as an average of the single EQRs;
- DE: The total EQR is calculated for all metrics together as EQR = (Score-Min) / (Max-Min);
- FR: the mean of the two metrics.

It was concluded that

- Length frequency is a widely accepted substitute for age structure in fish ecology (so it is acceptable to use it in the WFD-compliant systems as an age structure substitute);
- All assessment systems were assessed as compliant (except FR);
- In the GIG`s opinion, in the present version of the French assessment method age structure and species composition are not sufficiently reflected.

## 2.2. Sampling and data processing

All countries use diverse sampling devices and strategies (Table 2.2). The target of all used sampling methods is to reveal a complete species list and an overall measure of catch frequency which can be translated in abundance classes (e.g. missing, sporadic, rare, frequent and numerous ). The main sampling methods are the same in all MS (gill netting and electrofishing) and some additional specific gears are optional. The difference between MS is that sampling in Austria and Italy is following CEN-standard, but not in Germany (alpine). For determination of a complete recent fish species list it is important and recommended to use different gears like in the 3 MS.

In summary: sampling is done in a comparable way by all participating MS and a similar data basis is provided.

*Table 2.2 Overview of the sampling of the national fish-based lake assessment methods*

| MS | Sampling device |
|---|---|
| AT | **Gill netting** is conducted between July and September by using NORDIC gillnets, according to the CEN standard EN-14 757.<br>The used number of bentic nets depends on lake surface and maximum water depth. The pelagic nets are set only at the deepest part of the lake if the lake area is < 5 $km^2$. If the lake area is between 5 and 10 $km^2$ the pelagic nets are additionally set at a second sampling station and<br>lakes > 10 $km^2$ are sampled on 3 pelagic sampling stations. 2.)<br>The shoreline is sampled by **electrofishing,** whereas one sample site (sampling time: 15 minutes) per $km^2$ surface area or at least 4 sample sites for small lakes are examined.<br>To get information on the overall fish biomass and abundance of a **lake hydroacoustic surveys** (Simrad EK 60; SONAR 5pro) are performed. Surveys have to be carried out during night time on three occasions between July and December. One of these<br>surveys is conducted parallel to the gill netting, the others are done between October and December. |
| GE | The fish community composition is modelled **with fishery statistics or scientific gear**. Data and information (e.g. of professional fisherman) of the precedent six years can be used. It is important to obtain a complete picture **of all lake habitats.** Therefore we strongly recommend that information on **at least one of the following fishing gear for each habitat** is included in the modelling procedure:<br>**Littoral: electrofishing, fyke net, beach seine**<br>**Benthic: (multimesh-)gill net, bottom trawl, extended fyke net**<br>**Pelagic: (multimesh-)gill net, trawl, purse seine**<br>If information is missing, a complemental scientific investigation becomes necessary. |
| IT | **Gill netting** is conducted between July and September by using NORDIC gillnets, according to the CEN standard EN-14 757. The used number of bentic nets depends on lake surface and maximum water depth. The number of pelagic nets depends on the area of the lake.<br>The shoreline is sampled by Point abundance **electrofishing** |
| FR | **Catches of the benthic nets** |

## 2.3. National reference conditions

Different approaches to define reference conditions are used in the MS (Table 2.3):

- Austria: site-specific approach (based on historical data);
- France: predicting reference by hindcasting models;

- Germany: site-specific  approach (based on historical data);
- Italy: site-specific  approach (based on historical data) and expert judgment.

At the present state it was not possible to establish useful and reliable type-specific near-natural reference condition (RC)  in the ALP FISH GIG for the following reasons:

- No or probably only a few lakes in reference or near natural fish ecological condition (fact: most fish communities are disturbed at present);
- At the most a handful of near natural lakes in the GIG should consequently be divided into 2 types (L-AL3 and L-AL4) resulting in 2-3 lakes per type. That would not lead to reasonable type-specific reference conditions;
- Number of fish species in alpine lakes is generally low (5-18 species in RC). Building up a transnational, type-specific RC would necessarily result in the lowest common denominator of a species list, composed only of a few non-sensitive, ubiquist and most likely omnivorous fish species. Such a type-specific reference list would have no or only a small potential for ecological assessment. Number of species is the crucial difference between BQE fish and other BQEs (e.g. algae and benthic invertebrates etc.)

As a result of these circumstances Austria, Germany and Italy decided to establish **reference conditions** on basis of reliable historical data **individually for each lake** (site-specific).

For that literature, catch statistics and fish collections in museums were analysed dating back to medieval times. From all the information a historical fish community was reconstructed and checked for plausibility for each lake. Different thresholds (1900 in AT, 1940 in DE and 1950 in IT) are a result of literature availability and have no or only minor impact on the reconstructed historical fish species lists, which are used in the IC exercise. The specification was that "historical" lakes were more or less free from the considered pressures (Eutrophication, general degradation, habitat destruction, shore line modification, hydromorphological degradation or biological degradation (alien species)). Furthermore commercial fisheries had also less impact before that time.

For the IC exercise **reference conditions** for each lake were established by the **national MS** and accepted and used by all other MS. Setting of RC was performed quite similar by all 3 MS (AT, DE and IT). See also Volta et al. 2011, Gassner et. 2005 and Zick at al. 2006.

In our opinion this procedure of setting RC is compliant with WFD (see WFD Annex II, 1.3V "...The methods shall use historical, paleological and other available data and shall provide a sufficient level of confidence about values for the reference conditions to ensure that the conditions so derived are consistent and valid for each surface water body type.")

*Table 2.3 Overview of the methodologies used to derive the reference conditions for the national phytoplankton assessment methods*

| MS | Austria | France | Germany | Italy |
|---|---|---|---|---|
| Key source to derive RC | Historical data, see GASSNER et al. 2005 and ZICK et al. 2006 | Hindcasting approach (predicting the metric value without anthropogenic pressures) | Historical records, scientific literature before 1940 and long time fisheries statistics, completed by expert knowledge based on the historical species inventory of nearby water bodies, evidence in the catchment area and general species ecology | Historical data, see VOLTA et al. 2011 |
| Geographical scope of reference definition | Whole Austria, all 43 natural Austrian Lakes | | Southern Germany (esp. Bavaria) | whole Italy, all natural Italian lakes larger >0.5 km$^2$ |
| Time period | Historical data for the pre-industrial time from around 1900, based on evidence specimens in museums, historical literature, and historical catch statistics | | | Historical data until 1950, based on evidence specimens in museums, historical literature, and historical catch statistics |

## 2.4. National boundary setting

Ecological status classifications of national methods were established individually by the Member States prior to the intercalibration process (see Table 2.4 for summary).

**Austria:** According to the WFD the ecological status of a water body is classified by 5 classes. The Austrian assessment method operates with 5 abundance classes. Thus, on a first step boundaries for EQR-values of the ecological status classes were set equidistantly (class width: 0.2). Compliance of the status class boundaries with the normative definitions of the WFD was investigated by an experiment with fish ecologist (expert experiment). A fish species list of lake Fuschlsee in reference condition (historical taxa AI=4 and alien taxa AI=0) was sent to 5 experts with the invitation to model fish communities and abundance index according to the normative definitions of the WFD. Experts were asked to model barely high, barely good and already moderate status. The modelled fish communities were then assessed by the Austrian assessment system. Results between experts were quite similar and all calculated EQRs met the according status class (see Figure 2.1). Thus it was decided to keep equidistant status classes:

- High ecological status: EQR >0.8
- Good ecological status: EQR 0.60-0.79;
- Moderate ecological status: EQR 0.40-0.59;
- Poor ecological status: EQR 0.20-0.39;
- Bad ecological status: < 0.20.

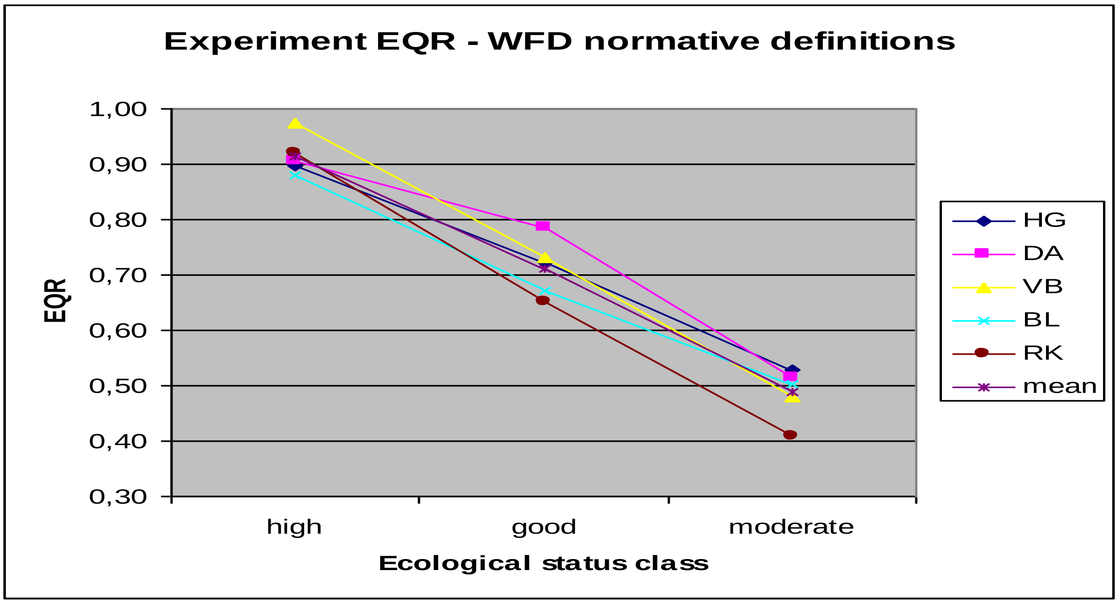



*Figure 2.1 Relationship between EQR and ecological status class based on expert opinion*

**Germany (alpine)**: The boundaries for the five ecological status classes are based on expert judgement. The division of the EQR gradient results in class boundaries of ≥0. 90/0.75/0.50/0.25 beginning with high ecological status (see also: Attachment 3)

**Italy:** The ecological status of a lake is classified by 5 classes. As a first step the boundaries for the EQR-values were set equidistantly (class width: 0.2). During the IC process arose the need of slightly modifying EQR thresholds (see below).

**France:** The class boundaries have been set by using the specific stressor value that distinguishes reference lake from non-reference lakes. These values are 0.08 mg TP/l and 10% of non-natural land-cover. By projecting these values on the regression libe it has bene posible to set the HG boundary and then, by dividing the part below in 4 equal sections to obtain the other classes.

*Table 2.4 Overview of the methodology used to derive ecological class boundaries*

| | Austria | Germany | France | Italy |
|---|---|---|---|---|
| Pressure(s) assessed | Eutrophication, Hydrology Water level, Shore line degradation, Connectivity, Recreation, Biological degradation, Fisheries exploitation | Eutrophication, general degradation, habitat destruction, hydromorphological degradation | Eutrophication General degradation | Catchment land use and Eutrophication, Hydrology Water level , Shoreline degradation, Connectivity, Fisheries exploitation |
| Rationale/ technique of quality class boundary setting | Due to the low number of sampled Austrian alpine lakes (n = 15) we set the boundaries pragmatically in equidistant status classes at first + expert experiment to validate the boundary setting | Total ecological status class boundaries are ≥0.90/0.75/0.50 /0.25, beginning with HIGH | HG – modelling based on pressure criteria Others – equidistant division | Due to the low number of sampled Italian alpine lakes (n = 9) we set the boundaries in equidistant status classes |
| H/G boundary | | | Projecting the threshold values (TP 8 µg/l) on the regression line | Equidistant division |
| G/M boundary | Equidistant division | Equidistant division | Equidistant division | Equidistant division |
| M/P boundary | Equidistant division | Equidistant division | Equidistant division | Equidistant division |

# 3. Results of WFD compliance checking

Austria, Germany (alpine) and Italy follow the normative definitions of WFD and it is tested by expert opinion (see Table 3.1) Recently it is also based on a relationship between a pressure index and EQR. As in the French system species composition and age structure are not reflected, it does not follow completely the normative definitions.

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

| Compliance criteria | Compliance checking |
| --- | --- |
| Ecological status is classified by one of **five classes** (high, good, moderate, poor and bad). | Austria: yes<br>France: yes<br>Germany: yes<br>Italy: yes |
| High, good and moderate ecological status are set in line with the WFD's **normative definitions (Boundary setting procedure)** | Austria: yes<br>France: yes<br>Germany: yes<br>Italy: yes |
| **All relevant parameters** indicative of the biological quality element are covered (see Table 1 in the IC Guidance). A **combination rule** to combine parameter assessment into BQE assessment has to be defined. If parameters are missing, Member States need to demonstrate that the method is sufficiently indicative of the status of the QE as a whole | Austria: covers all parameters<br>France: yes for abundance, not age structure metric<br>Germany: covers all parameters<br>Italy: yes |
| Assessment is adapted to **intercalibration common types** that are defined in line with the typological requirements of the Annex II WFD and approved by WG ECOSTAT | Austria: no, site specific approach is used (historical reference fore ach lake)<br>France: yes L-AL3 and L-AL4 lakes<br>Germany: no, site specific approach is used<br>Italy: no, site specific approach is used |
| The water body is assessed against **type-specific near-natural reference conditions** | Austria: no, site specific near natural (historical)<br>France: predicting reference by hindcasting models<br>Germany: no, site specific near natural Italy: no, site specific near natural and expert judgment |
| Assessment results are expressed as **EQRs** | Austria: yes<br>Italy: yes<br>Germany: yes |

| Compliance criteria | Compliance checking |
|---|---|
| | France: yes |
| Sampling procedure allows for **representative** information about water body quality/ecological status **in space and time** | For the whole alpine GIG:<br>Generally sampling fish communities of lakes is under intensive scientific discussion. The recent used CEN methods have great advantages, but they are not able to show a nearly true picture of the fish communities in lakes. But if the same methods combinations were used in the MS the data will be comparable because the error should be more or less equal.<br>See also:<br>Achleitner, D., H. Gassner & M. Luger (in press): Comparison of three standardized fish sampling methods (gill net, electric, hydroacoustic) in 14 alpine lakes in Austria. Fisheries Management and Ecology |
| All data relevant for assessing the biological **parameters** specified in the WFD's normative definitions are covered by the **sampling procedure** | Austria yes<br>Germany: yes<br>Italy: yes<br>France: yes |
| Selected taxonomic level achieves adequate **confidence and precision** in classification | Austria yes<br>France: yes<br>Germany: yes<br>Italy: yes |

# 4. Results IC Feasibility checking

## 4.1. Typology

*For intercalibration data of L-AL3 and L-AL4 lakes of the MS Austria, Germany and Italy were used. We tried to include all lakes of these types where a usable data set (based on on standardized catches, reliable historical data set and commercial catch statistics) is available (*

Table 4.1).

*Table 4.1 Description of common intercalibration water body types and the MS sharing each type*

| Common IC type | Type characteristics | MS sharing IC common type |
|---|---|---|
| L AL3 | Lowland or mid altitude (50-800 m a.s.l), deep (> 15 m mean depth), moderate to high alkalinity (> 1mmol $L^{-1}$), large (> 50 ha)<br>Fish based lake Type: Arctic char or Minnow lakes | Austria – yes<br>Germany (alpine) - yes<br>Italy – yes<br>France - yes |
| L AL4 | Mid-altitude altitude (200-800 m a.s.l), shallow(3-15 m mean depth), moderate to high alkalinity (> 1mmol $L^{-1}$), large (> 50 ha)<br>Fish based lake Type: Bleak lakes | Austria - yes<br>Germany (alpine) - yes<br>Italy – yes<br>France - yes |

Intercalibration is feasible in terms of typology (Table 4.2).

*Table 4.2 Evaluation if IC feasibility regarding common IC types*

| Method | Appropriate for IC types/subtypes | Remarks |
|---|---|---|
| Austrian | L AL3<br>L AL4 | L AL3 equates to Arctic charr and Minnow Lakes in the Austrian Typology<br>L AL4 equates to Bleak Lakes |
| German (alpine) | L AL3<br>L AL4 | |
| Italian | L AL3<br>L AL4 | L AL3 equates mostly to Whitefish + Burbot + Shad lakes<br>L AL4 equates mostly to Pike + Tench +Rudd lakes |
| France | L AL3<br>L AL4 | |

## 4.2. Pressures addressed

*For BQE fish in Alpine lakes it was not possible to build up single metric-pressure-relationships:*

- Obviously fish show a wide range of responses to **different impacts** (see Table 4.3);
- In contrast to plants (algae and macrophytes) and invertebrates, fish as vertebrate animals respond in **more complex ways** to pressures;
- Fish represent the top most level of the aquatic trophic cascade in lakes and thus have the potential of **integrative indication** of biological alterations.

