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# Intercalibration of Fish-based Methods to evaluate River Ecological Quality

Report from an EU intercalibration pilot exercise

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# Content

## Background and purpose of this report

According to the time plan for the implementation of the WFD, the member states should establish a monitoring network to be functional at the end of 2006. An important step was to develop comparable methods for evaluating the status of the water-bodies. In the cases where member states already had operational methods, these had to be made comparable or intercalibrated. For several reasons one of the four quality elements (QE) namely the fish, were left behind in this process. Despite a general consensus that fish are important indicators of EQ in rivers, only few member states have developed national methods. This has been due to the fact that sampling is not at all straight forward and the institutional setup has not been in favour of developing fish methods. Most often the responsibility and the capacity for monitoring fish in rivers are placed in the fisheries and agricultural sectors and not in the environmental sectors. In short; fish are more likely to be regarded as food than as environmental indicators, so it has been difficult for the member states (MS) to establish methods for monitoring and assessing the fish populations.
However, in May 2006, 17 researchers representing 8 MS, met in Paris to make an attempt to start an intercalibration exercise.
During this first meeting it was decided:

- *to compare national classifications, directly , 2 by 2 at a regional scale and by using common metrics.*

It was also decided that for the pilot exercise it was not necessary to organise this work within the already existing Geographical Intercalibration Groups (GIG's). However, it seemed relevant to make regional groups that were responsible for the exchange of data and the reporting of the results. The main difference being that the process was centrally guided and that all data was submitted to the central database to facilitate comparisons between the national methods and the common metrics.

**The real upstart** of this work and the formation of groups took place at the second meeting in Rotterdam October 2007. Here 48 researchers representing 22 ms were participating.

*Austria, Belgium, Czech Rep., Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Lithuania, Luxemburg, Netherlands, Poland, Romania, Sweden, Slovakia, Slovenia, Spain, United Kingdom, Portugal, Norway.*

In this meeting the following fish IC-groups were formed:

*Nordic group*
Finland, England, Ireland, Scotland.

*Alpine group*
Austria, Germany, France, Slovenia

*Lowland Group*
Netherlands, Germany, England, Denmark, Belgium (Flanders)

*Midland Group*
France, Luxembourg, Belgium (Wallonia)

*Atlantic Group*
Portugal, Spain, France

*Mediterranen Group*
France, Spain, Italy, Portugal

*Carpathian Group*
Romania, Poland, Czech Republic, Slovakia

These groups started working immediately and have thus only had 6 months to gather and exchange national data, calculate metric scores and boundaries for national methods and common metrics and compare the results and draw conclusions. This report presents the outcome of the work in the groups and with the common data base.
For the common approach at the European level using common metrics, France (Cemagref) was mainly in charge of the constitution of the common database and of the data analysis.

JRC was mainly in charge of organization of the meetings, the writing and distribution of minutes, the collection of all the national datasets on the CIRCA web-site and the synthesis of regional group results.

## Contents of the fish intercalibration report

This report is mainly based on results and descriptions submitted from each of the 7 IC-groups. We (Jepsen & Pont) have tried to draw some main conclusions and recommendations based on the work done by all the people involved and also some editing of the reports and other documents to make the information more accessible and clearer for the reader, however the contend is unaltered and expresses the experience and views from the groups.
Each group report is placed as an annex. To limit the variation, these group reports are organised in a similar way, first answering a set of questions, then describing in more detail the process and the results, then descriptions of the national methods used and finally the criteria used for setting reference conditions. For countries involved in several groups (like Germany and France) the description of method and reference setting is only given once!

## General results and conclusions

Since the first meeting one year ago in May 2006, much effort has been put into this pilot exercise by a number of people from more than 20 MS. We have been working with 3 categories: 1) MS with an accepted/approved national method, 2) MS with methods under development/approval and 3) MS without any national method (planning to use common metrics or other countries methods).

This intercalibration work included 12 national methods being compared in 7 regional groups. Some of the methods showed very similar response and here it would be possible to set boundaries, provided that results from more sites (especially reference sites) were available.

**Conclusions from the groups** (*Exempts from the group reports*):

*Mediterranean*:  All the applied methods in the Mediterranean region must be related to the local fish fauna (WFD: Water district concept).
At least at this moment, there are no possibilities to intercalibrate methods or to search for common metrics. The proposal is to work on impact evaluating criteria (preclassification).
The method must be used as benchmark (as diagnostic tool) and the final judgement should be issued by experts.

*Alpine*: Bilateral data exchange was problematic due to the short timeframe and the limitation in resources. For Germany the federal structure seems to create some organizational problems concerning comprehensive availability and support of suitable data sets.
The common method (EFI) does not react to hydromorphological pressures, which are clearly dominating in the concerned countries. There is no correlation with national methods.
As a result boundaries could not be set.
Comparisons between the different datasets with all applicable methods showed that correlations between Austrian (FIA) and German (fiBS) methods are relatively good, correlations of EFI with FIA and fiBS do not work well at all, as does FBI compared to FIA or fiBS. Since FBI does not have a Danube fish region it obviously can not be expected to work with our data. On the other hand, the French data would work with Austrian and German methods, so this would have been an interesting comparison.

*Carpathian*: The (IC-) work is at its beginning and national methods are being developed now. Only Czech Republic has a national method, Romania is expected to have a method ready this year (2007).

*Nordic*: Good correlation between Finnish and Swedish methods. The FIFI method appears to consistently class sites higher than the VIX method. There are considerably more sites classified as high or good status using FIFI than using VIX. Furthermore, the outcome in the FIFI and VIX indices appear to be clearer regarding chemical impact, especially impacts from increased nutrient input compared to hydrological or morphological impact. However, it is still apparent that FIFI generally gives a higher index value compared to VIX.

*Midland*: Due to a very short timetable, the full intercalibration process couldn’t be achieved for the midlands. Some indexes are still under development, do not exist or are applicable only to some of river types or region. There was a big difference in the number of data provided by the countries which limit the conclusions. The provisional results are interesting and show that the three indexes gave different classification status using the same data.
Considering the reference data set, the three indexes (EFI, IBIP and FBI) identify in a comparable way the reference sites as good or high quality status, but there are strong differences between indexes concerning the HG boundary. For the moment it seems that criteria for selecting reference sites are not fully comparable. Moreover, indexes developed at a regional scale are not expected to be applied elsewhere, this extrapolation could explain a part of the divergences observed.
For the moment, the EFI does not constitute a highly consistent intercalibration tool, since it does not exhibit better results than direct national indices comparison ; but in the perspective of joining lowland and midland, EFI and *a fortiori* the EFI+ version could be really helpful.

*Lowland*: It was possible to build a large dataset for comparison within a short time. An intercalibration exercise within the participating countries of the lowland and midland group will be possible. But there is a lot of work to do, several crucial issues (e.g. reference sites) still have to be addressed and the development of different assessment methods is still going on. For the 47 sites that could be calculated by all methods the German method assessed the sites as being the worst. Then the Netherlands method was most severe. EFI and IBI gave comparable average values. Regarding correlations between the results the EFI, FIBS and Dutch Index were best comparable. The Flanders IBI did not correlate with the other methods.
So we conclude that the intercalibration for fish in Low- and Midland Rivers will be possible by June 2009.

*Atlantic*: The preliminary results indicate that the indication provided by the EFI in relation with pressures should be improved, at least for the Spanish dataset. Moreover, even if the response to pressures provided by EFI in the French dataset seems better in comparison with the Spanish one, the comparison between the French national system and the EFI shows a weak relationship ($r^2=0.4$).

These results will prevent the use of the present EFI index as an IC common metric for the Atlantic river types if a regression approach is followed. A more promising result was provided by the Spearman correlation value.

This results strongly recommend the improvement of the EFI index, as it is planned in the new EFI + index under development, before is used as an ICM common metric for the IC comparison within the Atlantic group. Also, Spanish data should be included into the EFI+ to improve the indication provided by the EFI+ for this type of rivers, characterized by a small number of fish species. Due to the small size of the Atlantic group (only 2 countries), it is suggested to either fuse the Atlantic group with a similar group, in regard to fish community similarities, or to increase the Atlantic group with more countries.

Unfortunately Portugal had to withdraw from this work because in the Atlantic rivers fish densities and number of species are frequently very low, and it was not possible to develop fish indexes actually responding to human pressures. The EFI is not applicable because of the low densities. It should be mentioned that Portugal has developed and launched a national method (May 2007) which is described in the report from the Mediterranean Group.

*Table 1. Overview of the national methods used in the pilot exercise. More details are given in the group reports.*

| National method | Type | Status (official, under approval, newly developed, .. | Comments |
|---|---|---|---|
| AT-FIA | Type-specific multimetric index (9 metrics); score 1 to 5; measures deviation from reference conditions; 9 fish-bioregions and 8 fish zones; reference fish communities. | Official | A method with considerable detailed adjustment to local areas |
| DE-FIBS | Multimetrics (6 or 9), measures deviation from a constructed reference fish community Score1-5 | Official | Very detailed and elaborate method, clear stepwise construction of a reference community. |
| SP-IBICAT | Multimetrics (1 to 3) depending on 5 fish based river types | Can be considered official in Catalan watersheds | Under revision |
| SE-VIX | Multimetrics (6). Deviations from calculated reference condition at site. Index score 0-1, five status classes. | Newly developed, under approval until August 2007, expected to be officially decided in September 2007. | Adjustment to population type of trout (migrating or resident). VIX followed EFI although maximum of eutrophication, toxic/acidification, morphological, hydrological impact was used to define references, rather than the mean. |
| NL-FI | Multimetrics (8), score 0-1, measures deviation from a predefined reference community for several river types | Official | The method is published as a draft version, but will not change anymore and is expected to be approved and finalized in this year (2007) |
| FR-FBI | Multimetrics (7). Deviations from reference cond. Score 1- >100 | Official | A statistical based method, close to the American IBI. |
| LT-LFI | Multimetrics (12), score 1-5 | ? | Based on fish ecological guilds and sentinel species |
| BWLUX-IBIP | Multimetrics (6), Score 6-30. | ? | IBI-based method |
| FIN-FIFI | Multimetric (5), type-specific (national typology) , continuous scoring | Non-official | IBI-based method |
| CZ-FI | Multimetric; 3 indices selected on the base of their discrimination power between reference and non-ref. sites; range 0 – 1. | Under development | New indices should be tested in consecutive years |
| BF-IBI | Multimetrics (8 or 9)<br>Score expressed as EQR ranging between 0 and 1 with five integrity classes | Official | A statistical based method explained in two papers; one an adoption of Karr’s approach and one a modification of the trisection method |
| IT-FIDESS | Decision support system | Under development | The Decision Support System is based on a neural network that mimics the expert judgment on the basis of geomorphological and faunistic data |
| PT-PoFI | Multimetrics (5 or 6), score 0-10, 3 groups of river types | Official | Index includes metrics which were tested for responsiveness to degradation in each river type. |

*Table 2. Overview of the various national criteria for reference site selection. More detail is given in the group reports.*

| Country | Water quality | Physical pressures | Biological pressures | Recreation-al pressures | Land-use | Data/method | Comments |
|---|---|---|---|---|---|---|---|
| Austria | X | X | X | X | | According to the REFCOND guideline | Some impacts below defined thresholds are accepted. |
| Germany | X | X | X | X | | Expert judgement and regional databases | Some pressures are accepted as no sites remain unimpaired. |
| Slovenia | X | X | X | X | X | Spatial approach, using national monitoring | A list of 9 simple criteria must be fulfilled. Some impact is accepted. |
| Slovakia | ? | ? | ? | ? | ? | EFI + expert judgement | Briefly described |
| Czech Republic | X | X | | | | Method for Benthos | Criteria under development |
| Romania | ? | ? | ? | ? | ? | Benthos/land cover | Criteria under development |
| Netherlands | ? | ? | ? | ? | ? | | No criteria yet! |
| Spain | X | X | X | | X | Multi-criteria analyses | Three spatial scales |
| Italy | X | X | X | X | X | Expert judgement | In FIDESS all records act as reference, not only those referring to pristine or undisturbed sites |
| France | X | X | X | X | X | Data from FAME and national ref. sites. | |
| Belgium (WA) | X | X | X | X | X | According to the REFCOND guideline | |
| Luxembourg | X | X | X | X | X | According to the REFCOND guideline | |
| Finland | X | X | | | X | Multicriteria analyses, expert judgement | Morphology, Human disturbance and water quality, Sites with lowest pressures (20%) are selected as ref. sites |
| Scotland | X | X | X | X | | Referring to REFCOND | |
| Sweden | X | X | X | | | Referring to REFCOND, Not yet complete list | Sites with very few fish were excluded |
| Lithuania | | | | | | Fish-index | Sites with highest scores are selected as ref. sites |
| Portugal | X | X | X | X | X | FAME variables using data and expert judgement based on field inspections | |

As can be seen from the tables above, there are rather large differences between the national methods of which only few are fully WFD compliant. Furthermore, there is very little consensus about the way to define reference sites. This is problematic because the methods to be intercalibrated should all be based on a measure of deviation from a reference condition that should be defined by very similar criteria in all countries. It is generally agreed that it is necessary to select specific “fish reference sites” and some MS have selected national reference sites using REFCOND criteria. Others have used data from the reference sites pointed out through the FAME project. Ideally, a list of reference criteria could be extracted from the REFCOND list and used universally to select the reference sites in all MS to ensure that the same level of pressure is accepted.

**Conclusion from the common European approach using ICMs**

The main objective was to test the usefulness of common metrics at the European level for comparison between national methods, without splitting countries and /or ecoregion in several GIG groups.

Some elements of the FAME project were useful for this purpose the 10 selected EFI metrics could be used for this first step as common intercalibration metrics. Nevertheless, at the end of the FAME project, it was recognized that this metrics selected at the European level demonstrated some limitations in assessing the impact of physical disturbances (i.e. case of the Alpine rivers). And also, the EFI metrics were not calibrated for Mediterranean rivers (see below).

Then, the objective in this exercise was mainly to evaluate the feasibility of an intercalibration exercise at the European level. Such tentative is new as all the other intercalibration groups are working at a regional level.

The first step of the work was to establish a common database and to harmonize all the national datasets. This common database did not include all the data used in the regional intercalibration groups but most of them. In total, 20 countries have delivered data from 37,114 fishing occasions corresponding to 16,276 sites. For all these sites, a description of the most important environmental conditions is provided. The data also include a description of the site status regarding reference conditions and a rough evaluation of pressures when available. 12 national assessment methods are used by 13 of the 15 member states participating to the exercise.

In a second part, the method used to define and calibrate the ICM in the FAME project is summarized, and the present limitations of the ICM described.
The third part is to set the reference condition and to select the reference sites at the European level (definition of criteria).
The next parts are the transformation of the ICM into EQR (ICM-EQR) and the comparison between national methods and ICM-EQR.
Finally, a first attempt to set the boundaries between H/G and G/M ecological classes is presented

**The first results demonstrate the feasibility of the intercalibration exercise using common metrics at the European level, but also pointed out the weaknesses of the ICMs at the moment.**

One of the main problems is the lack of well-defined criteria used for selecting reference sites by the different MS. A harmonisation of these criteria is needed. In addition, the number of reference sites is very often too low to really intercalibrate correctly between MS.

Available common ICM are correctly correlated with 7 of the 12 methods. For the 5 others, problems are mainly linked with the situations where:

- some countries or regions were not participating to the FAME project and the common metrics are not correctly calibrated for this area (especially Mediterranean countries, but also eastern Europe).
- the common metrics do not take hydromorphological pressures impacts sufficiently into account (in particular for alpine rivers which are only affected by physical pressures).

These points correspond to the main objective of the new EFI+ project (2007-2008). In this project, it is planned that the development of new metrics and their re-calibration. A special effort will be put on:

- development of new metrics more appropriate to assess the consequences of hydrological, morphological pressures and connectivity disruption on the ecological status of rivers
- pressures – impact analysis for the different types of pressure
- development of metrics based on length-age structure of population

- calibration of these new metrics for Mediterranean and eastern countries from Europe

The objective is to produce new calibrated metrics at the end of June 2008. These new metrics can be then tested as common metrics for the next step of the intercalibration exercise.

**Common conclusions**

1. The pilot exercise did not produce common boundaries between any national methods, but the first results demonstrate the feasibility of the intercalibration exercise and pointed out the main problems and weaknesses of the methods.

2. One of the main problems is the lack of well-defined criteria used for selecting reference sites by the different MS. It is necessary that each MS decide how they will select reference sites. If there are no such sites to be found, they must decide how to overcome this problem (by constructing theoretical reference conditions or use reference sites from abroad). It is important that these criteria are as similar as possible, to make intercallibration possible. If different countries use different definitions of reference conditions, it will make comparisons very complicated. Thus, a harmonisation of these criteria is needed!

3. Available ICM are correctly correlated with 7 of the 12 methods. For the 5 others, problems are mainly linked with the situations where:

- some countries or regions were not participating to the FAME project and the common metrics are not correctly calibrated for this area (especially Mediterranean countries, but also eastern Europe).
- the common metrics do not take hydromorphological pressures impacts sufficiently into account.

4. In general there is agreement on the sampling methods and the vast majority of sampling is done using electrofishing according to the CEN-standards. The capacity for monitoring the fish populations in the rivers has been greatly developed both in terms of equipment and experience in many MS over the last few years.

5. Several national methods are still under development and will be ready within short time, making intercalibrating even more relevant.

6. A well-developed and tested ICM would be an important asset for the intercalibration of the quite different national methods.

7. The method of comparing methods by using linear regression (least squares) is not really appropriate and for future comparisons it is suggested to use regressions by “major axis” or “reduced major axis” methods.

## Proposal for a future Work Program

*During the last IC-meeting in Ispra in March 2007, it was decided to propose the following 2-year workplan to complete the intercalibration of national methods for evaluating fish communities in rivers.*

Main tasks:

- Final list of (common?) reference criteria
- Reference sites selection (~ 30-50 per country/region). Comparison between countries.
- All data (including Regional groups) centralized in one common database.
- Comparison between National Methods within Regional groups and between countries if necessary (DE, FR).
- Pre-classification of pressures: recommended but not an obligation.
- Evaluation and Testing of a new set of common metrics.
- Harmonizing H/G and G/M class boundaries between MS.

Time-Table

October 2007: Official confirmation of the mandate by ECOSTAT/JRC. Reformation of regional groups, inclusion of countries with new national methods. Drafting of workplans for the groups. (MEETING).

January 2008: Final list of Reference sites. Comparison of Reference sites between countries. Definition of the methodology, agreement on a common approach. (MEETING).

July 2008: Reporting of Regional Groups. New ICM's.
1-2 meetings:

June 2009: Final Report: boundaries setting

## Common Approach at the European level using ICMs

*Didier PONT* (Cemagref, France)

The main objective was to test the usefulness of common metrics at the European level for comparison between national methods, without splitting countries and /or ecoregions into several GIG groups.

Some elements of the FAME project were useful for this purpose the 10 selected metrics could be used for this first step as common intercalibration metrics. Nevertheless, at the end of the FAME project, it was recognized that this metrics selected at the European level demonstrated some limitations in assessing the impact of physical disturbances (i.e. case of the Alpine rivers). And also, the EFI metrics were not calibrated for Mediterranean rivers (see below).
Then, the objective in this exercise was mainly to evaluate the feasibility of an intercalibration exercise at the European level. This approach is novel as all the other intercalibration groups are working at a regional level.
The first step of the work was to establish a common database and to harmonize all the national datasets. This common database did not include all the data used in the regional intercalibration groups but most of them.
In a second part, the method used to define and calibrate the ICM in the FAME project is summarized, and the present limitations of the ICM described.
The third part is to set the reference condition and to select the reference sites at the European level (definition of criteria).
The next parts are the transformation of the ICM into EQR (ICM-EQR) and the comparison between national methods and ICM-EQR.
Finally, a first attempt to set the boundaries between H/G and G/M ecological classes is presented

<u>Contents</u>



### Database description

In total, 20 countries have delivered data from 37,114 fishing occasions corresponding to 16,276 sites (see Table 3). Most sites have been provided by Sweden (11,258). For other countries, the number of sites range from 31 (Poland) to 1875 (Spain). For Spain and Belgium, the national dataset is organized in two parts corresponding to regions where the national assessment methods are not the same: Flanders and Wallonia in Belgium, Northern Spain (mainly Galicia) and Catalonia in Spain.

*Table 3. For each country, number of fishing occasions, sites, reference sites and sites where common metrics and/or national method are computed.*

| Country | Number of fishing occasion | Number of sites | Number of Reference sites | Sites with common metrics values | Sites with national assessment method values |
|---|---|---|---|---|---|
| AT | 147 | 147 | 30 | 147 | 147 |
| BF | 51 | 47 | 1 | 47 | 47 |
| BW | 95 | 90 | 24 | 90 | 90 |
| CZ | 177 | 177 | 81 | 177 | 177 |
| DE | 497 | 497 | 0 | 497 | 497 |
| DK | 65 | 65 | 0 | 65 | - |
| FIN | 71 | 71 | 7 | 70 | 71 |
| FR | 727 | 461 | 240 | 461 | 461 |
| HU | 169 | 169 | 1 | 0 | - |
| IR | 497 | 497 | 8 | 497 | - |
| IT | 59 | 59 | 0 | 59 | 59 |
| LT | 513 | 342 | 9 | 338 | 342 |
| LUX | 20 | 20 | 2 | 20 | 20 |
| NL | 76 | 76 | 14 | 76 | 76 |
| PL | 31 | 31 | 6 | 31 | - |
| PT | 50 | 50 | 32 | 32 | - |
| RO | 101 | 79 | 18 | 79 | - |
| SE | 31625 | 11258 | 6 | 11258 | 11258 |
| SK | 53 | 50 | 22 | 49 | - |
| SL | 36 | 36 | 6 | 36 | - |
| SP-Catal | 268 | 268 | 38 | 268 | 268 |
| SP-North | 1607 | 1607 | 82 | 1607 | - |
| UK | 229 | 229 | 0 | 229 | - |
| **Total** | **37164** | **16326** | **624** | **16136** | **13513** |

*AT: Austria*
*BF: Belgium Flanders*
*BW: Belgium Wallonia*
*CZ: Czech Rep.*
*DK: Denmark*
*FIN: Finland*
*FR: France*
*DE: Germany*
*HU: Hungary*
*IR: Ireland*
*IT: Italy*
*LT: Lithuania*
*LUX: Luxemburg*
*NL : Netherlands*
*PL: Poland*
*PT: Portugal*
*RO: Romania*
*SE : Sweden*
*SK : Slovakia*
*SL: Slovenia*
*SP-Catal: Spain (Catalonia)*
*SP-North: Spain (mainly Galicia)*
*UK: United Kingdom*

For all these sites, a description of the most important environmental conditions is provided (drainage area, altitude, river slope, river width, distance from source, mean air temperature, flow regime, geological characteristics, etc). The between site variability of the electrofishing method is also summarized by two variables (partial or complete sampling, wading or boating) and the sampling effort is described by the fished area.
Most sites are from small to medium size rivers with a mean distance from the sea of 41 km (median of 12 km), a mean river wetted width at the end of the low flow period of 15 m (median of 5m). Only 455 sites are characterized by an upstream drainage area larger than 10,000 $km^2$.
The data also include a description of the site status regarding reference conditions and a rough evaluation of pressures (when available).
Considering the fish community, the mean total fish richness is 3.09 (range 0 to 27 species). For half of the sites, the total number of fish caught is under 30 (the minimum number required to calculate the ICM-metrics).
Sites from 13 countries/regions are assessed both by the Intercalibration Common Metrics (ICM, see below) and a national assessment method (Table 3). The pilot intercalibration exercise will then mainly focus on these areas.

**The intercalibration common metrics (ICM)**

The 10 common metrics used in this pilot exercise are those defined and selected during the FAME Project (2002-2004. Development, Evaluation and Implementation of a Standardised Fish-based Assessment Method for the Ecological Status of European Rivers. A Contribution to the Water Framework Directive. 5th Framework Programme Energy, Environment and Sustainable Development. Key Action 1: Sustainable Management and Quality of Water. Contract No: EVK1 - CT-2001-00094).
A short description of the method is given in Annex I and all information is available on the Web-site http://fame.boku.ac.at and Pont et al. 2006).

In this exercise, we only consider the sum of the values of the 10 metrics, but not the ecological class boundaries defined in the FAME project as the objective in this report is to test the 10 metrics as common metrics at the European level to compare class boundaries between national methods.
Most of the MS have computed the common metrics using the Software produced by the FAME consortium. Nevertheless, in numerous cases, the name of the river region (or Hydrological unit) provided by the MS was not included in the list of pre-defined river regions considered in the Software (see EFI application manual p. 76, available on the web site) or not correctly spelled (including capital letters). And in some cases, environmental variables were missing and/or incorrectly spelled. Then, the common metrics values obtained from the software are wrong.
Thus, all the common metrics values were recomputed from the database after checking all the environmental variables and redefining the name of the river group corresponding to the correct river region name (see Annex I). Common metrics were not re-computed for sites where at least one environmental variable was missing (169 sites in Hungary and 4 sites in Lithuania).
In this report, we will use the term ICM to define the sum of the 10 common metrics. Each of the 10 metrics varies between 0 and 1. Their sum between 0 and 10 is rescaled from 0 to 1. Nevertheless, this rescaled sum cannot be considered as an EQR. The value of 1 does not correspond to the median value of reference sites but to the maximum value of reference site.

**Limitations of the present ICMs**

There are clear limitations to the use of the present ICMs. The most important are listed below.

1) Only fish data obtained with single-pass electric fishing may be used to calculate the ICMs.

2) This index has been developed and calibrated only for sites located in the ecoregions and countries represented in the FIDES database of the FAME project. Therefore, the ICMs should not be used (or only used with caution) in e.g. Mediterranean rivers with high proportion of endemic species or in the rivers of the south-eastern part of Europe which support fish communities that differ greatly in species composition.

3) Although the validation of the ICMs also proved its applicability for large rivers, the ICMs should be used with caution in the lowland reaches of very large rivers.

4) For a given site, 30 specimens is the minimum sample size required to be able to calculate the ICMs with appropriate statistical confidence. When fewer specimens are caught, the results must be considered with care and the method cannot be applied when no fish occur at the site. The same applies when the sampled area is smaller than 100 m². Two cases could be problematic and the ICMs should be used with care: (a) undisturbed rivers with naturally low fish density and (b) heavily disturbed sites where fish are nearly extinct.

5) In addition, it has been demonstrated that the responses of the ICMs for sites only impacted by hydrological and/or morphological pressures are clearly weaker (even significant) than their responses for sites characterized by a decrease of water quality (Pont et al., in press).

In this exercise, the first limitation applies to data provided by countries and/or region which were not participating to the FAME project. **It is in particular the case for Italy, Northern Spain (mainly Galicia), South Portugal and Ireland**. The objective is to get a preliminary test of the metric responses. For that purpose, we considered that these countries/regions were part of some of the river groups pre-defined during the EFI project, but with the exception of 18 sites from South portugal which were excluded (see Annex I for details). Then, the results for these countries must be considered carefully.

For Baltic countries and eastern countries for which the ICMS were also not calibrated (Finland, Denmark, Czech Republic, Romania, Slovakia, Slovenia), the ICMs have also been computed. These countries belong to ecoregion and/or river groups which were considered during the FAME project (e.g. Danube, Baltic Sea) even if the countries themself were not included.

**Setting of Reference conditions and Selection of reference sites**

The objective is to compare reference sites between countries using the ICM and to transform the ICM in EQR by dividing by the median of all European reference sites available.

Of the 16,326 sites, 11,767 have no status (reference or not). Among the others, 624 are characterized as reference sites by the MS, and 3903 as disturbed sites. 32 sites from FR and LT are considered as least impacted sites (large rivers in FR) or sites only impacted by connectivity disruption and will not be considered. The criteria used by each MS to define reference sites are presented elsewhere in this report.

Concerning the evaluation of pressure, 11,694 sites are not classified. 1174 sites are considered as non-impacted (neither hydrological, morphological nor water quality pressures), 2070 sites with hydrological pressures, 362 with water quality problems, and 991 with mixed pressures.

The cross-table between site status and type of pressure show that there are both reference sites which are disturbed (167 sites with HP and/or WQ pressures) and sites with no pressures but not considered as reference sites (691).

Results of the fish river IC-pilot exercise

| Pressures \ Site Status | Reference sites | Disturbed sites | No Information |
|---|---|---|---|
| No pressures | 452 | 691 | 31 |
| HP | 79 | 1948 | 43 |
| MIX | 81 | 777 | 133 |
| WQ | 7 | 283 | 72 |
| Only connectivity disruption | 3 | 0 | 6 |
| No Information | 2 | 194 | 11482 |

*Table 4. Site status and type of pressure.*

As confirmed during the 3rd meeting in Ispra (March 07), the criteria used by MS to define reference conditions need to be harmonized in the future. In this pilot exercise, as a first step, we consider as reference sites at the European scale, only sites which are classified as reference by MS and for which no pressure are described (at least concerning HP and WQ pressures).
As written previously, one of the limitations for the use of the ICM is the number of fish caught. For a given site, 30 specimens is the minimum sample size required. And the fished area must be at least 100 $m^2$. If fewer individuals are caught, the results must be considered with care. This case is really problematic when the sampling site is classified as a reference site. In that case, the fish density is naturally low and a correct estimation of the fish community composition could require an unrealistic increase of the sampling effort (increasing the fished area).
We verified, using a dataset of reference sites, that a low number of fish caught significantly decreases the ICM value. The dataset includes reference sites without pressure and with a fished area over 100 $m^2$. 5 classes of sites are defined as a function of the number of fish caught and only the lower class (no more than 30 fish caught) is characterized by a ICM mean value significantly lower than the other classes (Levine's test for homogeneity of variance: p=0.201; variance, p=0.017; post-hoc Tukey test).

We then define reference sites only the sites characterized by:

- a reference status as reference site
- no pressure
- a fished area >100 m2
- a number of fish caught >30.

**Transformation of the ICM into EQR**

The total number of selected reference sites is 396. Most of them are from France (222) and secondarily from Spain and Austria (Table 5). Clearly for most of the countries, the number of reference sites is too low.

| AT | BF | BW | FN | FR | IR | LT | LUX | PL | PT | RO | SE | SK | SL | SP-Catal | SP-North |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 1 | 24 | 4 | 222 | 7 | 7 | 2 | 6 | 16 | 3 | 5 | 5 | 5 | 25 | 47 |

*Table 5. Number of selected reference sites per country*

Mean ICM values per country range from 0.47 (IR) to 0.64 (LT), with the exception of PL and PT which are characterized by lower values than the others (resppectively mean values of 0.31 and 0.34). There is only one reference site for BF (value 0.35).

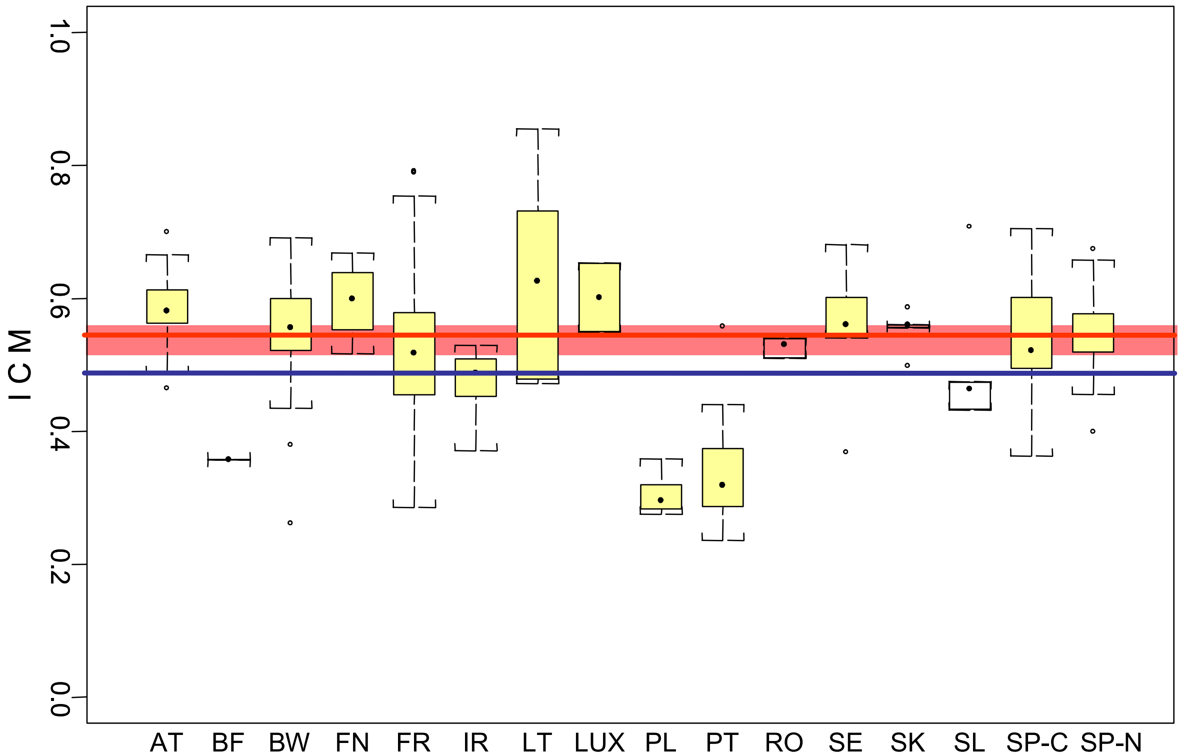



*Figure 1. Box and whisker plot for ICM values for each of the 15 countries applied to the reference sites dataset. The number of sites per country is given on the abscises line. The red line is the mean of the distribution of median values (red area: range between max and min). The blue line is the mean of the distribution of the 1$^{st}$ quartile value (see text for explanation).*

**Common median values for reference sites**

In order to consider the different number of site per country, we only considered countries with at least 5 references sites (but excluding PL and PT): AT, BW, FR, IR, LT, SE, SK, SL, SP-Cat, SP-Nor. For countries with more than 5 sites, we randomly sampled 5 sites and the procedure was repeated 200 times.