As a result of this specifications effort was taken to build up a **pressure-index (See** Table 4.4**)**, including all common pressures (eutrophication, water level fluctuation, shoreline degradation, connectivity, fisheries intensity, recreation and alien (translocated) species).

For all tested lakes of the IC dataset (15 lakes: 10 AT and 5 IT) pressures were scored according to the following table with values between 0 (low) and 4 (high) by experts. The idea behind this procedure was that fish have an integrating or summarizing function of indication, thus **all pressure values were summed up to a pressure-index**.

*Table 4.3 Pressures addressed by the MS assessment methods*

| Method | Pressure | |
|---|---|---|
| Austria | Water level fluctuation<br>Shore line degradation<br>Connectivity<br>Recreation<br>Fisheries intensity<br>Alien (translocated) fish species<br>Eutrophication | Pressure index based on expert judgement<br>$R^2$=0.38 $p<0.05$ |
| German | Water level fluctuation<br>Shore line degradation<br>Connectivity<br>Recreation<br>Fisheries intensity<br>Alien (translocated) fish species<br>Eutrophication | Pressure index based on expert judgement<br>$R^2$=0.38 $p<0.05$ |
| Italy | Water level fluctuation<br>Shore line degradation<br>Connectivity<br>Recreation<br>Fisheries intensity<br>Alien (translocated) fish species<br>Eutrophication | Pressure index based on expert judgement<br>$R^2$=0.50 $p<0.05$ |
| French | Eutrophication,<br>General degradation | Total Phosphorus $R^2$=0.66, $P<0.001$<br>Non-natural land cover R2=0.46, $P<0.001$ |

*Table 4.4. Scores of Pressure Index, summing up all pressure values.*

| PRESSURE-INDEX | | **eutrophication *** (compared to RC) | **water level** fluctuation | **shoreline** modified | **Connectivity** (up- and downstream) | **Fisheries** (intensity) | **Recreation** (camping, swimming etc) | **Species plus** (aliens and translocated) |
|---|---|---|---|---|---|---|---|---|
| **Intensity** | **SCORE** | Status | Dimension | Percent | Percent | Activity | Activity | Number |
| **low** | **0** | oligo | natural | 0-10% | >70% | no fisheries | extensive bathing | 0-1 |
| | **1** | oligo-meso | <1m | 11-30% | 51-70% | angling | bathing, rawing and electroboats | 2-3 |
| **medium** | **2** | meso | 1-3m | 31-50% | 31-50% | extensive commercial OR angling | bathing, rawing and electroboats and sailing | 4-5 |
| | **3** | meso-eutroph | 3-5m | 51-70% | 11-30% | extensive commercial AND angling | intensive bathing, rawing and electroboats, sailing, motorboats and excursion boating | 6-7 |
| **strong** | **4** | eutroph | >5m | >70% | 0-10% | intensive commercial and angling | intensive bathing, rawing and electroboats, sailing, motorboats, excursion boating, water skiing and diving | >7 |

* Eutrophication is based on trophic classification and reflects recent analyses (total phosphorus, chlorophyll-a and Secchi depth). Score is calculated by recent trophic classification minus reference trophic status.

Subsequently the pressure index values were validated by experts and then correlated with the EQRs of the different assessment methods (AT, DE and IT).

Analyses revealed significant ($p<0.05$) correlations with coefficients of R=0.70, R=0.58 and R=0.71 for AT, DE and IT, respectively (Figure 4.1). The linear regression between the PCM and the pressure-index (Figure 4.2) showed a coefficient of R=0.69 ($R^2$=0.48; p=0.007). Thus the assessment systems are able to reflect an overall degradation.

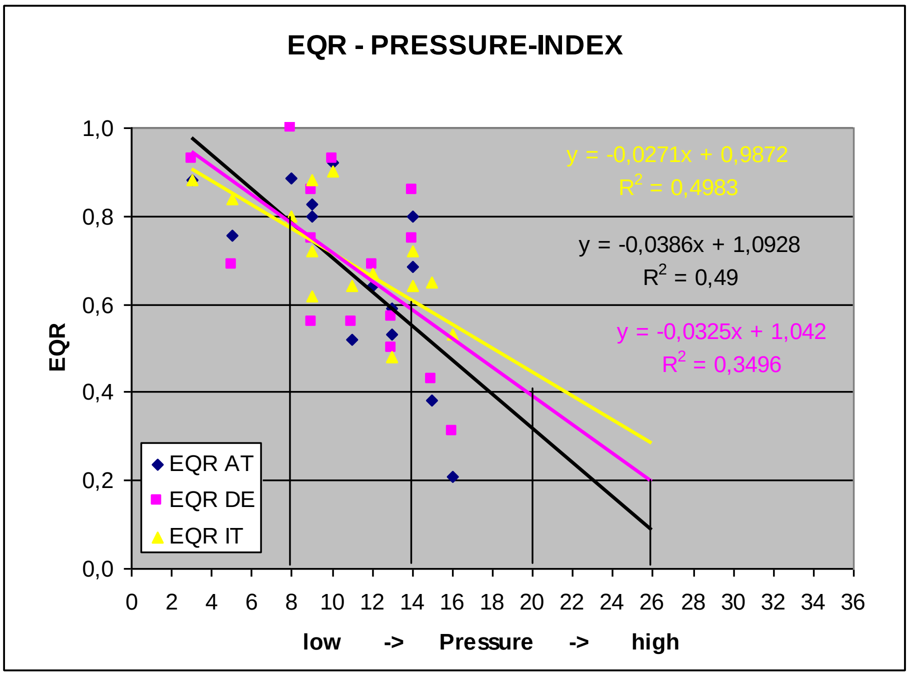



*Figure 4.1 Relationship between pressure index and national EQR values*

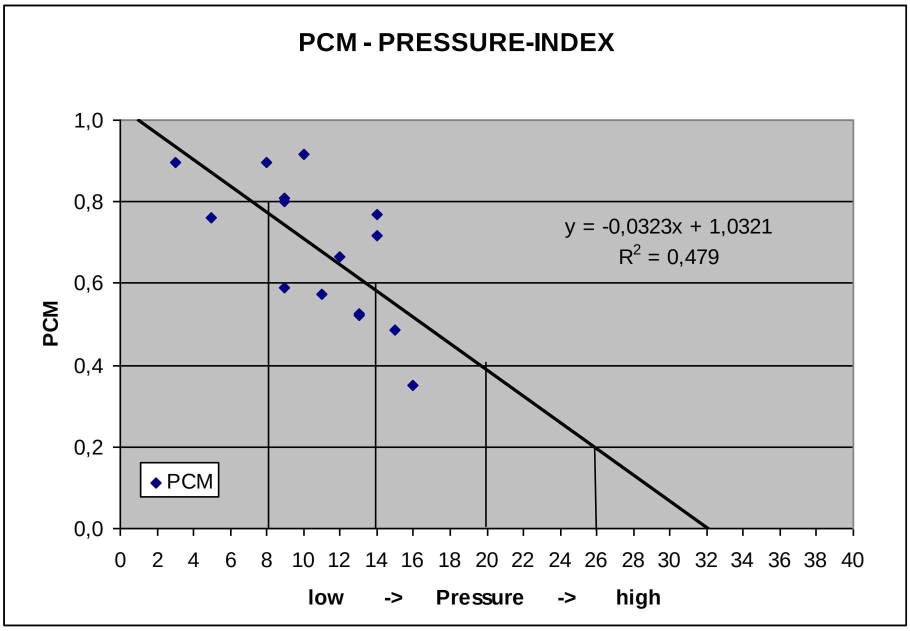



*Figure 4.2 Relationship between pressure index and Pseudo-common metrics (PCM)*

French Multimetric Index resulting of a mean of the two metrics is correlated to:

- the total phosphorus values (adjusted R2 =0.46, P<0.001);
- percentage of non-natural land cover in the catchment (adjusted R2 =0.46, P<0.001);

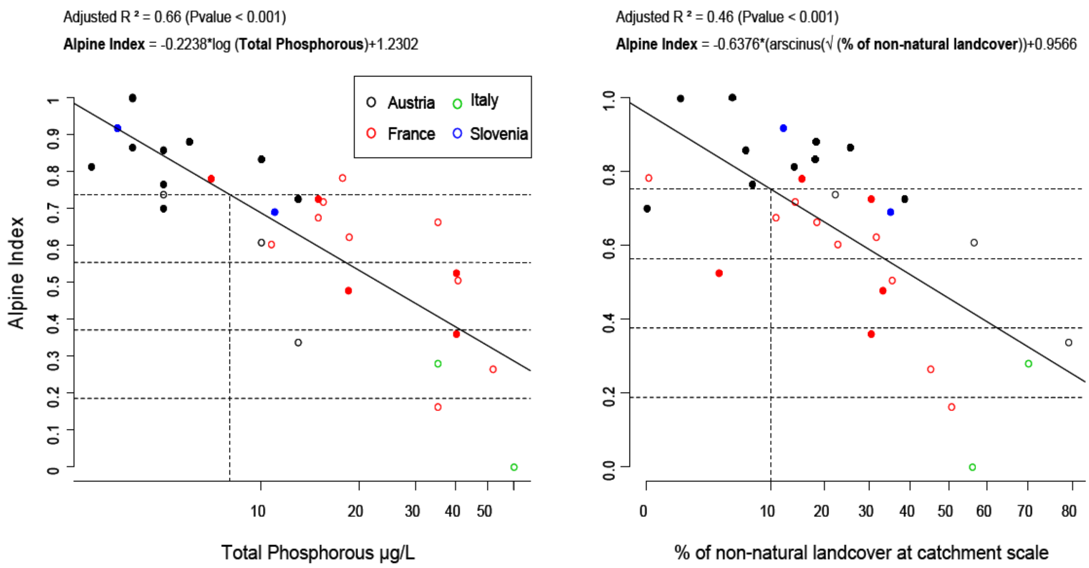



*Figure 4.3 Relationship between French Multimetric Index and total phosphorus and percentage of non-natural land cover in the catchment.*

Also both metrics separately show significant correlation to the pressure indicators:

- CPUE with the total phosphorus values R = - 0.6 (P<0.001), with percentage of non-natural land cover in the catchment R = - 0.76 ( P<0.001);
- OMNI with the total phosphorus values R = - 0.72 (P<0.001), with percentage of non-natural land cover R =-0.81 (P<0.001).

## 4.3. Assessment concept

Intercalibration is feasible with the AT, DE and IT assessment systems of the Alpine GIG (see Table 4.5). France follows a completely different assessment concept. Thus including the FR method into the IC exercise seems to be possible but complex. As the FR method description was submitted one month after deadline it was not possible to take it into account for the actual phase of the IC exercise due to the advanced progress at this time.

*Table 4.5 Evaluation if IC feasibility regarding assessment concept of the national methods.*

| Method | Assessment concept | Remarks |
|---|---|---|
| Austria | For the Austrian assessment system 8 metrics were used, comparing the current with the **historical situation**. Conceptual it is a combination of fish community characteristics (type specific species, alien species), functional groups (spawning guilds, migrating spawners, sensitive species, overall fish biomass) and metrics for single populations (length frequency). Assessment of a lake relates to the whole lake. | See description in Annex A |
| Italy | For the Italian assessment system 5 metrics were used including fish community characteristics (composition, sensitive species, migratory species), relative number, population characteristics (age-size structure) and comparing current situation with the **historical situation plus literature models** (size-structure stock-density models) | See description in Annex A |
| France | Prediction of **reference condition by hindcasting method** in comparison with the observed value | See description in Annex A |
| German (alpine) | The German assessment concept for the Alpine region is comparing the current condition of the fish community with a **historical reference condition**. Both situations are modeled and thus refer to a whole community description including all lake habitats/zones. Absolute abundance, functional characteristics and dependence on quality of habitats are considered in the metric selection. | See description in Annex A |

## 5. IC dataset collected

Generally a GIG common dataset was build up by CEMAGREF (FR) including the data of Austria, France Germany, Slovenia and Italy. This was used to build up the French assessment system for alpine lakes.

However, the existing common dataset is only partly applicable for the IC exercise of alpine MS since it doesn't include historical data which were used to build up their assessment systems. Therefore for the IC exercise of the alpine lake fish GIG available standardized data sets (including also historical data) were exchanged between the countries AT, DE and IT for IC purposes.

**Austria:** CEN standards (pelagic and bentic gill nets), electrofishing and hydroacoustics see detailed description in Leitfaden Lebensministerium: http://wisa.lebensministerium.at/ article/articleview/74897/1/27032/, see also Achleitner et al 2012.

**Germany (alpine):** Reference fish species composition was derived from historical and recent information's. Reference abundance estimates are based on literature data and expert judgement. The recent data set is based on available fish stock surveys and long term commercial catch statistics, which were checked for plausibility and converted to abundance index classes.

**Italy:** Reference fish species composition was derived from historical information. Reference abundance was derived from literature and expert judgment. Age-size structure was derived from literature. Present data were collected by CEN standards (pelagic and benthic gill nets) and electro fishing (CEN standards and point abundance sampling). See detailed description in Volta 2010, Volta & Oggioni 2010, Volta 2011, Volta et al 2011.

**France:** CEN standards (benthic gill nets only)

**Slovenia:** CEN standards (gill nets) and electrofishing

*Table 5.1 Overview of the Alpine GIG phytoplankton IC dataset. L AL3 and L AL4 – 15 lakes (10AT and 5 IT) were included in the common data set for IC exercise*

| Member State | Number of sites or samples or data values | | |
|---|---|---|---|
| | Biological data | Physico- chemical data | Pressure data |
| Austria | 15 | 43 | 43 |
| Germany (alpine) | 8 | 8 | 8 |
| Slovenia | 2 | 2 | 2 |
| Italy | 9 naturals<br>2 reservoirs 2011 | 30 | 10 |
| France | 14 | 14 | 14 |

*Table 5.2 Overview of the data acceptance criteria used for the data quality control*

| Data acceptance criteria | Data acceptance checking |
|---|---|
| Data requirements (obligatory and optional) | Reliable abundance class data (obligatory) from different sources like CEN standard (multimesh gillnets and electrofishing) and/or longterm fishery statistics (optional) |
| The sampling and analytical methodology | CEN standard sampling, calculation of abundance index or population density index |
| Level of taxonomic precision required and taxalists with codes | Species level with according codes |
| The minimum number of sites (lakes) / samples per intercalibration type | All available lakes with a usable dataset. |
| Sufficient covering of all relevant quality classes per type | High to poor |
| Other aspects where applicable | Overall fish biomass estimates by hydroacoustics are only available for the Austrian lakes |

In fact the data basis assessed with **all three** methods (AT, DE and IT) contains 10 lakes from Austria and 5 from Italy. There are no DE lakes in the dataset, because the IT method cannot be applied to DE data. The lack of DE lakes is of less concern due to the following 2 major reasons:

- There is no difference between alpine lakes of DE and AT neither biologically nor biogeographically. The border between German (e.g. Ammersee, Starnberger See and Chiemsee) and Austrian (e.g. Attersee, Obertrumer See and Altausseer See) alpine lakes is of political and not ecological origin;
- Germany provided data of 8 lakes which were assessed by the AT and DE method at the beginning of the IC exercise. In summary the German and Austrian assessment methods were applied on a set of 26 lakes (8 DE, 13 AT and 5 IT) resulting in a very strong correlation (Figure 5.1).