The mean of the median value distribution is 0.55 (range from 0.518 to 0.564)

All ICM values are transformed into EQR by dividing by 0.55.

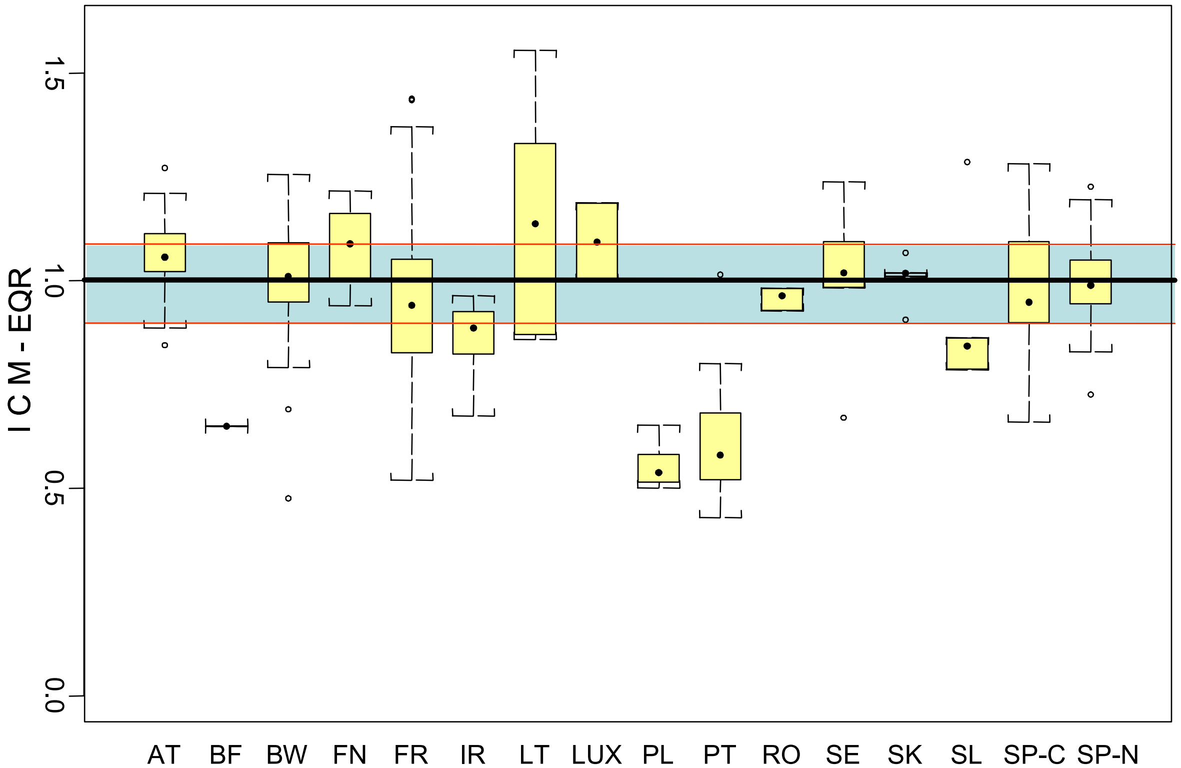



*Figure 2. Box and whisker plot for ICM - EQR values for each of the 14 countries applied to the reference sites dataset. The number of sites per country is given on the X axis line. The black line is the median values of reference sites (blue area: range between 1$^{st}$ quartile and 3$^{rd}$ quartile).*

The median values of most of the MS reference sites distribution are between the 1$^{st}$ and the 3$^{rd}$ quartile values. Only four MS show a median value for reference sites outside this range (LT, PL, SL, PT), but only the reference sites values from PL and PT are far from the others These must be only considered as preliminary and indicative results. The number of reference per MS is too low for most of them. Nevertheless, these results demonstrate that an intercalibration is needed and possible using the ICM-EQR.

## Comparison between national methods and ICM-EQR

### Correlation and linear regressions

Twelve national assessment methods are used by 13 of the 15 MS (Table 7). Two MS (LUX and BW) are using the same method and the data from these two countries are pooled (BWLUX-IBIP). For most of national methods, the values range from 0 to 1. Others range from 6 to 30 (IBIP), 1 to 5 (IT, DE, LT) or from 0 to more than 100 (FR). These methods greatly differ between countries. All the methods use a multimetric approach (like the EFI) with the notable exception of the Italian method. Descriptions of the national methods can be found in the relevant group reports, except for the Lithuanian method (Lithuania was not part of any IC-group). A short description of the Lithuanian method can be found in Annex III of this report.
For most of the methods, the index value increases with increasing ecological status, with the exceptions of AT-FIA, FR-FBI, IT-FIDESS and LT-LFI.

Results of the fish river IC-pilot exercise

| Country | High-Good | Good-Moderate | Range |
|---|---|---|---|
| AT-FIA | 1.5 | 2.5 | 1 to 5 |
| BF-IBI | 4.5 | 3.5 | 0 to 5 |
| BW-IBIP | 26.5 | 22.5 | 6 to 30 |
| CZ-FI | 0.8 | 0.6 | 0 to 1 |
| DE-FIBS | 3.75 | 2.5 | 1 to 5 |
| FIN-FIFI* | 0.70 | 0.53 | 0 to 1 |
| FR-FBI | 7 | 16 | 0 to over 100 |
| IT-FIDESS | 1.5 | 2.5 | 1 to 5 |
| LT-LFI | 1.15 | 2.05 | 1 to 5 |
| LUX-IBIP | | | 6 to 30 |
| NL-FI | 0.8 | 0.6 | 0 to 1 |
| SE-VIX | 0.7492 | 0.46675 | 0 to 1 |
| SP-IBICAT | Impacted/No impacted | | 0 to 1 |

*Table 5. Range and boundaries between High/good and Good/Moderate classes for the 12 national assessment methods.*
** The Finnish method is using different boundaries depending of the river type. These values are then just indicative of the position of the boundaries.*

The 12 methods demonstrate a significant Pearson correlation coefficient with the ICM-EQR (Table 6). As a first step, a linear regression is fitted between each national method and ICM-EQR (Fig. 3).

| National Method | N- sites | Correlation coefficient | *P* value |
|---|---|---|---|
| AT-FIA | 147 | 0,233 | 0,00453 |
| BF-IBI | 47 | 0,319 | 0,02888 |
| BWLUX-IBIP | 110 | 0,666 | <0,00001 |
| CZ-FI | 177 | 0,796 | <0,00001 |
| DE-FIBS | 497 | 0,350 | <0,00001 |
| FIN-FIFI | 70 | 0,694 | <0,00001 |
| FR-FBI | 461 | 0,622 | <0,00001 |
| IT-FIDESS | 59 | 0,391 | 0,00223 |
| LT-LFI | 342 | 0,774 | <0,00001 |
| NL-FI | 75 | 0,823 | <0,00001 |
| SE-VIX | 10456 | 0,616 | <0,00001 |
| SP-IBICAT | 268 | 0,447 | <0,00001 |

*Table 6. Pearson correlation coefficients and p values between ICM-EQR and the 12 national methods. The coefficient is over 0.6 for 7 of the 12 methods.*

For 7 methods, the coefficients are relatively good, with values ranging from 0.62 to 0.82. The values remain close to 0.45 for SP-IBICAT. For the others (AT, DE, IT, BF), the coefficients are low (0.23 to 0.39). For two methods (AT-FIA and BF-IBI), there is no link with the ICM-EQR: The values of ICM-EQR remain constant at a high level for AT (close to 1.0) and at a low level for BF (close to 0.5).
In the case of IT-FIDESS, all sites are from the central part of Italy, a Mediterranean region for which the common metrics were not calibrated during the FAME. As said previously, in this first attempt, we did not use the “true river region” to compute the ICM but the closest one from the previous FAME list. And in addition, there is a clear limitation, at present, to use EFI for Mediterranean rivers.
In the case of BF-IBI, the results could tend to indicate that the ecological status of these sites is over-estimated by the national method. Further investigations are needed.
Regarding the three other methods (AT-FIA, DE-FIBS, SP-IBICAT), they are characterized by giving a strong response, when they are impacted by hydro-morphological pressures. This is in

particular the case for Austria for which hydro-morphological pressures are the only ones. Except for these three countries, water quality degradation and/or mixed pressures are dominant.

| National Method | HP | WQ | MIX |
|---|---|---|---|
| AT-FIA | 100% | 0% | 0% |
| DE-FIBS | 89% | 2% | 9% |
| SP-IBICAT | 79% | 5% | 15% |
| SE-VIX | 36% | 43% | 21% |
| NL-FI | 32% | 0% | 68% |
| FR-FBI | 26% | 15% | 59% |
| LT-LFI | 17% | 29% | 54% |
| BWLUX-IBIP | 14% | 53% | 33% |
| FIN-FIFI | 2% | 44% | 55% |
| CZ-FI | 1% | 0% | 99% |
| BF-IBI | 0% | 0% | 100% |
| IT-FIDESS | - | - | - |

*Table 7. Types of pressure per country. HP: Hydro-morphological pressures, WQ: Water quality pressures, MIX: Mixed pressures.*

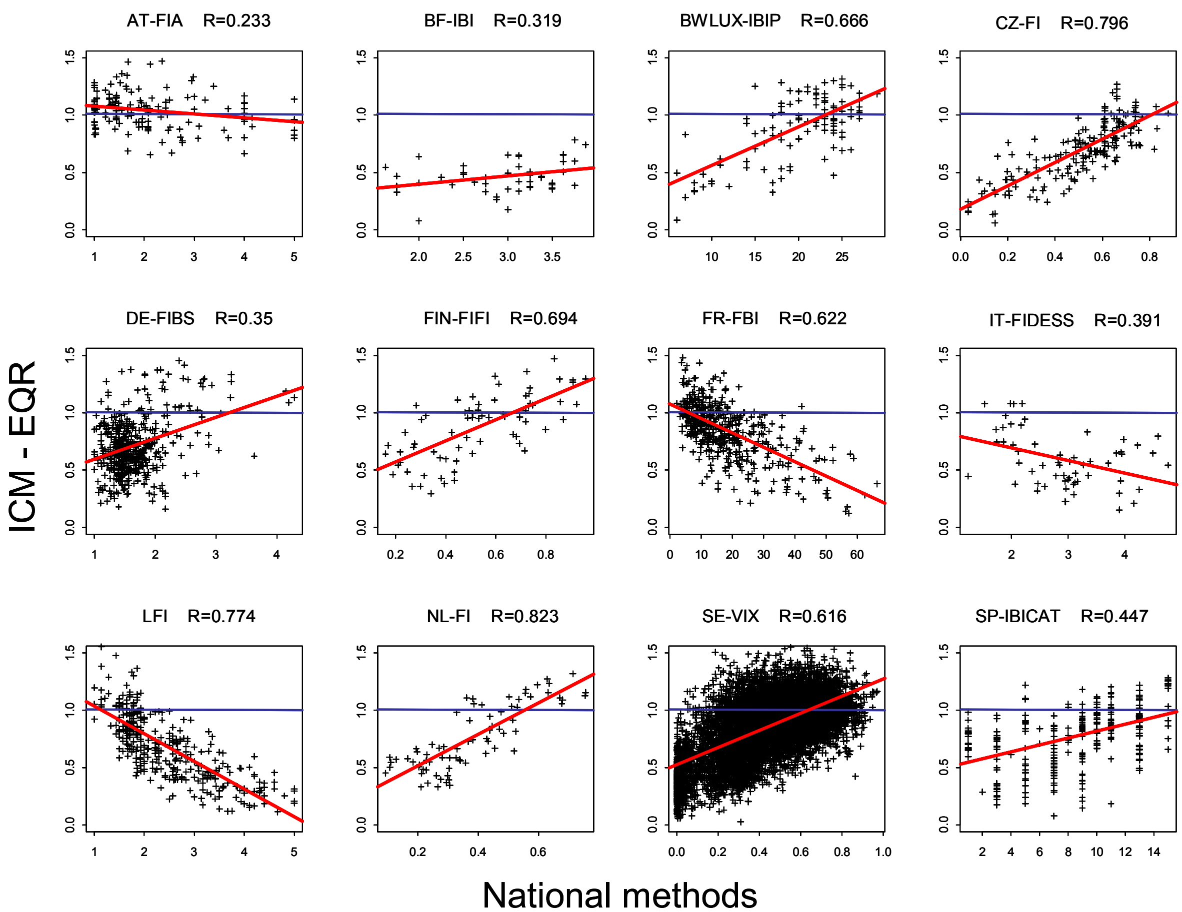



*Figure 3. Linear regression of ICM-EQR values against the national methods.*

This result is in agreement with the previous demonstration (Pont et al. 2007) that the responses of the European fish assessment method (FAME) for sites only impacted by hydrological and/or morphological pressures are clearly weaker (even if significant) than their responses for sites characterized by a decrease of water quality. The ICM's must be improved to increase the sensitivity to such type of pressures.

**Quality of the linear regressions**

The quality of the 12 linear regressions has been checked using different criteria.
The residuals have been examined to check for the normality of their distribution (qqplot). The main problems are linked to outliers.

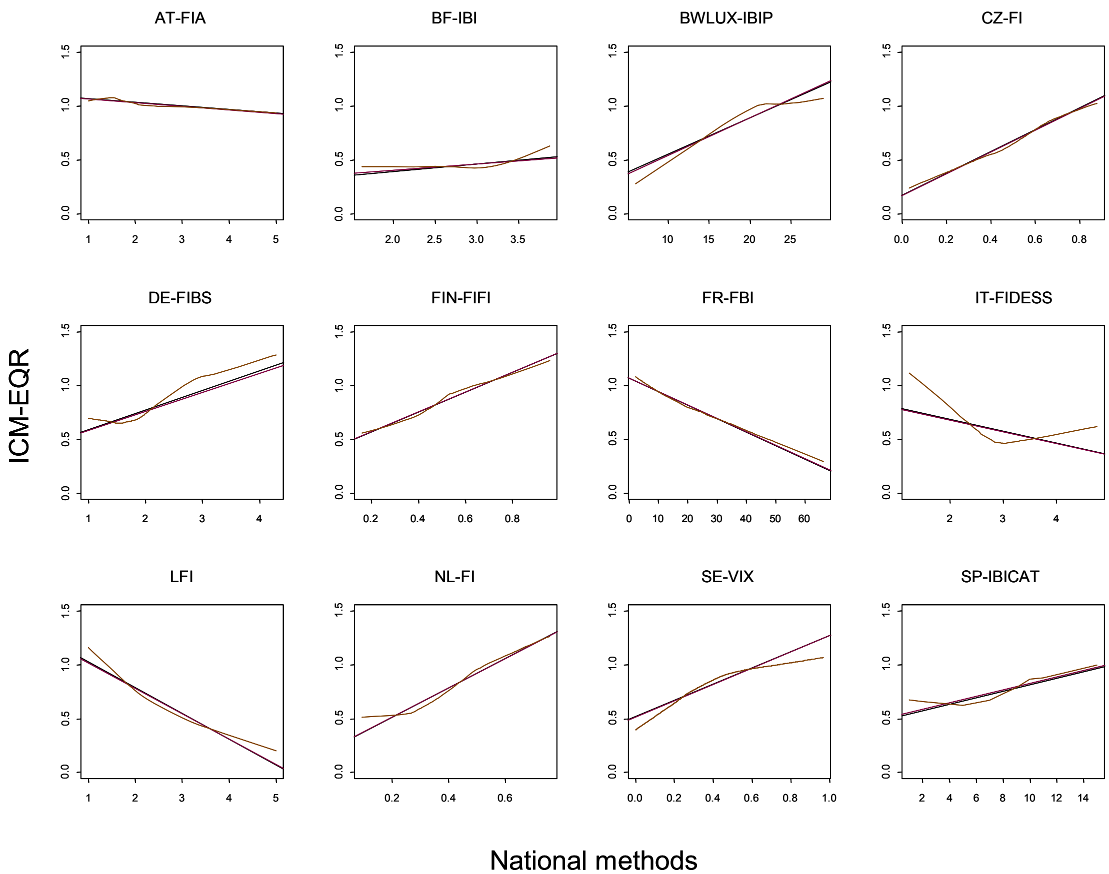



*Figure 4. Comparison between classical linear regression (black line), robust linear regression (red line), and lowess regression (brown line) for the 12 models.*

The residuals have been also plotted against the observed values to check for homoscedasticity.
To circumvent the problem of heteroscedasticity and the influence of outliers which can bias classical least square estimation, we used robust regression techniques.
To check for the fit of a first order linear model to the data, instead of a curvilinear one (for example), we used a lowess method. In that case, the lowess fit is calculated at each data point in the data set. At each point, a local polynomial (second order) is fit to a local region of the data set using linear least squares regression.
In some cases the dataset was not correctly distributed along the X axis (national method values). This is for example particularly the case for German data for which most of the points are close to the origin. In such case, we split the data set in classes (3-4) and resample points in order to equilibrate between classes.
In all cases, we finally compare the regression coefficient or the form of the curve (lowess regression) with the previous linear regression (Fig. 4). The linear regression and the robust linear regression are very close. In general, the lowess regression shows that a first order linear model is adequate to describe the link between the two methods, but with the clear exception of the Italian dataset for which a curvilinear model could be better. The Swedish dataset show also a similar trend but, at this first step, the simple linear model is retained.

As a first conclusion, the ICM-EQR, as defined here, can be use to compare between them 7 of the 12 national methods. The models can be improved in some case in the future (e.g. Sweden).
For others countries, the sensitivity of the common metrics to hydrological and morphological pressures have to be improved. These metrics have also to be calibrated for countries which were not participating to the previous FAME project (Ireland, Denmark, Romania, Northern Spain, Finland…). It is in particular the case for Mediterranean rivers for which new metrics are probably needed. All these points are the main objective of the new EFI+ project.

**Setting the boundaries between H/G and G/M ecological classes**

The 7 national methods selected previously are transformed in EQR (Nat-EQR) by rescaling, when necessary, between 0 and 1 and dividing by the median value of reference sites. In that case, we used as reference sites all sites considered as reference sites by MS, whatever the pressure status and the number of fish caught. Of course, as said several times before, this is just a preliminary attempt to evaluate the feasibility of the intercalibration exercise. And more reference sites, defined in a standardized way will be needed in the future.

The equation used for this transformation is:

$$\text{Nat-EQR}_i = [\,(V_i - V_{min}) / (V_{max} - V_{min})\,] \quad / \quad VRef_{median}$$

with:
$V_i$: National method value
$V_{min}$: minimum value
$V_{max}$: maximum value
$VRef_{median}$: Median value of the reference site distribution

When the national index value decreases with increase in the ecological (FR-FBI, LT-LFI), the formula is:

$$\text{Nat-EQR}_i = [\,(V_{min} - V_i) / (V_{min} - V_{max})\,] \quad / \quad VRef_{median}$$

The correspondence between the national boundaries (expressed in EQR) and the ICM-EQR (High-Good and Good-Moderate) is presented in Figure 4 and Table 8. On Figure 5, the estimated ICM-EQR's are given with the associated error. Finland is not considered any more in this first step as the boundaries between ecological classes are depending of the river type.

| | High / Good Boundary | | | Good / Moderate Boundary | | |
|---|---|---|---|---|---|---|
| Country | National value | National EQR | ICM-EQR | National value | National EQR | ICM-EQR |
| BWLUX-IBIP | 26.500 | 1.079 | 1.109 | 22.500 | 0.868 | 0.975 |
| CZ-FI | 0.800 | 1.328 | 0.987 | 0.600 | 0.996 | 0.784 |
| FR-FBI | 7.000 | 1.064 | 0.978 | 16.000 | 0.933 | 0.865 |
| LT-LFI | 1.150 | 1.123 | 0.991 | 2.050 | 0.860 | 0.775 |
| NL-FI | 0.800 | 1.258 | 1.332 | 0.600 | 0.943 | 1.059 |
| SE-VIX | 0.749 | 1.236 | 1.081 | 0.467 | 0.770 | 0.870 |

*Table 8. High/Good and Good/Moderate ecological classes boundaries from the different national method (expressed or not in EQR) and their correspondence in ICM-EQR.*

H/G boundaries in ICM-EQR range from 0.978 (FR) to 1.332 (NL). These boundaries seem in too high in comparison with the median value of reference sites as most of them are over 1. Independently from any others transformations (in EQR) or comparison with ICM-EQR, direct comparison between the High-Good boundaries (Table 8, 1$^{st}$ column) and the median values for reference sites confirm this point for most of national methods (Table 9). Most of time the H/G national boundaries correspond to sites with a higher ecological status than the median value of reference sites.

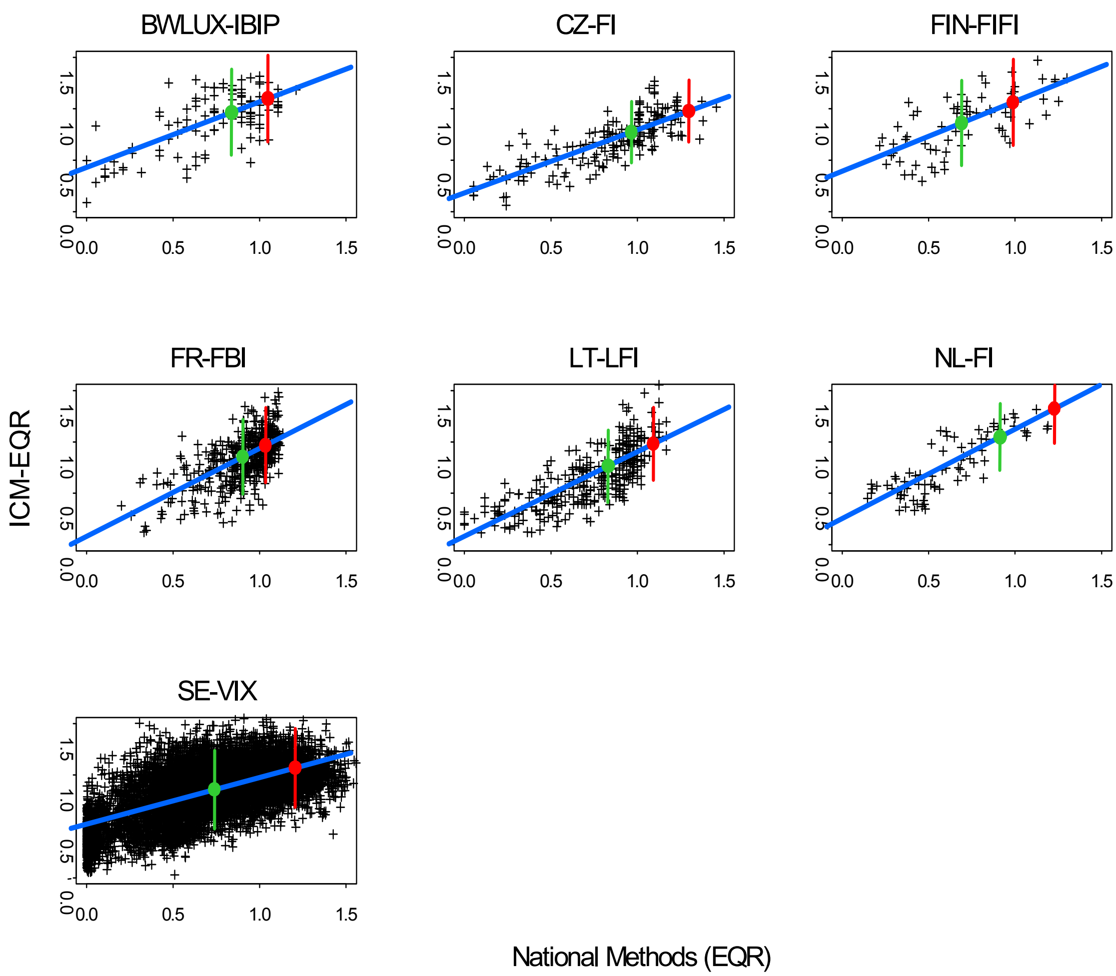
| Country | All Reference sites | Best Reference sites |
|---|---|---|
| BWLUX-IBIP | 25.000 | 25.000 |
| CZ-FI | 0.602 | - |
| FR-FBI | 11.422 | 11.738 |
| LT-LFI | 1.571 | 1.285 |
| NL-FI | 0.636 | - |
| SE-VIX | 0.606 | 0.685 |

*Table 9. Median values for Reference sites when considering all reference sites and only reference sites without any pressure, a fished area > 100m² and more 30 fish caught (see § 2.1).*

These results confirm that:

- the reference conditions must be harmonized between countries in the future
- the limits between H/G ecological classes must be set in agreement with the status of reference sites

Nevertheless, the variability between H/G boundaries expressed in ICM-EQR seems limited, with the exception of NL-FI. Good-Moderate boundaries in ICM-EQR range from 0.78 (LT) to 1.06 (NL) with a median value of 0.87. As for the H/G boundaries, this value is too high.



Results of the fish river IC-pilot exercise

*Figure 5. Regression of ICM-EQR against the national indexes (expressed in EQR). Correspondence between the national boundaries and the ICM-EQR (High-Good and Good-Moderate). The predicted ICM-EQR values are given with their confidence intervals.*

For a new X value, the prediction error is higher than for a value for the original dataset used to calibrate the model. The formula is given by:

$$\sigma^2(\hat{y}_x) = \left(1 + \frac{1}{n} + \frac{(x - x^2)}{s_{xx}^2}\right)\sigma^2$$

**Conclusion**

The first results demonstrate the feasibility of the intercalibration exercise using common metrics at the European level but also pointed out the weaknesses of the method at the moment.

One of the main problems is the lack of well-defined criteria used for selecting reference sites by the different MS. Each MS must decide on a set of criteria. It is important that these criteria is as similar as possible, to make intercallibration possible. If different countries use different definitions of reference conditions, it will make comparisons very complicated. Thus, a harmonisation of these criteria is needed.
In addition, the nuber of reference sites is very often too low to really intercalibrate correctly between MS.

Available common ICM are correctly correlated with 7 of the 12 methods. For the 5 others, problems are mainly linked with the situations where:

- some countries or regions were not participating to the FAME project and the common metrics are not correctly calibrated for this area (especially Mediterranean countries, but also eastern Europe).
- the common metrics do not take hydromorphological pressures impacts sufficiently into account (in particular for alpine rivers which are only affected by physical pressures).

# Annex I: Description of the Common Database and the EFI

**Quantitative environmental variables (one fishing occasion per site)**

| | Min | 1st.Quart. | Median | Mean | 3rd.Quar. | Max | Missing values |
|---|---|---|---|---|---|---|---|
| Dist to Source (km) | 0 | 6.00 | 12.00 | 40.77 | 30.0 | 900.0 | - |
| Altitude (m) | 0 | 54.00 | 150.00 | 211.70 | 303.0 | 1945.0 | - |
| Wetted.width (m) | 0 | 2.70 | 5.00 | 15.03 | 10.0 | 1300.0 | 2 |
| Mean Air temp. (°C) | -3 | 3.00 | 6.00 | 6.17 | 8.0 | 17.5 | 169 |
| Slope ($m.km^{-1}$) | 0 | 2.86 | 7.15 | 13.11 | 16.6 | 283.0 | - |
| Fished.area ($m^2$) | 3 | 120.00 | 230.00 | 448.30 | 454.0 | 48600.0 | - |
| Richness | 0 | 1.00 | 2.00 | 3.09 | 4.0 | 27.0 | - |
| N Fish Caught | 0 | 10.00 | 30.00 | 96.68 | 77.0 | 11660.0 | - |

**Qualitative variables (one fishing occasion per site)**

| Variable Name | Number of sites per modality | | | | | | |
|---|---|---|---|---|---|---|---|
| Site Status [1] | NA | No | Yes | Yes(?) | Yes2 | | |
| | 11767 | 3903 | 624 | 16 | 16 | | |
| Pressure.type [2] | (No) | HP | MIX | No | No(continuity) | WQ | NA |
| | 10 | 2069 | 987 | 1144 | 25 | 358 | 11683 |
| Upstream drainage area (class in $km^2$) | <10 | <100 | <1000 | <10000 | >10000 | | |
| | 3551 | 7295 | 3713 | 1312 | 455 | | |
| Presence of a natural lake upstream | No | Yes | | | | | |
| | 8364 | 7962 | | | | | |
| Flow regime | Permanent | Summer dry | | | | | |
| | 16171 | 155 | | | | | |
| Geology | Calcareous | Siliceous | | | | | |
| | 16171 | 155 | | | | | |
| Sampling Strategy | Partial | Whole | | | | | |

Results of the fish river IC-pilot exercise

| | | |
|---|---|---|
| | 2491 | 13835 |
| Sampling Method | Boat | Wading |
| | 859 | 15467 |

NA: no information (not available)
(1): Site.Status
No:not a reference site
Yes: Reference site
Yes(?): Reference site but with an alteration of river connectivity (Lithuania)
Yes2: HP and/or WQ pressure but least impacted sites for medium/large rivers (France)

(2): Pressure.type
HP: Hydro-morphological pressures
WQ: Water quality pressures
MIX: Mixed pressures
No: no pressures
(No): no HP or WQ pressure but others pressures possible (Germany)
No(continuity): no HP or WQ pressure but connectivity alterations (Lithuania)

**Description of Pressures per country**

| Countries | No Pressure | HP | WQ | MIX | (No) | No (continuity) | No information |
|---|---|---|---|---|---|---|---|
| AT | 64 | 77 | 0 | 0 | - | - | 6 |
| BF | 1 | 0 | 0 | 46 | - | - | 0 |
| BW | 42 | 7 | 25 | 16 | - | - | 0 |
| CZ | 3 | 1 | 0 | 173 | - | - | 0 |
| DE | 8 | 409 | 8 | 41 | 10 | - | 21 |
| DN | 0 | 0 | 0 | 0 | - | - | 65 |
| FN | 7 | 1 | 28 | 35 | - | - | 0 |
| FR | 238 | 55 | 28 | 124 | - | - | 16 |
| HU | 0 | 0 | 0 | 0 | - | - | 169 |
| IR | 213 | 82 | 59 | 143 | - | - | 0 |
| IT | 0 | 0 | 0 | 0 | - | - | 59 |
| LT | 39 | 43 | 72 | 134 | - | 25 | 29 |
| LUX | 2 | 2 | 10 | 6 | - | - | 0 |
| NL | 0 | 24 | 0 | 52 | - | - | 0 |
| PL | 11 | 19 | 1 | 0 | - | - | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PT | 32 | 5 | 3 | 10 | - | - | 0 |
| RO | 45 | 0 | 0 | 34 | - | - | 0 |
| SE | 38 | 40 | 58 | 22 | - | - | 11100 |
| SK | 7 | 19 | 18 | 6 | - | - | 0 |
| SL | 7 | 18 | 0 | 11 | - | - | 0 |
| SP-Catal | 80 | 149 | 10 | 29 | - | - | 0 |
| SP-North | 337 | 1119 | 42 | 109 | - | - | 0 |
| UK | 0 | 0 | 0 | 0 | - | - | 229 |

HP: Hydro-morphological pressures
WQ: Water quality pressures
MIX: Mixed pressures
(No): no HP or WQ pressure but others pressures possible (Germany)
No(continuity): no HP or WQ pressures but connectivity alterations (Lithuania)

Results of the fish river IC-pilot exercise

Correspondence between river group, river region and countries.

| River Group | Corrected River Region name | River_region | AT | BF | BW | CZ | DE | DN | FN | FR | HU | IR | IT | LT | LUX | NL | PL | PT | RO | SE | SK | SL | SP-Catal | SP-North | UK | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northern.Europe | | Baltic_Sea | | | | | 56 | | 71 | | | | | 55 | | | 31 | | | 7646 | | | | | | 7859 |
| North.Portugal | NE_Atlantic_Ocean | Bay of Biscay | | | | | | | | | | | | | | | | | | | | | | 351 | | 351 |
| United.Kingdom | | Bristol_Channel | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 |
| Danube | | Danube | 137 | | | 51 | 22 | | | | 169 | | | | | | | | 103 | | 52 | 36 | | | | 570 |
| North.Portugal | | Douro | | | | | | | | | | | | | | | | 32 | | | | | | 33 | | 65 |
| Ebro | | Ebro | | | | | | | | | | | | | | | | | | | | | 89 | | | 89 |
| Northern.Europe | | Elbe | 2 | | | 111 | 177 | | | | | | | | | | | | | | | | | | | 290 |
| United.Kingdom | | English_Channel_ER_18 | | | | | | | | | | | | | | | | | | | | | | | 209 | 209 |
| West.France | | Garonne | | | | | | | | 84 | | | | | | | | | | | | | 8 | | | 92 |
| Northern.Europe | Baltic_Sea | GulfofBothnia | | | | | | | | | | | | | | | | | | 15437 | | | | | | 15437 |
| Northern.Europe | Baltic_Sea | GulfofRiga | | | | | | | | | | | | 38 | | | | | | | | | | | | 38 |
| United.Kingdom | Irish_Sea | IrishseaandtheSt.George'schannel | | | | | | | | | | 104 | | | | | | | | | | | | | 15 | 119 |
| South.Sweden | Kattegat_Sound | KattegatSound | | | | | | | | | | | | | | | | | | 2484 | | | | | | 2484 |
| Med.Catalonia | | Mediterranean_Sea_WB | | | | | | | | | | | | | | | | | | | | | 171 | | | 171 |
| Med.France | | Mediterranean_Sea_WB_North_Pyrenees | | | | | | | | 99 | | | 59 | | | | | | | | | | | | | 158 |
| Meuse.NorthSea | | Meuse | | | | | | | | 139 | | | | | | | | | | | | | | | | 139 |
| Meuse.NorthSea | Meuse | Meuse.NorthSea | | 51 | 94 | | 8 | | | | | | | | | 31 | | | | | | | | | | 184 |
| North.Portugal | NE_Atlantic_Ocean | Miño | | | | | | | | | | | | | | | | | | | | | | 407 | | 407 |
| North.Portugal | NE_Atlantic_Ocean | NE Atlantic Ocean | | | | | | | | | | | | | | | | | | | | | | 821 | | 821 |
| North.Portugal | NE_Atlantic_Ocean | NEAtlanticocean | | | | | | | | | | 393 | | | | | | | | | | | | | | 393 |
| Northern.Europe | | Nemunas | | | | | | | | | | | | 420 | | | | | | | | | | | | 420 |
| | | | | | | | | | | | | | | | | | | 18 | | | | | | | | 18 |
| West.France | | North_Atlantic_Ocean | | | | | | | | 51 | | | | | | | | | | | | | | | | 51 |
| Meuse.NorthSea | | North_Sea | | | | | 27 | | | 13 | | | | | | | | | | | | | | | | 40 |
| Northern.Europe | Odra | Oder | | | | | 155 | | | | | | | | | | | | | | | | | | | 155 |
| Northern.Europe | | Odra | | | | 15 | | | | | | | | | | | | | | | 1 | | | | | 16 |
| Northern.Europe | | Rhine | 8 | | 1 | | 41 | | | 136 | | | | | 20 | 45 | | | | | | | | | | 251 |
| Rhone | | Rhone | | | | | | | | 126 | | | | | | | | | | | | | | | | 126 |
| West.France | | Seine | | | | | | | | 79 | | | | | | | | | | | | | | | | 79 |
| South.Sweden | | Skagerrak | | | | | | 65 | | | | | | | | | | | | 6058 | | | | | | 6123 |
| Northern.Europe | | Weser | | | | | 11 | | | | | | | | | | | | | | | | | | | 11 |
| | | Total | 147 | 51 | 95 | 177 | 497 | 65 | 71 | 727 | 169 | 497 | 59 | 513 | 20 | 76 | 31 | 50 | 103 | 31625 | 53 | 36 | 268 | 1612 | 229 | 37171 |

The river region names had to be corrected for 9 (at least) river regions before recomputing the common metrics.
The river group used for the computation of common metrics is given in the first column

# Description of the European fish-based method (FAME project 2002-2004).

The following description is taken from the publication:
*FAME CONSORTIUM (2004). Manual for the application of the European Fish Index - EFI. A fish-based method to assess the ecological status of European rivers in support of the Water Framework Directive. Version 1.1, January 2005.*

## Introduction

In the year 2000, the European Commission adopted a new legislation, the Water Framework Directive. This new legislation, now implemented in 25 EU member countries, strives for good ecological conditions in all surface waters. Fishes are, for the first time, part of a European monitoring network designed to observe the ecological status of running waters. Due to the lack of standardised fish-based assessment methods, FAME aimed to develop a new assessment method, the European Fish Index. This method is founded on the concept of the Index of Biotic Integrity. FAME started in 2001 and was finished in 2004. Further information on FAME is provided at the project website http://fame.boku.ac.at.