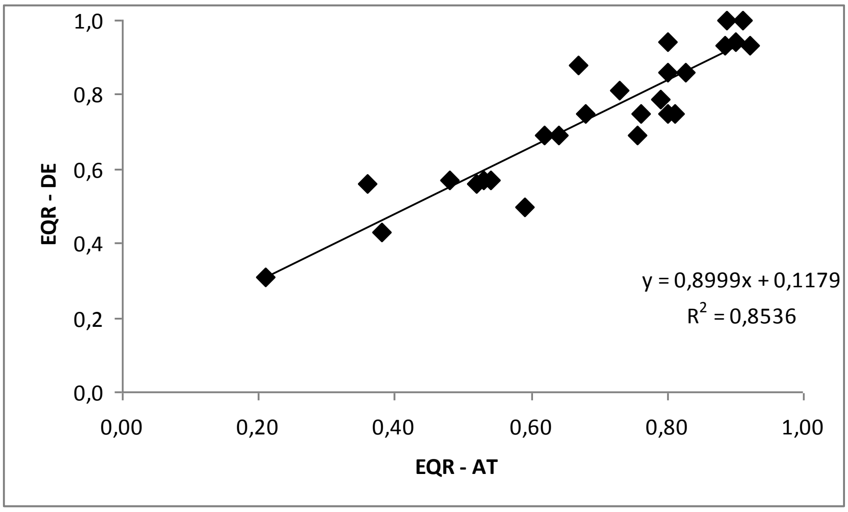



*Figure 5.1 Congruency of DE and AT assessment results (EQRs, n=26)*

# 6. Common benchmarking

Benchmarking is not performed due to the following reasons:

- Sampling methods, setting of RC and assessment concepts are similar and comparable among the participating MS in this phase of IC (AT, DE and IT) and therefore benchmarking is not needed;
- RC are NOT set type-specific (see above) but lake-specific historical references are used. In the alpine region there are no lakes inhabited by an undisturbed fish community. Thus, our common **dataset does not contain reference lakes in a sufficient number** and probably there are in general **not enough reference lakes available** in the whole alpine region;
- As there are no transnational type-specific fish communities used there is no need for benchmarking;
- The use of lake-specific RC avoids biogeographical effects on the assessment results;
- The total inventory of species in alpine lakes of the 3 MS is very similar (see below), sub-typological differences are only given in the number of species per lake (lower numbers in L-AL 3 and slightly higher numbers in L-AL 4). As lake-specific reference is used, this is of no concern;
- Direct comparison (option 3a) was chosen for the IC-exercise in the alpine fish GIG. A pseudo-common metric (PCM; mean EQR) was created and EQRs of MS are strong and highly significant correlated with the PCM (Figure 7.2);
- The IC dataset contains lakes of a wide range of ecological status classes (high to poor) and assessment results of the 3 methods (AT, DE and IT) show good

correlations over the whole gradient (see below). In addition all methods are well indicating the whole pressure gradient (Figure 4.1 and Figure 4.2).

With the process of benchmark standardisation the guideline aims to correct any sub-typological differences that could cause incomparability. As there are no type-specific references used in the assessment methods of the participating MS, this correction is not needed.

# 7. Comparison of methods and boundaries

Option 3a with linear regression was used and a pseudo common metrics was created.

The IC-exercise in the alpine lake fish GIG had to ensure, that every single method (AT, DE and IT) measures the deviation of the recent from the reference state of a lake in a comparable way. For this purpose the alpine GIG built up a common data set with **15 lakes (10 AT and 5 IT)** covering a wide range of the ecological gradient (high to poor) and owning a reliable historical species list. The set includes lakes with reliable status classes, where resulting fish communities were tested for plausibility by experts according to the normative definitions of the WFD. In addition the created pressure-index was well correlated to these results (kind of "benchmark lakes"; e.g Altausseer See with low pressure-index (=4) and high ESC). Following the guidance and choosing "Option 3a" each MS applied its national method to the lakes of the common data set.

The resulting EQR-values of each method were well correlated and analyses revealed no significant differences between methods (Figure 7.1 and Figure 7.2). A pseudo-common metric was created and construction of regressions was performed (Figure 7.2).

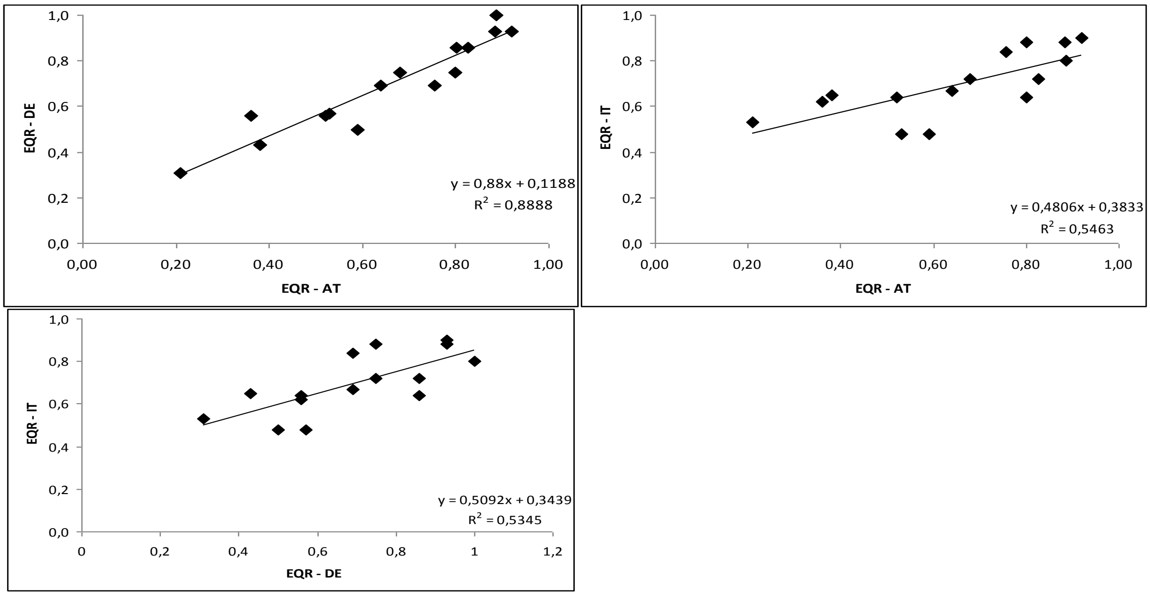



*Figure 7.1 Linear regressions between the EQR of the different assessment results of Austria, Germany (Bavaria) and Italy.*

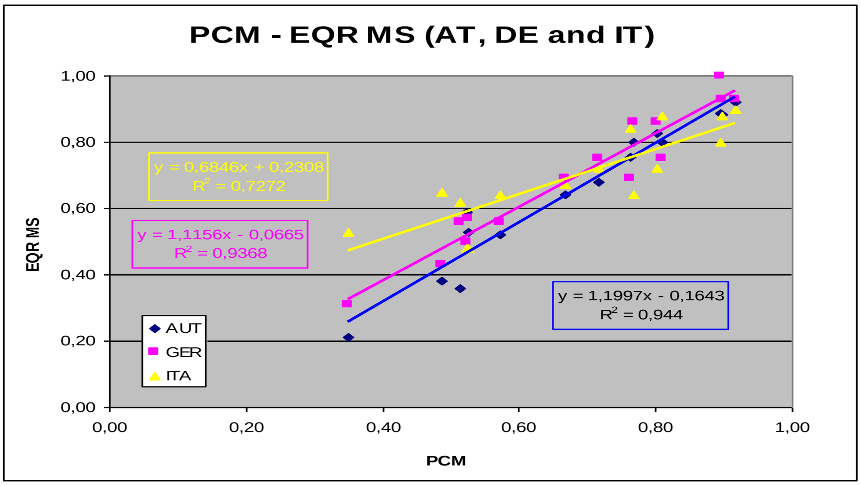



*Figure 7.2 Relationship between PCM and EQR for all national lake assessment methods*

Additionally we compared the assessment results of phytoplankton, macrophytes and fish (Table 7.1). Only two lakes (Attersee and Wörthersee) show the same assessment results for all BQE's and for the three assessment systems for fish. In all the other lakes we found **differences between the BQE fish and the other BQEs** showing that **each BQE is sensitive to different degradations**. This reflects the basic ecological idea of the WFD very well and it cannot be expected, that different BQEs react in a similar way to one ore more anthropogenic impacts. In contrast, they even may (should) show opposed results.

Table 7.1 Comparison between assessment results of phytoplankton, macrophytes and fish

| Lake | Country | Type | phytopl | macroph | fish AT | fish GE | fish IT | ESC similar |
|---|---|---|---|---|---|---|---|---|
| Achensee | Austria | L-AL3 | | | | | | |
| Altausseer See | Austria | L-AL3 | | | | | | |
| Attersee | Austria | L-AL3 | | | | | | Attersee |
| Faakersee | Austria | L-AL4 | | | | | | |
| Grundlsee | Austria | L-AL3 | | | | | | |
| Hintersee | Austria | L-AL4 | | | | | | |
| Mattsee | Austria | L-AL4 | | | | | | |
| Millstätter See | Austria | L-AL3 | | | | | | |
| Obertrumer See | Austria | L-AL4 | | | | | | |
| Toplitzsee | Austria | L-AL3 | | | | | | |
| Wolfgangsee | Austria | L-AL3 | | | | | | |
| Wörthersee | Austria | L-AL3 | | | | | | Wörthersee |
| Zellersee | Austria | L-AL3 | | | | | | |
| Bodensee Obersee | Germany | L-AL3 | | | | | | |
| Chiemsee, Weitsee | Germany | | | | | | | |
| Starnberger See | Germany | L-AL3 | | | | | | |
| Ammersee | Germany | L-AL3 | | | | | | |
| Walchensee | Germany | L-AL3 | | | | | | |
| Brombachsee, Großer | Germany | | | | | | | |
| Königssee | Germany | L-AL3 | | | | | | |
| Wörthsee | Germany | | | | | | | |
| Alserio | Italy | L-AL4 | | | | | | |
| Caldaro | Italy | L-AL4 | | | | | | |
| Candia | Italy | L-AL4 | | | | | | |
| Mergozzo | Italy | L-AL3 | | | | | | |
| Piano | Italy | L-AL4 | | | | | | |

The main principle of all three available assessment systems is a comparison between historical (reference) and recent fish ecological status. Similar in the methods is also the use of abundance indices and presence/absence data. Therefore it is possible to adapt and apply the different assessment systems on the data sets of the IC-lakes of the three MS. This was possible for all combinations between the Austrian, German (alpine) and Italian system (AT-IT; IT-AT, AT-DE, DE-AT, DE-IT). The only exception was the assessment of German lakes by the Italian (IT-DE) system, which did not work due to lacking CEN data from German alpine lakes.

As IT and DE do not have data for overall fish biomass and DE does not have data about length frequency we tested differences in the Austrian results between assessment with and without these data. The relationship (Figure 7.3) is very close to the one to one line indicating that for the intercalibrated lakes there are no significant differences for the assessment without the two metrics.

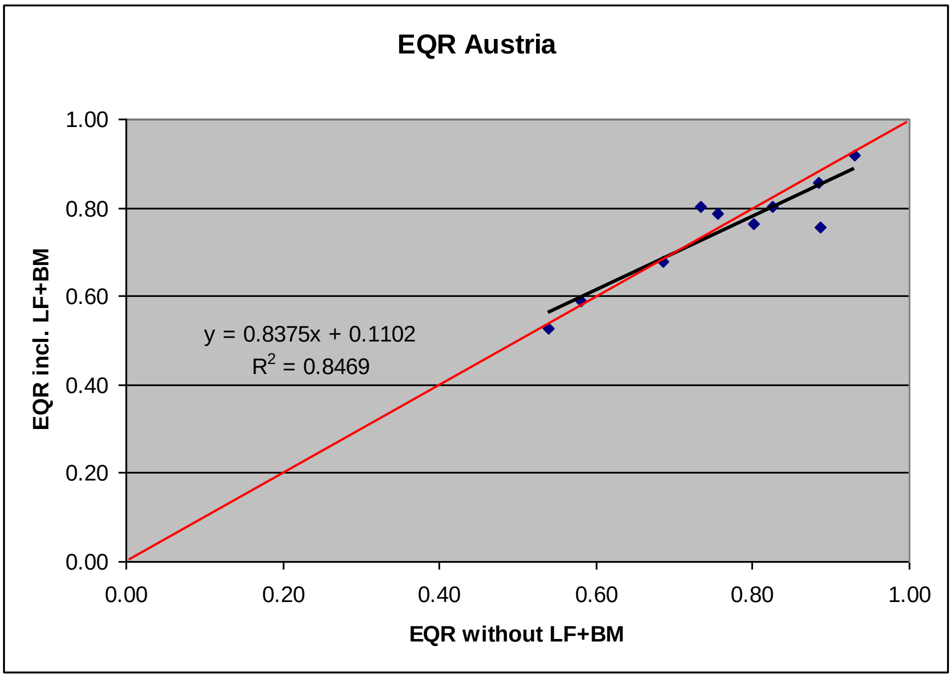



*Figure 7.3 Relationship between the assessment results with and without the metrics length-frequency and overall fish biomass.*

## 7.1. Results of the regression comparison

All methods have significant regressions to the **pseudo-common metrics** (see table below). Regressions between the PCM and the single EQRs were (Figure 7.4) strong and significant (PCM–AT: R=0.97, PCM–DE: R=0.97 and PCM–IT: R=0.84 with $p<0.001$ in all cases). The requirements of the guidance are all met (R ≥ 0.5 (Pearson´s correlation coefficient), the slope of the regressions between 0.5 and 1.5, the minimum $R^2$ at least half of the maximum $R^2$, assumptions of a linear regression (normality and variance) passed).

*Table 7.2 Correlation coefficients (r) and the probability (p) for the correlation of each method with the pseudo-common metric*

| Member State/Method | r | p |
|---|---|---|
| Austria | 0.97 | <0.001 |
| Germany (alpine) | 0.97 | <0.001 |
| Italy | 0.84 | <0.001 |

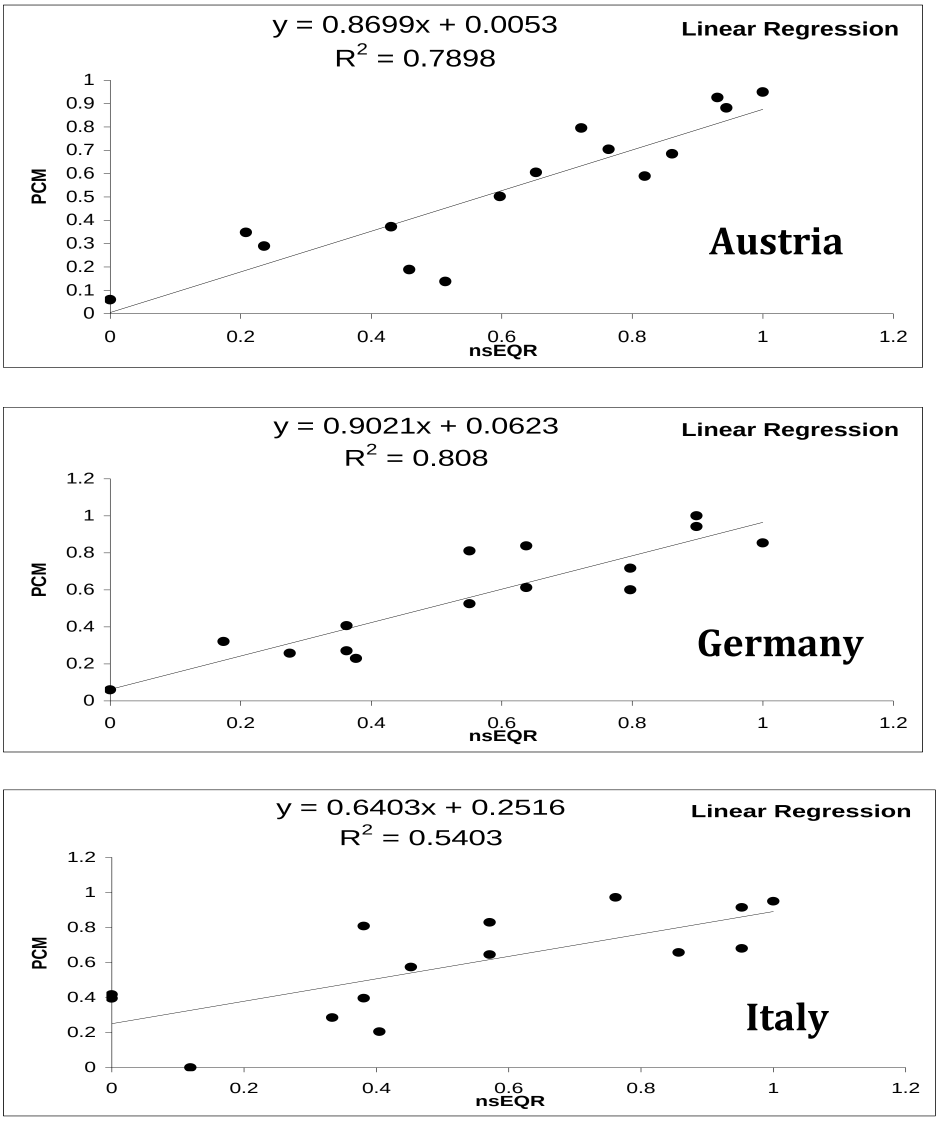



*Figure 7.4 Linear regressions between PCM and EQR of the assessment results of Austria, Germany (Bavaria) and Italy.*

## 7.2. Valuation of comparability criteria

Comparability criteria are acceptable according to the Annex V requirements:

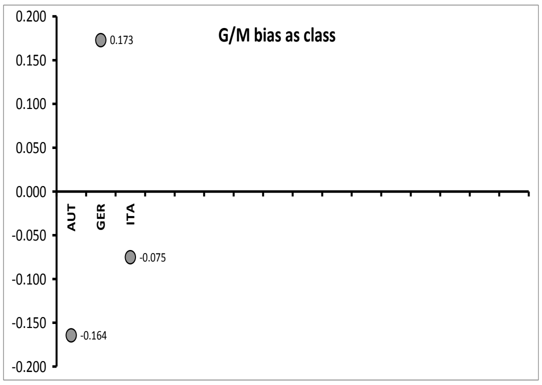
- All boundary biases for MS methods is <0.25;
- Average class agreement equals to 0.45, for all MS methods class agreement < 0.5 (for FR – 0.51).