Currently, different fish-based methods are used in Europe, while most countries have not yet included fish in their routine monitoring programs. Thus, the successful implementation of the WFD depends on the provision of reliable and standardised assessment tools. This was the motivation for the EC-funded FAME project. The project aimed to develop, evaluate and implement a fish-based assessment method for the ecological status of European rivers to guarantee coherent and standardised monitoring throughout Europe.

The principle of the Index of Biotic Integrity (IBI, Karr 1981) is based on the fact that fish communities respond to human alterations of aquatic ecosystems in a predictable and quantifiable manner. An IBI is a tool to quantify human pressures by analysing alterations of the structure of fish communities. The original IBI (Karr 1981) uses several components of fish communities, e.g. taxonomic composition, trophic levels, abundance and fish health. Each component is quantified by metrics (e.g. proportion of intolerant species). A metric is a measurable variable or process that represents an aspect of the biological structure, function, or other component of the fish community and changes in value along a gradient of human influence. Depending on the underlying biological hypotheses, a metric may decrease (e.g. number of sensitive species) or increase (e.g. number of tolerant species) with the intensity of human disturbances.

## Description of the method

The European Fish Index (EFI) is based on a predictive model that derives reference conditions for individual sites and quantifies the deviation between predicted and observed conditions of the fish fauna. The ecological status is expressed as an index ranging from 1 (high ecological status) to 0 (bad ecological status).

1. In the first step the EFI uses data from single-pass electric fishing catches to calculate the assessment metrics (Fig.1). The EFI employs 10 metrics belonging to the following ecological functional groups: trophic structure, reproduction guilds, physical habitat, migratory behaviour and capacity to tolerate disturbance in general (Table 1). Six metrics are based on species richness and four on densities.

***Table 1**: The 10 metrics used by the EFI and their response to human pressures (↓ = decrease; ↑ = increase of metric)*

| Selected metrics | Response to human pressures |
|---|---|
| Trophic level | |
| 1. Density of insectivorous species | ↓ |
| 2. Density of omnivorous species | ↑ |
| Reproduction strategy | |
| 3. Density of phytophilic species | ↑ |
| 4. Relative abundance of lithophilic species | ↓ |
| Physical habitat | |
| 5. Number of benthic species | ↓ |
| 6. Number of rheophilic species | ↓ |
| General tolerance | |
| 7. Relative number of intolerant species | ↓ |
| 8. Relative number of tolerant species | ↑ |
| Migratory behaviour | |
| 9. Number of species migrating over long distances | ↓ |
| 10. Number of potamodromous species | ↓ |

2. In the second step a theoretical reference value, indicating no or only slight human disturbances (equals high or good status), is predicted for each metric using environmental variables by means of a multilinear regression model calibrated with FIDES reference data (Fig. 1, step 2). Ten environmental factors and three sampling variables pertaining to the specific site and sampling strategy are used to predict reference values. Additional information on location, site name, sampling date is required (Table 2). Nine environmental variables account for local natural variability in fish communities (e.g. altitude, slope). One environmental variable, river region, is used to explain regional differences. To identify the main river regions 36 hydrological units were defined using two criteria: each large basin (over 25 000 $km^2$) was considered as a separate unit characterised by its native fauna list, whereas all smaller basins flowing to the same sea coast were grouped (IHBS Sea area codes). Finally, the 36 hydrological units were grouped into 11 main river regions based on the similarity of their native fish fauna.

3. The residuals of the multilinear regression models are used to quantify the level of degradation. Residuals are calculated as observed metric values minus theoretical (predicted) metric values (Fig. 1, step 3).

4. Residual metric values scatter around the theoretical value. Impacted sites exhibit a greater deviation from the theoretical value and thus are less likely to belong to the reference residual distribution than un-impacted or only slightly impacted sites (Fig.1, step 4).

5. The metrics in the EFI are based on different units (e.g. number of species, number of individuals). To make metrics comparable they are standardised through subtraction and division by the mean and the standard deviation of the residuals of the reference sites, respectively (Fig.1, step 5).

***Table 2:** Abiotic variables and sampling method variables required for the EFI to predict reference conditions (variable codes for the EFI software in italics)*

| Environmental variables describing the sampling site | |
|---|---|
| Altitude<br>*E_altitude* | The altitude of the site in **metres above sea level** (data source: maps). |
| Lakes upstream<br>*E_lakeupstream* | Are there natural lakes present upstream of the site? Answer *Yes* or *No*. Only applicable if the lake affects the fish fauna of the site, e.g. by altering thermal regime, flow regime or providing seston. |
| *Distance from source*<br>E_distsource | Distance from source **in kilometres** to the sampling site measured along the river. |
| Flow regime<br>*E_flowregime* | *Permanent*: never drying out.<br>*Summer dry*: drying out during summer (data source: gauging station or hydrological reports). |
| Wetted width *E_wettedwidth* | Wetted width **in metres** is normally calculated as the average of several transects across the stream. The wetted width is measured during fish sampling (performed manly in autumn during low flow conditions) (data source: field measurement). |
| Geology *E_geotypo* | *Siliceous* or *calcareous* (based on dominating category) (data source: geological maps). |
| Mean air temperature<br>*E_tempmean* | Yearly average air temperature measured for at least 10 years. Given **in degrees Celsius (°C)** (data source: nearby measuring site, interpolated data). |
| Slope<br>*E_slope* | Slope of streambed along stream expressed **as per mill**, m/km (‰): drop of altitude divided by stream segment length. The stream segment should be as close as possible to 1 km for small streams, 5 km for intermediate and 10 km for large streams (Data source: maps with scale 1:50 000 or 1:100 000). |
| ***Size of catchment***<br>**E_catchclass** | 1.1. Size of the catchment (watershed) upstream of the sampling site.<br>Classes are: *<10, <100, <1000, <10 000, >10 000* **km²**. |
| River region *E_riverregion* | To define the river region use Table and map in part III (e.g. *Danube, Ebro, North_Sea, Mediterranean_Sea_WB*). |
| **Variables describing the sampling methods** | |
| Sampling strategy<br>*E_strategy* | Definition of how the section was sampled. Whole river width (*Whole*) or only parts of the river (*Partial*). |
| Method<br>*E_method* | Define if electric fishing was carried out by wading (*Wading*) or boat (*Boat*). |
| Fished area<br>*E_fishedarea* | Area of the section that has been sampled (sampled length * sampled width) **in m²**. |
| **Variables describing the location, name of site and date of fishing** | |
| Site code *E_sitecode* | Unique reference number per sampling site. User defined schemes. |
| Date *E_date* | Day/Month/Year e.g. 23/04/2004. |
| Latitude *E_latitude* | Latitude is given in degrees followed by a decimal point and than minutes and seconds, two digits each. It is always followed by N (e.g. 51.1927N) (data source: GPS, digital maps). |
| Longitude *E_longitude* | Longitude is given in degrees followed by a decimal point and than minutes and seconds, two digits each. It is always followed by E or W (e.g. 4.5509E) (data source: GPS, digital maps). |
| River name *E_rivername* | The official name used in your country. |
| Site name *E_sitename* | Location name e.g. indicating a nearby town or village. |

6. As some standardised residuals values tend to increase with disturbance (i.e. density of omnivorous species), whereas others decrease (i.e. density of insectivorous species, Table 1), they are transformed into probabilities (Fig.1, step 6). This transformation presents two main advantages. Firstly, all metrics will vary between 0 and 1, whereas the standardised residuals have no finite values, and secondly, all metrics will have the same response to disturbance, i.e. a decrease. This final metric value describes the probability for a site to be a reference site, i.e. a site belonging to the two best ecological integrity classes (1 and 2). A site that fits perfectly with the prediction (theoretical value) will have a final metric value of 0.5, whereas the value for an impaired site will decrease when disturbance intensity increases. If the final probability value of the metric is higher than 0.5, the situation observed on the field is better than the predicted one and the probability for these site to be an excellent site (ecological integrity class 1) increases.
7. The final European Fish Index (EFI) is obtained by summing the ten metrics, and then by rescaling the score from 0 to 1 (Fig.1, step 7).

8. The final step is to assign index scores to ecological status classes. Class boundaries have been defined based on the comparison of data sets with different degrees of human pressures (Fig.1 step 8).

The EFI was validated within the FAME project with independent data stets. The EFI was also validated against a pre-classification of site status based on assessment of human pressures to the hydrology, morphology and chemical quality of the water body. The EFI was able to discriminate between non-impacted and impacted sites in about 80 % of the cases.

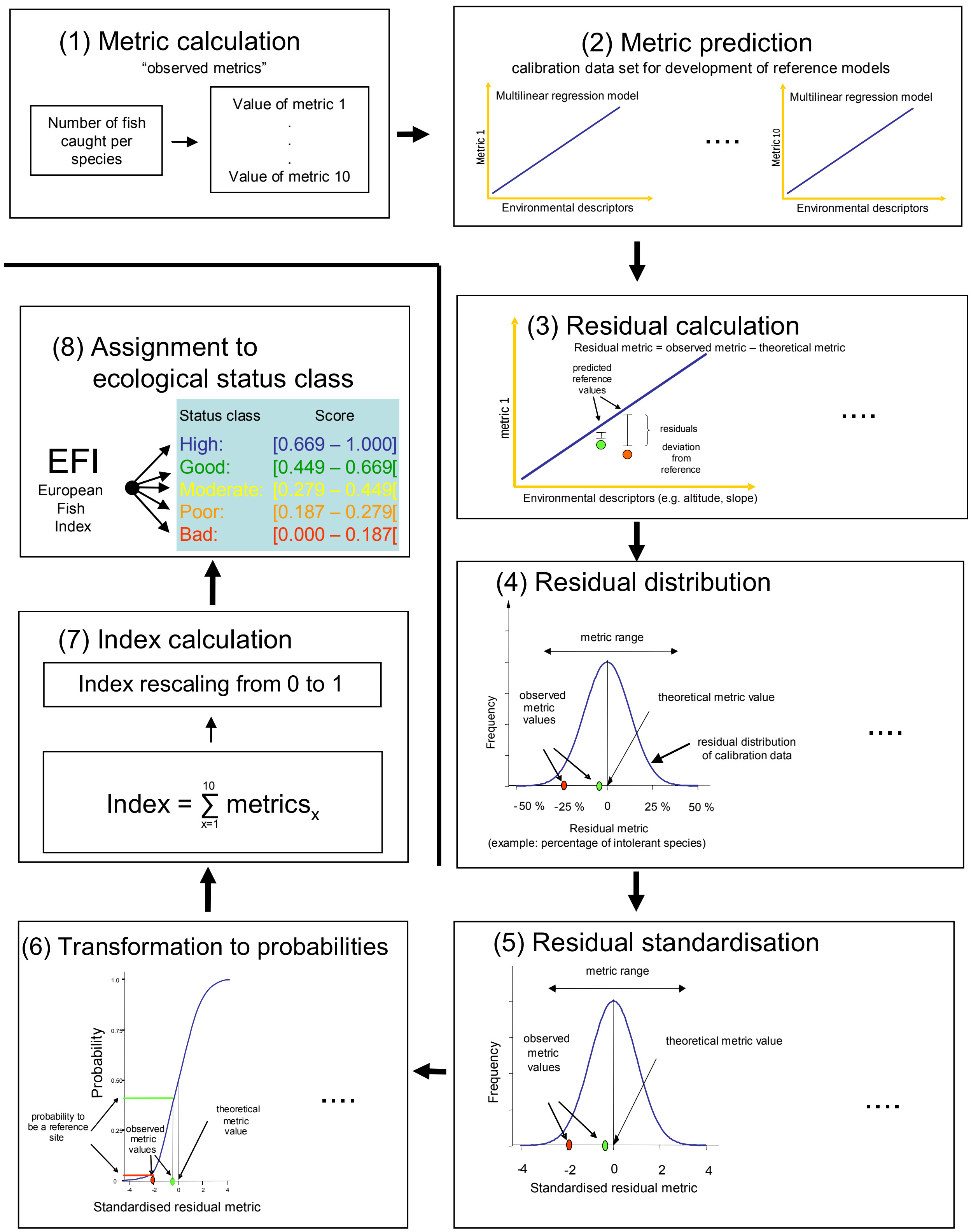
## Limitations of the EFI

This index has been developed for sites located in the ecoregions presented in Annex 2. A sufficient number of sites were available in 11 of the 25 European ecoregions. Therefore, the EFI should not be applied in areas with a fish fauna and/or a environment deviating from those of the tested ecoregions. The EFI should not be used (or only used with caution) in e.g. Mediterranean rivers with high proportion of endemic species or in the rivers of the south-eastern part of Europe which support fish communities that differ greatly in species composition. Although the validation of the EFI also proved its applicability for large rivers the index should be used with caution in the lowland reaches of very large rivers such as the Rhine and Danube as no reference sites from these reaches have been used for the calibration of the EFI. In those cases the EFI uses only extrapolated predictions based on the trends observed in the models.

The statistical models that are used for the EFI reflect the average response of fish communities to environmental conditions. The application of the EFI for particular environmental situations such as the outlet of lakes or predominantly spring fed lowland rivers might cause problems. However, those unique situations are mostly spatially limited and are therefore less important in countrywide monitoring programmes. Only fish data obtained with single-pass electric fishing may be used to calculate the EFI. If data from multiple passes are used (i.e. same site fished several times and catches cumulated) the EFI produces erroneous results.

As the EFI is a statistical method to assess the community composition, a minimum number of data is required to run the software. For a given site, 30 specimens is the minimum sample size required to be able to calculate the EFI with appropriate statistical confidence. When fewer specimens were caught the software still allows you to calculate the EFI, but the results must be considered with care. The same applies when the sampled area is smaller than 100 $m^2$. Consequently, when no fish occur at a site, this method is not applicable. Two cases could be problematic and the EFI should be used with care: (1) undisturbed rivers with naturally low fish density and (2) heavily disturbed sites where fish are nearly extinct. In the first case, fish are close to the natural limits of occurrence and therefore might not be good indicators for human impacts. The occurrence of fish in those rivers is highly coincidental and therefore not predictable. If the very low density is caused by severe human impacts more simple methods or even expert judgement are sufficient to assess the ecological status of the river.

The EFI provides a continuous score from 0 to 1. The discrimination between ecological classes, i.e. between un-impacted and impacted sites was based on validated statistical tests. However, due to the low number of minimally disturbed sites (class 1) and heavily disturbed sites (class 5) in FIDES, the limits between class 1 and 2 and class 4 and 5 were set arbitrarily. Therefore, the probability to misclassify sites of high and bad status is higher than for sites of good, moderate and poor status.




*The methodology of EFI. In step 3 to 6 two examples, a reference site (green) and a disturbed site (red) are shown.*

The model was developed using data from sites with environmental characteristics ranging between specific limits. These values are given in Table 5. Your site should have characteristics within these ranges in order to obtain a confident EFI.

***Table 5****: Minimum, median and maximal values of environmental characteristics*

| Characteristics | *Minimum* | *Median* | *Maximum* |
|---|---|---|---|
| Distance from source [km] | 0.0 | 20.0 | 990.0 |
| Altitude [m.a.s] | 0.0 | 56.0 | 1950.0 |
| Slope gradient [m.km-1] | 0.50 | 7.00 | 199.00 |
| Wetted width [m] | 0.5 | 7.0 | 1600 |
| Mean air temperature [°C] | -2.0 | 10.0 | 16.0 |

The WFD requires the use of s*pecies composition, abundance, sensitive species, age structure and reproduction* within assessment criteria. The ten metrics used in the EFI only represent the species composition, abundance and sensitive species criteria. However, at the time the FAME project was developed, the data on fish length necessary to calculate metrics for age structure and reproduction were not available in all European countries. These metrics could be integrated in a future version of the EFI.

## Fish sampling

To calculate the index only fish data obtained by electric fishing can be used. Standardised electric fishing procedures are precisely described in the CEN directive, “Water Analysis – Fishing with Electricity (EN 14011; CEN, 2003) for wadable and non-wadable rivers.

Fishing procedures and equipment differ depending upon the water depth and wetted width of the sampling site. The selection of waveform, DC (Direct Current) or PDC (Pulsed Direct Current), depends on the conductivity of the water, the dimensions of the water body and the fish species to be expected. AC (Alternating Current) is harmful for the fish and should not be used. The fishing procedure is summarised below, separately for wadable and non-wadable rivers. In both cases, fishing equipment must be suitable to sample small individuals (young-of-the-year).

According to the CEN-standard, the main purpose of the standardised sampling procedure is to record information concerning fish composition and abundance; therefore, no sampling period is defined (according to CEN). However, FAME agreed on a sampling period of late summer/early autumn except for non-permanent Mediterranean rivers where spring samples may be more appropriate.

Concerning the minimum river length to be sampled, because of the variability of habitats and fish communities within rivers sections and in order to ensure accurate characterisation of a fish community, electric fishing at a given site must be conducted over a river length of 10 to 20 times the river width, with a minimum length of 100 m. However, in large and shallow rivers (width >15 m and water depth <70 cm) where electric fishing by wading can be used, several sampling areas cumulating in total at least 1000 $m^2$ should be prospected, covering all types of mesohabitats present in a given sampling site (partial sampling method). The length of the sampling site (station) is also calculated as 10 to 20 times the river width. Fishing of longer river sections should be avoided as some metrics referring to the number of species caught (e.g. number of rheophilic species) might be biased due to over sampling.

In wadable rivers as a general guide one anode per 5 m width should be appropriate. The operators should fish upstream so that water discoloured by wading does not affect efficiency. They should move slowly, covering the habitat with a sweeping movement of the anodes and attempt to draw fish out of hiding. To aid effective fish capture in fast flowing water the catching nets should be held in the wake of the anode. Each anode is generally followed by one or two hand-netters (hand net: mesh size of 6 mm maximum) and one suitable vessel for transporting fish.

In large rivers, the depth (> 0.7 m) and variety of habitats makes prospecting the entire area impossible. Therefore, a partial sampling procedure is applied covering all types of habitats to obtain a representative sample of the site. Qualitative and semi-quantitative information can be obtained by using conventional electric fishing with hand held electrodes in the river margins and delimited areas of habitat. Alternatively, where resources exist capture efficiency can be improved by increasing the size of the effective electric field relative to the area being fished by increasing the number of catching electrodes (electric fishing boats with booms). Arrays comprising many pendant electrodes can be mounted on booms attached to the bows of the fishing boat. The principal array should be entirely anodic with separate provision being made for cathodes. Depending upon water conductivity, the current demands of multiple electrodes can be high and large generators and powerful control boxes may be needed.

# Annex II: Report from the Alpine Group

EUROPEAN COMMISSION
DIRECTORATE GENERAL JRC
JOINT RESEARCH CENTRE
Institute of Environment and Sustainability

Report – River Fish Groups

| GIG | **FISH- REGIONAL GROUP "ALPINE"** |
|---|---|
| Information provided by | Nikolaus Schotzko, Haimo Prinz, Markus Diekmann, Uwe Dussling, Andreas Kolbinger, Gorazd Urbanic, Nicolas Roset |

**A – General approach**

1. Describe the common intercalibration types, specifying the countries participating for each type and the biological quality elements/ pressures that are intercalibrated (update 'types manual' tables)

Fish intercalibration:
Data input of the participating countries not yet specified regarding common intercalibration types, sites belong to the following types:

Intercalibration Sites

| | R-A1 | R-A2 | R-A3 | R-A4 | R-C2 | R-C3 | R-C4 | R-C5 | R-E4 | R-M2 | R-M4 | sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AT | 63 | 41 | 9 | 9 | - | 12 | 8 | 1 | 4 | - | - | 147 |
| DE | 21 | 6 | - | - | - | 1 | 3 | 1 | - | - | - | 32 |
| FR | 27 | 2 | 23 | 8 | - | 1 | 1 | 2 | - | 1 | 4 | 69 |
| SLO | 27 | 3 | 1 | - | 1 | 3 | 1 | - | - | - | - | 36 |

Alpine regions RA-3 and RA-4 were created to assign sites which could not be categorized by using the existing definitions (Common Intercalibration types, Final Version 5.1).

| Type | River characterisation | Altitude & geomorphology | Alkalinity |
|---|---|---|---|
| R-A3 | Alpine - small to medium, very high altitude, calcareous | > 800 m | Medium to high alkalinity |
| R-A4 | Alpine - small to medium, very high altitude, siliceous | > 1000 m | Medium to low alkalinity |

Germany on a regional level: alpine region (first of all Bavaria; in addition Baden-Württemberg)
Austria - whole
Slovenia – alpine Region of the Danube basin
France – alpine, but only common metrics and results from EFI and FBI

**Biological quality element**: fish

Pressures considered are:
Water quality, physico-chemical pressures, nutrient load, chemical pollutants, acidification, temperature alteration, morphology, water abstraction, hydropeaking, connectivity, and impoundment.

2. Describe the general intercalibration approach
   - Approach for comparison (e.g. ICMi using common reference criteria), including statistical procedures
   - Approach for harmonisation (if applicable, e.g. use of common benchmark)
   - Specify which data was used to set the boundaries applying the BSP (e.g. common benchmark data [option 2], all MS data [option 3]

For the pilot phase we used a direct comparison between national assessment methods by checking whether there are major differences in the results of the national methods when applied to the same sites. The European Fish Index (EFI) was used as a common method.

Data availability for the different assessment methods:

| Country | N-sites | Reference sites | EFI | FIA (Austria) | FIBS (Germany) | FBI (France) |
|---|---|---|---|---|---|---|
| Austria | 147 | 30 | 147 | 147 | 147 | 121 |
| France | 69 | 55 | 69 | 0 | 0 | 69 |
| Germany | 32 | 3 | 32 | 32 | 32 | 32 |
| Slovenia | 36 | 6 | 36 | 15 | 15 | 36 |

Number of fishing occasions calculated with each index:

| | |
|---|---|
| EFI | 308 |
| FIA | 195 |
| FIBS | 195 |
| FBI | 282 |

3. Identify the national methods that were intercalibrated (for all countries, if available); provide detailed description in Annex A

**FIA – FISH INDEX AUSTRIA:** Austrian national method, used for data from Austria, Germany and partially Slovenia

**fiBS – fischbasiertes BewertungsSystem:** German national method, used with data from Germany, Austria and partially Slovenia

**FBI – French Fish Based Index:** French national method, used with data from Austria, Germany, Slovenia and France

The above methods are officially accepted methods in their respective countries.

**EFI – EUROPEAN FISH INDEX** common method, used for all data

**Slovenia** does not have an own national method at this time.

**B – Setting of Reference conditions**

Summarize the common approach for setting of reference conditions. Give a more detailed description of procedure and criteria, and identify reference sites for each country and type according to those criteria in Annex B

There is no common approach so far.
Reference sites proposed by:
Austria (30 sites), Germany (3 sites), Slovenia (6 sites) and France (55 sites).

Reference Sites

| | R-A1 | R-A2 | R-A3 | R-A4 | R-C2 | R-C3 | R-C4 | R-C5 | R-E4 | R-M2 | R-M4 | sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AT | 15 | 6 | 3 | 1 | - | 3 | 2 | - | - | - | - | 30 |
| DE | - | 2 | - | - | - | 1 | - | - | - | - | - | 3 |
| FR | 24 | 1 | 19 | 8 | - | - | - | - | - | 1 | 2 | 55 |
| SLO | 5 | - | - | - | - | 1 | - | - | - | - | - | 6 |

| **C – Setting of Boundaries** |
|---|
| 1. Summarize how boundaries were set following the framework of the BSP for the HG and GM boundaries, demonstrating that this was done in accordance to WFD Annex V, normative definitions<br>a. For the benchmark (if applicable)<br>b. For the national methods (obligatory if no benchmark is used; also recommended if benchmark is used);<br>Provide a description of the full procedure in Annex C |
| The common method (EFI) does not react to hydromorphological pressures, which are clearly dominating in the concerned countries. There is no correlation with national methods.<br>As a result boundaries could not be set. |

| **D – Results of comparison and harmonisation of boundaries between countries** |
|---|
| 1. Present the results of the comparison demonstrating comparability of class boundaries between the countries within the GIG for all types (if applicable) |
| No results yet (class boundaries have not been set). |

**E – Boundary EQR values**

Provide a table with HG and GM boundary EQR values for the national methods and the common metrics (where applicable) for each type as a table

| | Austria - FIA | | Austria - EFI | | Germany - FIBS | | Germany - EFI | |
|---|---|---|---|---|---|---|---|---|
| | France - FBI | | France - EFI | | Slovenia - EFI | | | |
| High-Good | 0.88 | 1.19 | 0.85 | 1.03 | 1.04 | 1.39 | 1.49 | |
| Good-Moderate | | 0.63 | 0.80 | 0.47 | 0.69 | 0.94 | 0.94 | 1.00 |

These are the national boundaries as EQR values and the corresponding EQR of EFI, each calibrated with the median of the national reference sites.

Alpine Group report

| Indicate plans and appropriate timing for continuation of the intercalibration for types and quality elements not currently included |
|---|
| What strategy seems to be most promising and feasible for the next 2 years<br><br>There were not enough resources from the different MS for the pilot exercise of IC. But after all it can be expected that there will be more input from all sides for the remaining IC-process.<br><br>There is high confidence to be able to intercalibrate the German (fiBS) and the Austrian national method (FIA) bilaterally. We already found high correlations. To be able to proceed with the IC we will need larger and better defined data sets.<br>There is no perspective for the current EFI to work sufficiently as a common benchmark-method.<br>There might be the ad-hoc-possibility for common metrics, or a combination of some of the 10 EFI-metrics.<br>The new European fish index EFI+ is under development. It is intended to solve the deficiencies of EFI in regard of hydromorphological pressures. However, the new index will be ready 2009 and then needs to be checked for validity and reliability of its results before it might be considered as a benchmark system.<br>Slovenia has just started its national monitoring program on fish and 50 additional sites for the alpine region are to be expected until the end of this year.<br><br>Germany – it is imperative to get a much larger data set from rivers and streams in Southern Germany with highland and alpine character.<br><br>France – exchange of data has to be initiated.<br><br>Italy north – perspective to receive data from Bioplan and Aquaplan through the National Italian representatives for Northern Italy is very promising for the bilateral approach.<br><br>Spain – contact with the representative from Spain for the mountainous northern part has to be established<br><br>There are some common sites with the Midland and Lowland group, in order not to divide the different regional groups too far.<br><br>The future Alpine Group could consist of the following MS:<br>France-Germany-Austria-Slovenia-Northern Italy and possibly Spain. |

| E – Comments and remarks |
| --- |
| Problems encountered:<br>Bilateral data exchange was problematic: cooperation with France was almost nonexistent due to the workload of the French representative; similar problems on a lesser scale were encountered with Germany and Slovenia. For Germany the federal structure seems to create some organizational problems concerning comprehensive availability and support of suitable data sets. |

## Results from the pilot phase of rivers-fish Intercalibration, alpine group

**Current state of data:**

Listed below are the numbers of sites each country has delivered and which index can be calculated with the supplied data:

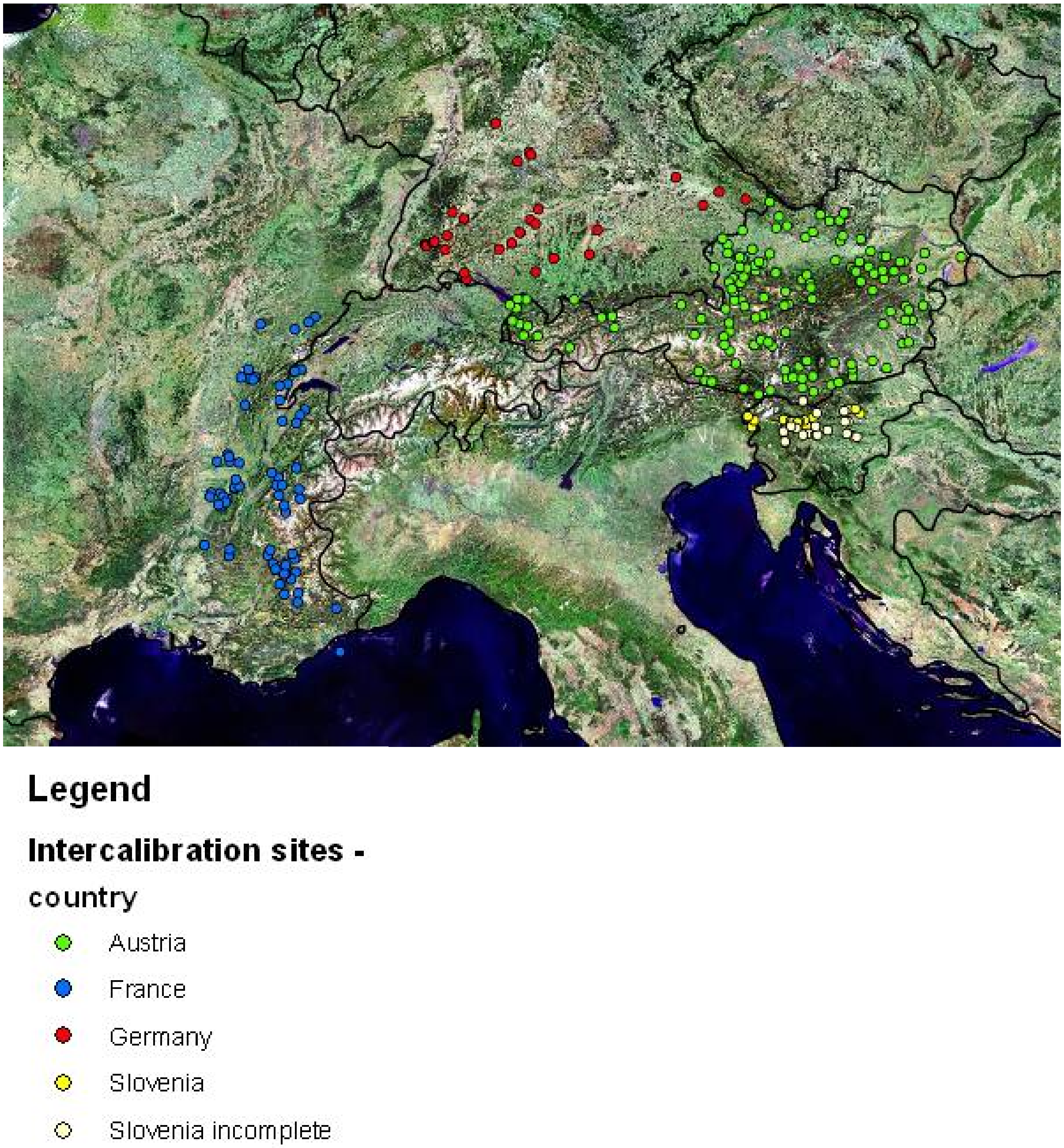
| Country | N-sites | Reference sites | EFI | FIA (Austria) | FIBS (Germany) | FBI (France) |
| --- | --- | --- | --- | --- | --- | --- |
| Austria | 147 | 30 | 147 | 147 | 147 | 121 |
| France | 69 | 55 | 69 | 0 | 0 | 69 |
| Germany | 32 | 3 | 32 | 32 | 32 | 32 |
| Slovenia | 36 | 6 | 36 | 15 | 15 | 36 |

EQR values were calculated for the datasets with reference sites; the calculations were done according to the formula as described in the WFD: EQR=metric value/reference value.

Before this formula could be applied, the metric values had to be normalized to a range of 0 to 1 (1 = high status), this had to be done so the whole range of possible results from the national method was represented between 0 and 1 and not just 0 as the worst and 1 as the best value from the selected IC values. This posed a problem with the French Index, as this has a range of 0 to >100 (theoretically∞); we arbitrarily chose 100 as the upper limit for the French FBI.

The reference value was calculated as the median of all reference values, so some sites may have EQR values above 1 because some sites may have better values than the median of the reference sites and different assessment methods may give different values for the reference sites.

**Location of IC sites:**




This graphic representation already shows some problems with data quality: one of the French sites is located in the Mediterranean Sea and one of the Slovenian sites is located in Austria according to the delivered coordinates.

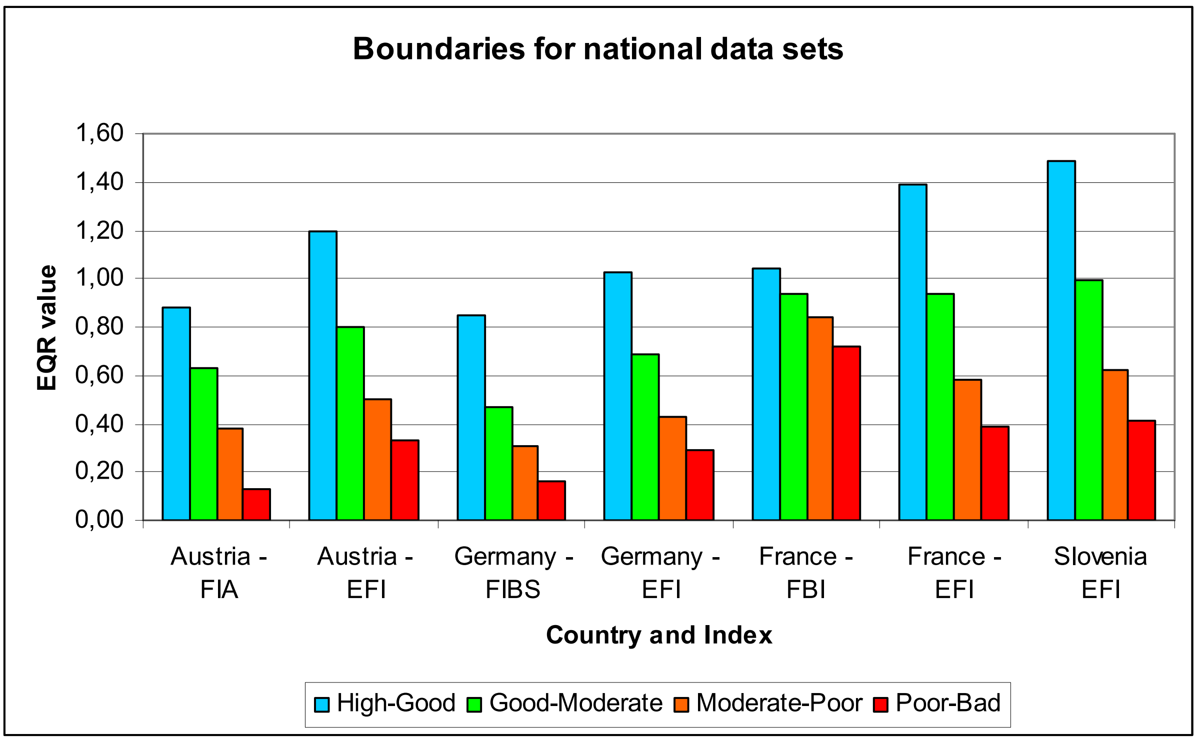
**Updates**

The German fish index fiBS has recently been updated from version 7.4 to 8.0. An updated description is included in Appendix A.

## Boundaries

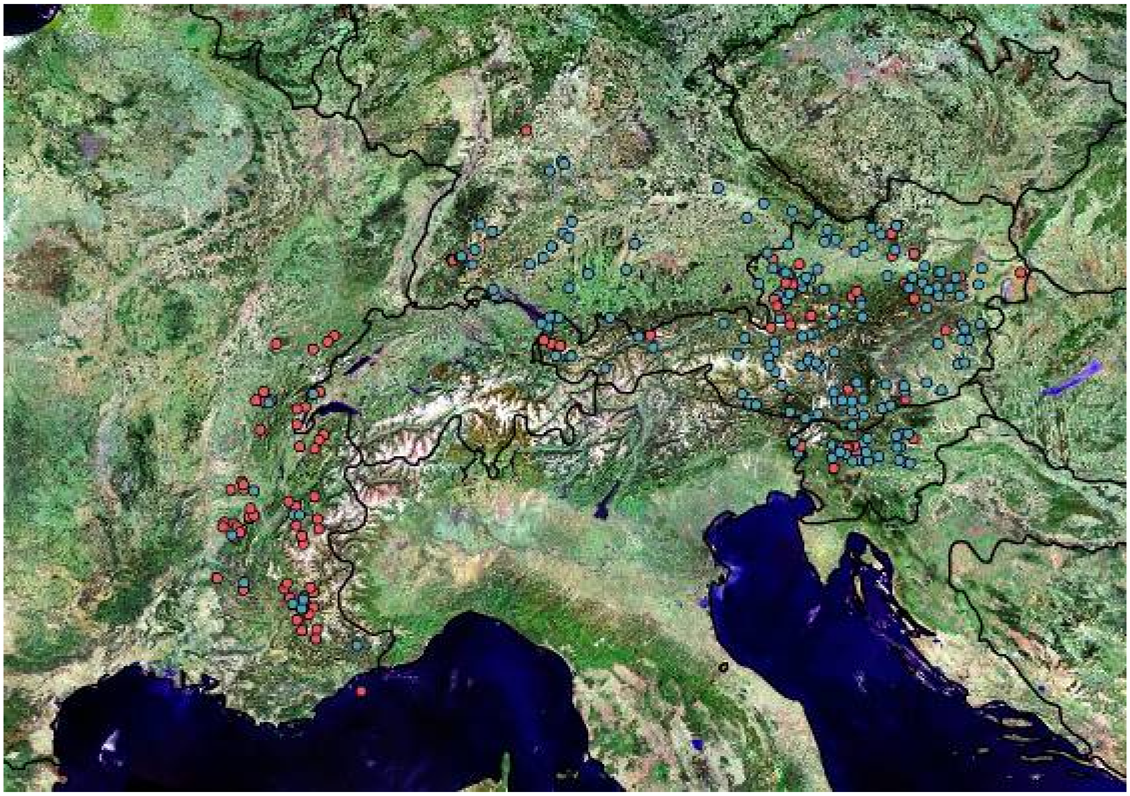
| | Austria - FIA | Austria - EFI | Germany - FIBS | Germany - EFI | France - FBI | France - EFI | Slovenia EFI |
|---|---|---|---|---|---|---|---|
| High-Good | 0,88 | 1,19 | 0,85 | 1,03 | 1,04 | 1,39 | 1,49 |
| Good-Moderate | 0,63 | 0,80 | 0,47 | 0,69 | 0,94 | 0,94 | 1,00 |
| Moderate-Poor | 0,38 | 0,50 | 0,31 | 0,43 | 0,84 | 0,58 | 0,62 |
| Poor-Bad | 0,13 | 0,33 | 0,16 | 0,29 | 0,72 | 0,39 | 0,42 |

Status: boundaries will need harmonisation.



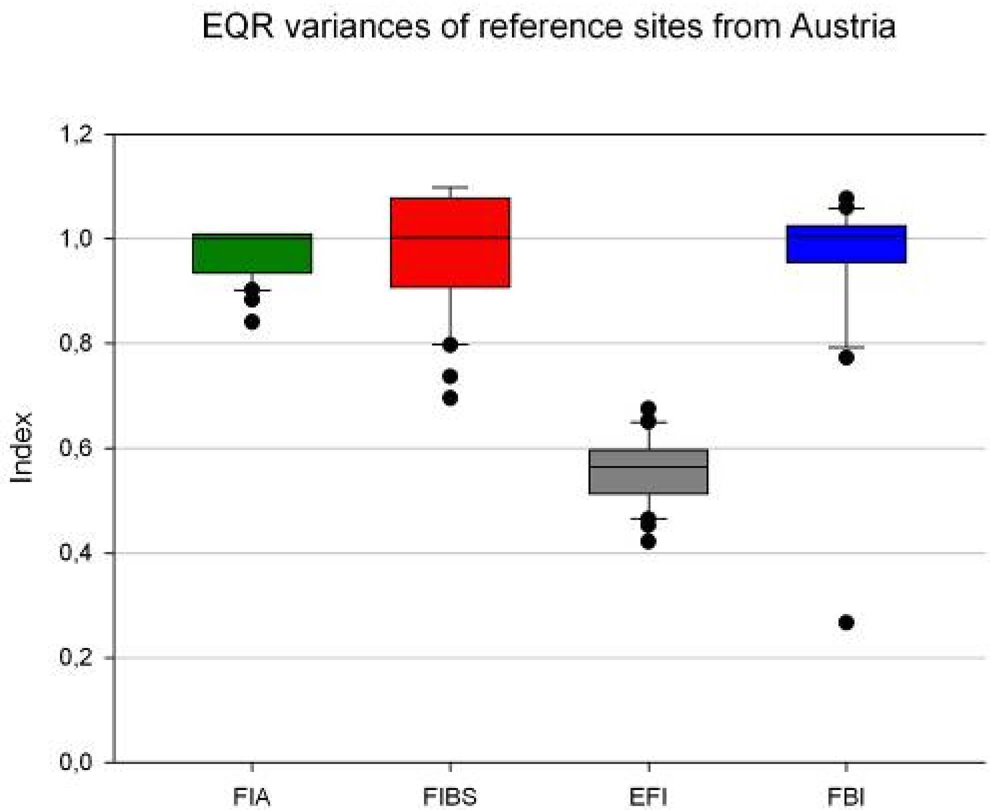
**Reference sites**

Distribution of reference sites Blue are normal sites and red are reference sites

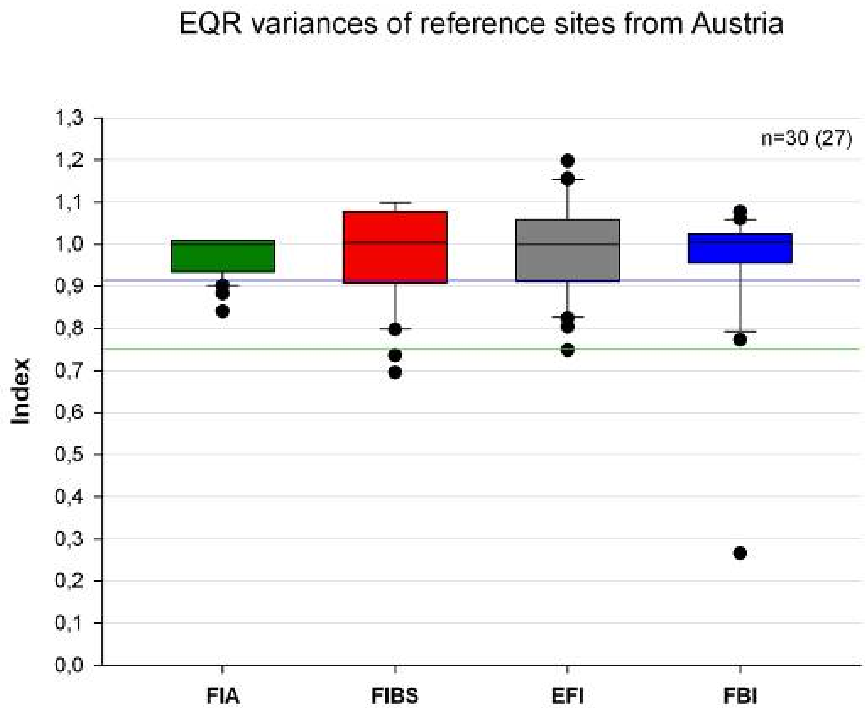


As can be seen in this GIS picture, the majority of IC sites from France are reference sites. These reference sites are problematic, since they encompass sites with status classes ranging from High to Bad!

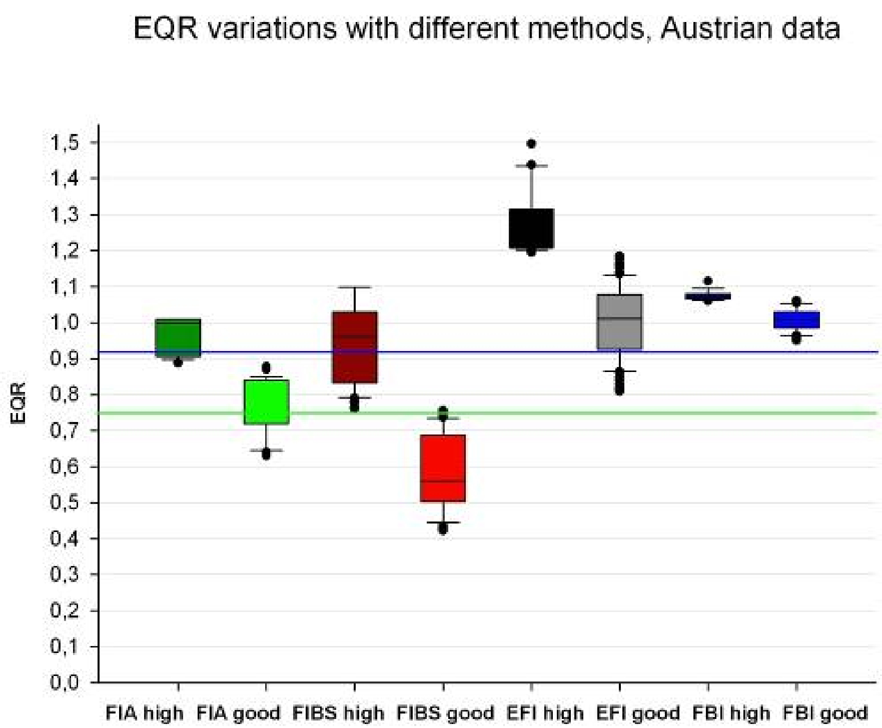
Variations in the assessment of reference sites from Austria are shown below:




The median of 3 indices (FIA, FIBS and FBI) are remarkably consistent and close to 1, as is to be expected. Only EFI breaks ranks, this is due to EFI not being calculated as EQR (divided by median of reference site values). The following graph shows the variances with EFI as EQR; also added are two lines showing the borders between High/Good (blue line and between Good/Moderate (green line): the blue line represents the border between High and Good calculated as the 25$^{th}$ percentile of reference values from the common method (EFI) and the green line the border between Good and Moderate status, calculated as 25% deviation from the median of reference values. These borders were proposed by the macroinvertebrate alpine IC group.
The basis for these calculations was the Austrian data set.




The same graph with variances from status classes high and good from all IC-sites included shows a different picture:



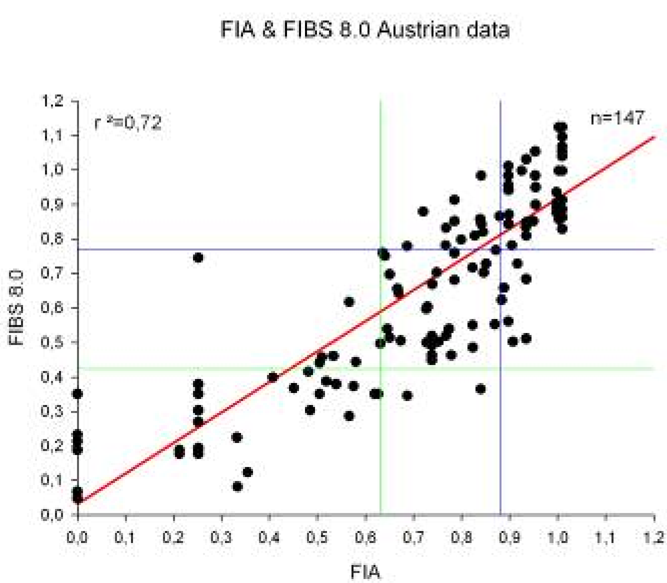
## Correlations

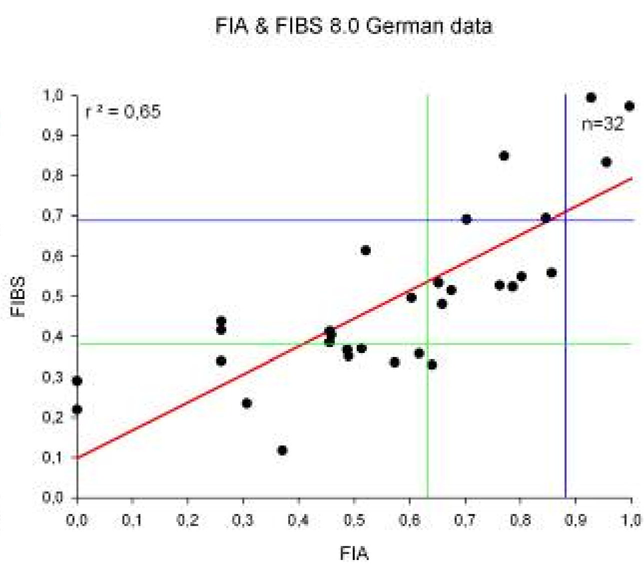
We have compared for the different datasets all applicable methods and found that correlations between Austrian (FIA) and German (fiBS) methods are relatively good, correlations of EFI with FIA and fiBS do not work well at all, as does FBI compared to FIA or fiBS. Since FBI does not have a Danube fish region it obviously can not be expected to work with our data; many fish species from Austria and Germany are missing (see list below). On the other hand, the French data would work with Austrian and German methods, so this would have been an interesting comparison.

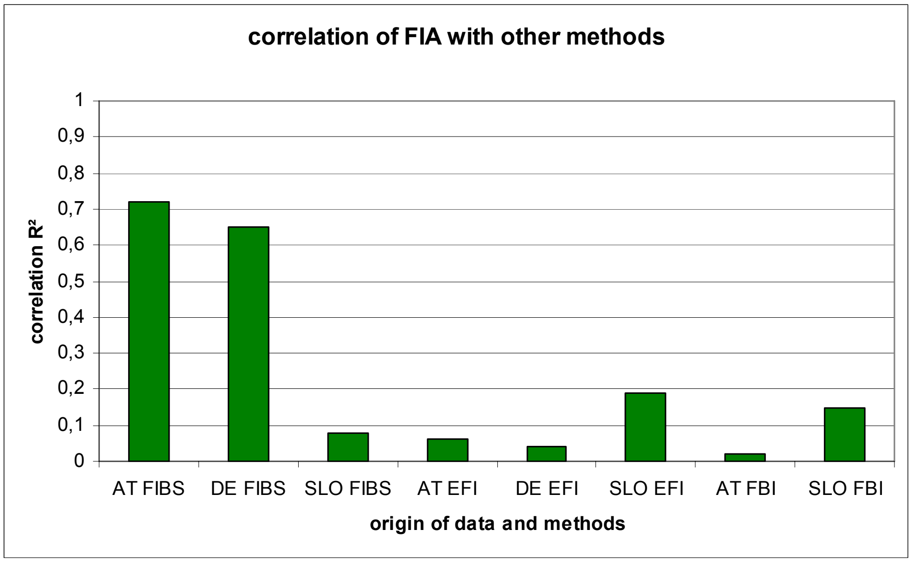
| | |
|---|---|
| number of species for French method | 34 |
| number of species for Austrian method | 58 |
| number of species for German method | 72 |

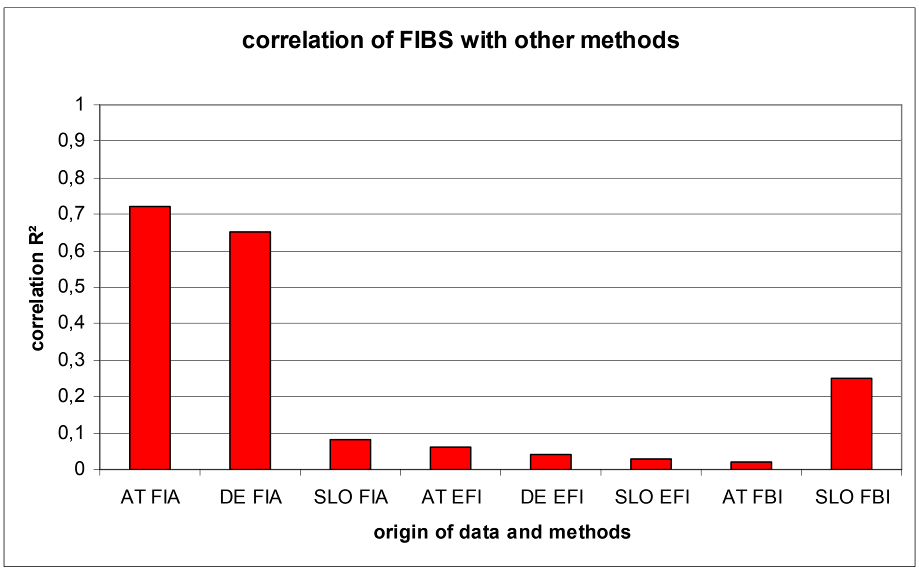
## Austrian and German methods (FIA and fiBS 8.0)

These methods seem to work relatively well together. Correlations of EQR values are 0.72 with Austrian data and 0.65 with German data.
The blue lines in the following graphics represent the boundary between high and good status and the green line the boundary between good and moderate status, these boundaries are from the national methods and not the experimental IC boundaries displayed in the two graphs before.
The extreme outliers in the left graph are caused by knockout-criteria from FIA.




correlation of FIA with other methods
correlation R²
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
AT FIBS
DE FIBS
SLO FIBS
AT EFI
DE EFI
SLO EFI
AT FBI
SLO FBI
origin of data and methods


correlation of FIBS with other methods
correlation R²
1
0,9
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AT FIA
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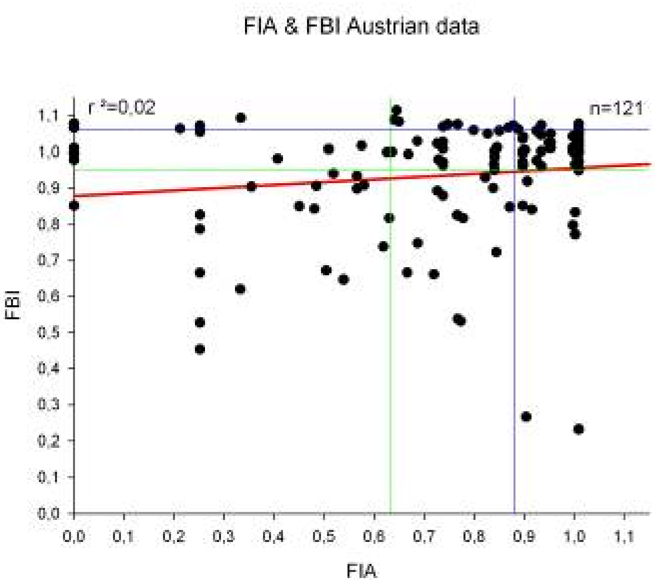
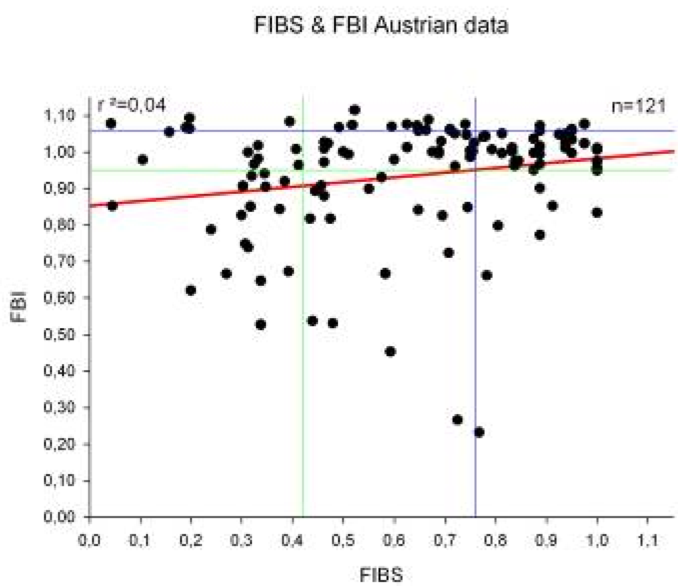
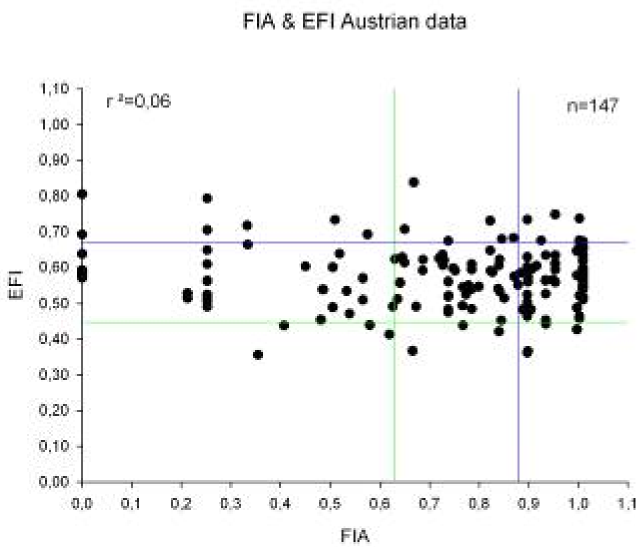
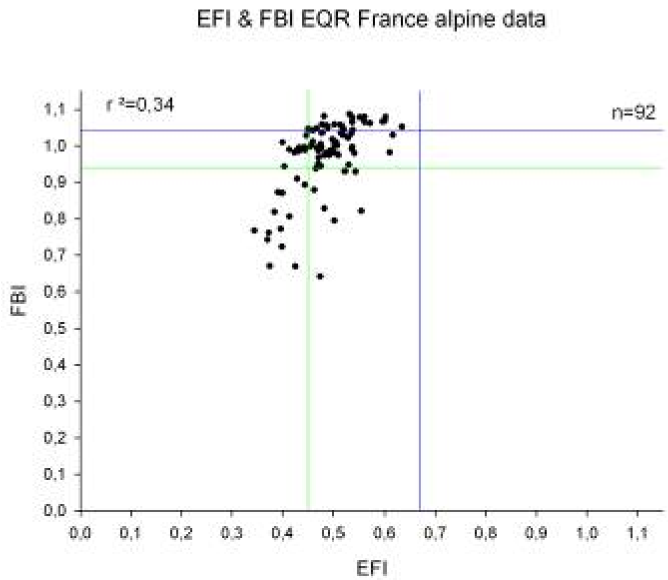
origin of data and methods


FIA & FBI Austrian data
r ²=0,02
n=121
FBI
FIA


FIBS & FBI Austrian data
r ²=0,04
n=121
FBI
FIBS

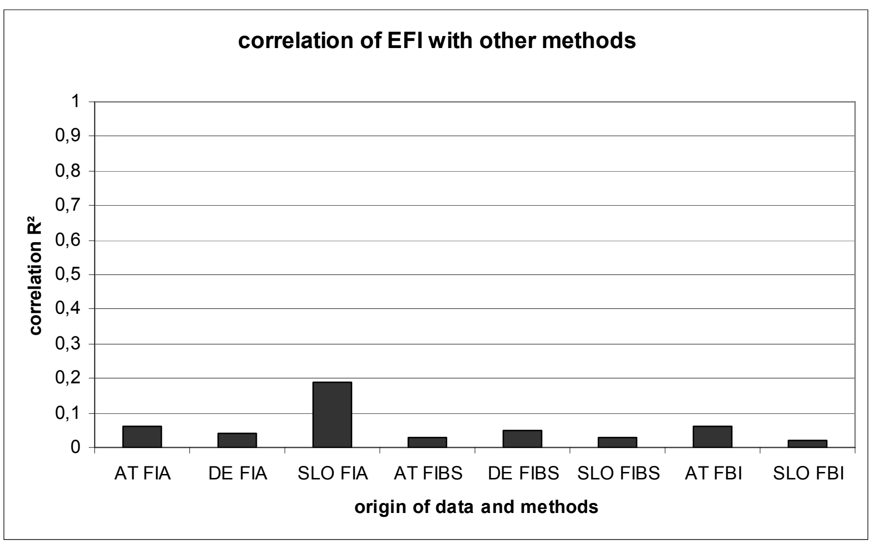



As mentioned before the French FBI does not work for our alpine data in its present form without a fish assembly for the Danube, relevant correlations are not to be found.

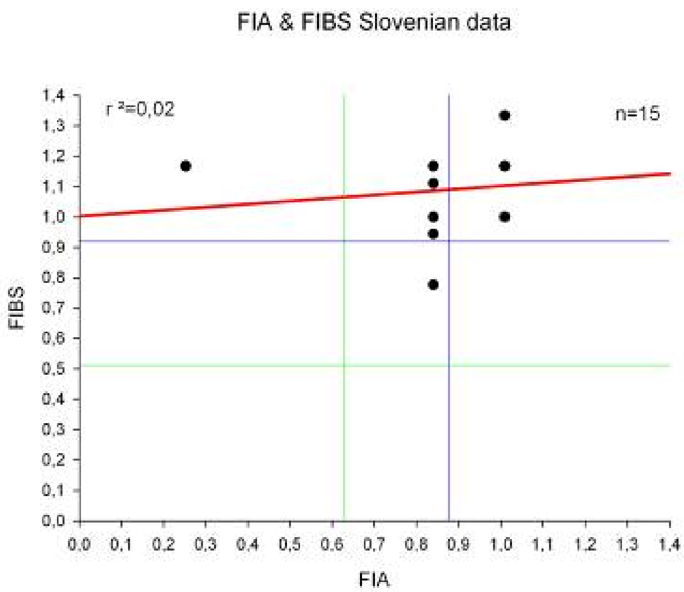
**EFI**

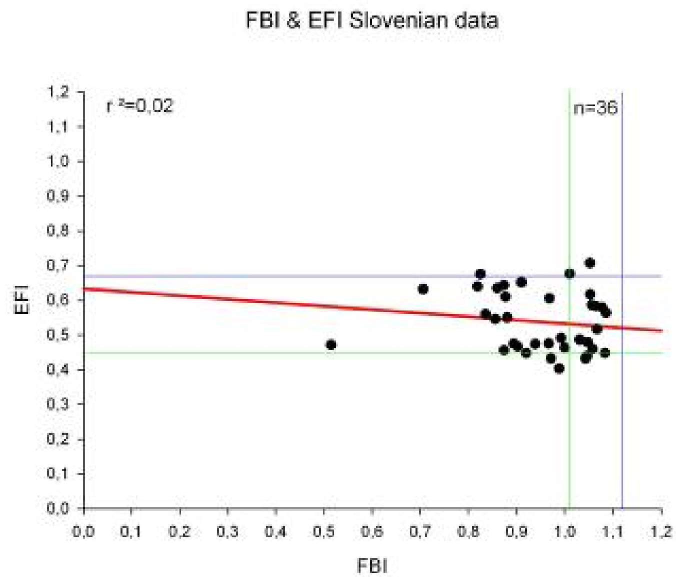
Correlations of the EFI with other methods are not satisfactory. We found no useful correlations among the datasets, although the correlation with the French FBI is better, but not as good as we would have expected.




**Slovenian data**

Correlations with Slovenian data did not work out, the main reasons for this are the low number of sites (15) and the type of reference fish community for these sites; the submitted reference fish community for all 15 sites consists of 100% brown trout. These single fish communities seem to amplify the differences of our national methods.