**Our results show a high comparability of the three assessment methods:**

- As already in the past results of the different methods (EQR values) were highly and significantly correlated (AT – DE: R=0.94, AT – IT: R=0.72 and DE – IT: 0.73 with $p<0.05$ in all cases, see Figure 7.2);
- The correlations between the PCM and the single EQRs were strong and significant as well (PCM–AT: R=0.97; PCM–DE: R=0.97 and PCM–IT: R=0.84 with $p<0.001$ in all cases, see Figure 7.4);
- **The boundary bias is < 0.25 for high/good and good/moderate boundaries (**Figure 7.5**).**
- The mean average absolute class difference is below 1.0 class in 14 of our 15 assessed lakes. Only the assessment of the Italian lake Caldaro exceeds the recommended difference of 1.0 class (0.33) classes above (Figure 7.6 and Figure 7.7).

Table 7.3 Results of the boundary comparison: Absolute class differences.

| | AT | GE | IT |
|---|---|---|---|
| Absolute Class Difference | 0.30 | 0.40 | 0.50 |



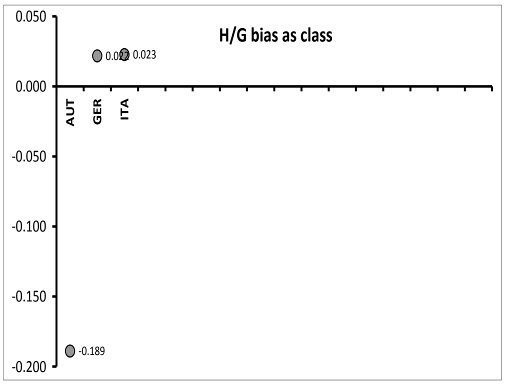




*Figure 7.5 Differences in the good/moderate and high/good class biases for the three MS Austria, Germany and Italy.*

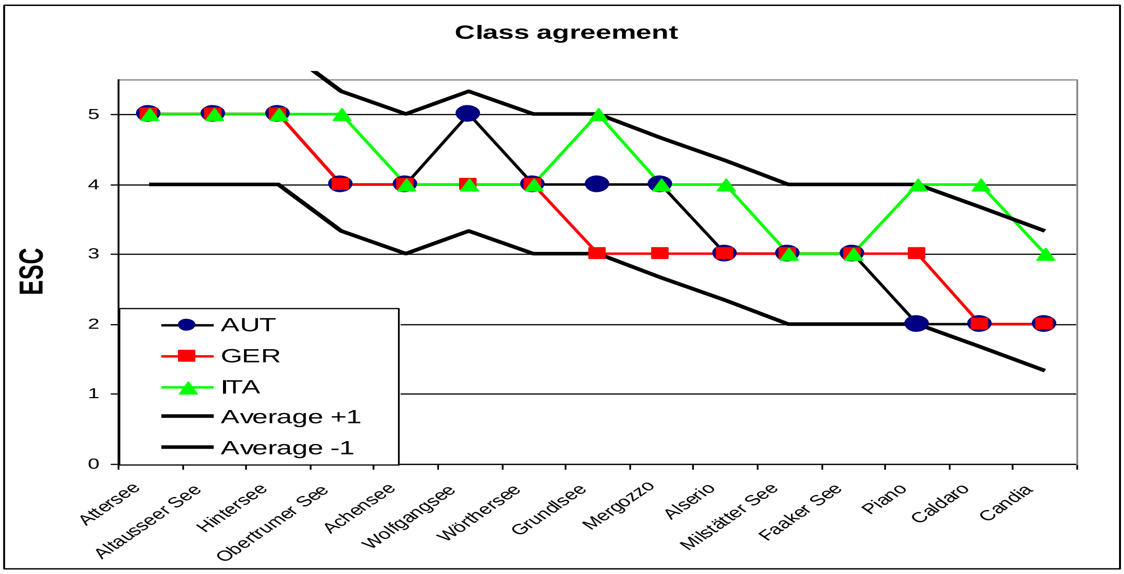



*Figure 7.6 Comparison of the ECR results of all three assessment systems (n = 15).*

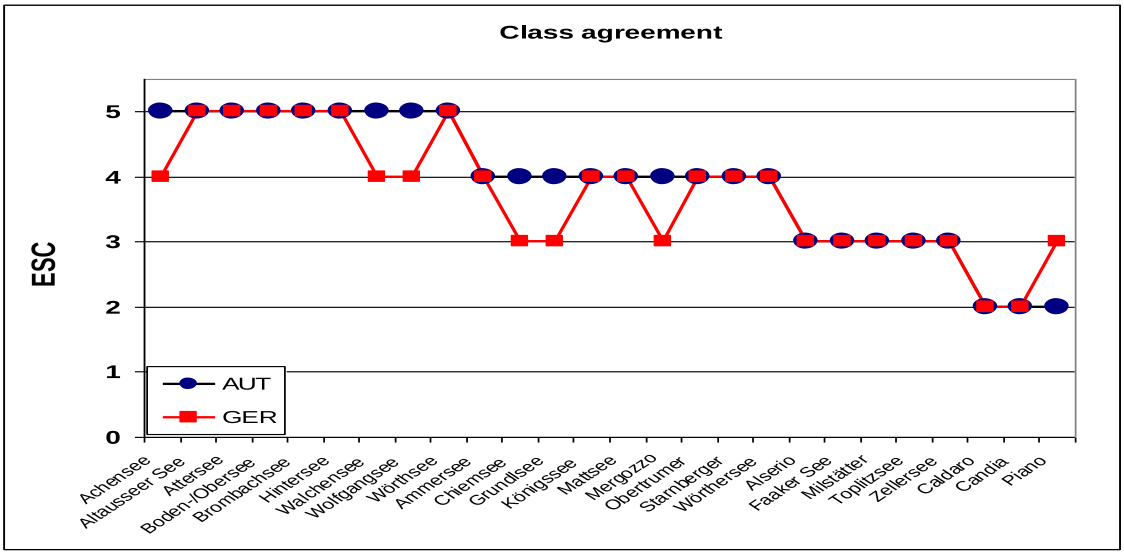



*Figure 7.7 Comparison of the ECR results of the Austrian and German assessment systems (n = 26).*

## 7.3. Boundary adjustments:

The boundary bias is < 0.25 for high/good and good/moderate boundaries (Figure 7.5):

- Thus, principally no changes are necessary according to the IC-guideline;
- However, for a better comparison and for improving the assessment results a slight adaptation of the boundary classes would be reasonable.

It is recommended and accepted by the MS :

- Decrease the high /good boundary from 0.90 to 0.85 and the good/moderate boundary from 0.75 to 0.69 for the German assessment system;
- For the Italian system it is recommended that high /good boundary should be increased from 0.80 to 0.82 and good/moderate boundary from 0.60 to 0.64;
- For the Austrian assessment system no adaptations are necessary.

Agreements:

- The Member States Germany, Italy and Austria agree with the recommended slight adaptations of the boundaries for the improvement of the assessment results (Table 7.4).

*Table 7.4 Class boundaries to be included in the IC decision (adjusted boundaries in bold)*

| Member State | Classification Method | Ecological Quality Ratios | |
|---|---|---|---|
| | | High-good boundary | Good-moderate boundary |
| Germany | | **0.85** | **0.69** |
| Austria | | 0.80 | 0.60 |
| Italy | | **0.82** | **0.64** |

## 7.4. Summary and perspective

The present results of the IC exercise of the alpine lake fish GIG are based on a small number of lakes, but data of these lakes are of a very high quality and thus results have a high reliability. All participating methods (AT, DE and IT) revealed high correlations among the assessment results (EQR and ESC) over a wide range of status classes as well as over a wide gradient of the pressure-index. Thus the principle idea of intercalibration (comparison of the assessement results) of the WFD seems to be fulfilled.

Fish represent the top most level of the aquatic cascade in lakes and show obviously a wide range of responses to different impacts. In contrast to other BQEs (e.g. algae or MZB) fish respond in more complex ways. The BQE fish in lakes is therefore probably not appropriate to show precise responses to single pressures, but has the potential of integrative indication of biological alterations. The participating methods (AT, DE and IT) are composed of several metrics covering species composition, abundance, guilds, functional groups, reproduction and age structure. The power of these methods is that they do not only produce a single EQR or an ecological status class (ESC), which means a single number, but that they detect deficits of the fish communities due to their balanced composition of metrics. These facts should be taken into account in course of judging about potential of the BQE fish in lakes.

# 8. Description of the biological communities

## 8.1. Description of the biological communities at reference sites

Alpine lakes have been invaded by fish after the last ice age originating from the main river systems. Therefore the fish communities in the alpine lakes are quite young and they need in some phases of their live cycle (e.g. egg development) shoreline structures or tributaries. The alpine lakes are typically oligotrophic, cold, deep, clear and ice covered in winter and the fish communities consist mostly of coldwater adapted species. The intercalibrated lakes are geographically situated relatively close together and the alpine region is well definable.

Fish communities in the alpine lakes show a high similarity and there is a pool of fish species (22 fish species based on the intercalibrated lakes) spread over the whole alpine region. Based on the different colonisation history there are only few additional fish species either characteristic for the northern (7 fish species) or characteristic for the southern part of the Alps (4 fish species). Between the Austrian and German alpine lakes there are no differences in the fish communities. In total we found 33 fish species in our intercalibrated lakes and 67 % inhabit lakes north and south of the alps.

As there are only small differences in the fish communities, the lakes are well comparable and moreover as we use a lake specific reference there is no biogeographical effect on the assessments.

*Table 8.1 Comparison of fish species in alpine IC lakes of the 3 MS*

| Italy | Austria | Germany (Alpine) |
|---|---|---|
| Abramis brama | Abramis brama | Abramis brama |
| Anguilla anguilla | Anguilla anguilla | Anguilla anguilla |
| Carassius carassius | Carassius carassius | Carassius carassius |
| Cobitis taenia | Cobitis taenia | Cobitis taenia |
| Coregonus sp | Coregonus sp | Coregonus sp |
| Cottus gobio | Cottus gobio | Cottus gobio |
| Cyprinus carpio | Cyprinus carpio | Cyprinus carpio |
| Esox lucius | Esox lucius | Esox lucius |
| Gobio gobio | Gobio gobio | Gobio gobio |
| Gymnocephalus cernuus | Gymnocephalus cernuus | Gymnocephalus cernuus |
| Lota lota | Lota lota | Lota lota |

| Italy | Austria | Germany (Alpine) |
| --- | --- | --- |
| Perca fluviatilis | Perca fluviatilis | Perca fluviatilis |
| Phoxinus phoxinus | Phoxinus phoxinus | Phoxinus phoxinus |
| Rhodeus sericeus | Rhodeus sericeus | Rhodeus sericeus |
| Rutlus rutilus | Rutlus rutilus | Rutlus rutilus |
| Salmo trutta lacustris | Salmo trutta lacustris | Salmo trutta lacustris |
| Salvelinus umbla | Salvelinus umbla | Salvelinus umbla |
| Sander lucioperca | Sander lucioperca | Sander lucioperca |
| Scardinius erythrophthalmus | Scardinius erythrophthalmus | Scardinius erythrophthalmus |
| Slilurus glanis | Slilurus glanis | Slilurus glanis |
| Squalius cephalus | Squalius cephalus | Squalius cephalus |
| Tinca tinca | Tinca tinca | Tinca tinca |
| **Alburnus alburnus alborella** | Alburnus alburnus | Alburnus alburnus |
| **Alosa agone** | Alburnus mento | Alburnus mento |
| **Padogobius martensi** | Blicca bjoerkna | Blicca bjoerkna |
| **Rutilus aula** | Carassius gibello | Carassius gibello |
|  | Rutilus frisii | Rutilus frisii |
|  | Vimba vimba | Vimba vimba |

## 8.2. Biological communities representing high and good status class

In alpine lakes with a **high ecological status** no fish species are lost and the abundance of the different fish species is the same or nearly the same compared to the historical reference situation. There are no changes in the abundance of type-specific species and all relevant spawning guilds inhabit the lake. The length frequency distribution doesn't show any gaps indicating a loss of reproduction. The proportion between the total number of fish species and number of alien or translocated fish species is higher than 3.0. Value of pressure index should be low (< 8).

In alpine lakes with a **good ecological status** not more than two fish species are lost and the abundance of the different fish species can be moderately different compared to the historical reference situation. There can be moderate changes in the abundance of type-specific species and most of the relevant spawning guilds inhabit the lake. The length frequency distribution can show moderate gaps indicating a loss of reproduction for certain years. The proportion between the total number of fish species and number of alien or translocated fish species is higher than 2.0. Value of pressure index should be low to moderate (8 – 14).

In alpine lakes with a **moderate ecological status** several fish species are lost and the abundance of the different fish species is often diverse compared from the historical reference situation. There are changes in the abundance of type-specific species and loses of the relevant spawning guilds inhabiting the lake. The length frequency distribution can show gaps indicating a loss of reproduction. The proportion between the total number of fish species and number of alien or translocated fish species is smaler than 2.0. Value of  the pressure index is moderate (14 – 20).

See description in Gassner et al (2005), Zick et al (2006) and Volte et al (2011).

## 8.3. Example for an alpine high status lake:

Lake **Altausseersee** is assessed in high status by all three assessment methods. Pressure-index is low (=4; near natural).

**Reference**

Altausseersee is definded as Arctic charr lake (Austrian fish typology) and was historically (around 1850) inhabited by 7 species at Abundance index 4 (numerous): Burbot (*Lota lota*), Chub (*Squalius cephalus*), Minnow (*Phoxinus phoxinus*), Stone loach (*Barbatula, barbatula*), Bull head (Cottus gobio), European Lake Trout (*Salmo trutta* f. *lacustris*) and Arctic charr (*Salvelinus umbla*).

Typespecific fish species are Arctic charr, European Lake Trout, Bullhead and Minnow.

Small bodied species are Bullhead and Minnow. Sensitive species are Burbot, Minnow, Bullhead, European Lake Trout and Arctic charr. Migrating spawners are Chub and European Lake Trout and abundance index of spawning guilds is 4 (numerious).

Overall fish biomass is 35 kg/ha in reference.

Length frequency of Arctic charr (sentinel fish species) shows no differences to an average length-frequency distribution of Arctic charr lakes.

**Assessment**

<u>WFD definition for high status: Species composition and abundance correspond totally or nearly totally to undisturbed conditions</u>

The recent fish species composition corresponds totally (all historically described fish species are evident actually) to undisturbed (historically) conditions. We only found one translocated fish species (Perch; *Perca fluviatilis*) in the Lake.

The abundance of 4 fish species (Arctic charr, Bullhead, Minnow, Stone loach) corresponds totally (abundance class 4 = numerous) and 3 fish species (Burbot, Chub, European Lake Trout) corresponds nearly totally (abundance class 3 = frequent) to undisturbed conditions.