**Spearman Rank Correlations**

The above correlations were calculated using linear regression. To use linear regression some assumptions (linear relationship between variables, Normal distribution, only one source of random variation affecting the variables) have to be made, which are not valid for these data, so correlations were also calculated using Spearman's rank correlation coefficient, here these assumptions are not required.

| data from | Indices | ρ | P-value | samples |
|---|---|---|---|---|
| Austria | FIA-FIBS 8.0 | 0,889 | 0 | 147 |
| | FIA-EFI | 0,213 | 0,00981 | 147 |
| | FIA-FBI | 0,168 | 0,0654 | 121 |
| | FIBS-EFI | 0,0818 | 0,324 | 147 |
| | FIBS-FBI | 0,213 | 0,0191 | 121 |
| | EFI-FBI | 0,279 | 0,00202 | 121 |
| Germany | FIA-FIBS 8.0 | 0,818 | 0 | 33 |
| | FIA-EFI | 0,365 | 0,0367 | 33 |
| | FIA-FBI | 0,288 | 0,104 | 33 |
| | FIBS-EFI | 0,41 | 0,018 | 33 |
| | FIBS-FBI | 0,366 | 0,0361 | 33 |
| | EFI-FBI | 0,379 | 0,0296 | 33 |
| Slovenia | FIA-FIBS 7.4 | 0,416 | 0,12 | 15 |
| | FIA-EFI | -0,0165 | 0,944 | 15 |
| | FIA-FBI | 0,54 | 0,0367 | 15 |
| | FIBS-EFI | 0,176 | 0,523 | 15 |
| | FIBS-FBI | -0,382 | 0,154 | 15 |
| | EFI-FBI | -0,184 | 0,281 | 36 |
| France | FBI-EFI | 0,554 | 0 | 92 |

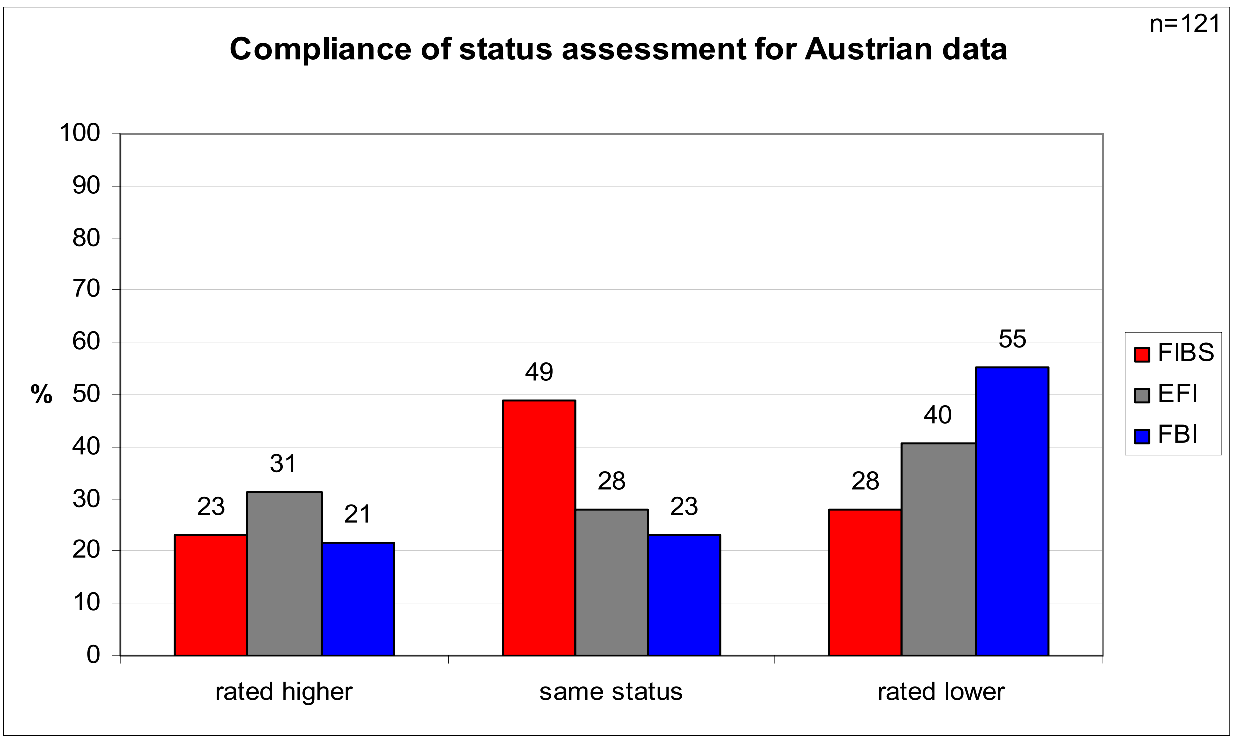
no significant relationship between variables

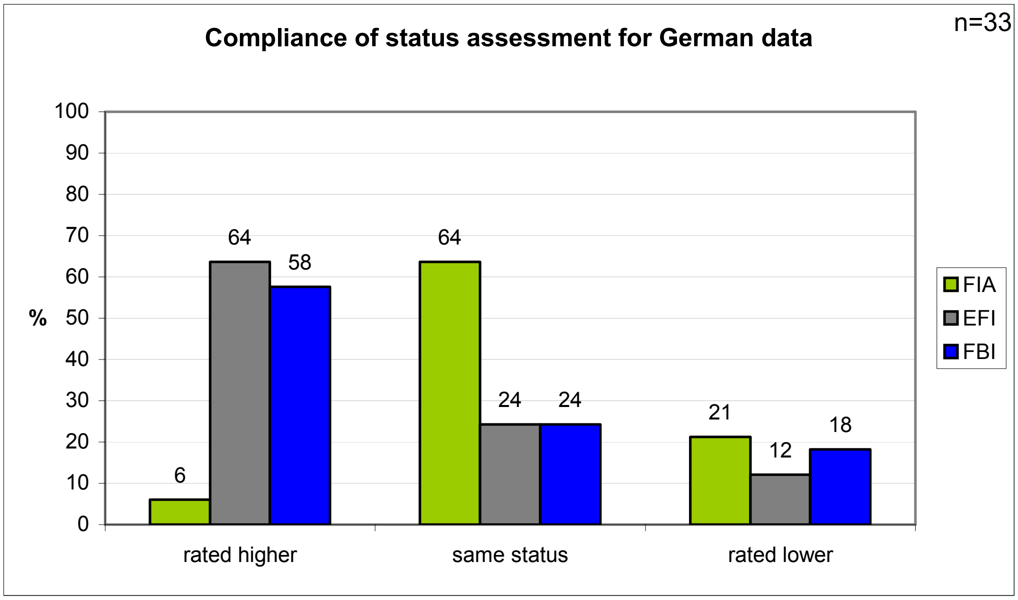
The pair(s) of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables.

Spearman's rank correlation also show a good correlation between FIA and fiBS and low correlations where EFI is involved except for French data where FBI and EFI achieve better correlations. For Slovenian data the only significant relationship detected was between FIA and FBI.

**Compliance**

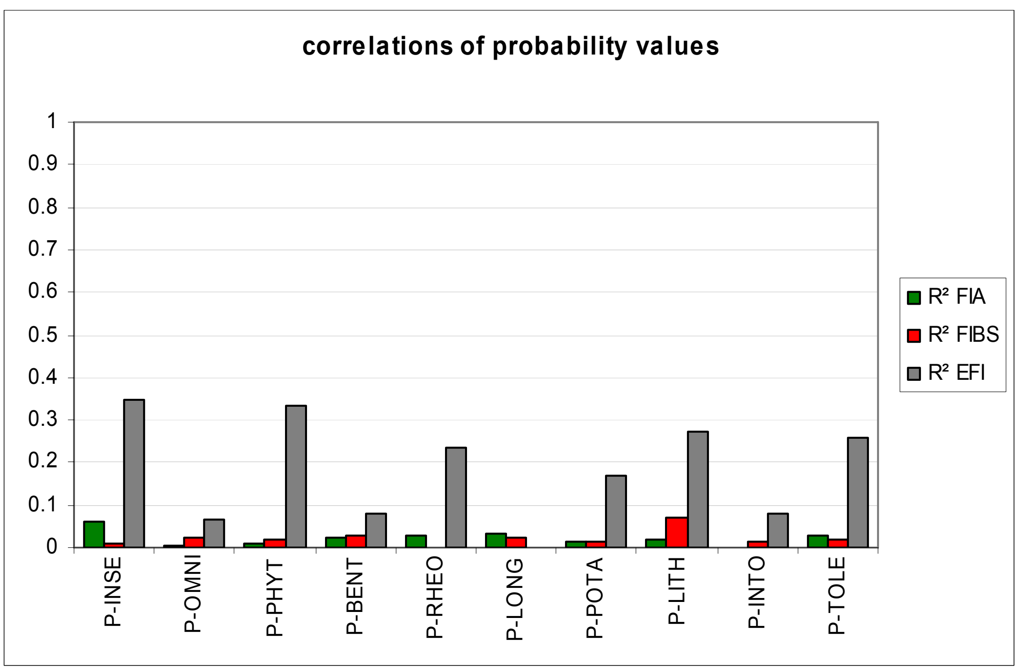
The below graphs compare national results (FIA for Austrian data, fiBS for German data) with other methods and rate whether the result is the same, higher or lower, in percent. These graphs illustrate that although correlations between FIA and fiBS are very good the status boundaries will need harmonisation.






**EFI – common metrics**

We made comparisons between the common metrics from EFI and the results for these sites from FIA, FIBS 7.4 and EFI. No useful correlations were found.
It is unclear how we can proceed with the IC using EFI common metrics.



## Summary of the fish-based method for assessing ecological status of rivers in France

### General principles

To meet the requirements of the WFD, the French Water Agencies, the Ministry of the Environment and the French Fishery Council initiated in 1997 a research program to develop a fish-based index for assessing ecological status of rivers, that would be applicable nationwide. This program involving scientists (bio-statisticians and fish biologists) and fish manager (end-user).....

Effectively developing such a tools to cover that broad geographic area, requires:

1/ a detailed understanding of the patterns of fish assemblage composition and distribution, both within and among water bodies under natural conditions, and

2/ an accurate study of the response of fish community characteristics to several types and intensity of human disturbance.

Following the fundamentals of IBIs, originally developed in the United States (namely the use of several functional descriptors of the fish fauna characteristics = metrics), the method is based on the measure of the deviation between an observed fish community and the fish community expected under natural condition (reference).

Design of the French fish-based index (FBI) paid a special attention to the environmental factors controlling fish assemblage structure in natural conditions, in order to improve its efficiency in distinguishing effects of human-induced disturbances from natural variation.

To standardise and automatise the assessment and then overcome the variability of expert judgment, statistics procedure was used at the different stage of the process:

- Statistical models were used for predicting both species occurrence and abundance in relation to regional and local environmental factors (i.e. hydrographical units, climatic variables, position within the upstream downstream gradient and local habitat characteristics), under natural condition.
- Statistical were also used to select the most appropriate metrics (redundancy and sensitivity) and to determine to what extent the observed fish community is conform to the expected reference community.

The stages of the assessment process can be summarised as follow:

From the environmental characteristics of the study site, the theoretical fish attributes are computed from statistical models. Then the observed community characteristics are compared to the reference and the deviation between observed and theoretical values are quantifies for each metrics. Then an index score compiles these deviations for the different metrics and a quality class can be calculated after thresholds have been statistically defined from the comparison between two independent subset of reference and degraded sites.

### Stages of the design process

*Reference sites*

The first step of the process consists of selecting a reliable set of reference sites fairly distributed across the national territory and representing the main river types and region of France. A data set of 650 sites has been selected

The selection was done by regional experts (fish biologists) on the basis of water quality map inspection and field reconnaissance. Factors considered in the field inspection included the amount of stream channel modification, channel morphology, substrate character and condition, and the general representativness of the site within the region. Reference sites were not pristine nor totally undisturbed, but were those that have suffered the least impact within a particular biogeographical region.

*Data*

Then two types of data were used for modelling reference fish community characteristics:

- fish data coming from electrofishing operations carried out for years by the French Fishery Council, through monitoring programs and fish population studies. They consist of abundance of species caught t the first pass by electrofishing a stretch of river as long as ten-fold the mean river width.
- abiotic characteristics collected from maps, GIS or measured in the field. They include parameters controlling fish assemblage structure at several spatial scales. At a large scale (regional), 8 hydrographic units have been defined considering their control on the pool of species that could occur, resulting from dispersion and speciation process. At a medium scale (within catchment), catchment area (SAD), distance to source (DIS), altitude (ELE) and air temperature (climate) were chosen (Tjuly, Tjanuary). At the local scale gradient slope (GRA), wetted width (WID) and mean depth (DEP) were also included in the models.
  These variables were combined or transformed to obtain six independent environmental descriptors:

- A Velocity Index (V) estimating local water velocity was calculated using the Chezy formula : V=Log(WIDm)+log(DEPm)+log(GRA‰)-log(WIDm +2*DEPm)
- Elevation was defined as E=log(ELE)
- Climatic variables were defined as mean air temperature (T1=Tjuly+TJanuary) and mean range temperature (T2= Tjuly-TJanuary)
- Position along the longitudinal gradient : G is a synthetic variables reflecting the position of each site in the upstream-downstream gradient, derived from DIS and SAD as the first principal component of a PCA
- Hydrological units. The 8 hydrological units are discrete physical units that provide well-defined boundaries with a real biological significance for riverine assemblages. The first four hydrological units represent large river basins while the last four hydrological units were established on the basis of autochtonous fauna lists and a subsequent PCA analysis of faunal similarities.

*Statistical models*

Two types of statistical models were used depending on the metric group:

- occurrence metrics are calculated as the sum of the probabilities of the species belonging to the guild considered. These probabilities resulted from logistic models (multiple stepwise logistic regressions using the Akaïke criterion) which give the occurrence of each of the 34 most common fish species in France in relation to the 6 regional and local environmental factors presented above.

- density metrics are modelled directly by the use of stepwise multiple linear regression analyses (using Akaike Information criterion) performed for each metric (log ((x + 1)/S) transformed; with S = total surface area prospected (m2)) on the six explanatory environmental variables.

Statistical models were validated by the use of an independent data reference data set.

*Deviation*

The measure of the deviation between observed and theoretical (reference) situation is calculated by the way of the residuals of the models, which represent the reference value once natural variation has been removed. Each value of an observed metric at a given site is compared to the distribution of the residuals of the reference models, and the probability for this metric value to belong to the reference residuals is easily computed. Finally, these probabilities are log-transformed ($f(p) = -2\log(p)$): if the sites belong to the reference condition, then the distribution of transformed probabilities is equivalent to a $\chi 2$ distribution with two degrees of freedom.
The sensitivity of metrics to human disturbance were tested using an independent disturbed data set, and all the metrics statistically unresponsive to perturbations were removed. The final list of validated metrics is: Total number of species, Number of lithophilic species, Number of rheophilic species, Number of tolerant species individuals, Number of omnivorous species individuals, Number of invertivorous species individuals and Total density of individuals.

*Index score and quality classes*

The final value of the index is obtained by summing up the value of each of the 7 remaining metrics. Using the distribution of the percentage of unimpaired sites for RS88 and DS88 as a function of index score values, the index value for the optimal cut-off for impaired site was defined and rated the index in five class (unimpaired: Excellent, Good, impaired: Moderate, Poor and Bad). 74% of the sites for RS88 and 77% of the sites for DS88 were correctly classified respectively as reference and disturbed sites.
In conclusion, the index proposed can be applied in the different regions and river types of France using a consistent set of metrics despite the complex and heterogeneous geology and climate of this country.

**References**

T. Oberdorff, D. Pont, B. Hugueny, J.P. Porcher(2002) Development and validation of a fish-based index for the assessment of 'river health' in France. Freshwater Biology 47: 1720-1734

T.Oberdorff, D. Pont, B.Hugueny, J.Bélliard, R.Berrebidit Thomas, J.P. Porcher (2002) Adaptation et validation d’un indice poisson (FBI) pour l’évaluation de la qualité biologique des cours d’eau français. Bull. Fr. PêchePiscic. 365/366: 405-433.

AFNOR (2004) Qualité de l'eau - Détermination de l'indice poissons rivière (IPR) / Water Quality standard –Calculation of the French fish-based index (FBI)

## The German fish-based assessment system for the ecological classification of rivers – FIBS

The present short description outlines the principles necessary for the utilization of FIBS, the German assessment system for the fish-based classification of rivers. FIBS is based on a comparison of metrics from fish sampling data with the corresponding values of a reconstructed reference fish community. The referring deviations are scored according to defined criteria. Details are given by Dussling et al. (2004).

*Characterization of German River Fish Species*

In order to define the indicatory function of German riverine fish, species have been characterized by categorization into different ecological guilds for habitat use, reproduction, trophic range, migration distance and migration type. Additionally, the concept of Index of Fish Regions (Schmutz et al. 2000) has been adapted to German conditions to elaborate species-specific index-values, indicating the species' average preference for a distinct river region according to Illies (1961).

**Reference Conditions**

To use FIBS, defined reference fish communities are needed, consisting of a complete list of all species which can be expected under widely unimpacted conditions for the corresponding river/river section. Moreover, an expected relative abundance (percentage) of each fish species has to be defined. Depending on their reference percentage fish can be grouped into Guiding Species (≥ 5 %), Typespecific Species (≥ 1 %) or Accompanying Species (< 1 %). Within the assessment procedure these groups are treated differently.

Reference fish communities have to be reconstructed by combined use of historical information, recent sampling data and expert judgement, taking into account zoogeographical and regional aspects as well as the longitudinal zonation of the corresponding river/river section.

## Principles of the Ecological River Assessment with FIBS

FIBS considers several ecological attributes of fish communities by implementing 6 fish-ecological quality features referring to the terms given by the WFD, namely “species composition”, “species abundance” and “age structure”. Each quality feature is linked with one or more metrics to be assessed separately.

As in small rivers with low species diversity other metrics are of high indicative importance than in rivers with high species diversity, partly different metrics have been selected for the assessment of rivers with > 9 reference species and rivers with ≤ 9

reference species. All metrics used are solely based on proportions (percentages) of single species, 0+ age classes or ecological guilds. Neither absolute abundances (related to areas or stretches) nor biomasses are used in FIBS.

The 6 fish-ecological quality features (A to F) and the number of linked metrics to be assessed is as follows:

**(A) Inventory of species and guilds**

⇒ 6 metrics for rivers > 9 reference species;
10 metrics for rivers ≤ 9 reference species

**(B) Abundance of species and guilds**

⇒ 3 metrics for all rivers

**(C) Age structure**

⇒ 1 metric for all rivers

**(D) Migration**

⇒ 1 index-based metric for all rivers

**(E) Fish Region**

⇒ 1 index-based metric for all rivers

**(F) Dominant species**

⇒ 2 index-based metrics for rivers with > 9 reference species;
1 index-based metric for rivers with ≤ 9 reference species

The assessment itself comprises three steps at different levels. In a first step, all metrics are scored with 5, 3 and 1, following the three-stage approach of the American Index of Biotic Integrity (Karr 1981) as follows:

**5** ⇒ The metric reflects a **high** ecological status;

**3** ⇒ The metric reflects a **good** ecological status;

**1** ⇒ The metric reflects an ecological status which is **moderate or worse**.

The score of each metric result from a comparison between the metric's value calculated from the sampling result with the corresponding value calculated from the reconstructed reference fish community. The assessment is applied to the resulting deviation according to the defined criteria. In rivers with lower species diversity it is possible that certain metrics obtain a reference value of zero. The assessment of the referring metric is not applied in such a case.

If all metrics have been scored, an assessment of each of the 6 quality features is carried out in a second step. For quality features with more than one metric, this is done by taking the average of all metric's scores. Finally, in a third step the overall classification of the referring sampling site is performed by an algorithm taking a weighted average from the six quality features assessed. Finally, a decimal value in the range from 1 to 5 is obtained.

Sub-ranges of this scale are associated with the 5 ecological quality classes according to the WFD as follows:

| | |
|---|---|
| High status: | 3.76 – 5.00 |
| Good status: | 2.51 – 3.75 |
| Moderate status: | 2.01 – 2.50 |
| Poor staus: | 1.51 – 2.00 |
| Bad status: | 1.00 – 1.50 |

In rivers with a reference fish community of < 10 species, the total density of sampled individuals additionally has to be assessed by expert-judgment. If assessed as being too low due to anthropogenic impacts this metric is used as a "KO-criterion". Independent of the "regular" FIBS-value, a sampling site can not achieve a state better than moderate (a FIBS value > 2.25) in such a case.

The concept of the ecological river assessment with FIBS is schematically illustrated in Figures 1 and 2.

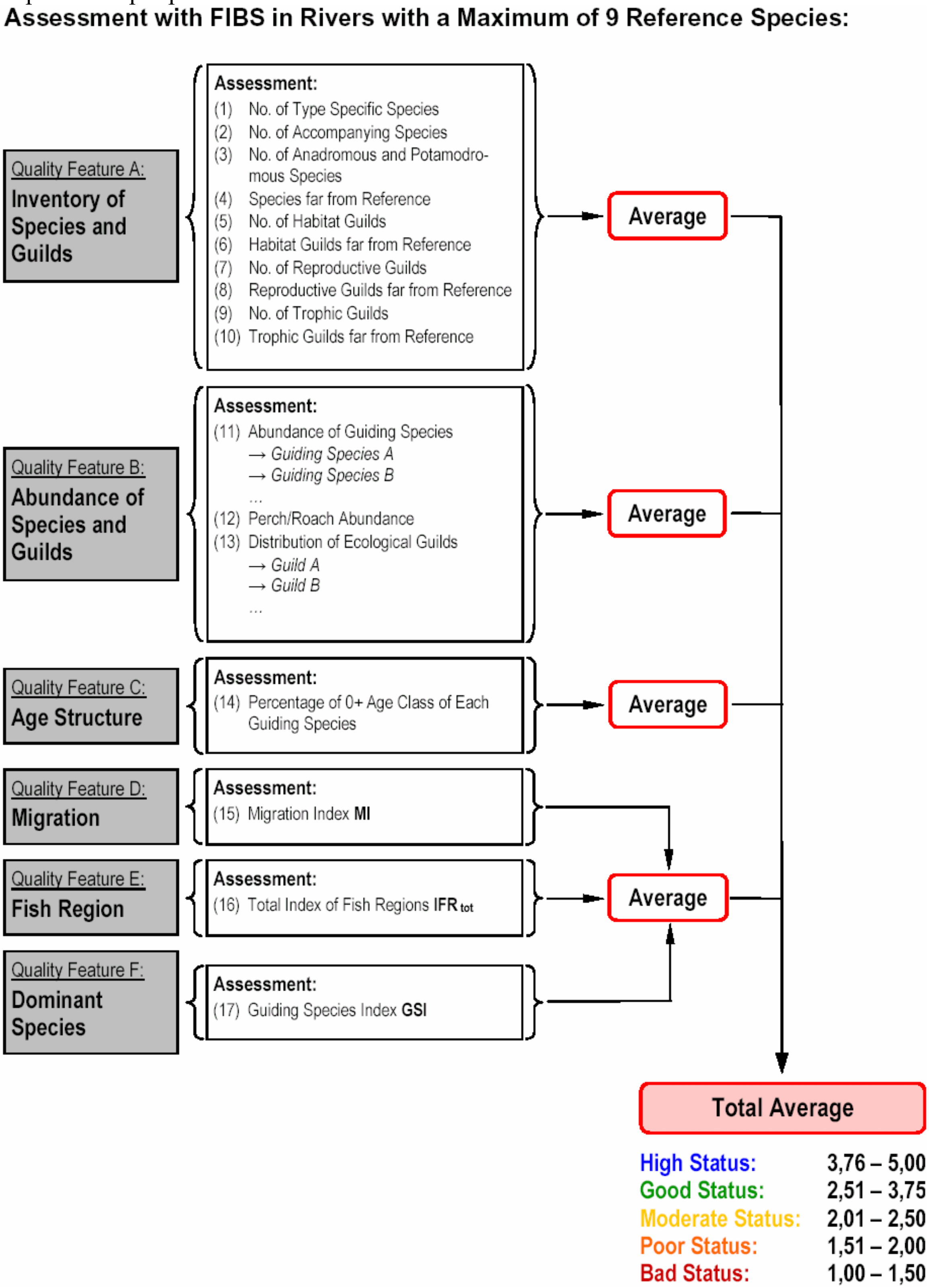



***Fig. 1**: Schematic overview of the assessment algorithm applied within FIBS for the fish-based ecological assessment of river sites with up to 9 reference species.*

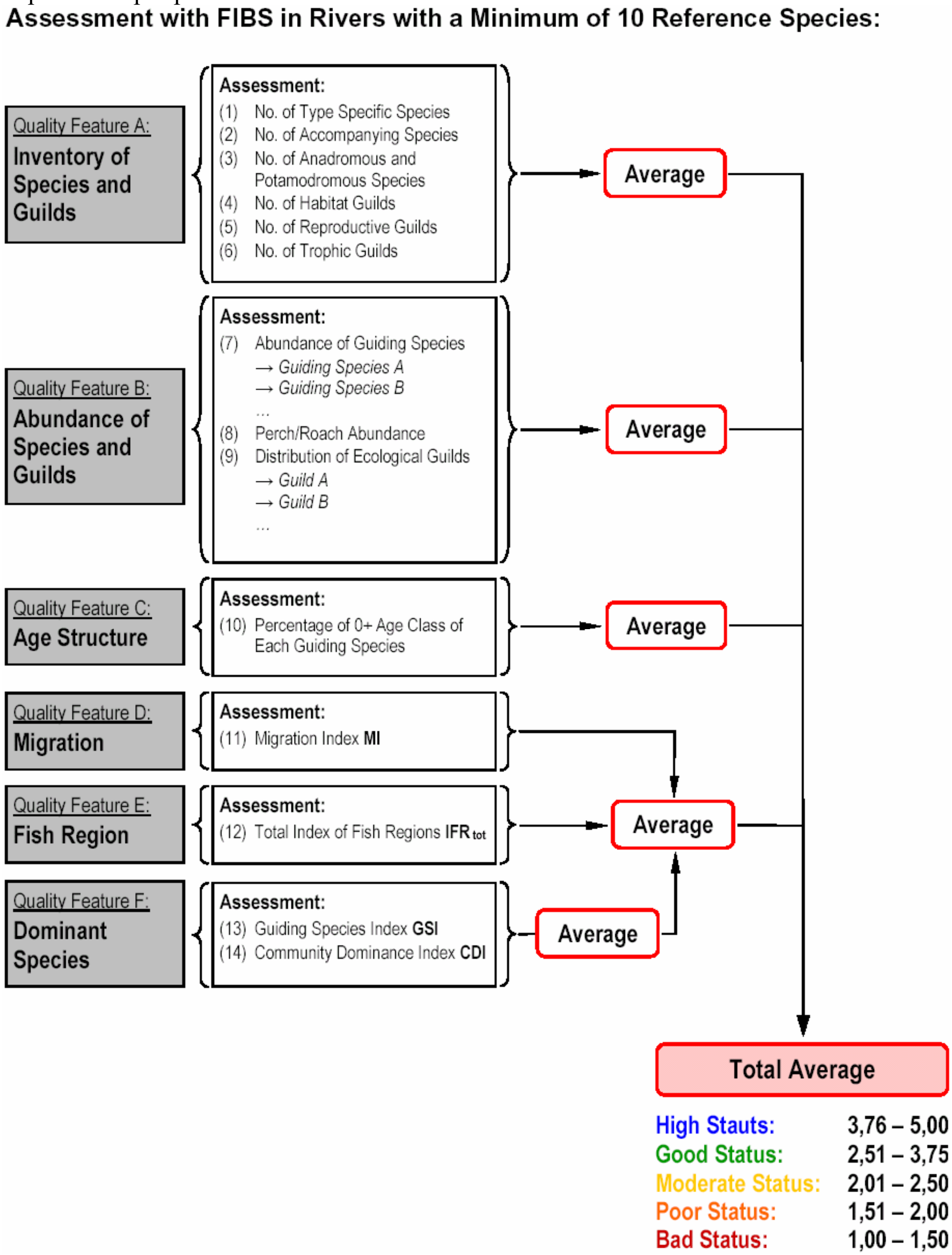



***Fig. 2****: Schematic overview of the assessment algorithm applied within FIBS for the fish-based ecological assessment of river sites with 10 or more reference species*

## Sampling Requirements

Generally, the river assessment by use of FIBS is performed on selected sampling sites. Thus, accuracy of the results obtained with FIBS depends on the representativness of the sampling result and the established reference fish community. Fish sampling data must fulfil the following minimum quality criteria:

1) all fish species must be counted separately,
2) 0+ age class (estimated from fish size during sampling) and older individuals of each species have to be counted separately,
3) the total number of individual fish sampled should not drop significantly below the 30-fold of the number of species of the reference fish community and
4) the fish community has to be sampled in adequate river stretches depending on river size and river type (accordingly, recommendations have been elaborated).

The sampling site has to be representative for the river or river stretch to be assessed. If significant parts of a river or river stretch to be assessed are characterized by differing impacts, they have to be covered by separate sampling sites. Sampling within a site has to cover all relevant habitats and to focus on the detection of at best all species and all age classes present. Moreover, it is highly recommended to perform multiple sampling of the same site in various years, e.g. to cover inter-annual variability and variances of sampling results. Data from multiple samplings within one assessment period (6 years according to the WFD) are pooled for river assessment (Dussling et al. 2004).

## Reconstruction of Reference Fish Communities for FIBS

The reconstruction-process of defining reference fish communities comprises several steps which in the following are briefly described. **Additionally these steps are illustrated by example of the river Große Lauter**, a sub-montaneous tributary of the upper Danube naturally covering a longitudinal range from epirhithral zone to hyporhithral zone. However, it is emphasized, that the river Große Lauter is only an example and reference fish communities in other rivers might look different even if belonging to the same longitudinal zones!

### Step 1: Make a list of species which can be expected in the whole river under widely unimpaired conditions (reference species inventory)

The reconstruction process is performed by use of

a) historical data,
b) data from recent fisheries
c) expert judgement,

taking into account known zoogeographical and regional patterns of fish distribution as well as the natural longitudinal zonation of the referring river/river section. Historical and recent fish data must be validated by expert judgment. Thus, species described in historical references are only considered if their description is unmistakeable and historical occurrence is also plausible from nowadays point of view. Species from recent datasets are not considered for the reference if they are allochthonous or if their occurrence can be solely attributed to human impacts on the river. C*yprinus carpio* and *Carassius gibelio* are also treated as autochthonous in the context of fiBS.

**Große Lauter – Step 1:**

Historical descriptions from the river Große Lauter refer to 5 species (green). None of these species is questionable to occur in a hyporhithral river. 11 more species (blue) have been recently detected. From those species eel and rainbow trout have been introduced by human activities. Bream is considered as being present in the hyporhithral zone only due to human impacts on the river. Thus, eel, rainbow trout and bream are skipped from the reference. Another 5 species (yellow) are added to the reference by expert opinion.

| Species | historical descriptions | | | recently detected | expert judgement |
|---|---|---|---|---|---|
| | v. d. Borne (1882) | Klunzinger (1881) | Münsingen (1825) | | |
| *Cottus gobio* | X | | X | X | OK |
| *Chondrostoma nasus* | | | X | | OK |
| *Phoxinus phoxinus* | X | | X | X | OK |
| *Salmo trutta fario* | X | X | X | X | OK |
| *Thymallus thymallus* | | X | X | X | OK |
| *Barbatula barbatula* | | | | X | OK |
| *Barbus barbus* | | | | X | OK |
| *Esox lucius* | | | | X | OK |
| *Lampetra planeri* | | | | X | OK |
| *Leuciscus cephalus* | | | | X | OK |
| *Lota lota* | | | | X | OK |
| *Perca fluviatilis* | | | | X | OK |
| *Rutilus rutilus* | | | | X | OK |
| ~~*Anguilla anguilla*~~ | | | | X | allochthonous |
| ~~*Oncorhynchus mykiss*~~ | | | | X | allochthonous |
| ~~*Abramis brama*~~ | | | | X | human impact |
| *Alburnoides bipunctatus* | | | | | added |
| *Alburnus alburnus* | | | | | added |
| *Cyprinus carpio* | | | | | added |
| *Gobio gobio* | | | | | added |
| *Leuciscus leuciscus* | | | | | added |

**Step 2: Define for each species of the reference fish inventory (step 1) if it belongs to the group of "Guiding Species", "Typespecific Species" or "Accompanying Species"**

**Guiding Species** under unimpaired conditions are expected to be found most frequently in the referring river/river section as they are adapted optimally to the prevailing conditions. Guiding Species are linked with percentages of **≥ 5 %** in the reference fish community.

**Typespecific Species** though not as frequent as Guiding Species under unimpaired conditions are expected still abundant enough to be detected regularly in the referring river/river section. Typespecific Species are linked with percentages of **≥ 1 %** in the reference fish community.

**Accompanying Species** under unimpaired conditions are expected to be rare or very rare in the referring river/river section and might not always show a continual or homogenous presence. Accompanying Species are linked with percentages **< 1 %** in the reference fish community.

To decide which species belong to which group again historical information, recent sampling data and expert knowledge is used. The decision also has to be made on base of the natural longitudinal zonation of the referring river/river section and other faunistic shift that become evident from the referring data.

It is clear, that a particular species might belong to different groups in different river sections (dependant on longitudinal zonation) and that not all species of the reference fish inventory (step 1) have to be considered for each river section (longitudinal zone). Consequently, different groupings have to be made for different river sections

**Große Lauter – Step 2:**

Historical descriptions, recent sampling data and expert judgement lead to the groupings shown in the following table. The complete reference fish inventory reconstructed in step 1 is only considered in the most downstream hyporhithral zone. Several species are not expected anymore in the metarhithral zone. In epirhirthral zone only brown trout and bullhead are expected as Guiding Species

The grouping of the species for differing river sections is a first step of quantification. In the case of river Große Lauter the grouping of species is corresponding with the longitudinal zones. However, data from other rivers indicate that there might be also relevant faunistic shifts or changes which are not always corresponding to changes of the longitudinal zonation.

| | hyporhithral zone | metarhithral zone | epirhithral zone |
|---|---|---|---|
| **Guiding Species (≥ 5 %)** | *Barbatula barbatula*<br>*Cottus gobio*<br>*Leuciscus cephalus*<br>*Phoxinus phoxinus*<br>*Salmo trutta fario*<br>*Thymallus thymallus* | *Barbatula barbatula*<br>*Cottus gobio*<br>*Phoxinus phoxinus*<br>*Salmo trutta fario*<br>*Thymallus thymallus* | *Cottus gobio*<br>*Salmo trutta fario* |
| **Typespecific Species (≥ 1 %)** | *Barbus barbus*<br>*Chondrostoma nasus*<br>*Gobio gobio*<br>*Lampetra planeri*<br>*Leuciscus leuciscus*<br>*Rutilus rutilus* | *Lampetra planeri*<br>*Leuciscus cephalus* | |
| **Accompanying Species (< 1 %)** | *Alburnoides bipunctatus*<br>*Alburnus alburnus*<br>*Cyprinus carpio*<br>*Esox lucius*<br>*Lota lota*<br>*Perca fluviatilis* | *Barbus barbus*<br>*Gobio gobio*<br>*Leuciscus leuciscus*<br>*Lota lota* | |

### Step 3: Assign rough percentages within each group of species corresponding to the approximate dominance of each species expected under unimpaired conditions

Once more this is done with help of historical information, recent datasets from sites of good ecological condition and expert judgement. The percentages have to be one-decimal

Adequate accuracy of assignments are as follows:

Guiding Species: 0,5 to 5 % (depending on total number of species and percentage: accuracy usually is less with higher percentages)

Typespecific Species: 0,5 %

Accompanying Species: 0,1 to 0,2 %

Of course the sum of all percentages must amount to 100,0 % in each river section. This mathematical requirement for single species might result in values slightly deviating from the accuracy mentioned above

**Große Lauter – Step 3:**

For the hyporhithral and the metarhithral zone of the river Große Lauter two different percentages have been assigned in the group of Guiding Species. These differences correspond to different dominances of the referring species evident in the underlying data and also by expert judgement.

The percentages of 17,4 and 17,3 for bullhead, brown trout and grayling are due to the mathematical need of summing up all percentages to 100 %.

| | rough reference percentages for river Große Lauter | | | | | |
|---|---|---|---|---|---|---|
| | hyporhithral zone | | metarhithral zone | | epirhithral zone | |
| **Guiding Species** | *Cottus gobio* | 17,4 | *Cottus gobio* | 35,0 | *Cottus gobio* | 50,0 |
| | *Salmo trutta fario* | 17,3 | *Salmo trutta fario* | 35,0 | *Salmo trutta fario* | 50,0 |
| | *Thymallus thymallus* | 17,3 | *Barbatula barbatula* | 8,0 | | |
| | *Leuciscus cephalus* | 10,0 | *Phoxinus phoxinus* | 8,0 | | |
| | *Barbatula barbatula* | 10,0 | *Thymallus thymallus* | 8,0 | | |
| | *Phoxinus phoxinus* | 10,0 | | | | |
| **Typespecific Species** | *Barbus barbus* | 2,5 | *Lampetra planeri* | 2,0 | | |
| | *Chondrostoma nasus* | 2,5 | *Leuciscus cephalus* | 2,0 | | |
| | *Gobio gobio* | 2,5 | | | | |
| | *Lampetra planeri* | 2,5 | | | | |
| | *Leuciscus leuciscus* | 2,5 | | | | |
| | *Rutilus rutilus* | 2,5 | | | | |
| **Accompany-ing Species** | *Alburnoides bipunctatus* | 0,5 | *Barbus barbus* | 0,5 | | |
| | *Alburnus alburnus* | 0,5 | *Gobio gobio* | 0,5 | | |
| | *Cyprinus carpio* | 0,5 | *Leuciscus leuciscus* | 0,5 | | |
| | *Esox lucius* | 0,5 | *Lota lota* | 0,5 | | |
| | *Lota lota* | 0,5 | | | | |
| | *Perca fluviatilis* | 0,5 | | | | |
| **Sum:** | | 100,0 | | 100,0 | | 100,0 |

Additionally it has to be stated that the process of reconstructing reference fish communities can be stopped at this point if information (historical data, recent data and expert judgement) on the referring river/river section is scarce or poor. fiBS is already working with rough references. However, it is recommended to add a 4th step of fine-adjustment of the reference percentages whenever possible.

### Step 4: Fine-adjust the reference percentages

The process of fine-adjustment of the reference percentages fixed in step 3 is dependant on the quality of information available about the referring river/river section. Fine-adjustment is performed by up-weighing and down-weighing the percentages of single species and re-adjusting the total to 100 %.

Up-weighing might be adequate for species described as very "common" or "abundant" in historical literature or species recently detected very dominant in sites of high ecological quality. Down-weighing correspondingly might be adequate for species described as "rare" in historical literature or species recently detected very sparsely in sites of high ecological quality.

Additionally ecological knowledge and expert judgement should always be used to verify the reference percentage of each species.

**Große Lauter – Step 4:**

Fine adjustment based on recent data and expert judgement leads to shifts of percentages for particular species in the river Große Lauter.

| | detailed reference percentages for river Große Lauter | | | | | |
|---|---|---|---|---|---|---|
| | hyporhithral zone | | metarhithral zone | | epirhithral zone | |
| **Guiding Species** | *Cottus gobio* | 17,5 | *Cottus gobio* | 35,0 | *Cottus gobio* | 50,0 |
| | *Salmo trutta fario* | 17,5 | *Salmo trutta fario* | 35,0 | *Salmo trutta fario* | 50,0 |
| | *Thymallus thymallus* | 15,0 | *Thymallus thymallus* | 10,0 | | |
| | *Leuciscus cephalus* | 12,5 | *Barbatula barbatula* | 7,0 | | |
| | *Barbatula barbatula* | 10,0 | *Phoxinus phoxinus* | 7,0 | | |
| | *Phoxinus phoxinus* | 10,0 | | | | |
| **Typespecific Species** | *Barbus barbus* | 3,5 | *Lampetra planeri* | 1,8 | | |
| | *Chondrostoma nasus* | 2,6 | *Leuciscus cephalus* | 1,8 | | |
| | *Gobio gobio* | 2,0 | | | | |
| | *Lampetra planeri* | 2,0 | | | | |
| | *Leuciscus leuciscus* | 2,0 | | | | |
| | *Rutilus rutilus* | 2,0 | | | | |
| **Accompany-ing Species** | *Esox lucius* | 0,9 | *Barbus barbus* | 0,8 | | |
| | *Lota lota* | 0,9 | *Lota lota* | 0,8 | | |
| | *Alburnoides bipunctatus* | 0,6 | *Gobio gobio* | 0,4 | | |
| | *Perca fluviatilis* | 0,6 | *Leuciscus leuciscus* | 0,4 | | |
| | *Alburnus alburnus* | 0,2 | | | | |
| | *Cyprinus carpio* | 0,2 | | | | |
| **Sum:** | | 100,0 | | 100,0 | | 100,0 |

## Technical adjustments

Due to the conception of fiBS, technical adjustments of the reference percentages for some species are necessary (Tab. 1).

***Tab. 1**: species that need technical adjustments of their reference percentages (Diekmann et al 2005).*

| species/group of species | Technical reference percentage |
|---|---|
| all lampreys | usually < 1 %<br>only in rhithral streams percentages up to appr. 2 % are appropriate |
| *Lota lota* | max. 0,9 %<br>only in large rivers and river segments with typical high abundance of *Lota lota* higher percentages are appropriate |
| pelagic fish species in large rivers e.g. *Abramis ballerus* | usually max. 0,9 % |
| all anadromous species | In migration corridors: < 1 %<br>in reproduction habitats: up to 2 %<br>in significant spawning areas: up to 7 % in some cases (e.g. *Salmo salar*) |

For more detailed information see Dussling et al. 2004 and Diekmann et al. 2005 (in German only) or contact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## FISH INDEX AUSTRIA (FIA)

FIA is the Austrian approach to classify the ecological status of rivers according to their fish biocoenosis. It is a multimetric index representing the deviation of the river type-specific fish assemblage without or under low anthropogenic pressures (abiotic reference conditions), taking into account species composition, abundance and age structure.
To start with, we have developed a fish-based typology of Austrian rivers by means of cluster analysis, resulting in 8 different fish zones in 9 different geographical regions (fish bioregions). Discrimination criteria for the fish zones were the well-known longitudinal zonation of slope and coarse river width (HUET 1949) refined by taking into account mean discharge and/or special width limits. A catalogue of reference fish communities ("leitbild") has been established for all defined biocoenotic zones in the different bioregions. Since reference conditions nowadays are very rare and mainly restricted to the headwaters, even in Austria, we used a combined approach of actual data sets, historic documents and expert judgement due to historic maps (undisturbed abiotic conditions) for these reference communities. According to their occurrence species were divided into 3 classes within each "leitbild" – dominant, subdominant and rare species.

We have chosen 9 fish ecological metrics and tested their reaction to a number of anthropogenic pressures and their combinations by comparing reference and impaired sites for redundancy purposes. As a result of these tests all of them were selected for the development of the index.

These metrics are

1) fish biomass (kg/ha), as a metric for the trophic level and of special importance in systems with low diversity (epirhithron, metarhithron f.i.)
2) percentage of dominant species
3) percentage of subdominant species
4) percentage of rare species

5) presence of habitat guilds
6) deviation from the fish region index (SCHMUTZ et al. 2000)
7) presence of reproduction guilds
8) expert judgement on length frequency-distribution of dominant species
9) expert judgement on length frequency-distribution of subdominant species

For each metric except biomass and fish region index we determined boundaries of 5 classes using datasets from sites preclassified by expert judgement.

**Boundaries and Calculation**

The boundaries between the five fish-ecological classes are shown in table 1, expressed as Fish Index Austria „FIA".

**Table 1**: FIA-class boundaries for the assessment of fish-ecological classes

| Fishecological status class | | Boundaries<br><br>Fisch Index Austria |
|---|---|---|
| 1 | High | 1 - <1.5 |
| 2 | Good | 1.5 - < 2.5 |
| 3 | Moderate | 2.5 - <3.5 |
| 4 | Poor | 3.5 - < 4.5 |
| 5 | Bad | 4.5 – 5 |

For the determination of the Fish Index Austria the parameters stated in 1.2, 1.3 and 1.4, respectively fish species assemblage, fish region index and age structure, are to be weighted according to this equation:

$$FIA = \frac{(ZK_{ART} * 2 + ZK_{FRI} + ZK_{AS} * 3)}{6}$$

| | | |
|---|---|---|
| FIA | Fish Index Austria | |
| $ZK_{ART}$ | status class – fish species assemblage | (decimal from 1 to 5) |
| $ZK_{FRI}$ | status class – fish region index | (whole numbers from 1 to 5) |
| $ZK_{AS}$ | status class – age structure | (decimal from 1 to 5) |

**Knockout-criteria**

Should the fish region index be rated worse than good (a difference of the current index to the reference index $\geq 0.6$), then the overall result can not be better than the result of the fish region index. In these cases the status class of the fish region index acts as a so called "Knockout-criterion": for a difference between current and reference index of $\geq 0.6$ to

0.9 the overall assessment is at best “moderate” (3), between ≥ 0.9 to 1.2 at best “poor” (4) and for a difference of ≥ 1.2 it is in any case “bad” (5).
If biomass is lower than 50 kg/ha, then the overall result is at best “poor” (4); if biomass is below 25 kg/ha, the overall status is “bad” (5). Exceptions are river stretches which are strongly impaired by bed load or of an altitude more than 1200 m above sea level, in these cases this second ko-criterion “biomass” does not apply. For the calculation of biomass allochthonous salmonids are to be included.
From these two ko-criteria, fish region index and biomass, the lower or worse value is to be used for the overall result.

**Fish Species Assemblage**

Usually, to determine FIA, only autochthonous species present in the reference fish assemblage are taken into account. An exception to this is made in the case of allochthonous salmonids with the calculation of biomass and with rainbow trout for the calculation of the current fish region index (see 1.3).

The assessment of the fish species assemblage consists of the following parameters:

- Relative proportion of the number of dominant species compared to the reference fish assemblage
- Relative proportion of the number of subdominant species compared to the reference fish assemblage
- Relative proportion of the number of rare species compared to the reference fish assemblage
- Number of missing habitat guilds
- Number of missing reproductive guilds

**Table 2: Parameters and boundaries for status classes**

| | | **Status class** | | | | |
|---|---|---|---|---|---|---|
| | Parameter | **1** | **2** | **3** | **4** | **5** |
| Dominant species | % of species compared to reference assemblage | 100 % | 90 - 99% | 70 - 89% | 50 - 69% | <50% |
| Subdominant species | % of species compared to reference assemblage | 100-75% | 74-50% | 49 - 25% | < 25% | 0 |
| Rare species | % of species compared to reference assemblage | >49% | 49 - 20% | 19 - 10% | < 10% | 0 |
| Habitat guilds | Missing guilds compared to reference assemblage | None missing | 1 missing | 2 missing | > 2 missing | All missing |
| Reproductive guilds | Missing guilds compared to reference assemblage | None missing | 1 missing | 2 missing | > 2 missing | All missing |

The classification of status classes (whole numbers from 1 to 5) is given for each parameter “ZKBP” according to table 2 by means of the difference from the respective reference status. An example for the reference assemblages is shown in table 4 (dominant, subdominant and rare species).
For the determination of the overall fish species assemblage the acquired status classes of the individual parameters are to be weighted with the weighing factor “G” according to this equation:

$$ZK_{ART} = \frac{\sum_{i=1}^{n} ZKBP_i * G_i}{\sum_{i=1}^{n} G_i}$$

| | |
|---|---|
| $ZK_{ART}$ | status class – fish species assemblage |
| $ZKBP_i$ | status class of parameter *i* |
| $G_i$ | weighing factor of parameter *i* |
| $n$ | total number of parameters |

**Table 3** Weighing factor G for the parameters of fish species assemblage

| Parameter “ZKBP“ | Weighing factor “G“ |
|---|---|
| Dominant species | 4 |
| Subdominant species | 2 |
| Rare species | 1 |
| Habitat guilds | 1 |
| Reproductive guilds | 1 |

**Table 4** Reference fish assemblage ("Leitbild") for dominant (d), subdominant (s) and rare (r) species for each fish-bioregion (1-9) and each fish zone; only one example is given, Hyporhithron large.

| Hyporhithron large | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Alburnoides bipunctatus | r | r | r | s | s | s | r | r | r |
| Barbatula barbatula | r | r | r | s | s | d | r | d | d |
| Barbus barbus | r | s | r | s | s | s | s | s | s |
| Barbus meridionalis | | r | | r | r | | | | |
| Chondrostoma nasus | r | s | r | r | r | s | s | r | s |
| Cobitis taenia | | | | | r | | | | r |
| Cottus gobio | d | d | d | d | d | d | d | d | d |
| Esox lucius | r | r | r | r | r | r | r | r | r |
| Gobio gobio | r | s | s | s | s | s | r | r | s |
| Hucho hucho | d | d | d | d | r | s | s | | s |
| Leuciscus cephalus | r | s | s | s | s | s | s | s | s |
| Leuciscus leuciscus | r | | r | r | r | s | r | r | s |
| Leuciscus souffia | s | r | s | r | r | s | r | s | |
| Lota lota | r | s | s | s | r | d | s | r | s |
| Perca fluviatilis | r | r | r | r | r | r | r | r | r |
| Petromyzontidae | r | s | s | s | s | r | | | s |
| Phoxinus phoxinus | s | r | r | r | s | d | s | s | s |
| Salmo trutta fario | d | d | d | d | d | d | d | d | d |
| Salmo trutta lacustris | | | | | | | | r | |
| Thymallus thymallus | d | d | d | d | d | d | d | d | d |
| Zingel streber | | | | r | r | | | | |

**Fish Region Index**

The status classes for this metric (whole numbers from 1 to 5) are given by table 5 using the deviation from reference conditions.

**Table 5:** Classification parameters and boundaries for the status classes of FRI.

| | status classes FRI | | | | |
|---|---|---|---|---|---|
| | High | Good | Moderate | Poor | Bad |
| | (1) | (2) | (3) | (4) | (5) |
| Difference of Fish Region Index to reference (±) | 0.3 | ≥0.3 – 0.6 | ≥0.6 – 0.9 | ≥0.9 – 1.2 | ≥1.2 |

The current Fish Region Index is calculated using this equation:

$$FRI = \frac{\sum_{i=1}^{n} AZ_i * FRI_i}{\sum_{i=1}^{n} AZ}$$

| | |
|---|---|
| FRI | Fish Region Index |
| AZi | Abundance of species *i* |
| FRIi | Fish Region Index of species *i* |
| n | total number of observed species |

Exception: Rainbow trout are the only allochthonous species considered in the Fish Region Index with a value of 4.0.

**Calculation of a reference value for the Fish Region Index of adapted reference fish assemblages and special cases**
Calculation of the FRI for reference assemblages is done according to the equation shown above, but instead of using abundance values (AZi) the weighing factors shown in table 6 for each category are employed.

**Table 6** Weighing factors for the calculation of the FRI

| Category | Weighing Factor |
|---|---|
| Dominant species | 10 |
| Subdominant species | 5 |
| Rare species | 1 |

## Age Structure

The status classes for age structure (whole numbers from 1 to 5) are given by table 7 referring to the description in table 8.

**Table 7.** Classification parameters and boundaries for age structure.

| | Status class / Age structure | | | | |
|---|---|---|---|---|---|
| | High | Good | Moderate | Poor | Bad |
| Population structure dominant species | 1 | 2 | 3 | 4 | 5 |
| Population structure subdominant species | 1 | 2 | 3 | 4 | 5 |

**Table 8.** Evaluation of length frequency distributions by expert judgement.

| Status class | Characteristic features * |
|---|---|
| 1 | All age classes are present, (near) natural population structure, juveniles are dominant. |
| 2 | All age classes are present, juveniles are noticeably underrepresented or adults overrepresented. |
| 3 | Some age classes are missing, disturbed distribution of age classes (e.g. only juveniles or only adults, subadults missing, etc.) |
| 4 | Seriously disturbed distribution, often very low density, e.g. only individual fish of varying size are present. |
| 5 | No fish. |

*** Exceptions in this classification are made for species, which, according to their feeding behaviour (piscivorous), habitat selection (benthic), their migration habits (potamodromous) or for those which are difficult to sample and therefore can show irregular length-frequency-distributions even in high status, such as Hucho hucho, Esox lucius, Barbus barbus, Cottus gobio.**

The individual resulting values of the age structure are to be combined to partial results for each of the two categories (dominant and subdominant species) as follows:

$$TB_{KAT} = \frac{\sum_{i=1}^{n} EBAS_i + (N_{ref} - n) * 5}{N_{ref}}$$

| | |
|---|---|
| $TB_{KAT}$ | Partial result of each category |
| $EBAS_i$ | Individual result of the age structure for species *i* |
| $N_{ref}$ | Number of species per category in reference assemblage |
| $n$ | Number of current confirmed species per category |

The overall result of the parameter "age structure" is calculated with the partial results from categories dominant and subdominant species as follows:

$$ZK_{AS} = \frac{2 * TB_{Leit} + TB_{Beg}}{3}$$

| | |
|---|---|
| $ZK_{AS}$ | Status class age structure |
| $TB_{Leit}$ | Partial result dominant species |
| $TB_{Beg}$ | Partial result subdominant species |

**River Typology – Fish Zones and Fish Bioregions**

**Table 9** Allocation of biocoenotic regions according to HUET (1949)

| Huet 1949 | slope [ ‰ ] for waterwidths of | | | | |
|---|---|---|---|---|---|
| **fishzone** | **< 1 m** | **1 - 5 m** | **5 - 25 m** | **25 - 100 m** | **> 100 m** |
| upper trout zone | 100 - 16,5 | 50 - 15,0 | 20 - 14,5 | | |
| lower trout zone | 16,5 - 12,5 | 15,0 -7,5 | 14,5 - 6,00 | 12,5 - 4,5 | |
| grayling zone | | 7,5 - 3,0 | 6,0 - 2,0 | 4,5 - 1,25 | - 0,75 |
| barbel zone | | 3,0 - 1,0 | 2,0 - 0,5 | 1,25 - 0,33 | 0,75 - 0,25 |
| bream zone | | 1,0 - 0,0 | 0,5 - 0,0 | 0,33 -0,0 | 0,25 - 0,0 |
| smelt zone | tidal influenced river mouth | | | | |

HUET (1949) has described the classification of the fish fauna from the trout to the smelt zone, which is similar to the system of biocoenotic regions by ILLIES & BOTOSANEANU 1963. This classification was refined by including mean discharge and width boundaries (table 10).

**Table 10** Classification of Fish Zones according to HAUNSCHMID et al. (2006)

| Fish Zone | | Mean discharge | Width |
|---|---|---|---|
| Epirhithron | ER | No limit | No limit |
| Metarhithron | MR | No limit | No limit |
| Hyporhithron small | HR small | <= 2 $m^3s^{-1}$ | <= 5 m |
| Hyporhithron large | HR large | > 2 $m^3s^{-1}$ | > 5 m |
| Epipotamon small | EP small | <= 1 $m^3s^{-1}$ | <= 3 m |
| Epipotamon medium | EP medium | 1 - 20 $m^3s^{-1}$ | 3 - 25 m |
| Epipotamon large | EP large | > 20 $m^3s^{-1}$ | > 25 m |
| Metapotamon | MP | No limit | No limit |

In Austria upper and lower trout zone, grayling, barbel and bream zone are present. The last is only represented by the rivers March and Thaya; especially the March is heavily influenced by the Danube, which represents the Epipotamon large in Austria.

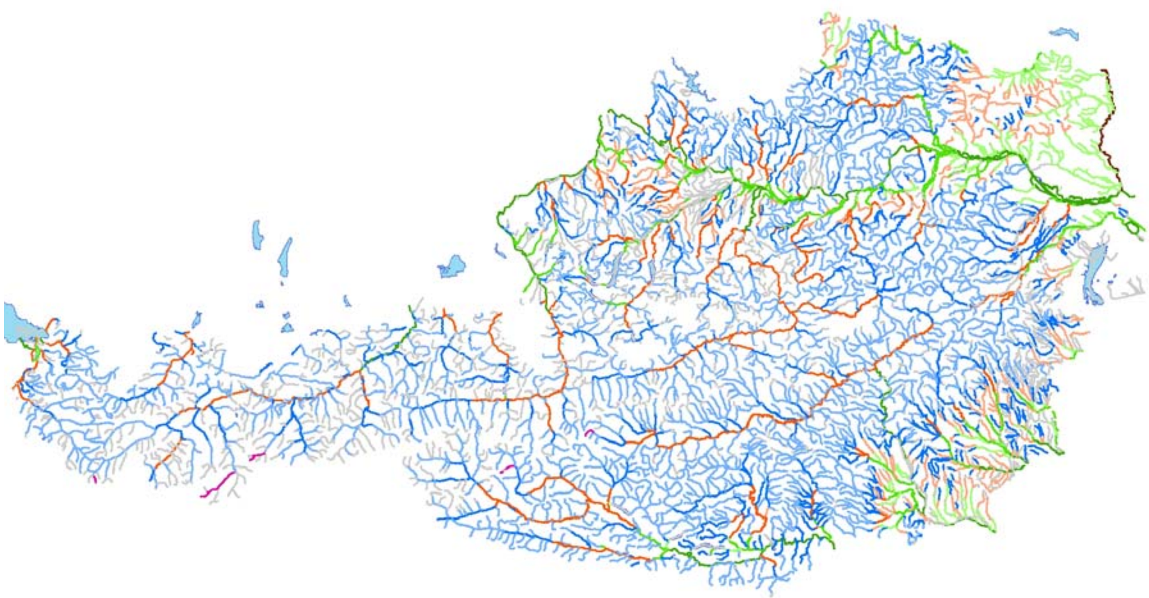

**Table 11** Fish Bioregions in Austria

| | | |
|---|---|---|
| 1 | vergletscherte Zentralalpen | Glaciated central alpine region |
| 2 | unvergletscherte Zentralalpen | Unglaciated central alpine region |
| 3 | Südalpen | Southern alpine region |
| 4 | inneralpine Beckenlandschaften | Interior alpine basins |
| 5 | Östliche Flach- und Hügelländer | Eastern Lowlands |
| 6 | Bayr. Österr. Alpenvorland und Flysch | Foothills of the central mountains |
| 7 | Kalkvoralpen und nördliche Kalkhochalpen | Limestone mountains of the alps |
| 8 | Flysch, Helvetikum und Alpenvorland in Vorarlberg | Flysch and Helvetikum in Vorarlberg |
| 9 | Granit und Gneisgebiet | Central Highlands (Granite and Gneiss) |

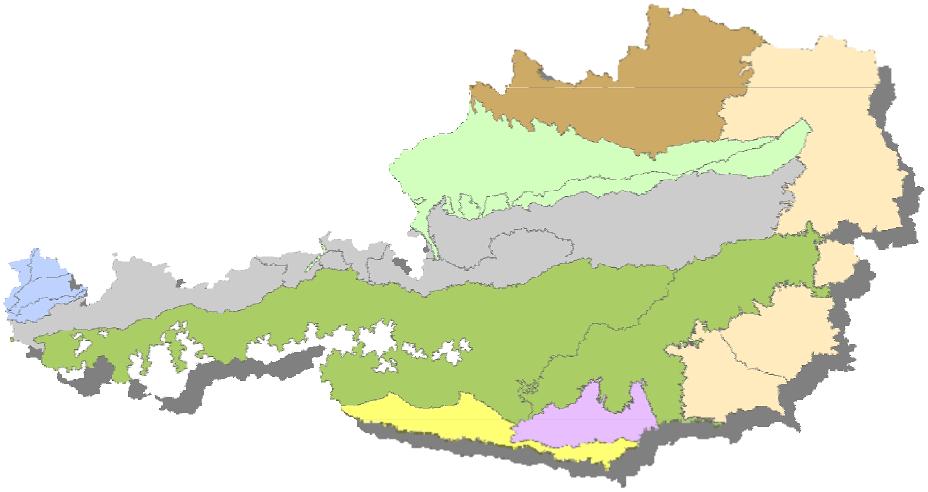

**Figure 2.** Map of Fish Bioregions in Austria

**Note on the Calculation of FIA**

Although FIA could be calculated by hand, there is an excel file to ease these calculations.
The name of the latest version is "FISH_INDEX_AUSTRIA_engl.v3.xls" and it can be downloaded from the CIRCA server. Instructions for using this file are also available there.

## REFERENCE CONDITIONS
## - as used for the selection of reference sites in AUSTRIA

Please note that FISH INDEX AUSTRIA (FIA), which is the Austrian approach to classify the ecological status of rivers according to the fish biocoenosis, is based on type specific reference conditions which have been established using a combined approach of actual data sets, historic documents and expert judgment due to historic maps (undisturbed abiotic conditions) for these reference communities.
The selected actual sites for intercalibration purposes, situated mainly in headwaters, refer in principle to the reference criteria defined in the REFCOND-Guide for the GIGs, i.e. reference conditions or high status is a state corresponding to very low pressure, without the effects of major industrialization, urbanisation and intensification of agriculture, and with only very minor modification of physico-chemistry, hydromorphology and biology.
Points of deviation from the REFCOND Guidance are explained and defined below.

## Pressures listed by REFCOND Guidance

### Point source pollution

This pollution type is by and large negligible in Austrian waters, no impairment above threshold values could be found. Natural or near-natural background values are the rule.
<u>Other effluents/discharges (urban pollution)</u>
Our reference sites show natural or near-natural values including thermal pollution (see also physicochemical parameters – temperature alteration).

Specific synthetic pollutants
Concentrations below limit of detection.
Specific non-synthetic pollutants
Natural background level or load.

**Diffuse source pollution**

Land-use intensification: Agriculture, Forestry (land use upstream, cattle breeding, vineyards, orchards, irrigated fields, forestry, acidification, eutrophication)
This pressure type was not examined as closely as defined by the REFCOND-Guidance, expert judgment was used for our reference sites.
Acidification and eutrophication were added as separate fields in our physico-chemical parameters and are below threshold values in all selected reference sites.
Riparian zone vegetation
Generally not considered to be a problem. The selected reference sites are not impaired in regard to this parameter. Natural or semi-natural vegetation dominates. Although not examined as closely as suggested by REFCOND our reference sites comply with the guide according to expert judgment, i.e. no detectable influence on the regarded biological metrics.

**Morphological Alterations**

These parameters were examined closely as some of them are a massive threat to our water bodies. Only minor impairment below reference threshold was tolerated. The suggestions from REFCOND were followed.
River morphology
Sediment transport, migration barriers, flow impedance, channelisation, stabilisation, siltation, connection to groundwater, substrate conditions, river profile and variation in width and depth, river continuity.
The examined parameters connectivity, impoundment and morphology are used to judge these conditions.
Water abstraction; river flow regulation
These conditions are represented by the examined parameters hydropeaking, impoundment and residual water.

**Biological Pressures**

Introduction of alien species
Stocking for sport fishing is widely spread, also alien species, especially rainbow trout (*Oncorhynchus mykiss*) is meanwhile quite common in our running waters.
REFCOND states at the site scale, no invasive species, but alien species which are not at the invasive stage are tolerated. With the exception of the partially invasive rainbow trout this guideline was fulfilled. See also "Stocking and alien species".
Fisheries and aquaculture
See also "Stocking and alien species".
Recreational sport fishing is omnipresent in Austria. Practically speaking all natural fish habitats in running waters are under this kind of "pressure". However, in most cases only a few species are concerned, moreover "catch and release" with only marginal impact on the fish biocoenosis is quite common nowadays.
As for aquaculture impacts are very low on the fish fauna in running waters in Austria and confined to only few sites.
Biomanipulation:
Not relevant in our running waters.

**Other Pressures - Recreational Uses:**
REFCOND: No intensive use of reference sites for recreational purposes (no intensive camping, swimming, boating, etc.). This criterion was also fulfilled completely.

## Specific criteria screened for selection of reference sites in Austria

We refer to high status or reference conditions as a state in the present or in the near past corresponding to very low pressure, without the effects of major industrialisation, urbanisation and intensification of agriculture, and with only very minor modification of physico-chemical, hydromorphological and biological status below a rejection threshold.

### Selection process

Sites were preselected that showed no or nearly no signs of abiotic impairment referring to our national risk assessment analysis GIS database. Spatial scales of reach and reference site were examined.
Closer examination of these candidates and consultation of local experts followed.

**Abiotic Pressures**
Only sites with no or almost no detectable impact were chosen. Impairment by hydropeaking, connectivity or impoundment led to exclusion of the site.
The following criteria and threshold values were used:
Residual water: lower than mean annual discharge for a number of years (>9)
Hydropeaking: relation of flush to sink > 5:1
Connectivity: interrupted within 1 km for stream order of 1-3 (acc. to Strahler), 5 km for stream order of 4-5; 10 km for stream order of >5. Exceptions were made when the site was selected by experts as a potential reference site; some of the reference sites do not comply completely with these rigid rules, they have an obstruction to their connectivity slightly within the borders described above. Such deviations were judged to be minor impairments and accepted.
Impoundment was classified as such with a length of more than 500 m and 100 m for running waters with a catchment area above and below 100 $km^2$ respectively.
Morphology: classification of the ecomorphological status, on a scale of 1-5 (1 = not impaired, 5 = heavily impaired). Morphology values of up to 2 were tolerated.
Physicochemical parameters
No significant pressures could be found.
The following parameters and threshold values were applied:
$BOD_5$: mean 2.4 mg/l
$O_2$: 95 % saturation
Nutrient Load: $N\text{-}NO_3$ (mean 6 mg/l), $N\text{-}NH_4$ (mean 0.1 mg/l), $P\text{-}PO_4$ (mean 40 µg/l)
Chemical Pollutants: synthetic & non-synthetic; below detection limits
Acidification: pH ≥ 6
Temperature Alteration: an alteration of more than 3°C

**Biological Pressures**
To avoid circular reasoning, all sites preselected due to abiotic criteria where used even if the biological classification by the national fish index delivered values below 1,5 as far as these sites where confirmed to be reference sites by expert judgement. The following biological pressures were taken into account:

Pressure by predation (e.g. *Phalacrocorax carbo*, great cormorant; *Ardea cinerea*, grey heron; *Lutra lutra*, otter). Sites influenced by undue predation (such as massive foraging by large groups of cormorants) were excluded. That was a major reason for the lack of reference sites in the Hyporhithron.