There are no differences between recent and reference status in overall fish biomass and abundance class of small bodied taxa. The metrics sensitive species, spawning guilds and migrating spawners show only marginal differences in their abundance classes compared to the reference.

**WFD: All type specific species are present**

Arctic char, European Lake Trout, Bullhead and Minnow are present in frequent or numerous abundances.

WFD: The age structure 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

All native fish species show recently an abundance index of 4 or 3 and there is no evidence of failure in reproduction and development. The length frequency distribution (instead of age structure) of the sentinel fish species Arctic charr shows minor differences to the reference (Average length-frequency distribution of Arctic charr lakes)

**Conclusion**

The undisturbed and recent fish ecological condition of Lake Altausseeersee differs only slightly and therefore the assessment of "high ecological status" corresponds very well with the WFD normative definitions.

## 8.4. Example for an alpine good status lake

Lake **Achensee** is assessed in a good status by the three assessment methods.

**Reference conditions:**

- Achensee is defined as Minnow lake (Austrian lake fish typology) and was historically (around 1850) inhabited by 12 fish species at abundance index 4: Burbot (*Lota lota*), Bream (*Abramis brama*), Chub (*Squalius cephalus*), Minnow (*Phoxinus phoxinus*), Perch (*Perca fluviatilis),* Pike (*Esox lucius*), Bullhead (*Cottus gobio*), Whitefish (*Coregonus* sp.), Roach (*Rutilus rutilus*), Stone loach (*Barbatula, barbatula*), European lake Trout (*Salmo trutta* f. *lacustris*) and Arctic charr (*Salvelinus umbla*).
- Typespecific fish species are Minnow, Bullhead, Arctic char, European Lake Trout, Bream, Chub, Perch, Roach and Pike;.
- Small bodied species are Stone loach, Minnow and Bullhead;
- Sensitive species are Burbot, Minnow, Bullhead, Whitefish, European Lake Trout and Arctic charr.
- Migrating spawner are Chub and European Lake Trout;

- Overall fish biomass is 53 kg/ha in reference;
- Length frequency of Minnow (sentinel fish species) shows no differences to an average length-frequency distribution of Minnow lakes of a certain region.

**Assessment**

WFD definition for good status: There are slight chances in species composition and abundance from the type specific communities attributable to antropogenic impacts on physiochemical or hydromorphological quality elements.

In the recent fish species composition are slight changes as there are four additional species inhabiting the lake (Bitterling, *Rhodeos amarus*; Rudd, *Scardinius erythrophthalmus*; Danubian bleak, *Alburnus mento* and Tench, *Tinca tinca*. Recently we found all 12 historically native fish species. The abundance of one type specific species (Bream) was only sporadic (Abundance index 1) and the abundance of two further species (Chub and Stone loach) was rare (Abundance index 2). Minnow, the sentinel fish species of Lake Achensee, was observed only as numerous and not as frequent like in the reference.

There are no differences between recent and reference status in overall fish biomass an only marginal differences in the metrics sensitive species was detected.

The other metrics like small bodied taxa, spawning guilds, and migrating spawners show moderate differences in their abundance classes compared to the reference.

WFD: The age structure of the fish communities show sign of disturbance attributable to anthropogenic impacts on physiochemical 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.

The length frequency distribution (instead of age structure) of the sentinel fish species Minnow shows considerable signs of disturbance compared to the reference (Average length-frequency distribution of Minnow lakes).

**Conclusion**

Lake Achensee is mainly influenced by huge water level fluctuation (maximum 15 m) caused by a hydropower plant. The main deviations from the reference status are found in the length frequency of the sentinel species and in a lower abundance of small bodied taxa and migrating spawners. Together with moderate differences in the other metrics the assessment is in good fish ecological status corresponding to the WFD normative definitions.

## 8.5. Example for an alpine moderate status lake:

Lake **Millstättersee** is assessed in a moderate status by the three assessment methods.

**Reference**

Millstätteree is defined as Bleak lake (Austrian lake fish typology) and was historically (around 1850) inhabited by 11 fish species with abundance index 4: Bitterling (*Rhodeus amarus), *Bleak *(Alburnus alburnus)*, Burbot (*Lota lota*), Bream (*Abramis brama*), Chub (*Squalius cephalus*), Perch (*Perca fluviatilis)* Pike (*Esox lucius*), Gudgeon (*Gobio gobio*.), Roach (*Rutilus rutilus*), European lake Trout (*Salmo trutta* f. *lacustris*) and Catfish (*Silurnus glanis*). Typespecific fish species are Bleak, Catfish, Bream, Rudd, Tench, Chub, Perch, Roach, and Pike. Small bodied species are Bitterling, Gudgeon and Bleak.

Sensitive species are Burbot, Whitefish, European Lake Trout and Bitterling. Migrating spawners are Chub, Bleak and European Lake Trout. Overall reference fish biomass is 65 kg/ha in reference. Length frequency of Bleak (sentinel fish species) shows no differences to an average length-frequency distribution of Bleak lakes of a certain region.

**Assessment**

<u>WFD definition for moderate status: The composition and  abundance of fish species differ moderately from the type specific communities attributable to antropogenic impacts on physiochemical or hydromorphological quality elements.</u>

In the recent fish species composition are moderate changes as there are seven additional species inhabiting the lake (Eel, *Anguilla anguilla*; Ruffe, *Gymnocephalus cernuus*; Carp, *Cyprinius carpio*; Whitefish, *Coregonus sp*.; Tench, *Tinca tinca*; Archtic charr, *Salvelinus umbla*; Pikeperch, *Sander lucioperca*). Three historically native species are lost Burbot (*Lota lota*), Bitterling (*Rhodeus amarus),* Gudgeon (*Gobio gobio*) and the abundance of one type specific species Bream (*Abramis brama*) was only sporadic (Abundance index 1). The abundance of European Lake trout (*Salmo trutta f. lacustries*) was rare (Abundance index 2).

There are slight differences between recent and reference status in overall fish biomass but strong differences in the metric sensitive species and small bodied taxa .The other metrics like spawning guilds, and migrating spawners show moderate differences in their abundance classes compared to reference condition.

<u>WFD: The age structure of the fish communities shows major signs of disturbance, attributable to anthropogenic impacts on physiochemical or hydromorphological quality elements, to the extent that moderate proportion of the type specific species are absent or in very low abundance.</u>

The length frequency distribution (instead of age structure) of the sentinel fish species Bleak shows strong signs of disturbance (recently only 3 length classes from 14 length classes under reference conditions) compared to the reference (Average length-frequency distribution of bleak lakes).

Conclusion

Lake Millstättersee is mainly influenced by long term consequences of eutrophication, biological degradation and tourism. The main deviations from the reference status are found in the species composition and in a lower abundance of small bodied taxa and sensitive species. Together with moderate differences in the other metrics the assessment resulted in a moderate fish ecological status corresponding to the WFD normative definitions.

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# Annexes

# A. Description of Member states assessment methods

## A.1 Austria: ALFI (Austrian lake fish index): A multimetric index for the assessment of lake fish fauna of alpine lakes

According to the European WFD (2000/60/EC) a multimetric index was developed to assess the ecological status class of fish communities (BQE fish) in alpine lakes of Austria. The index is based on fish data resulting from standardized surveys (Gill netting according to the CEN standard EN-14 757, electrofishing (EN 14011, Gassner et al. 2006), information (inquiries) from fisheries managers and hydroacoustic surveys). The present version of the Austrian assessment method includes eight metrics and covers all requirements (species composition, abundance and age structure) of the WFD. A combination of fish community characteristics (type specific species, alien species), functional groups (spawning guilds, migrating spawners, sensitive species and overall fish biomass) and metrics for single populations (length frequency) evaluates the deviation (EQR) of the current from the reference (historical) situation. Data from standardized fishing surveys are transformed into an abundance index (AI), which are then used for calculation of metrics (Table A.1). The Austrian assessment method addresses a set of different pressures (Water level fluctuation, shore line degradation, connectivity, recreation, fisheries intensity, alien (translocated) fish species and eutrophication) by combination of several parameters of the fish community. The overall EQR for a single lake is the unweighted mean of all metrics and can reach a value between 1 (high) and 0 (bad). Boudaries were set equidistantly and tested for plausibility and reliability by expert judgement.

**Dataset**

Standardized fishing methods using gill nets (EN 14575), electricity (EN 14011, Gassner et al. 2006) and hydroacoustics (WI 00230244 CEN enquiry) were compared in 14 alpine lakes larger than 50 ha regarding species composition, abundance, biomass and size distribution. Additional information was gathered from local fisheries managers to obtain a complete list of species. Each standardized method showed typical shortcomings, but combination of gears obtained comparable fish data (Achleitner et al., 2012).

**Abundance Index**

*Table A.1 Definition of the abundance index classes*

| Relative Abundance = Abundance Index (AI) of each species (standardized survey) | | |
|---|---|---|
| 0 | no catch in standardized survey, no evidence in the last 5 years | missing |
| 1 | no catch in standardized survey, but evidence not older than 5 years | sporadic |
| 2 | 1-4 fish caught in standardized survey | rare |
| 3 | 5-15 fish caught in standardized survey | frequent |
| 4 | > 15 fish caught in standardized survey | numerous |

### Austrian fish based lake typology

Based on reconstructed native fish communities all natural Austrian lakes >50ha (n=43) were classified into four groups using cluster analysis methods. Type-specific species and sentinel species were defined by similarity analysis. The name of the four lake types were derived from the according sentinel species: char-lake (high altitude, small surface and low fish species number), minnow-lake (intermediate altitude, large surface, high maximum water depth), bleak-lake (intermediate altitude, low maximum water depth and long retention time) and pike perch-lake (low altitude, very shallow water depth). For details and methods see Gassner et al. (2005).

### Reference condition

Reference conditions are based on historical data, because there are no "less impacted" (reference) lakes in Austria at present state. The native fish communities were reconstructed for every Austrian lake larger than 50 ha (Gassner et al., 2005; Zick et al., 2006). For the Austrian assessment procedure it was assumed that every fish species belonging to the native fish community originally showed the undisturbed, highest abundance index (4=reference status). The Austrian lake fish index (ALFI) measures the deviation of the present state of a given fish community from the reference state for each individual lake.

### Set of metrics

Metrics were designed to address the impact of several pressures (Table A.3), but also targeted on achieving a balanced assessment of the ecological status of the present fish community. The present version of the Austrian assessment method includes 8 metrics and covers all requirements (species composition, abundance, age structure) of the WFD. A combination of fish community characteristics (type-specific species, alien species), functional groups (small-bodied species, sensitive species, spawning guilds, migrating spawners), length frequency of the sentinel species and overall fish biomass evaluates the deviation (EQR) of the current from the reference (historical) situation. The metrics "AI of type-specific species", "Length frequency of sentinel species" and "Fish biomass" refer to the Austrian fish based lake typology.

### Metric 1: Abundance Index of type-specific species

Motivation: Type-specific fish species have the highest indicator value for a certain lake type. Loss or decrease in abundance of these species indicates changes in their habitat.

Reference: Abundance index 4 for each native type specific fish species.

Data set: Reconstructed historical fish species list for the lake including type specific species according to the Austrian fish based lake typology, recent abundances, calculation of the abundance index.

Calculations: Sum of AI of type-specific native species from recent survey divided by sum of AI of type-specific native species in reference conditions (EQR value between 0 and 1); Value of this metric decreases with deteriorating number and abundance of type-specific species.

**Metric 2: Proportion of Abundance Index alien species**

Motivation: Alien species are indicators for a biological degradation. Lakes inhabited by a high number of alien species with abundance index 4 frequently show decreased or eliminated numbers of sensitive native fish species.

Reference: Abundance index 0 for alien fish species.

Data set: Reconstructed historical fish species list for the lake, definition of the alien species, recent abundances based on standardized catches, calculation of the abundance index.

Calculations: Sum of AI of all recent alien species divided by sum of total AI from recent survey (proportion of AI alien species on total AI) subtracted from 1 (EQR value between 0 and 1); Value of this metric decreases with increasing number and abundance (proportion) of alien species.

**Metric 3: Abundance Index of small-bodied species**

Motivation: Small-bodied species are indicators for hydrological and morphological changes as well as for the degree of recreation activities. They mostly prefer shallow shore areas and therefore display shoreline degradation, water level fluctuation or intensive recreation activities, which can cause a loss or a decrease in abundance of these species.

Reference: Abundance index 4 for native small-bodied species.

Data set: Reconstructed historical fish species list for the lake, definition of small-bodied taxa, recent abundance based on standardized catches, calculation of the abundance index.

Calculations: Sum of AI of native small-bodied species from recent survey divided by sum of AI of native small-bodied species in reference conditions (EQR value between 0 and 1); Value of this metric decreases with deteriorating number and abundance of small-bodied species.

**Metric 4: Abundance Index of sensitive species**

Motivation: Sensitive species are indicators for eutrophication, degradations in the catchment area as well as for hydrological and morphological changes. They inhabit cold, nutrient poor, oxygen rich, and clear lakes and indicate changes in the habitat.

Reference: Abundance index 4 for sensitive species.

Data set: Reconstructed historical fish species list for the lake, definition of sensitive fish species, recent abundances based on standardized catches, calculation of the abundance index.

Calculations: Sum of AI of native sensitive species from recent survey divided by sum of AI of native sensitive species in reference conditions (EQR value between 0 and 1); Value of this metric decreases with deteriorating number and abundance of sensitive species.

**Metric 5: Abundance Index of migrating spawners**

Motivation: Migrating spawners are indicators for the connectivity between a lake and its tributaries. They need a running water ecosystem for spawning and for the development of the eggs and the first stages. Decreased or missing connectivity results in prohibited access of the spawning places and further on in a loss of age classes or in a loss of the species.

Reference: Abundance index 4 for migrating spawners.

Data set: Reconstructed historical fish species list for the lake, definition of migrating spawners, recent abundances based on standardized catches, calculation of the abundance index.

Calculations: Sum of AI of native migrating spawners from recent survey divided by sum of AI of native migrating spawners in reference conditions (EQR value between 0 and 1); Value of this metric decreases with deteriorating number and abundance of migrating spawners.

**Metric 6: Abundance Index of spawning guilds**

Motivation: Composition of spawning guilds is included as reproductive metric. Many fish species are assigned to a certain spawning guild according to their spawning substrate preferences and their spawning behaviour. The method considers the two most frequent groups of lithophilic and phytophilic spawners. Deterioration of spawning grounds results in decrease or loss of specific spawners. The metric is an indicator for Eutrophication (oxygen depletion, siltation of spawning grounds), hydrology, water level fluctuations and shoreline degradation.

Reference: Abundance index 4 for lithophilic and phytophilic spawners.

Data set: Reconstructed historical fish species list for the lake, definition of lithophilic and phytophilic spawners, recent abundances based on standardized catches, calculation of the abundance index.

Calculations: Sum of AI of lithophilic and phytophilic spawners from recent survey divided by sum of AI of native lithophilic and phytophilic spawners in reference conditions (EQR value between 0 and 1); Value of this metric decreases with deteriorating number and abundance of lithophilic and phytophilic spawners.

**Metric 7: Length-frequency of sentinel species**

Motivation: Due to the longevity of fish, age structure or length-frequency data of the sentinel fish species are good long time indicators for anthropogenic impacts. Loss of certain length classes indicate impairments caused by anthropogenic impact.

Reference: Average length-frequency distribution of the sentinel fish species according to the Austrian fish based lake typology.

Data set: length-frequency data of the sentinel fish species based on standardised samples from survey.

Calculations: Number of detected length classes from recent survey divided by number of length classes in reference condition (EQR value between 0 and 1); Value of this metric decreases with deteriorating number of recently detected length classes.

**Metric 8: Fish biomass (hydroacoustics)**

Motivation: Overall fish biomass of a lake is an indicator for eutrophication and biological degradation. Fish biomass is increasing with higher nutrient content in a lake and decreasing with biological degradation.

Reference: Average fish biomass according to the Austrian fish based lake typology (if available) or paleolimnological reconstruction of TP and calculation of fish biomass via relationship between TP and fish biomass.

Data set: Overall fish biomass estimated by hydroacustic surveys.