**Stocking and Alien Species**:
Stocking with alien species is widespread in Austria. More than 50 % of all potential reference sites in the Epirhithron show occurrence of alien species, mainly *Oncorhynchus mykiss* (and *Salvelinus fontinalis* in two instances).
All reference sites lower than the Epirhithron (Metarhithron and Epipotamon) are influenced by stocking and alien species, again mostly *Oncorhynchus mykiss* (and *Salvelinus fontinalis*), but also other alien species are present in the Epipotamon: *Lepomis gibbosus, Proterorhinus marmoratus* and *Pseudorasbora parva*.
*Oncorhynchus mykiss* is an alien species in Austria, but due to its natural reproduction in many hydromorphologically intact rivers and partially displacing brown trout and even grayling, it is included in the computation of our national fish index (FIA) as far as biomass is concerned. Therefore we did not exclude even potential reference sites impaired only by occurrence of rainbow trout.
If we would exclude sites with obvious stocking of alien species only 9 out of 21 Epirhithron reference sites and none out of the other biocoenotic regions (7 sites) would remain. Sites definitely without stocking with alien species are 121, 158, 591, 613, 633, 674, 680, 1295, and 3943.
Either choice does not affect EQR calculations, the median of both groups of reference site values remains the same (0,99).
Of course stocking is not only done with allochthonous species, stocking with autochthonous species is certainly more common. Only two of our reference sites are not stocked at all (sites 674 and 1295), but even there stocking may occur above or below. However, condition of the fish and population structure did not give any evidence of significant impact by stocking at the selected reference sites.

**Other Pressures - Recreational Uses**
In some Austrian rivers impairment is given by kayaking, rafting, canoeing etc.
The extent of these pressures was not classified, but rivers known to be heavily used for recreational purposes were excluded. The same applies to recreational sport fishing activities.

### Reference Conditions for the Fish Fauna in German Rivers

Due to land use and urbanisation in Germany there is a lack of natural running waters without any human impact on the fish fauna. Even (almost) natural river sections are influenced negatively, e.g. by migration obstacles. However, it is asked for the WFD-intercalibration process to define reference sites. In consequence sites have to be found, which still show almost natural habitat conditions.
We refer to high status or reference conditions as a state in the present corresponding with very low pressure, without the effects of major industrialisation, urbanisation and intensification of agriculture, and with only very minor modification of physico-chemical, hydromorphological (incl. connectivity) and biological status below a rejection threshold.

**Criteria**
The following criteria have to be applied for defining reference sites for fish in German running waters:

- **Chemical pressures**

- Criteria: Site not at risk due to chemical pollutants.
  Source: Regional survey data

- **Thermal pressures**

- Criteria: No temperature alteration which harms the reference fish coenosis
  Source: Temperature values described in the RaKon document (by LAWA)

- **Nutrients / organic pollution**

- Criteria 1: Site not at risk due to trophic status.
  Source: Regional survey data
- Criteria 2: German saproby system I or I-II, large rivers II (I: not impaired, V: heavily impaired)
  Source: Water quality maps (Gewässergütekarten)

- **Hydromorphological alterations and pressures**

- Criteria 1: Natural or only minor impacts on waterbody (Morphology Assessment good or better).
  Source: Morphology assessment, regional survey data (Gewässerstruktur-Güte-Kartierung)
- Criteria 2: Site not at risk due to a lack of lateral and longitudinal connectivity impacts.
  Source: Regional survey data, expert judgement
- Criteria 3: All habitats needed by the type specific fish fauna show only minor alterations regarding quantity, quality and connectivity (e.g. hyporheic interstitial, floodplains etc.)
  Source: Expert judgement

-- Criteria 4: No hydropeaking.
  Source: Expert knowledge

- Criteria 5: Levels of abstraction resulting in only very minor reductions of flow level and hydrodynamic (surface waters, groundwater abstraction in the catchment).
  Source: Regional survey data, expert judgement
- Criteria 6: No flow regulation
  Source: Regional survey data, expert knowledge

- **Biological pressures**

- Criteria 1: No or only few alien fish individuals, no invasive species.
  Source: Expert knowledge / fish data basis / expert judgement
- Criteria 2: No intensive predation caused by non-aquatic, piscivorous fauna (cormorant, otter etc.)
  Source: Expert judgement

- **Other pressures - recreational uses:**

- Criteria: Only minor recreational pressures
Source: Expert knowledge / expert judgement

Recent inventory of fish species should be very close to reference fish inventory and fish composition should not be significantly influenced by stocking.

## CRITERIA FOR SELECTING RIVER REFERENCE SITES IN SLOVENIA

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### INTRODUCTION

The new approach for evaluating the ecological status of water bodies, given in the Water Framework Directive (Directive 2000/60/EC), requires among other a description of specific reference conditions. Reference conditions may be identified using various methods:

- Spatially based reference conditions (sampling in the field)
- Modelling
- Historical data
- paleoreconstruction
- expert judgement

The method used depends on the amount and quality of data from the past and the adequacy of different approaches for specific biological elements. The spatially based approach is considered to be the best, since the data is obtained in the field. This approach is used for undisturbed or minimally disturbed sites where no adequate data is available. In this case, the criteria for reference conditions is determined a priori, followed by reference site selection.

Criteria for reference site selection was prepared in accordance with the normative definitions for high ecological status of biological, hydromorphological and physico-chemical conditions, as stated in the Water Framework Directive (Directive 2000/60/EC), Annex V and the guidance on establishing reference conditions (Wallin et al. 2003).

High status or reference conditions is a state in the present or in the past corresponding to very low pressure, without the effects of major industrialisation, urbanisation and intensification of agriculture, and with only very minor modification of physicochemistry, hydromorpology and biology.

a) Length of the reference site (RS)

The reference site length is:
- 500 m, if the catchment area to the reference site is 10 -100 $km^2$
- 1000 m, if the catchment area to the reference site is 100 - 1000 $km^2$
- 2000 m, if the catchment area to the reference site is 1000-2500 $km^2$ and it its not categorised as a »large river« (sensu Urbanič 2005)
- 5000 m, for all »large rivers« (sensu Urbanič 2005)

b) Hydromorphological state of the reference site

The reference site is classified in the hydromorphological class 1 or 1-2, according to the categorisation of important Slovene waters (VGI, 2002).

c) Amount of water taken away upstream from the reference site

The water abstraction is less than 10% of the natural flow.

d) Bank vegetation

Natural bank vegetation, which suits the geographical position of the river, is preserved.

e) Flood plains

In the case of specific flood plains, the lateral and vertical connection of the riverbed with the flood plain must be preserved. Reference site flood plains should not be changed due to human activity.

f) Land use of the catchment area

The percentage of natural areas in the catchment area (after Corine Land Cover) of the river to the reference site is:
- > 70 % or
- > 50 %, if at least 50 m from the edge of the riverbed (on both banks) of double riverbed width (for rivers wider that 25 m) there are no agricultural or urban areas (after Corine Land Cover).

g) Physico-chemical conditions

A) There is no point source of pollution on the reference site (such as industrial waste outflow, communal waste outflow or water treatment plant outflow), that would influence physico-chemical parameters.
B) There are no known sources of pollution or loading with any specific synthetic or non-synthetic pollutants (data from MOP-ARSO 2004).

h) Saprobic index value at the reference site

A) Hydroecoregion Alps: ≤ 1,8
B) Hydroecoregion Dinarids:
   - If the terrain slope is > 1°, the saprobic index value ≤ 1,8
   - If the terrain slope is < 1°, the saprobic index value ≤ 2,0
C) Hydroecoregion Pannonian lowland: ≤ 2.0
D) Hydroecoregion Po lowland: ≤ 2,0

i) Biological pressures

A) There is no impact from non-autochtonous species, which would competitively endanger autochtonous species, disrupt the habitats and genetically weaken the populations.

B) There is very little or no impact from fishery. The reference site is chosen on the section of the river that is either not used for fishing or it is categorised as protected water (after Bertok et al. 2000, 2003).

j) Other pressures

Reference sites are not used for intensive recreational purposes (camping, swimming, rowing).

# Annex III: Report from the Atlantic Group

EUROPEAN COMMISSION
DIRECTORATE GENERAL JRC
JOINT RESEARCH CENTRE
Institute of Environment and Sustainability

Report – River Fish Groups

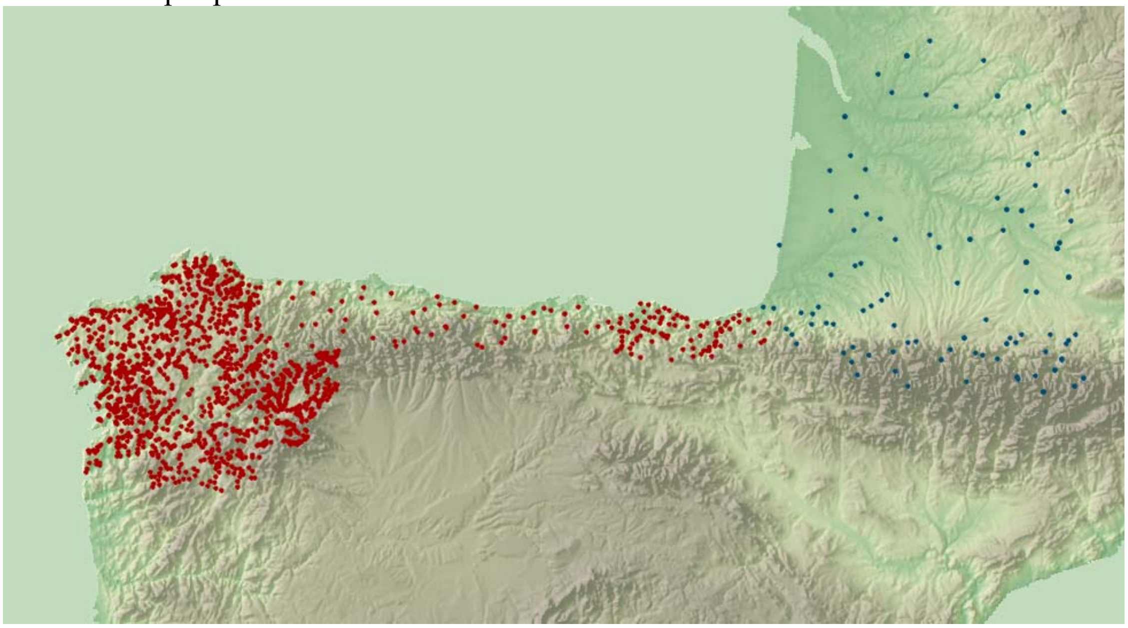
| GIG | **FISH- REGIONAL GROUP " Atlantic"** |
|---|---|
| Information provided by | Francisco Hervella Rodríguez |

## Short description of preliminary results in the Atlantic group

Francisco Hervella (Xunta de Galicia, Spain)
Isabel Pardo (University of Vigo, Spain))
Nicolas Roset (Conseil Sepérier de la Pêche, France)

## General approach

Rivers from the Atlantic coast of France and Spain are included in this preliminary exercise, but no attempt to specify types according the WFD has been applied. Portugal was initially part of this GIG but decided to withdraw, because fish densities and number of species are very low in many sites of this type of rivers.



Map 1. Points submitted to the pilot exercise on fish intercalibration from the Atlantic regions of Spain (red points) and France (blue points).

Fish is the biological quality element to be intercalibrated under a combination of general degradation pressures, including morphological alteration and organic pressures.

*Describe the general intercalibration approach*

The approach for comparison will be to use a common ICM (EFI index) to derive common boundaries. For each dataset, the EFI index will be calculated, and a preliminary analysis will be produced applying the normalisation by the median of the reference population to derive EQR values. After that the EFI_EQR will be tested for its efficiency to discriminate pressures in Spanish and French datasets, prior to its consideration as an ICM for the IC exercise.

*Identify the national methods that were intercalibrated*

There is no yet a National Spanish fish index for the N-NWSpain Atlantic region, but it is presently under development, in line with WFD requirements. France is intercalibrating the FBI described in Annex A. For the present pilot exercise the IC approach in the Atlantic group can not include for that the comparison of MS official methods.

The table below represents a summary of the information provided by each country within the Atlantic group, and the indices applied to the datasets.

| Country | N-sites | Reference sites | EFI index | FBI (France) |
|---|---|---|---|---|
| Spain | 1608 | 82 | 1608 | |
| France | 104 | 35 | 104 | 104 |

## Setting of Reference conditions

Selection of reference sites in **Spain** was done in three steps:

- Pre-selection of sites for the different N-Spanish river types. This pre-selection was based on best results obtained from biological metrics indicators of fish populations from N-Spain river types (characterised by low richness of fish species): density of trout or density of salmonids (ind/m²), density of autochthonous species (ind/m²), and the number of autochthonous species.
- A priori analysis based on expert judgement on the level of pressure: a rejection threshold of sites with a value of >3 for any pressure parameter, or >2 in the case of 'connectivity river' pressure; rejection of sites with a value >14 for the sum of 9 pressure parameters (minimum value is 9, maximum is 30); rejection of sites with moderate impacts both in 'water quality pressure' and 'hydromorphological condition'
- Rejection of sites regarded as 'free access for fishermen' and a heavy fishing pressure associated (excluding small streams).

Spain is presently further developing reference criteria for the different BQE. The presented approach, based on biological information on reference fish communities (historical reference fish species), and pressure level according expert judgement, will be integrated within the general context proposed by REFCOND for the "a priori" pressure analysis, to identify a spatial network of reference sites.
*A more detailed description is given in the report from the Mediterranean group*.

*The French method and criteria for reference conditions can be found in the report from the Midland group.*

It is possible that once Spanish reference criteria are fully developed for fish, it will be possible to reach an agreement on the consistency of the reference criteria between both countries.

## Testing the EFI index in Spanish and French datasets

As a first step, the EFI index was calculated on both datasets. Figure 1 represents the EFI index values for reference and non reference sites for Spanish and French datasets. The median value of the EQR_EFI for the reference population for both countries is very similar, indicating that the view of reference criteria for both countries is very consistent.

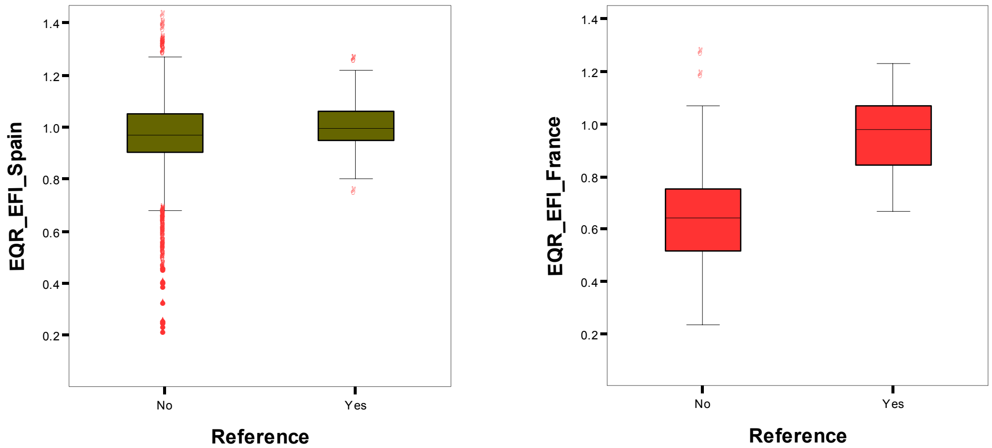



**Figure 1.** EQR values for EFI index in both Spanish and French datasets.

The relationship with pressures of the EQR_EFI in the French database points at its good indication for both, morphological alterations and organic pressure.

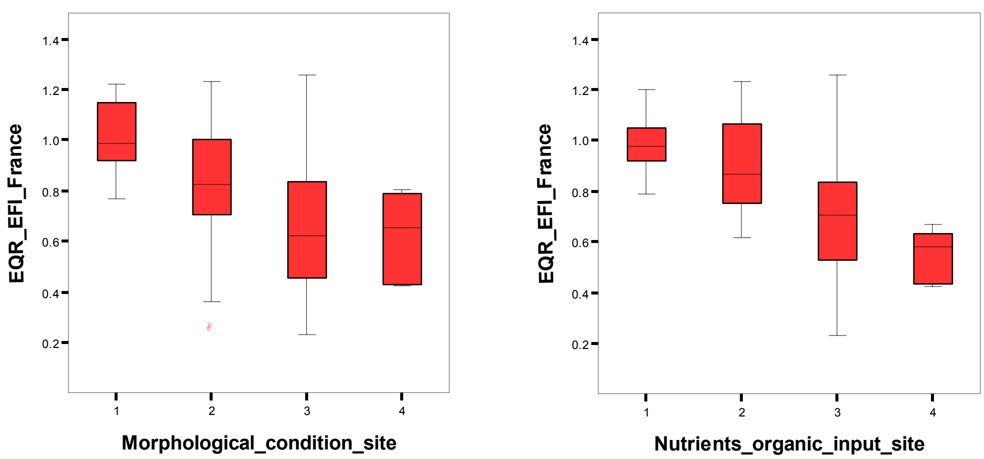



**Figure 2**. French EQR_EFI values response along 2 gradients of pressure, morphological and nutrients.

Meanwhile, the EQR_EFI in the Spanish database had a worse indication for Morphological alterations, a known weakness of the present EFI index in our river types.

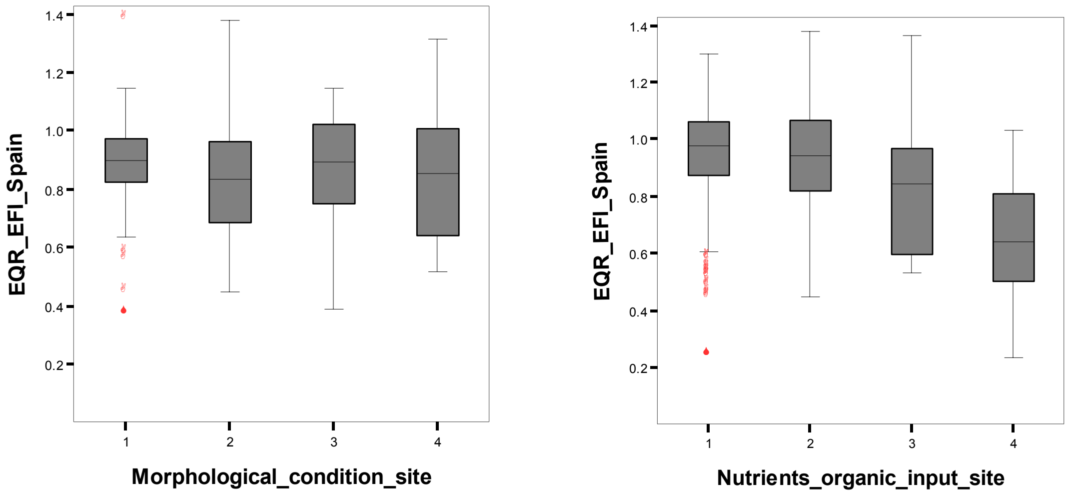



**Figure 3.** Spanish EQR_EFI values response along 2 gradients of pressure, morphological and nutrients.

## Setting of Boundaries

Spain has not set their boundaries for the biological element of fish, due to the fact that we are developing the national system for fish assessment. There is no presently an option to compare boundaries, but the exercise will be possible is an extension of time is provided.

## Results of comparison of national systems with EFI as an ICM

A comparison was performed between the EQR_EFI calculated for France and the EQR of the National system, the EQR_FBI (FBI was transformed into EQR by dividing the values by the median value of the FBI of the Atlantic group reference, FBI= 10.19). The regression indicates a weak relationship between both systems ($r^2$=0.4), mostly at the worse classes. Meanwhile the value of the Spearman correlation was of r =-0.74 between both EQRs.

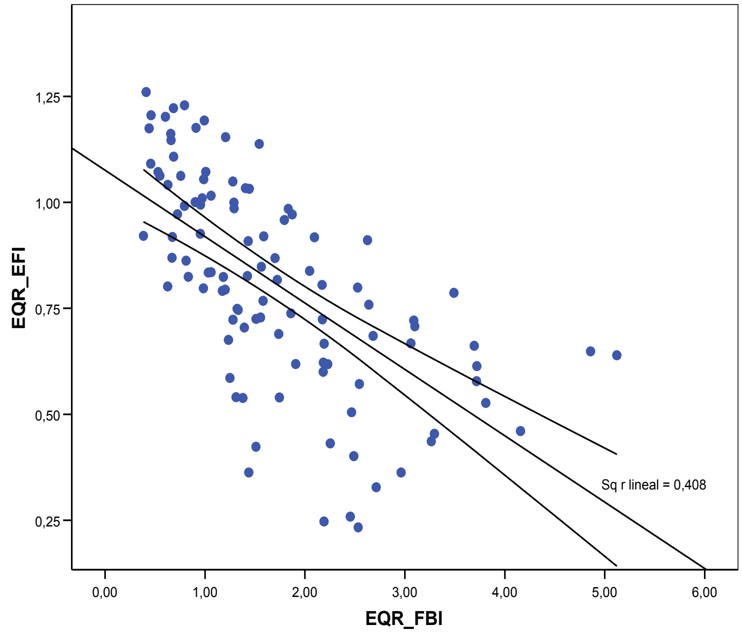



**Figure 4**. Bilateral comparison between EQR index values for EFI and FBI for the French dataset.

## Conclusions

The preliminary results indicate that the indication provided by the EFI in relation with pressures should be improved, at least for the Spanish dataset. Moreover, even if the response to pressures provided by EFI in the French dataset seems better in comparison with the Spanish one, the comparison between the French national system and the EFI shows a weak relationship ($r^2$=0.4). These results will prevent the use of the present EFI index as an IC common metric for the Atlantic river types if a regression approach is followed. A more promising result was provided by the Spearman correlation value.

This results strongly recommend the improvement of the EFI index, as it is planned in the new EFI + index under development, before is used as an ICM common metric for the IC comparison within the Atlantic group. Also, Spanish data should be included into the EFI+ to improve the indication provided by the EFI+ for this type of rivers, characterised by a small number of fish species.

Due to the small size of the Atlantic group (only 2 countries), the intercalibration results which can be provided by this group may have a higher confidence, according last analyses presented at ECOSTAT (April 2007, Ispra) on the lake GIGs results. For that we will like to either fuse the Atlantic group with other more similar group, in relation with fish community similarities, or, to increase the Atlantic group with more countries.

# Annex IV: Report from the Carpathian Group

EUROPEAN COMMISSION
DIRECTORATE GENERAL JRC
JOINT RESEARCH CENTRE
Institute of Environment and Sustainability

| GIG | **Carpathian Fish GIG** |
|---|---|
| Information provided by | Dr. Serban Iliescu |

Report – River Fish Groups

| |
|---|
| **A – General approach** |
| 1. Describe the common intercalibration types, specifying the countries participating for each type and the biological quality elements/ pressures that are intercalibrated (update 'types manual' tables |
| The Carpathian Intercalibration Group (EC GIG) includes the following countries: Czech Republic (CZ), Slovak Republic (SK), Poland Republic (PL) and Romania (RO). In this GIG five common intercalibration types were defined based on the typological factors ecoregion, catchments area, and altitude, geology and channel substrate (see table 1). |
| 3. Describe the general intercalibration approach<br>- Approach for comparison (e.g. ICMi using common reference criteria), including statistical procedures<br>- Approach for harmonization (if applicable, e.g. use of common benchmark)<br>- Specify which data was used to set the boundaries applying the BSP (e.g. common benchmark data [option 2], all MS data [option 3] |
| Work is at beginning. |
| 3. Identify the national methods that were intercalibrated (for all countries, if available); provide detailed description in Annex A |
| For these exercises all countries used EFI method. Except for Czech Republic that used CZ index as well (see table 1). For description of CZ index see Annex A. |
| |

Summarize the common approach for setting of reference conditions. Give a more detailed description of procedure and criteria, and identify reference sites for each country and type according to those criteria in Annex B

### 1.2. Romania

High status or reference conditions is a state in the present or in the past corresponding to very low pressure, without the effects of major industrialization, urbanization and intensification of agriculture, and with only very minor modification of physic-chemistry, hydro morphology and biology.
It is proposed to use the CORINE Land Cover (CLC) classification for the evaluation of the land use in the catchments and riparian area.
For small streams: no known point source discharge, or much localized impact with self purification.
For larger streams and rivers: very low point source discharge level. If point source pollution is present, a validation with chemical parameters is necessary.
As an alternative, the British ASPT index can be used to validate very minor effect of organic pollution on **the Macrozoobenthos community**. The reference threshold value for the common type R-E1 is 6.4.
Other effluents/discharges (urban pollution), specific synthetic pollutants, and specific non-synthetic pollutants, land-use intensification: agriculture, forestry, riparian zone, vegetation, river morphology, water abstraction, river flow regulation, introductions of alien species, fisheries and aquaculture, biomanipulation, recreation uses.

### Czech Republic

Reference conditions that were used for definition of reference sites in the Czech Republic were adopted from the assessment of benthos. Thus, they are not consistent with all the requirements for fishes. This problem is being solved nowadays and reference conditions are being redefined. Some criteria should be adopted from Austrian conditions, where they were successfully used. New as well as current sites corresponding to these conditions should be sampled and tested this year.

### Poland

### Slovakia

METHOD FOR DERIVING REFERENCE CONDITIONS IN SLOVAKIA

The European Fish Index (EFI) is based on a predictive model that derives reference conditions for individual sites and quantifies the deviation between predicted and observed conditions of the fish fauna.

- Candidate common metrics

Slovak common metrics are derived from the FAME project which is the platform to determine the EFI. As we all know, this is done by calculating the residuals of the multilinear regression models and are used to quantify the level of degradation.

Residuals are calculated as observed metric values minus theoretical (predicted) metric values representing standard undisturbed conditions.

In Slovakia we want to use 10 EFI-metrics belonging to the following ecological functional groups: trophic structure, reproduction guilds, physical habitat, migratory behavior and capacity to tolerate disturbance in general.

There are 89 fish species in the Slovak rivers. All of them are included in the EFI software. The intensity of atrophic devastation of rivers is indicated by the presence of the particular species as well as the quantitative and qualitative structure of the fish community.

Fish communities

Slovak national method suggests 22 types of fish communities. They are distinguished by the presence of particular indicator fish species and main abiotic environmental variables (Tab 19). According to EFI the reference conditions are determined for each river type based on the structure of corresponding fish community.

From the methods for deriving reference conditions stated in the Directive 2000/60/EC we decided to use the data from the FAME project in combination with the expert judgments on the parameters of fish communities in Slovakia.

The proposal of Slovak fish communities is an expert judgment based on the analysis of ichthyological studies conducted on Slovak rivers as well as personal ichthyological praxis.

The types “Big rivers” were derived with the help of statistical analysis of the summaries of caught fish during the late nineties of the last century. The statistic methods used include weighted averages and modeling of fish communities according to the dominant species corresponding to the river segment.

Tab. 19 presents a model state of “natural/unaffected” fish communities which would have existed in the antropically undisturbed or moderately disturbed basins.

In compliance with the WFD the creation of suggested 22 Slovak river types (Tab. 16) is based on following principles. The rivers are first divided in groups according to the main abiotic characteristics. Subsequently, the particular structure of the ichthyofauna is assigned within each river group which results in unique river type. The classification of the river types corresponds with the Tab. 19.

Table 1. Overview of the type of data used in the Carpathian group.

| County | River region | Total number of fishing occasion | IC type ecoregion | Referen ce sites | Other sections | National method |
|---|---|---|---|---|---|---|
| **Romania (RO)** | Danube | 101 | Carpathians small to medium altitude and Transilvanian Plateau Ecoreg.10 – 77<br>Hungarian Lowlands Ecoreg. – 11<br>Pontic Province Ecoreg. 8 | 23 | 78 | No |
| **Czech Rep. (CZ)** | Danube 51<br>Odra 15<br>Elbe 111 | 177 | | 27<br>15<br>41 | 94 | Yes |
| **Poland (PL)** | Baltic Sea | 31 | | 6 | 25 | No?/ |
| **Slovakia (SK)** | Danube 64<br>Odra2 | 66 | 10-Carpathians: 63<br>11- Hungarian Lowlands:3 | 37 | 29 | No// |

**C – Setting of Boundaries**

2. Summarize how boundaries were set following the framework of the BSP for the HG and GM boundaries, demonstrating that this was done in accordance to WFD Annex V, normative definitions
    a. For the benchmark (if applicable)
    b. For the national methods (obligatory if no benchmark is used; also recommended if benchmark is used);

    Provide a description of the full procedure in Annex C

**Romania**

In Romania there are 126 reference sites and 48 Best Available Sections established on the macrozoobenthic element, which were as the basis the fish intercalibration exercises.

**Czech Republic**

Data from reference sites were used as a basis for setting of boundaries. From these data were values of CZ index obtained. Median value of CZ index was suggested as the H/G boundary and 10 % percentile value was suggested as the G/M boundary.

**Poland**

**…**

**Slovakia**

In Slovakia there are 12 sites in Ecoregion (K) Carpathians zone and 10 in Ecoregion (PP)Panonia lowlands.

**E – Boundary EQR values**

Provide a table with HG and GM boundary EQR values for the national methods and the common metrics (where applicable) for each type as a table

***Romania***:
All assessment metodologies for biological elements are in progress.
**Czech Republic**
Values for the national method provided in the table correspond to the type 23 (elevation 200 – 500 m; stream order 3-4); values for remaining types are not relevant due to the lack of the data.

| Metric | Boundary | reference |
|---|---|---|
| POTA | H/G | 1.0 |
| | G/M | 3.0 |
| LITH | H/G | 86.9 |
| | G/M | 39.1 |
| TOLE | H/G | 14.3 |
| | G/M | 42.9 |

**F – Indicative work plan for the continuation of the intercalibration**

Indicate plans and appropriate timing for continuation of the intercalibration for types and quality elements not currently included

We will continue IC process with the following procedures: 1. computation of the CZ index for all the GIG countries. 2. Compare the results of the CZ index and EFI for these data sets. 3. Incorporate Romanian index that is under development.

**E – Comments and remarks**

Romanian fish- index should be developed at the end of July.

**Annexes**

**Annex A – Description of national classification methods included in the intercalibration; please provide the reference to the method, the status of the method (officially accepted, finalized, under development), describe the metrics and approach.**

## Romania

Romanian Methods for assessment of the water quality are under development.

## Czech Republic

The computation of the Czech version of multimeric index for the evaluation of ecological state by fish communities is described below.
The method is still under development and new metrics like presence/absence of reproductive guilds should be tested during this year.

# Czech approach in classification the ecological status of rivers according to the fish biocoenosis

## Introduction

The aim of present document is to describe the Czech approach in classification the ecological status of rivers according to the fish biocoenosis. The first part of the document is focused on the methodology of the Czech approach in general, the second part concern on the description of present status of the Czech Index and its future development needs.

## Methodology

The Czech approach is focused on the 0+ (juveniles) sampling. This method was predominantly used to describe the species-specific microhabitat requirements of juveniles and their dynamics during the 24-h cycle (e.g. Copp, 1989a,b; 1992a,b; Copp & Jurajda, 1993; Copp & Jurajda, 1999). The main advantage of the 0+ sampling is the sensitive response of the 0+ assemblage to the habitat quality (Copp, 1992b). For instance, progressive regulation caused local extinction of some fish species in river Great Ouse (Maitland and Lyle, 1991) as well as the low recruitment of some species of the coarse fishes (Copp, 1990, 1992b, Copp & Mann, 1993). In an attempt to enhance the low natural recruitment of fish populations, a variety of restocking programs have been undertaken. However, restocking responds the symptoms only, and does not address the roots of the problem – low abundance of suitable spawning, nursery and refuge habitats (Copp, 1992b).

A similar situation occur in the Czech Republic, since widespread restocking of many coarse as well as salmonid riverine fishes is the obligation of fisheries organizations. Thus, sampling of adults could cause serious misclassifications of the ecological status of rivers**,** as the data on the restocked adults do not respond to the abundance of suitable spawning, nursery and refuge habitat and therefore to the habitat quality in general.

In order to verify the use of juveniles as indicators of the ecological status, comparison of the results between the sampling of juveniles and the whole fish assemblage should be provided during autumn 2007. Main advantages and disadvantages of 0+ sampling are summarized below:

***Advantages:***

- good and relatively fast response to habitat quality and its alterations
- lower mobility and higher catchability of juveniles
- does not involve the effect of stocking
- easier to obtain representative samples in lowland rivers

***Disadvantages:***

- higher variability in 0+ assemblage among years
- higher impact of extreme discharges
- impossibility to describe age structure

***Brief description of 0+ sampling procedure:***

- sampling in August, with respect to the relative 0+ assemblage stability and advanced larvae development
- sampling with help of battery or generator powered portable electrofishing unit (Copp, 1989a)
- continuous sampling of the shoreline (in headwaters streamline as well)
- sampling of all mesohabitats (e.g. pool, riffle etc.) present at the study site; at least 20 meters each

## Czech Index

The response of common metrics from EFI to the 0+ assemblage was initially tested and those with the highest discrimination power were selected as a metrics for the Czech Index (see the text below for details). Czech Index should be improved further. New metrics like presence/absence of reproductive guilds etc. are supposed to be tested and incorporated. Thus, the Czech Index is still under development and the final version should be obtained in consecutive years. The computation of the present version of the Czech multimeric index for the evaluation of ecological state by fish communities is based on the following steps:

1) Selection of indices with the highest discrimination power between reference and non-reference sites.