Calculations: According to the Austrian fish typology for lakes (Char-, minnow- and bleak-lake) an average reference fish biomass for each lake type was determined (35 kg/ha, 53 kg/ha and 65 kg/ha, respectively). As the amount of deviation in both directions (too low/too high) is not linearly correlated with deterioration of the ecological status, the EQR is calculated and determined in the following way: at first the deviation of current and reference condition is calculated as percentage and on a second step the EQR value is assessed according to the following rules:

- Percent deviation 80-150% - EQR 1;
- Percent deviation 60-80 or 150-250% - EQR 0.8;
- Percent deviation 40-60 or 250-350% - EQR 0.6;

- Percent deviation 20-40 or 350-450% - EQR 0.4;
- Percent deviation < 20 or >450% - EQR 0.2.

**Ecological Status Classes and Boundaries**

According to the WFD the ecological status of a water body is classified by 5 classes (high, good, moderate, poor and bad). As the Austrian assessment method operates with 5 abundance classes, on a first step boundaries for EQR-values of the ecological status classes were set equidistantly (Table A.2). Compliance of the status class boundaries with the normative definitions of the WFD was investigated by an experiment with fish ecologist (expert judgement). A fish species list of a certain lake in reference condition (historical taxa AI=4 and alien taxa AI=0) was sent to 5 experts with the invitation to model fish communities and abundance index according to the normative definitions of the WFD. Experts were asked to model barely high, barely good and already moderate status. The modelled fish communities were then assessed by the Austrian assessment method. Results between experts were quite similar and all calculated EQRs met the according status class (Figure A.1). Thus, application of equidistant status classes seemed to be reliable.

*Table A.2 Ecological status classes (ESC) and according EQR-values.*

| Ecological Status | EQR |
|---|---|
| High | >0,8 |
| Good | 0,60-0,79 |
| Moderate | 0,40-0,59 |
| Poor | 0,20-0,39 |
| Bad | <0,20 |

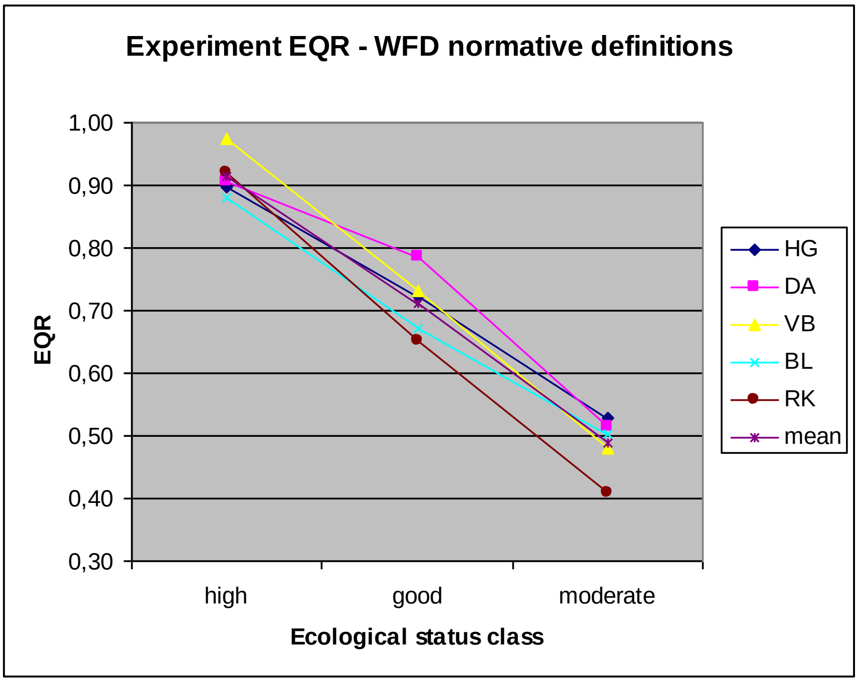


*Figure A.1 Relationship between expert modelled fish communities according to WFD normative definitions and resulting EQR-values from Austrian assessment method.*

*Table A.3 List of metrics used in ALFI (AI - abundance index; LF- length frequency; BM - biomass) and addressed pressures*

| Austrian Assessment Method | | Pressure | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Metric** | **Eutrophication** | **water level** | **shore line** | **connectivity** | **fisheries intensity** | **recreation** | **alien species** |
| Metric species composition | AI of type-specific species | + | + | + | + | + | + | + |
| | Proportion of AI alien species | | | | | | | + |
| | AI of small-bodied species | | + | + | | | + | |
| | AI of sensitive species | + | + | + | | | + | |
| Guilds | AI of migrating spawners | | | | + | | | |
| | AI of spawning guilds | + | + | + | + | | | |
| LF | Length frequency of sentinel species | + | | | | + | + | + |
| BM | Fish biomass (hydroacoustics) | + | | | | + | | + |

*Table A.4 Scores of pressure index*

| **PRESSURE-INDEX** | | **eutrophication *** (compared to RC) | **water level** fluctuation | **shoreline** modified | **Connectivity** (up- and downstream) | **Fisheries** (intensity) | **Recreation** (camping, swimming etc) | **Species plus** (aliens and translocated) |
|---|---|---|---|---|---|---|---|---|
| **Intensity** | **SCORE** | Status | Dimension | Percent | Percent | Activity | Activity | Number |
| **low** | **0** | oligo | natural | 0-10% | >70% | no fisheries | extensive bathing | 0-1 |
| | **1** | oligo-meso | <1m | 11-30% | 51-70% | angling | bathing, rawing and electroboats | 2-3 |
| **medium** | **2** | meso | 1-3m | 31-50% | 31-50% | extensive commercial OR angling | bathing, rawing and electroboats and sailing | 4-5 |
| | **3** | meso-eutroph | 3-5m | 51-70% | 11-30% | extensive commercial AND angling | intensive bathing, rawing and electroboats, sailing, motorboats and excursion boating | 6-7 |
| **strong** | **4** | eutroph | >5m | >70% | 0-10% | intensive commercial and angling | intensive bathing, rawing and electroboats, sailing, motorboats, excursion boating, water skiing and diving | >7 |

* Eutrophication is based on trophic classification and reflects recent analyses (total phosphorus, chlorophyll-a and Secchi depth). Score is calculated by recent trophic classification minus reference trophic status.

### Pressure-Index

As fish mostly do not show a precise response to a single pressure an integrating pressure-index was developed including all relevant pressures. Scores to different pressures are assigned according to a specified table (Table A.4) and summed up to a pressure-index for each lake.

### Assessment of Austrian lakes

The Austrian lake fish index (ALFI) was applied to 15 alpine Austrian lakes of different fish based lake typology (char-, minnow-, bleak-lakes) and a broad range of ecological gradients (near natural (high) – considerably modified (moderate)). Assessment procedure revealed 4 lakes in high, 6 lakes in good and 5 lakes in moderate ecological status class. Results were carefully analyzed and tested for plausibility by expert judgement. Results of the Austrian lake fish index (ALFI) were well correlated with the developed pressure-index (Figure A.2).

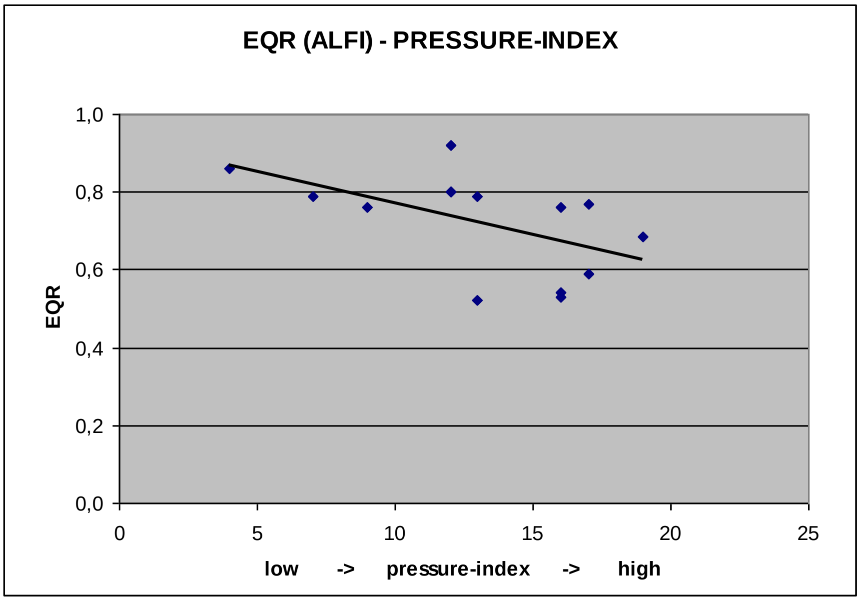


*Figure A.2 Relationship between EQR (ALFI) and pressure index*

### Characterization of fish communities in different status classes

In alpine lakes with a high ecological status no fish species are lost and the abundance of the different fish species is the same or nearly the same compared to the historical reference situation. There are no changes in the abundance of type-specific species and all relevant spawning guilds inhabit the lake. The length frequency distribution does not show any gaps indicating a loss of reproduction. The proportion between the total number of fish species and number of alien or translocated fish species is higher than 3.0. Value of pressure index should be low (< 8).

In alpine lakes with a **good ecological status** not more than two fish species are lost and the abundance of the different fish species can be moderately different compared to the historical reference situation. There can be moderate changes in the abundance of type-specific species and most of the relevant spawning guilds inhabit the lake. The length frequency distribution can show moderate gaps indicating a loss of reproduction for certain years. The proportion between the total number of fish species and number of alien or translocated fish species is higher than 2.0. Value of pressure index should be low to moderate (8 – 14).

In alpine lakes with a **moderate ecological status** several fish species are lost and the abundance of the different fish species is often deviating from the historical reference situation. There are changes in the abundance of type-specific species and loses of the relevant spawning guilds inhabiting the lake. The length frequency distribution can show gaps indicating a loss of reproduction. The proportion between the total number of fish species and number of alien or translocated fish species is smaller than 2.0. Value of the pressure index is moderate (14 – 20).

**Conclusion**

The present results of the Austrian lake fish index (ALFI) are based on a small number of lakes (n=15), but data of these lakes are of a very high quality and thus results have a high plausibility. Fish represent the top most level of the aquatic cascade in lakes and show obviously a wide range of responses to different impacts. In contrast to other BQEs (e.g. algae or MZB) fish respond in more complex ways. The BQE fish in lakes is therefore mostly not appropriate to show a precise response to a single pressure, but has the potential of integrative indication of biological alterations. The Austrian lake fish index (ALFI) is composed of several metrics covering species composition, abundance, guilds, functional groups, reproduction and age structure. Thus, the Austrian assessment method does not only produce one overall EQR-value, but it detects detailed deficits of the fish communities due to its balanced composition of metrics. The extension of investigated lakes by standardised surveys during the next years will hopefully improve the understanding of pressure-response relationships of fish communities in alpine lakes.

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## A.2 Italy: Italian Lake Fish Index (I-LFI): official Italian method for the assessment of the status of the fish fauna in natural lakes

In this technical report the description of the rationale and application of the Italian Lake Fish Index (I-LFI) for Italian lakes is reported. The reference conditions are based on a historical reconstruction of fish communities and the use of literature models to assess the size structure (used as proxy of age structure). As the response of fish to a single pressure is often obscured by the response to other pressures, a common pressure index was created. This pressure index considers eutrophication, hydrological alterations, fisheries exploitation, water uses and biological pressures (non native species). A dataset of 12 natural lakes was used to test the relation between the Italian-LFI and the pressure index.

The I-LFI is a multimetric index, based on 5 metrics. Final score of the index is achieved by averaging the scores of each metrics. I-LFI is based on a standardized sampling. Both multimesh gillnets (CEN standards) and electrofishing (point abundance sampling) are included in the sampling strategy.

The Italian Lake Fish Index (I-LFI) is composed of metrics covering species composition and abundance, reproductive success and size (age) structure. Also indirectly it consider guilds and functional groups as accompanying and guiding species are representative of different functional guilds. The Italian Lake Fish Index does not only produce one overall EQR-value, but it can detect detailed deficits of single features of the fish communities. The extension of investigated lakes by standardised surveys during the next years will hopefully improve the understanding of pressure-response relationships of fish communities in Italian lakes.

**Introduction**

With the establishment of the Water Framework Directive (WFD; EU, 2000), there is an urgent need for expanding our knowledge of biological communities (including fish) in Italian lakes. The WFD requires assessment of the ecological status of lakes using four biological elements supported by physical–chemical and hydromorphological information. The present status of each biological quality element (BQE) has to be compared with the community in a 'near-natural state', i.e. a situation of minimum or no anthropogenic disturbance, the so-called 'reference state'. To determine

the reference state, the WFD proposes a comparison of the statuses of the BQEs of a particular waterbody with those of another waterbody of the same type, but in a 'near-natural' (least disturbed) state. If this is not feasible, use of historical data, modelling or expert judgement is required. Although the use of historical data involves a degree of uncertainty due to the different quality and quantity of data (often only qualitative data are available), it may provide important information on the composition and structure of the fish assemblages in a near-natural state (Steedman et al., 1996). Therefore, identifying indicator fish species for different lake types using historical data and thereby defining the minimum required fish assemblages for each lake type in a near-natural state might be an effective approach to overcome the present lack of reference sites.

The Italian Lake Fish Index (I-LFI) is an assessment method which combines an hystorical approach to modeling (based on literature models) to derive reference conditions and to assess the present status of fish fauna in natural Italian lakes.

**Dataset for reference conditions**

To determine the reference state, the available data extracted from multiple sources such as historical libraries, coupling scientific observations, paintings and photos from universities, research and fisheries institutions, commercial and fisheries statistics and local information from leasing contracts and fish market trades covering a period from 1700 to 1970 were analysed (Volta et al. 2011). Hence, a priori, the lakes as belonging to either the Alpine or the Mediterranean ecoregion were separated. Fish synonyms were checked, and all fish species were validated with the current official Italian taxonomy (Gandolfi et al., 1991). Due to the different sources considered, the data covered the whole geographical range and lake sizes enabling a satisfactory reconstruction of the fish assemblages in the first decades of the twentieth century in Italian lakes.

The year 1950 was a significant time threshold between low and high level of anthropogenic pressures on lakes, as it corresponds to the period between low and high human development in Italy (before and after the Second World War). This is particularly true for eutrophication which, although it began to increase already in the 18th century, did not seriously affect the Italian lakes until the 1950s (Guilizzoni et al., 1982; Margaritora, 1992; Marchetto et al., 2004; Salmaso et al., 2007).

**Italian fish-based lake typologies**

Based on reconstructed fish communities, six lake types (4 in ALP and 2 in MED) have been identified according to different fish communities. For each lake type a list of reference species was detected  (Table A.5).

**Type 1** – Large deep lakes of North West Italy. Oligotrophic, high species richness, cold stenothermal species and pelagi gregarious.

**Type 2** – Deep lakes of the north east Italy. Intermediate between type 1 lakes and shallow lakes. Mainly littoral/migratory species are characterized.

**Type 3** – Shallow/warm lakes of the lowlands. Shallow and small, oligomesotrophic, low species richness, littoral tolerant species, not very suitable for cold stenothermal species.

**Type 4** – High altitude lakes Alpine lakes. Oligo-ultraoligotrophic, very low species richness.

**Type 5** – Deep lakes of the Mediterranean Ecoregion. Mostly are volcanic lakes. High species richness, cold stenothermal species.

**Type 6** – Shallow mediterranean lakes. Low specie richness, tolerant species.

**Sampling and sample processing**

Sampling is carried on by means of multimesh gillnets and electrofishing.

1. Gill netting is conducted between July and October by using NORDIC gillnets, according to the CEN standard EN-14 757. The used number of bentic nets depends on lake surface and maximum water depth.  The number of pelagic nets depends on the area of the lake.
2. The shoreline is sampled by Point abundance Electrofishing, at least 60-80 points in each lake.
   For each fish captured the following parameters are determined/measured: species, total length, total weigth. For a subsample of at least 60 individuals of

each fish species scales or other bony structures are taken for age determination. This enables to set reliable growth curve and to determine maximum length of the species. Such data are necessary to tehcorrect application of the PSD index.

*Table A.5 Guiding and accompanying species for the ALPINE lakes*

| | Type 1 Very deep large lakes North West | Type 2 Deep lakes North East | Type 3 Shallow/warm lakes | Type 4 High altitude lakes |
|---|---|---|---|---|
| Guiding species | Whitefish *(Coregonus lavaretus)* Landlocked shad *(Alosa fallax lacustris)* Burbot *(Lota lota)* | Pike (*Esox lucius*) Rudd (*Scardinius erythrophthalmus*) Tench (*Tinca tinca*) | Pike (*Esox lucius*) Rudd (*Scardinius erythrophthalmus*) Tench (*Tinca tinca*) | Minnow (*Phoxinus phoxinus*) |
| Accompanying species | Bleak (*Alburnus alburnus alborella*) Chub (*Leuciscus cephalus* ) Carp (*Cyprinus carpio*) Pike (*Esox lucius)* Perch (*Perca fluviatilis*) Rudd (*Scardinius erythrophthalmus)* Tench (*Tinca tinca)* Italian roach (*Rutilus aula*) Trout (*Salmo trutta*) | Italian nase *(Chondrostoma soetta*) Chub (*Leuciscus cephalus*) Carp (*Cyprinus carpio*) Trout (*Salmo trutta*) | Bleak (*Alburnus alburnus alborella*) Carp (*Cyprinus carpio*) Perch (*Perca fluviatilis)* | Charr (*Salvelinus alpinus*) Bullhead (*Cottus gobio*) Trout (*Salmo trutta*) |

**Italian lake fish index (I-LFI)**

**Metrics**

The Italian Lake Fish index is a multimetric index composed by 5 metrics.

1. NPUE of the guiding species (Table A.6)
2. Population structure of the guiding species (Table A.7). See PSD-Proportional Stock Density Index (Anderson & Neumann 1996; Volta 2010; Zick et al. 2006)
3. Reduction % of guiding + accompanying species (Table A.8)
4. Reproductive success % of guiding + accompanying species (Table A.9)

5. Ratio% alien/total number of species (Table A.10)

*Table A.6 Score for Metric 1.*

| NPUE (n. individuals captured in the total effort) | 41-99 | 7-40 | 1-6/ 100-250 | Not captured but present in fisheries statistics in the last 5 years/251-400 | Neither captured nor present in the fisheries statistics in the last 5 years/>400 |
|---|---|---|---|---|---|
| Score* | 10 | 8 | 6 | 4 | 2 |

*If more than one guiding species is present, score is calculated for each species and then averaged.

If stocking of guiding species is present, the relative score has to be decrease of one position.

*Table A.7 Score for Metric 2.*

| PSD | 35-65 | 25-34/66-75 | <25/>75 |
|---|---|---|---|
| Score* | 10 | 6 | 2 |

*If more than one guiding species is present, score is calculated for each species and then averaged.

*Table A.8 Score for Metric 3*

| Reproductive success of guiding + accompanying (n. species) | >80% | 80- 60% | 59-41% | 40-20% | <20% |
|---|---|---|---|---|---|
| Score | 10 | 8 | 6 | 4 | 2 |

*Table A.9 Score for Metric 4*

| Decrease of the number of guiding + accompanying species | <20% | 20-40% | 41-60% | 61-80% | >80% |
|---|---|---|---|---|---|
| Score | 10 | 8 | 6 | 4 | 2 |

*Table A.10 Score for metric 5*

| % alien species | <20% | 20-40% | 41-60% | 61-80% | >80% |
|---|---|---|---|---|---|
| Score | 10 | 8 | 6 | 4 | 2 |

**Final score of I-LFI**

Average of the score of each metric according to:

$$EQR_{tot} = \left(\frac{scM_1 + scM_2 + scM_3 + scM4_4 + scM5_5}{50}\right)$$

Boundaries have been set in the intercalibration process. EQRs and ecological status evaluation are presented in the following Table A.11:

*Table A.11 EQR values and ecological status evaluation*

| EQR tot | Ecological State |
|---|---|
| > 0.82 | High |
| 0.64 – 0.82 | Good |
| 0.4 – 0.64 | Moderate |
| 0.2 – 0.39 | Bad |
| 0 – 0.19 | Worse |

**Pressure index**

As fish mostly do not show a precise response to a single pressure an integrating pressure-index was developed including all relevant possible pressures. Scores to different pressures are assigned according to the pressure index (Table A.12).

**Testing relation between the present available dataset with the pressure index**

The I-LFI (Italian-LFI) was applied to 12 Italian alpine lakes of different and a broad range of ecological gradients. Present dataset comprises a total of 12 lakes belonging to Lake Type 1-3-4.

Assessment procedure revealed 1 lake in high, 7 in good and 4 lakes in moderate ecological status class.  Results of the Italian Lake Fish Index (ILFI) were well correlated with the developed pressure-index (Figure A.3).

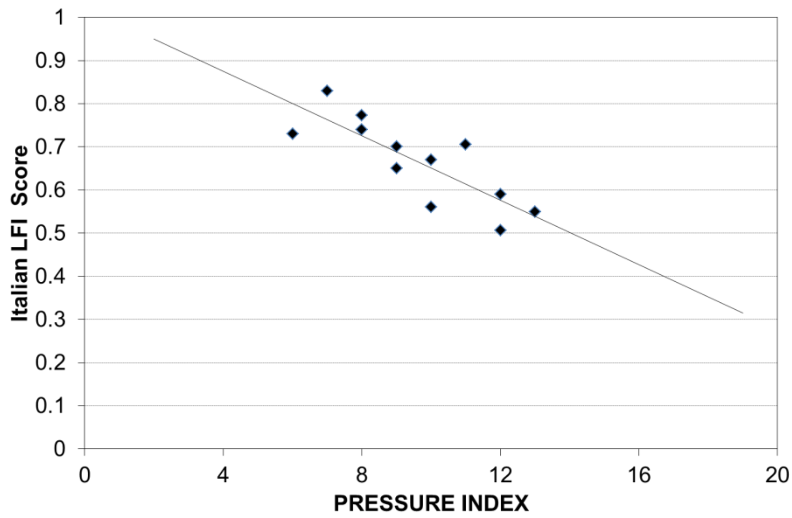


*Figure A.3 Relation between the score of LFI and the pressure index values*

*Table A.12 Pressure index*

| Intensity | Score | Trophic status | Water level fluctuation | Shoreline modification | Connectivity | Fisheries/Stocking | Water uses | Increase alien + translocated |
|---|---|---|---|---|---|---|---|---|
| | | Status | Dimension | Percent | Percent | Activity | Activity | Species + |
| Low | 0 | Oligo | Natural | 0-10% | >80% | No fisheries | No | 0-1 |
| | 1 | Oligo-meso | <1m | 11-30% | 60-79% | Angling | Extensive bathing | 2-3 |
| Medium | 2 | Meso | 1-2 m | 31-55% | 40-59% | Extensive commercial OR extensive angling | + Rowing, Electroboating and sailing | 4-5 |
| | 3 | Meso-eu | 2-3 m | 56-80% | 20-39% | Extensive commercial AND angling | + Excursion + Motorboating | 6-7 |
| High | 4 | Eu | >3 m | >80% | 0-19% | Intensive commercial AND angling | + Water skiing + Diving | >7 |

## Conclusions

The present results of the Italian-Lake Fish Index (I-LFI) are based on a relative small number of lakes (n=12). The dataset however is of very high quality as achieved by multiple sampling techniques. Therefore results should have a high plausibility. The Italian Lake Fish Index (I-LFI) is composed of metrics covering species composition and abundance, reproductive success and size (age) structure. Also indirectly it consider guilds and functional groups as accompanying and guiding species are representative of different functional guilds.

The Italian Lake Fish Index does not only produce one overall EQR-value, but it can detect detailed deficits of single features of the fish communities.

The extension of investigated lakes by standardised surveys during the next years will hopefully improve the understanding of pressure-response relationships of fish communities in Italian lakes.

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## A.3 France - Multimetric Index based on Fish Fauna for the assessment of the subalpine lakes.

**Introduction**

The Water Framework Directive 2000/60/EC (WFD) (Communauté Européenne 2000) requires the definition of the ecological status of European water bodies.

To assess ecological status of the Alpine lakes, fish communities shall be considered. These fish communities should be described by a single indicator that is a combination of standardized single metrics. According to WFD, the fish index has to aggregate metrics in relation with composition, abundance and age structure of the fish communities. These metrics must react to measurable stressors such as hydro-morphological pressures and/or eutrophication pressures.

The method implemented to develop a fish index of the eutrophication status of the alpine natural lakes is described below.

**Dataset**

*Fish data*

The dataset concerns 32 lakes located in the Alpine region, classified in L-AL3 or L-AL4 (Table A.13) and acquired in the framework of the subalpine GIG intercalibration work.

Fish campaigns have been performed from 2003 to 2009 in 13 Austrian, 14 French, 3 Italian and 2 Slovenian lakes. Fish data have been collected in application of the standardised method (C.E.N. 2005). This index is developed only with catches of the benthic nets.

All sampling sessions included in the dataset correspond to a single campaign for each lake, in order to be consistent with one-year environmental data.

Based on the benthic nets catches, 32 metrics have been calculated (Table A.14). Within this pool, 7 metrics were removed because of their narrow range of variation or because of their great number of outliers (Hering and al., 2006). The analyses were performed on the 25 remaining metrics.

*Table A.13 Characteristics of the intercalibration types considered in this analyse.*

| | Altitude (m) | Mean Depth (m) | Alkalinity (meq/L) | Lake Area (km2) |
|---|---|---|---|---|
| L-AL3 | 50 to 1000 | >15 | >1 | >0.5 |
| L-AL4 | 200 to 1000 | 3 to 15 | >1 | >0.5 |

*Table A.14 List of metrics tested, and expected variation with degradation.*

| Metrics | Shoreline degradation | Eutrophication | Water level regulation | General degradation |
|---|---|---|---|---|
| **Species composition** | | | | |
| Total number of species | - | - | - | ↓ |
| Number of cyprinids species | - | - | - | ↓ |
| Number of salmonids species | - | - | - | ↓ |
| **Diversity/abondance** | | | | |
| Shannon-Weaver (numbers) | - | - | - | ↓ |
| Simpson's Dn (numbers) | - | ↓ | ↓ | ↓ |
| Simpson's Dw (biomass) | - | ↑ | ↓ | ↓ **or** ↑ |
| Equitability index | - | - | - | ↓ |
| Total biomass | - | - | - | ↑ |
| Relative number of cyprinids | - | - | - | ↓ |
| Relative biomass of cyprinids | - | - | - | ↑ |
| Ratio Perch/Cyprinids (biomass) | - | ↓ | - | ↓ |
| Relative number of salmonids (& biomass) | - | - | - | ↓ **or** - |
| Relative number of percids (& biomass) | - | - | - | - |

| | | | | |
|---|---|---|---|---|
| Total number of individuals | - | - | - | ↓ |
| BPUE | - | - | - | ↓ **or** ↑ |
| CPUE | - | - | - | ↓ |
| Relative biomass of roach (& abundance) | ↑ | - | - | ↑ |
| Relative biomass of rudd (& abundance) | ↑ | ↓ | ↓ | ↓ |
| Relative biomass of bream (& abundance) | - | ↑ | - | ↑ |
| Mean mass (from total catch) | - | - | - | ↑ |
| **Trophic guild** | | | | |
| Relative biomass of piscivore percids | - | - | - | ↓ |
| Number of invertivore species | - | - | - | ↓ |
| Number of omnivore species | - | - | - | ↑ |
| Number of planktivore species | - | - | - | - |
| Number of strict piscivore species | - | - | - | ↓ |
| Relative number of omnivore (& biomass) | - | - | - | ↑ |
| Relative number of invertivore (& biomass) | - | - | - | ↓ |
| Relative number of piscivore | - | - | - | ↓ |
| **Reproductive guild** | | | | |
| Number of phytophile species | ↓ | ↓ | ↓ | ↓ |
| Relative number of phytophile | ↓ | ↓ | ↓ | ↓ |
| Relative biomass of strict phytophile | ↓ | ↓ | ↓ | ↓ |
| **Size structure** | | | | |
| Mean weight of the fish caught | - | - | - | - |

* Increased of algal growth, reduced water clarity & loss of submerged vegetation

** Loss of inundated areas & emergent vegetation

* Total biomass (g) and total number of individuals of all native species, divided by the number of nets.

*Environmental data*

All the lakes were described by environmental variables that are known to influence fish community structure (Table A.15). Maximum depth and lake area are strong drivers of the species richness (Barbour and Brown 1974, Eadie et al. 1986). Altitude is a factor of isolation that influences community composition (Godinho et al. 1998, Magnuson et al. 1998). Catchment area could be considered as a surrogate for habitat diversity upstream from the lake (Irz et al. 2004). Monthly mean air temperature data obtained in application of the CRU model (New et al. 2002) was used to calculate the mean temperature range between the maximum and the minimum annual temperatures and the annual mean temperature.

*Table A.15 Natural environmental parameters of the studied lakes*

| Environmental variables | Min | Max | Mean |
|---|---|---|---|
| Altitude (m) | 226.5 | 929 | 624.3 |
| Maximum Depth (m) | 7 | 141 | 46.47 |
| Lake Area ($km^2$) | 0.15 | 26.5 | 4.12 |
| Catchment Area ($km^2$) | 2.16 | 1033.0 | 102.2 |
| Mean Annual Temperature (C°) | 3.7 | 12 | 7.4 |
| Temperatures Amplitude (C°) | 17.2 | 20.7 | 18.2 |

Except some large systems (Annecy, Wörthersee…), the Alpine natural lakes are close to each other in terms of environmental characteristics. Although the size of the dataset is limited (32 lakes), analysing a pool of lakes which is quite uniform facilitate the discrimination of variability induced by given anthropogenic stressors from the natural variability of the fish fauna.

*Stressors*

The stressors used are the percentage of non-natural land cover extracted from Corine Land Cover and the concentration of total phosphorus (µg/L) collected by the different member state and available in the GIG database. The first one can be considered as a proxy of eutrophication and/or of general degradation, whereas total phosphorus is related to eutrophication.

*General Statistical Methodology*

Modelling metrics with environment and anthropogenic stressors

First, classic monotonic transformations were performed in order to meet the requirements of linear models (normality, linearity). Multiple Linear Regression (MLR) has been used to model each metric, by using environmental variables and stressors as predictor. The square of each environmental variable and stressor were also included to allow for possible non-linear relationships. After checking redundancy among environmental parameters and between the two stressors (Pearson correlation) we performed a stepwise procedure based on the AIC in order to select the best explaining model for each metric. Then, we analysed the adjusted $R^2$ of the selected model and checked the residuals for normality (Shapiro Wilk test).

Since this step of the procedure allows us to ensure that stressors have a significant influence in predicting accurately the metric value, we selected metrics for which (i) stepwise procedure retained at least one significant stressor, (ii) adjusted $R^2$ of the model was >0.3 and (iii) model's residuals were normally distributed.

Extrapolation of reference conditions

According to the national classifications, reference sites included in the dataset are scarce. Consequently, it was impossible to conduct an analysis based on reference sites and therefore it was decided to apply a hindcasting type approach (Baker et al. 2005, Kilgour and Stanfield 2006, Launois et al. 2011). This method consists in artificially "switching off" the stressors influence (stressor values set to 0 or to low level of pressure for all lakes) in order to predict the metric value without the anthropogenic pressures part. Thus, we assume that these predictions are representatives of what the metric value should be in the absence of pressure and so, could be considered as reference values.

EQR calculation and normalisation

The deviation score between the observed metric value and the expected reference value predicted by hindcasting is then normalised in a ratio contained between 0 and 1. To do so, we used the following formula (Hering et al. 2006):

$$EQR = \frac{(\text{obs\_metric - hind\_metric}) - \min(\text{obs\_metric - hind\_metric})}{\max(\text{obs\_metric - hind\_metric}) - \min(\text{obs\_metric - hind\_metric})} \qquad (1)$$

$$EQR = 1 - \frac{(\text{obs\_metric - hind\_metric}) - \min(\text{obs\_metric - hind\_metric})}{\max(\text{obs\_metric - hind\_metric}) - \min(\text{obs\_metric - hind\_metric})} \qquad (2)$$

(1) For metrics that decrease with increasing stress, (2) for metric that increase with increasing stress.

Then, Pearson correlation is calculated between the normalized EQR and the stressor in order to confirm that the deviation from the assume reference conditions is proportional to the disturbance level. Core metrics have been selected if the Pearson coefficient was equal or upper to 0.5 on the stressor gradient.

Generation of a multimetric index

After checking that the trend of the targeted metric on the pressure gradient was consistent with the expected one (described in the literature and/or explicable from an ecological point of view), Pearson correlation analysis were performed among the selected metrics (EQR) to identified the ones with a correlation value upper than 0.8 (Hering et al. 2006). Among each pairs of redundant metrics, the selected core metrics is the one exhibiting the higher correlation value with the stressor; the other one was removed from the analysis.

The core metrics were then aggregated by calculation of the average.

**Results**

**The French lake multimetric Index results**

From the 32 available metrics only two passed through the various selection steps listed above and exhibits acceptable correlation with stressors gradient (Table A.16):

- The number of individuals caught per unit effort (CPUE) and
- The relative number of omnivorous individuals (OMNI).

The first one is an abundance metric and is already part of European assessment system in particular for Finland (Rask et al. 2010). Selected model (Table A.18) for the CPUE metric explains 51.51% of the variance and the corresponding EQR is correlated to the percentage of non-natural land cover and to the rate of Total Phosphorous (Table A.17). On the other hand, the metric OMNI is related to trophic guild and therefore is representative of the fish fauna composition. This metric is increasing with the intensity of the pressure confirming its interest in bioindication emphasized in different studies on North American lakes and reservoirs (Drake and Pereira 2002, Hickman and McDonough 1996). Model explains 74.25% of the variance, and the EQR for this metric is also correlated to land use and total phosphorous (Table A.16).

*Table A.16 Models coefficients for the selected variables (AIC stepwise procedure)*

| | EQR CPUE | EQR OMNI |
|---|---|---|
| Intercept | -8.85* | -71.19* |
| Maximum Depth$^2$ | - | -3.27 |
| Lake Area | 0.83* | 14.53*** |
| Catch Area$^2$ | -0.23** | -2.04* |
| Altitude$^2$ | 1.70E-06** | 1.43E-05** |
| Average Temperature | - | 8.09* |
| Average Temperature$^2$ | -1.32E-02 | -0.76** |
| Temperature Amplitude | 0.27 | 3.39* |
| Percentage of Non-Natural Landcover$^2$ | 1.71** | 18.02** |
| Total Phosphorous | 0.36* | - |
| Total Phosphorous$^2$ | - | 1.45*** |

<0.001***0.01**0.05*

*Table A.17 Correlation of the core metrics with the anthropogenic factors*

| Metrics | % of non-natural land cover at catchment scale | Total Phosphorous |
|---|---|---|
| *CPUE* | *- 0.6 **** | *- 0.76 **** |
| *OMNI* | *- 0.72 **** | *- 0.81 **** |

The multimetric Index resulting of a mean of the two metrics is correlated to the percentage of non-natural land cover in the catchment (adjusted $R^2$ = 0.46, Pvalue<0.001) and to total phosphorous rate (adjusted $R^2$ = 0.66, Pvalue<0.001).

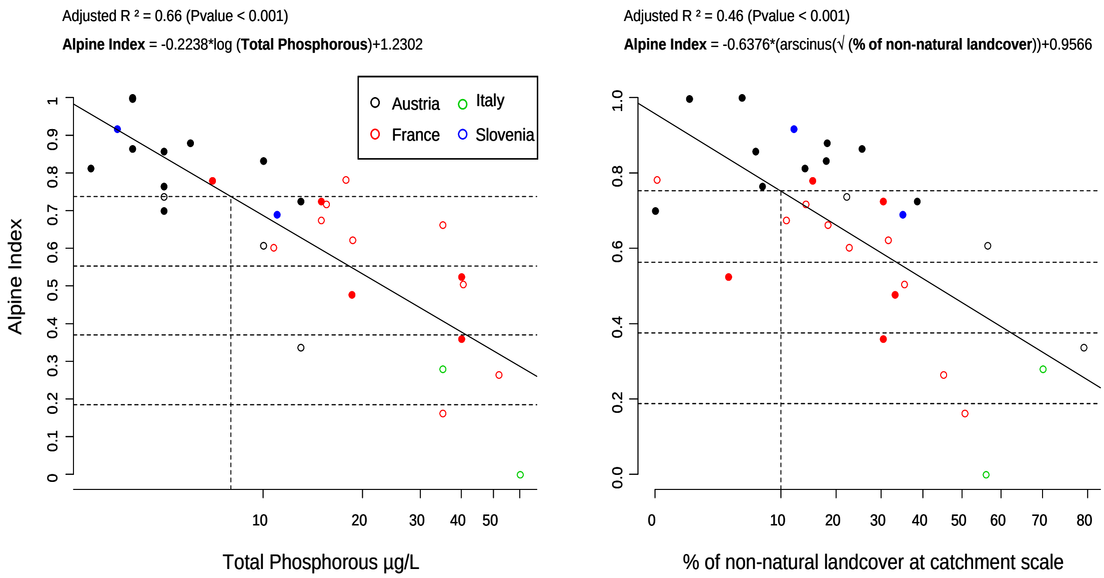



*Figure A.4 Relationships between the Index and a) Total phosphorous rate (µg/L, log scale); b) the percentage of non-natural land cover at catchment scale (arcsin squared-root scale). Full dots represent AL-3 lakes and empty dots represent AL-4 lakes. Vertical dotted lines represent the reference value for a given stressor, from which High/Good boundary is calculated.*

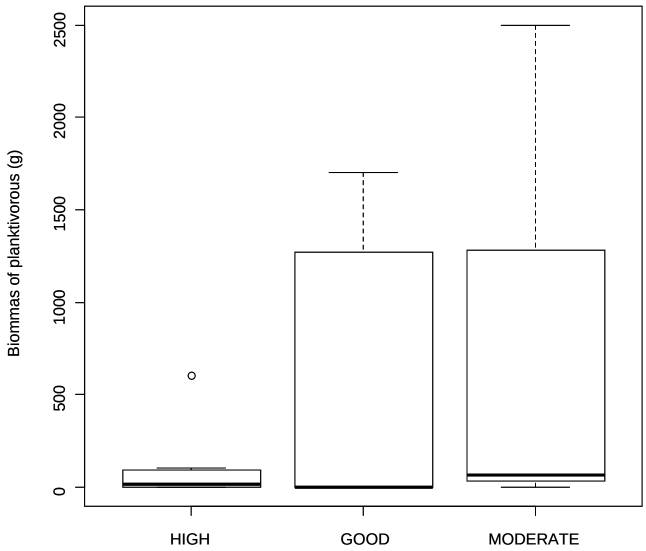
The class boundaries have been set according to the Guidance on the intercalibration process, by using the specific stressor value that distinguishes reference lake from non-reference lakes. These values are 8 µg/L for the total phosphorous rate and 10 % for the percentage of non-natural land cover. By projecting these thresholds values on the regression line it has been possible to set the High/Good boundary, and then, by dividing the part bellow in 4 equal sections we obtained the others classes.

Following this method, the thresholds defined are given in the table below.

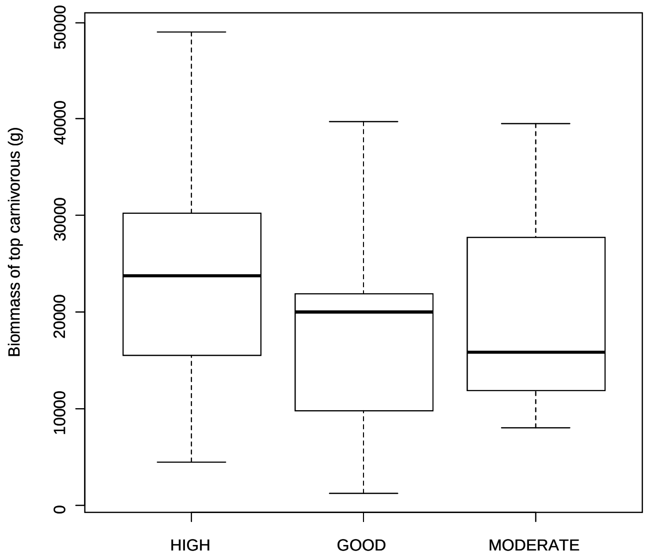
*Table A.18 Class boundaries defined for the fish index of the Alpine lakes*

| Thresholds | Classes |
|---|---|
| 1 - 0.75 | H |
| 0.75 - 0.56 | G |
| 0.56 - 0.37 | M |
| 0.37 - 0.18 | P |
| 0.18 - 0 | B |

The communities in High, Good and Moderate are characterised by changes in distribution of fish species. Biomass of planktivorous species is increasing from high to moderate classes. Conversely, biomass of top carnivorous fishes is decreasing from the high to the moderate classes.  Unfortunately, because the total number of lakes in each class is very low, this trend cannot be tested from a statistical point of view.




**(a)**




**(b)**

*Figure A.5 Distribution of (a) planktivorous biomasses and of (b) top carnivorous biomasses across High, Good and Moderate lakes.*

The final classification of the French lake is then shown in Table A.19.

*Table A.19 Classification of the French lakes*

| Lake Name | Types | EQR | Class |
|---|---|---|---|
| Barterand_(lac_de_) | L-AL4 | 0.163 | B |
| Chaillexon_(lac_de_) | L-AL4 | 0.265 | P |
| Saint_Point | L-AL3 | 0.358 | P |
| Chalain_(lac_de_) | L-AL3 | 0.476 | M |
| Petichet | L-AL4 | 0.505 | M |
| Nantua_(lac_de_) | L-AL3 | 0.525 | M |
| Entonnoir-bouverans_(l'_) | L-AL4 | 0.603 | G |
| Etival_(grand_lac_) | L-AL4 | 0.622 | G |
| Sylans_(lac_de_) | L-AL4 | 0.661 | G |
| Clairvaux_(Grand_lac) | L-AL4 | 0.676 | G |
| Pierre-châtel_(lac_de_) | L-AL4 | 0.717 | G |
| Laffrey_(grand_lac_de_) | L-AL3 | 0.725 | G |
| Annecy_(lac_d'_) | L-AL3 | 0.781 | H |
| Grand_maclu_(lac_du_) | L-AL4 | 0.782 | H |

**Conclusion**

This index has been developed by a site specific approach. The targeted pressures are eutrophication and also probably “general degradation”.

It includes abundance and composition metrics but no information in relation with age structure. Indeed, the metric calculated in order to address this issue was not selected by the models.

It has been developed on the GIG dataset and is well adapted to the two intercalibration types AL_3 and AL_4 considered by this GIG.

These results are now under validation at the national level.

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## A.4 Germany - German site specific system (DELaFi_SITE)

**System concept**: The German site-specific system to assess the ecological status of lakes with their fish fauna (DELaFi_SITE) compares the fish community of an individual lake in its reference/historical condition with the current situation. The fish community is described by the species inventory and one out of four abundance classes (absent, rare, regular, frequent) that is assigned to the relevant species.

The system was developed for lakes, for which the prevailing circumstances make standardized multimesh gillnet fishing procedures like CEN 14757 impossible or unreliable. This is the case in large lakes, where the CEN procedure is highly time consuming and expensive but provides results with lower representativeness. The SITE approach can also be applied in federal countries of Germany where multimesh fishing has a very bad acceptance in both the public and the fisheries right owners.

**Fish community modelling**: The historical fish community is modelled using any information available. Main sources are historical records, scientific literature before 1940 and long time fisheries statistics. The reference fish community is completed by expert knowledge based on the historical species inventory of nearby water bodies, evidence in the catchment area and general species ecology.

For the current situation, the fish community composition is modelled with fishery statistics or scientific gear. Data and information (e.g. of professional fisherman) of the precedent six years can be used. It is important to obtain a complete picture of all lake habitats. Therefore we strongly recommend that information on at least one of the following fishing gear for each habitat is included in the modelling procedure:

- Littoral - electrofishing, fyke net, beach seine
- Benthic - (multimesh-)gillnet, bottom trawl, extended fyke net
- Pelagic - (multimesh-)gillnet, trawl, purse seine

If information is missing, a complemental scientific investigation becomes necessary.

A complete modelling of the fish community of a specific lake usually is based on a number of different gear and sources. In order to make the information on the fish abundance comparable, data and other specifications are roughly translated into the following abundance classes:

*Table A.20 Assignment of abundance classes based on different sources of information. Scientific samples (electrofishing, CEN 14757) always refer to % number in gear with the highest percentage.*

| Abundance class | Fishery statistics | Literature | Scientific samples [%] | Scientific samples [abs.] |
|---|---|---|---|---|
| 0 (missing) | - | - | - | - |
| 1 - rare (side species) | < 10 Ind/km² | Rare, sporadic, | < 1% | No catch, found in the last 5 years |
| 2 - regular (type species) | < 1 kg/ha | Regular, steady | 1 - < 5 % | 1 - 15 |
| 3 - frequent (sentinel species) | > 1 kg/ha | Frequent, common, plenty | > 5 % | > 15 |

For the scientific samples, the values of the gear with the highest species-specific percentages are taken. This will usually be electrofishing for shore-bound species (Pike, Tench) and pelagic nets for species of the open water (Smelt, Vendace).

**Lake typology**: the DELaFi_SITE system is site specific, i.e. the reference conditions are modelled for each lake individually (in contrast to type specific standard values). This allows including lake specialties and rare or endemic species. The lake type is of lower importance. However, we have introduced three lake types (polymictic lakes. stratified lakes with a max depth ≤ 30 m and stratified lakes with a max depth > 30 m). For each of these types, default values have been set for the abundance of selected species. If deviations occur in the modelling procedure, they have to be substantiated.

**Metrics**: Nine metrics are used to assess the ecological status:

- Sentinel species number: scores the number of species that are sentinel species in reference condition but absent today
- Type species number: likewise
- Side species number: likewise
- Sentinel species abundance: scores the number of species that are sentinel species in reference condition but type or side species today
- Habitat preferences: scores the number of habitat preferences that exist in reference condition but are missing today (preferences are littoral, benthic, epilimnetic, hypolimnetic).
- Spawning preferences: likewise (preferences are lithophilic, psammophilic, phyto-lithophilic, phytophilic)
- Abundance of habitat preferences: scores the distribution of abundance classes within the habitat preferences (e.g. littoral species are sentinel in reference condition, but side today)
- Abundance of spawning preferences: likewise

- Reproduction of potentially stocked species: is a downgrading metric. For a selection of species it has to be checked if the species is stocked and if it reproduces naturally. Species which persist by stocking only are treated as if they were absent.

**Class boundaries and scoring**: each metric is scored 1, 3 or 5 points; according to the WFD compliant status classes poor, moderate or high. The class boundaries are described in Table A.21.

The total EQR is calculated for all metrics together as EQR = (Score-Min) / (Max-Min).

Total ecological status class boundaries are ≥0.90/0.75/0.50/0.25, beginning with HIGH.

*Table A.21 Class boundaries of the metrics used in the DELaFi_SITE system. The description always compares the present situation with the reference condition (pref: preference)*

| Metric | 5 (high) | 3 (moderate) | 1 (poor) |
|---|---|---|---|
| Sentinel species number | All present | - | ≥ 1 missing |
| Type species number | > 90 % present | 75-90 % | < 75 % |
| Side species number | > 50 % present | 25-50 % | < 25 % |
| Sentinel species abundance | 100 % of species are sentinel | 50-99 % | < 50 % |
| Habitat pref | All present | One pref missing represented by 1 species in refcond | More then one pref missing or one pref missing represented by > 1 species in refcond |
| Spawning pref | likewise | | |
| Abundance of habitat pref* | Mean of pref scores is > 4 | Mean of pref scores is > 2 | Mean of pref scores is ≤ 2 |
| Abundance of spawning pref* | likewise | | |

* In the two metrics ‘abundance of preference group’ the scoring is done stepwise. First, the abundance classes within a preference are scored (e.g. littoral-rare, littoral-regular, littoral-frequent). This is done using the absolute values of the log(reference species number/current species number). Afterwards the three values are combined to a preference score using the mean (e.g. littoral). Finally, the preferences are combined to a score of the preference group (e.g. habitat) like described in the table.

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Abstract

One of the key actions identified by the Water Framework Directive (WFD; 2000/60/EC) is to develop ecological assessment tools and carry out a European intercalibration (IC) exercise. The aim of the Intercalibration is to ensure that the values assigned by each Member State to the good ecological class boundaries are consistent with the Directive's generic description of these boundaries and comparable to the boundaries proposed by other MS.
In total, 83 lake assessment methods were submitted for the 2nd phase of the WFD intercalibration (2008-2012) and 62 intercalibrated and included in the EC Decision on Intercalibration (EC 2013). The intercalibration was carried out in the 13 Lake Geographical Intercalibration Groups according to the ecoregion and biological quality element. In this report we describe how the intercalibration exercise has been carried out in the Alpine Lake Fish fauna group.

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