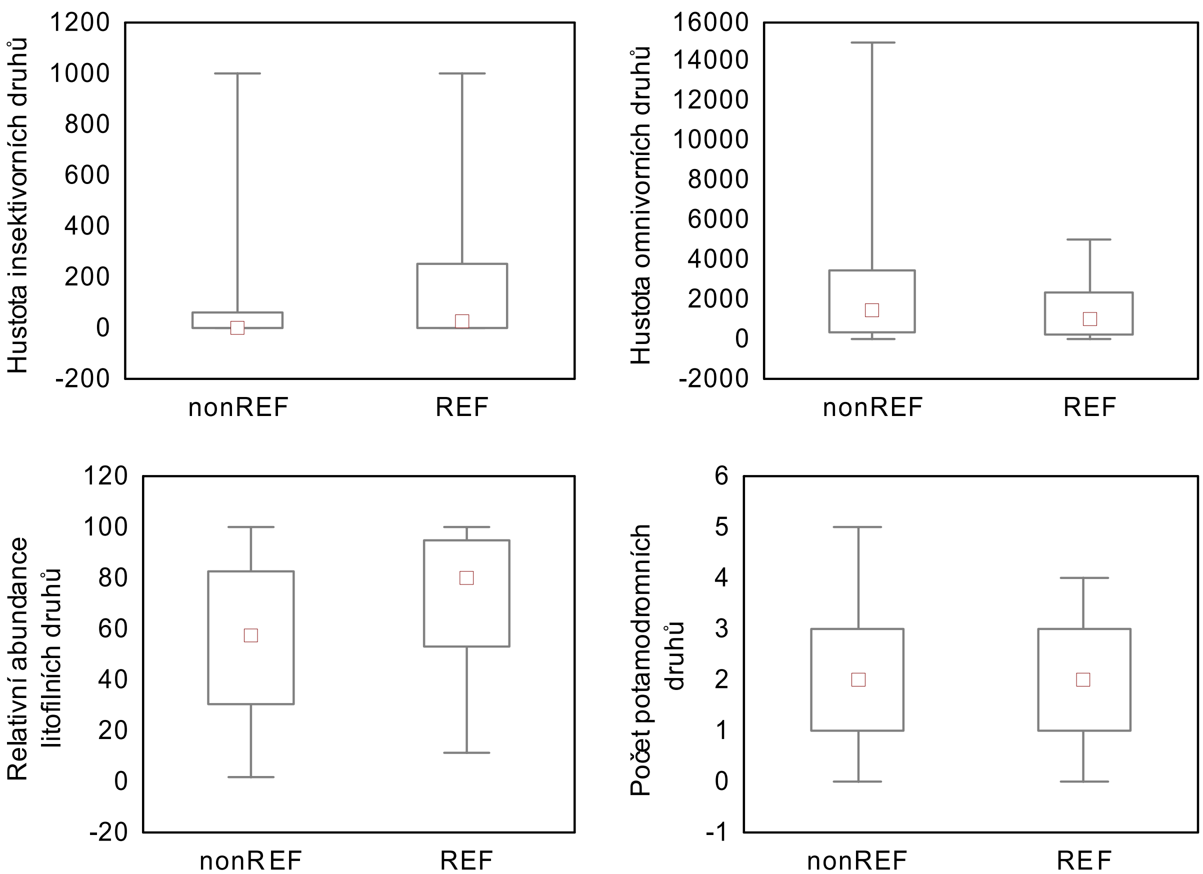
2) Cluster analysis of indices aimed on definition of groups of highly correlated indices.
3) One index with the highest discriminatory power was selected from each group of indices defined in the step 2. Such procedures lead to the selection of three indices

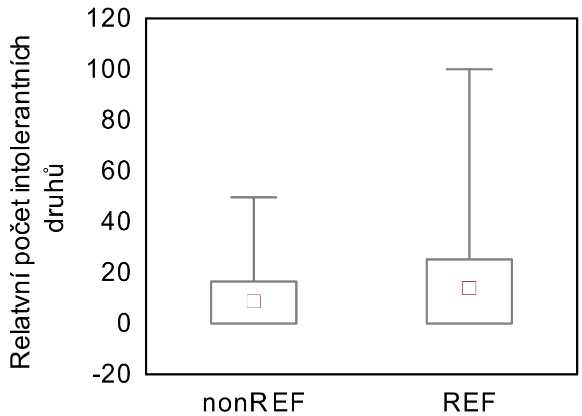
- O-POTA - number of the potamodromous species
- O-LITH - relative abundance of the lithophilous species
- O-TOLE - relative number of the tolerant species

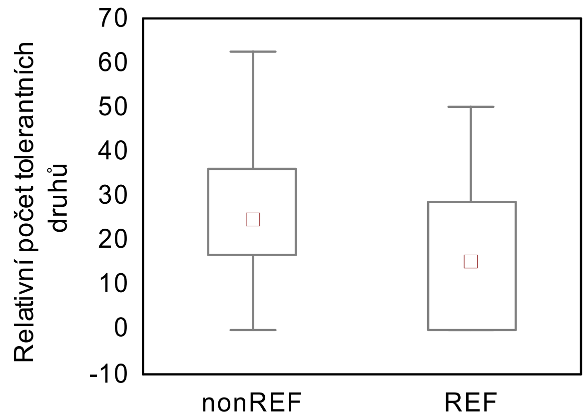
4) Each index was converted into the percentiles of normal distribution (parameters of given distribution were computed from the available reference and non-reference data), i.e. into range 0-1:

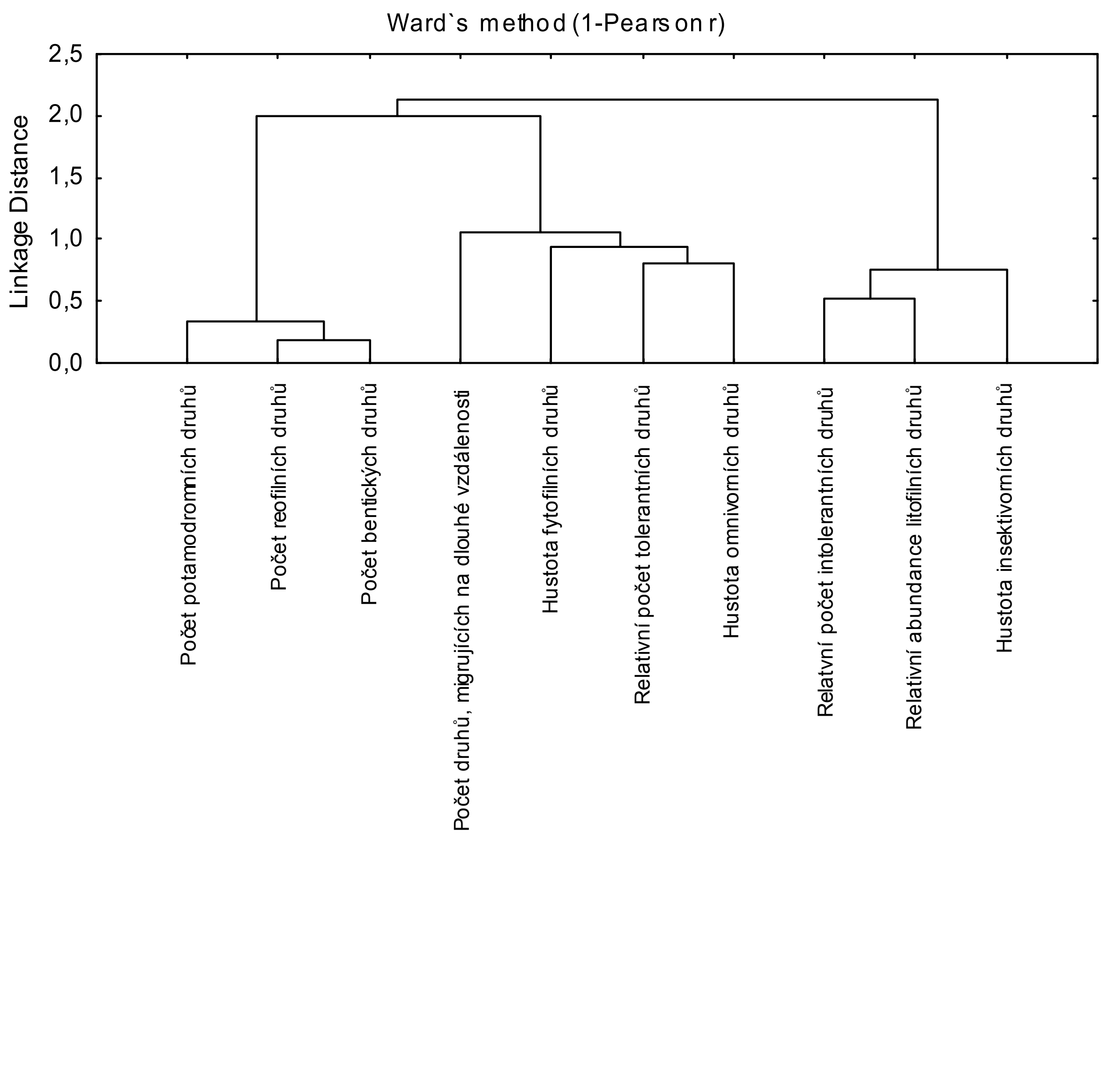
norm(O-POTA)
norm(O-LITH)
norm(O-TOLE)

5) selected indices were aggregated using the following function: mean(norm(O-POTA);norm(O-LITH);1-norm(O-TOLE) ) to obtain final value of the Czech multimetric index with theoretical range 0-1




Relatvní počet intolerantních druhů
120
100
80
60
40
20
0
-20
nonREF
REF


Relativní počet tolerantních druhů
70
60
50
40
30
20
10
0
-10
nonREF
REF


Ward`s method (1-Pearson r)
Linkage Distance
2,5
2,0
1,5
1,0
0,5
0,0
Počet potamodromních druhů
Počet reofilních druhů
Počet bentických druhů
Počet druhů, migrujících na dlouhé vzdálenosti
Hustota fytofilních druhů
Relativní počet tolerantních druhů
Hustota omnivorních druhů
Relatvní počet intolerantních druhů
Relativní abundance litofilních druhů
Hustota insektivorních druhů

## References:

Copp, G.H., 1989a. Electrofishing for fish larvae and 0+ juveniles: equipment modifications for increased efficiency with short fishes. Aquacult. Fish. Mgmt. 20: 453–462.

Copp, G.H., 1989b. The habitat diversity and fish reproductive function of floodplain ecosystems.Environ. Biol. Fish. 26: 1–26

Copp, G. H. 1990. `Effect of regulation on the fish recruitment in the Great Ouse, a lowland river', Regul. Riv., 5, 251-263.

Copp, G. H. 1992a. `Comparative microhabitat use of cyprinid larvae and juveniles in a lotic floodplain channel', Env. Biol. Fish., 33, 181 -193.

Copp. G. H. 1992b. `An empirical model for predicting the microhabitat of 0á juveniles in lowland streams', Ecologia, 91, 338-345.

Copp, G. H. and Jurajda, J. 1993. `Do small riverine fish move inshore at night?' J. Fish Biol., 43 (Suppl. A), 229-241.

Copp, G. H. and Mann, R. H. K. 1993. `Comparative growth and diet of tench Tinca tinca (L.) larvae and juveniles in river floodplain biotopes in France and England', Ecol. Freshwat. Fish., 2, 58-66.

Copp, G.H. & Jurajda, P. 1999. Size-structured diel use of river banks by fish. Aquatic Sciences 61: 75–91.

Maitland, P. S. and Lyle, A. A. 1991. `Conservation of freshwater fish in the British Isles : the current status and biology of threatened species', Aquat. Conserv., 1, 23-54.

# Annex V: Report from the Lowland Group

EUROPEAN COMMISSION
DIRECTORATE GENERAL JRC
JOINT RESEARCH CENTRE
Institute of Environment and Sustainability

**Report – River Fish Groups**

| GIG | FISH- REGIONAL GROUP "LOWLAND" |
|---|---|
| Information provided by | Cornelia Schuetz, Tom Buijse |

## A – General approach

1. Describe the common intercalibration types, specifying the countries participating for each type and the biological quality elements/ pressures that are intercalibrated (update 'types manual' tables

Fish intercalibration in the lowland region within ecoregions 8, 9, 13, 14, 18:

Data input of the participating countries not yet specified regarding common intercalibration types, sites consist of the types R-C1, R-C2, R-C3, R-C4, R-C5, R-C6;

Sites are characterised by altitudes below 200 m.a.s.l and less than 50 m wetted width; a sample should contain at least 30 individuals.

Countries participating: BE, DE, DK, GB, NL

4. Describe the general intercalibration approach

   - Approach for comparison (e.g. ICMi using common reference criteria), including statistical procedures

   - Approach for harmonisation (if applicable, e.g. use of common benchmark)

Specify which data was used to set the boundaries applying the BSP (e.g. common benchmark data [option 2], all MS data [option 3]

Lowland Group report

Use of direct comparison between national assessment methods by checking whether there are major differences in the results of the national methods when applied to the same site data.

Due to a lack of reference criteria almost no reference sites were indicated by the participating states. Therefore it was not possible to calculate EQR values yet.

Datasets received from 5 countries

| | |
|---|---|
| BE-FL | 51 |
| NL | 76 |
| DE | 500 |
| GB | 12203 |
| DK | 65 |
| = | 12869 data sets in total |

After filtering the site-data for inconsistencies and different parameters a reduced data set of totally 7277 sites remained. (see Annex C for details)

3. Identify the national methods that were intercalibrated (for all countries, if available); provide detailed description in Annex A.

IBI Flanders (Belgium)
Dutch System (The Netherlands)
EFI (GB)
FIBS (Germany)

IPR (France) - planned, no input at the moment

## B – Setting of Reference conditions

Summarize the common approach for setting of reference conditions. Give a more detailed description of procedure and criteria, and identify reference sites for each country and type according to those criteria in Annex B.

So far no reference criteria were agreed upon; possible reference sites were proposed by NL (14 sites) and BE (1 site);

For the proceeding work it is the first priority to define reference criteria and submit reference sites to the database.

## C – Setting of Boundaries

3. Summarize how boundaries were set following the framework of the BSP for the HG and GM boundaries, demonstrating that this was done in accordance to WFD Annex V, normative definitions
    a. For the benchmark (if applicable)
    b. For the national methods (obligatory if no benchmark is used; also recommended if benchmark is used);

Provide a description of the full procedure in Annex C

The method still has to be agreed upon. It will depend on the availability (or non-availability) of reference sites (see B).

**D – Results of comparison and harmonisation of boundaries between countries**

1. Present the results of the comparison demonstrating comparability of class boundaries between the countries within the GIG for all types (if applicable)

Comparisons of different sub datasets were done (see Annex C for details);

For the 47 sites that could be calculated by all methods the German method assessed the sites as being the worst. Then the Netherlands method was most severe. EFI and IBI gave comparable average values.

Regarding correlations between the results the EFI, FIBS and Dutch Index were best comparable. The Flanders IBI did not correlate with the other methods.

**E – Boundary EQR values**

Provide a table with HG and GM boundary EQR values for the national methods and the common metrics (where applicable) for each type as a table

**No results yet**

**F – Indicative work plan for the continuation of the intercalibration**

Indicate plans and appropriate timing for continuation of the intercalibration for types and quality elements not currently included

- define reference criteria and select reference sites
- call for more data (including reference data)
- calculate EQR (if reference sites are available)
- compare single metric values additional to total index values
- invite other countries to participate (Lithuania, Poland, France)
- merge the lowland group with the midland group and proceed with common database (if necessary work with sub-databases for details and special questions)
- include further developments/improvements of different national methods (e.g. German Index, French Index, UK Index) and EFI (results of EFI + project) and recalculate results if necessary

**E – Comments and remarks**

We have been able to build a large dataset for comparison within a short time. An intercalibration exercise within the participating countries of the lowland and midland group will be possible. But there is a lot of work to do, several crucial issues (e.g. reference sites) still have to be addressed and the development of different assessment methods is still going on.

So we conclude that the intercalibration for fish in low- and midland rivers will be possible by June 2009.

## Lowland Group:
## Intercalibration of fish assessment methods
## Annex C of the Group Report, 04-05-2007

*Cornelia Schuetz, Marco Beers, Tom Buijse*

## Data basis

Data received from the Lowland group members:

| | |
|---|---|
| Belgium-Flanders | 51 |
| The Netherlands | 76 |
| Germany | 500 |
| Great Britain | 12203 |
| Denmark | 65 |
| in total | 12869 |

After filtering the site-data for inconsistencies and for the following parameters

- < 200 m.a.s.l.
- < 50 m wetted width
- min. 30 individuals
- max. 15 ‰

a reduced data set of **totally 7277 sites** remained.

| Sites in | |
|---|---|
| Belgium-Flanders | 15 |
| The Netherlands | 72 |
| Germany | 207 |
| Great Britain | 6935 |
| Denmark | 48 |

**This dataset is the basis for the following analyses.**

Four national methods were calculated and compared:
- IBI Flanders (Belgium, BE)
- Dutch System (The Netherlands, NL)
- EFI (Great Britain, GB)
- FIBS (Germany, DE)

The number of sites that were calculated with two of these methods respectively ranged from 51 to 5684:

| | BE-IBI Flanders | NL-Dutch system | EFI |
|---|---|---|---|
| **DE-FIBS** | 53 | 167 | 258 |
| **BE-IBI Flanders** | | 51 | 54 |
| **NL-Dutch system** | | | 5684 |

47 sites were calculated with all four methods (= comparison sites).

Since the comparison NL_Dutch system vs. EFI is biased by the UK data, these analyses were done with and without UK datasets.

# Correlation matrix
**(Spearman Rank order correlation)**

**significance level ≤ 0.01**
**significance level ≤ 0.05**

| FIBS_DE - IBI_BE | all data | large catchments | small catchments | low altitudes | 47 comparison sites |
|---|---|---|---|---|---|
| correlation coefficient | -0.012 | -0.020 | 0.000 | -0.132 | -0.089 |
| significance level | 0.930 | 0.915 | 0.999 | 0.398 | 0.552 |
| sample size | 53 | 30 | 22 | 43 | 47 |

| FIBS_DE - Dutch index_NL | all data | large catchments | small catchments | low altitudes | 47 comparison sites |
|---|---|---|---|---|---|
| correlation coefficient | 0.526 | 0.500 | 0.521 | 0.419 | 0.456 |
| significance level | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| sample size | 167 | 99 | 67 | 127 | 47 |

| IBI_BE - Dutch index_NL | all data | large catchments | small catchments | low altitudes | 47 comparison sites |
|---|---|---|---|---|---|
| correlation coefficient | 0.241 | 0.310 | 0.125 | 0.207 | 0.218 |
| significance level | 0.089 | 0.101 | 0.590 | 0.188 | 0.141 |
| sample size | 51 | 29 | 21 | 42 | 47 |

| Dutch index_NL - EFI | all data | large catchments | small catchments | low altitudes | 47 comparison sites |
|---|---|---|---|---|---|
| correlation coefficient | 0.511 | 0.623 | 0.368 | 0.671 | 0.766 |
| significance level | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| sample size | 5684 | 2574 | 3110 | 2812 | 47 |
| **Dutch index_NL - EFI (without UK Data)** | all data | large catchments | small catchments | low altitudes | |
| correlation coefficient | 0.670 | 0.742 | 0.573 | 0.589 | |
| significance level | 0.000 | 0,000 | 0,000 | 0,000 | |
| sample size | 208 | 119 | 89 | 164 | |

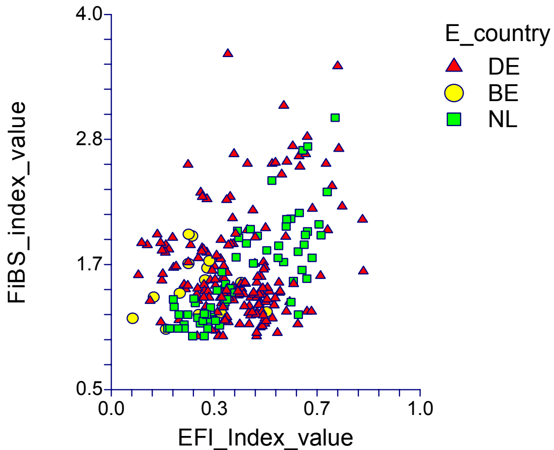
| FIBS_DE - EFI | all data | large catchments | small catchments | low altitudes | 47 comparison sites |
|---|---|---|---|---|---|
| correlation coefficient | 0.282 | 0.283 | 0.358 | 0.212 | 0.517 |
| significance level | 0.000 | 0.000 | 0.000 | 0.003 | 0.000 |
| sample size | 258 | 152 | 100 | 198 | 47 |

| EFI - IBI_BE | all data | large catchments | small catchments | low altitudes | 47 comparison sites |
|---|---|---|---|---|---|
| correlation coefficient | 0.348 | 0.316 | 0.387 | 0.356 | 0.219 |
| significance level | 0.010 | 0.079 | 0.075 | 0.016 | 0.139 |
| sample size | 54 | 32 | 22 | 45 | 47 |

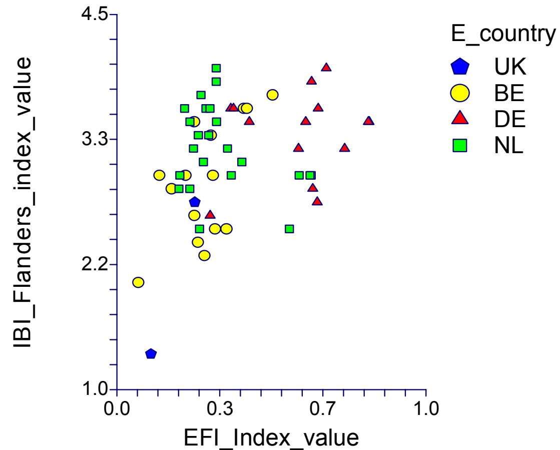
***While the German and Dutch system and the EFI correlate independent of the considered data set, the Flanders IBI correlates only slightly with the EFI.***

## **Scatter Plots (all data)** (Different symbols indicate the location of the sites)

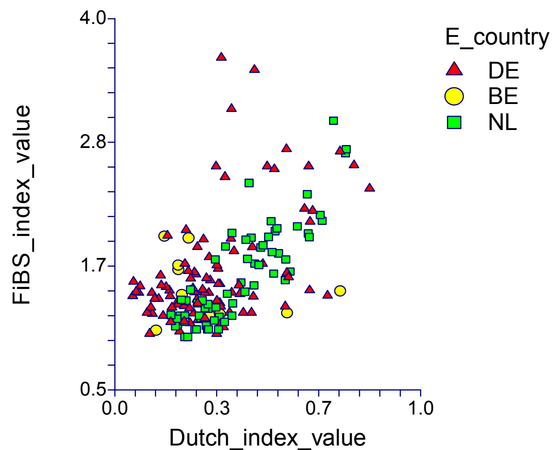
EFI_Index_value vs FiBS_index_value



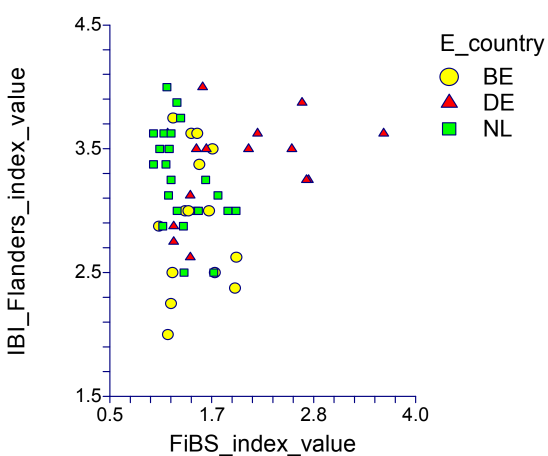

EFI_Index_value vs IBI_Flanders_index_value



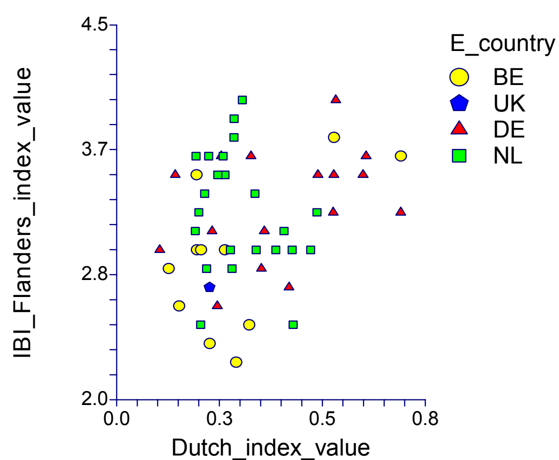

Dutch_index_value vs FiBS_index_value

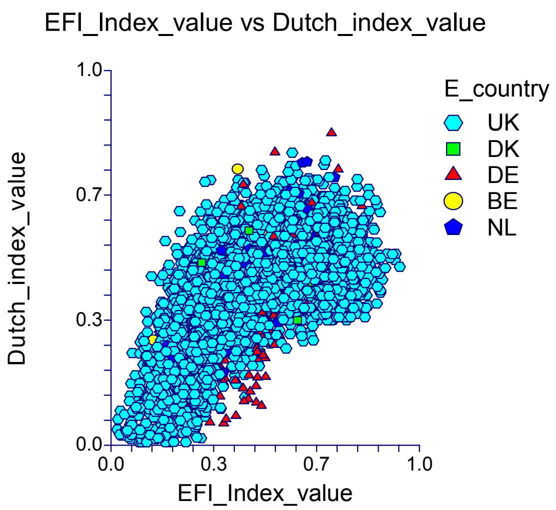


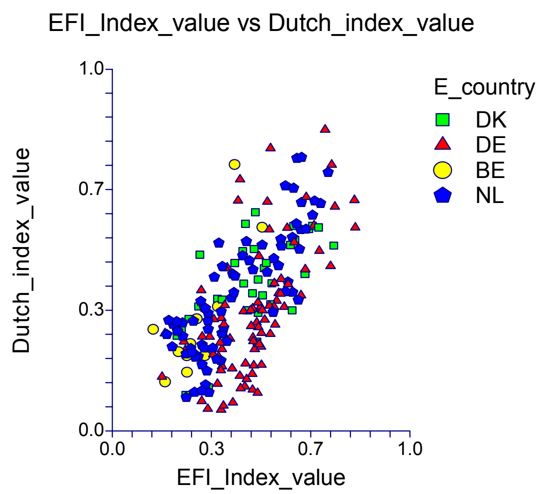

FiBS_index_value vs IBI_Flanders_index_value




Dutch_index_value vs IBI_Flanders_index_value





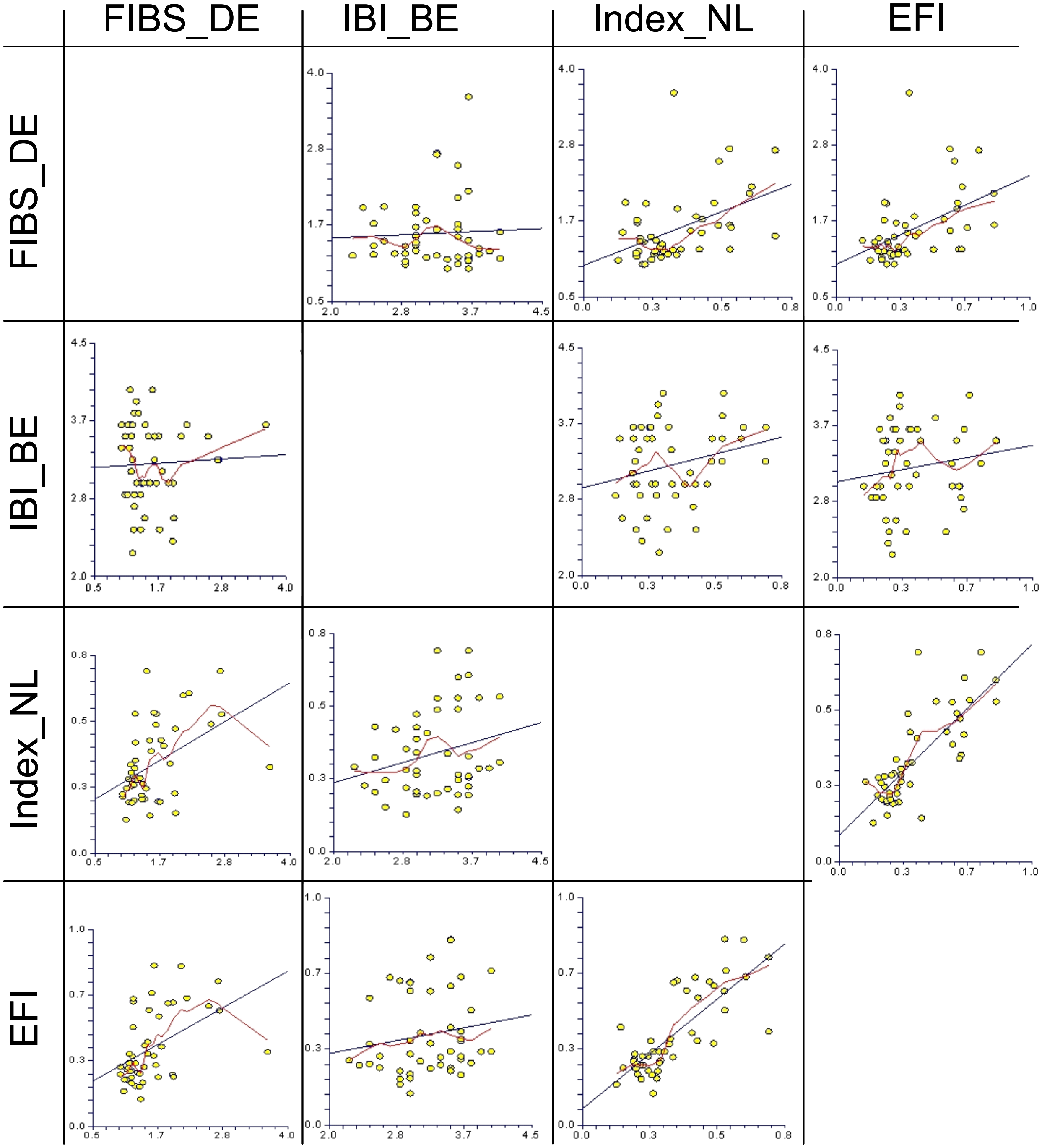

*EFI vers. Dutch index, with and without UK-Data*

## Regressions (comparison of sites)

Regressions were analysed for the same set of 47 sites that were suitable for all four methods (comparison sites).

X-axes = independent variable
Y-axes = dependent variable

blue line = linear regression (L.S.)
red line = lowess smooth line




For most of the cases the linear regression seems adequate, except for FIBS (independent) and EFI and NL-index (dependent).
For the calculation of the R-squared values, a robust regression model (downweighing the outliers) was chosen.

Robust Regression (Andrew's sine): Regression values (R-squared)

| | FIBS_DE | IBI_BE | NL_index | EFI |
|---|---|---|---|---|
| FiBS_DE | | 0.014436 | 0.576718 | 0.624231 |
| IBI_BE | 0.005056 | | 0.005886 | 0.042013 |
| NL_index | 0.529642 | 0.084395 | | 0.806972 |
| EFI_ | 0.571607 | 0.029279 | 0.806581 | |

accept $H_0$ ($p>0.01$)
reject $H_0$ ($p<0.01$)

***Similar to the results of the correlation, the comparability of the Flanders IBI to the other methods is low.***

## Classification of the sites

### *A) Overview of classifications of the 47 comparison sites*

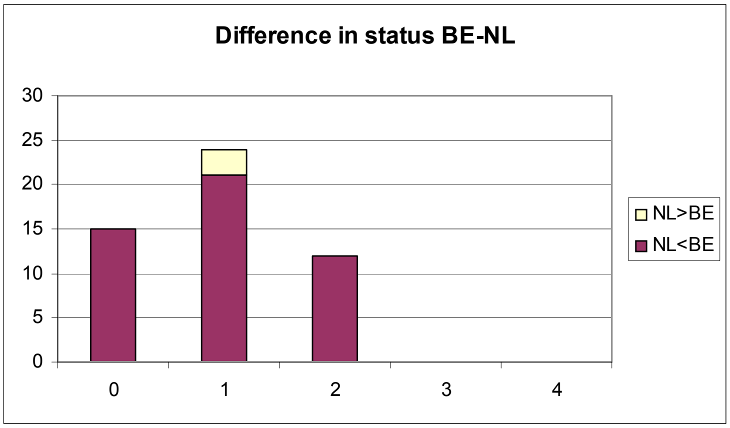
| Status | FIBS | IBI Flanders | Dutch Index | EFI |
|---|---|---|---|---|
| Bad | 29 | | 3 | 2 |
| Poor | 12 | 5 | 28 | 13 |
| Moderate | 2 | 30 | 12 | 18 |
| Good | 4 | 12 | 4 | 10 |
| High | | | | 4 |
| | | | | |
| Average | 1,60 | 3,15 | 2,36 | 3,02 |

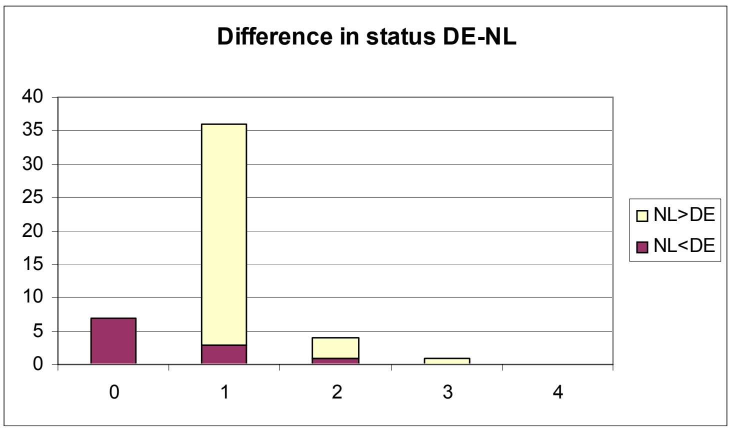
For each method an average value is calculated by giving score 1 to status Bad, score 2 to status Poor, etc.

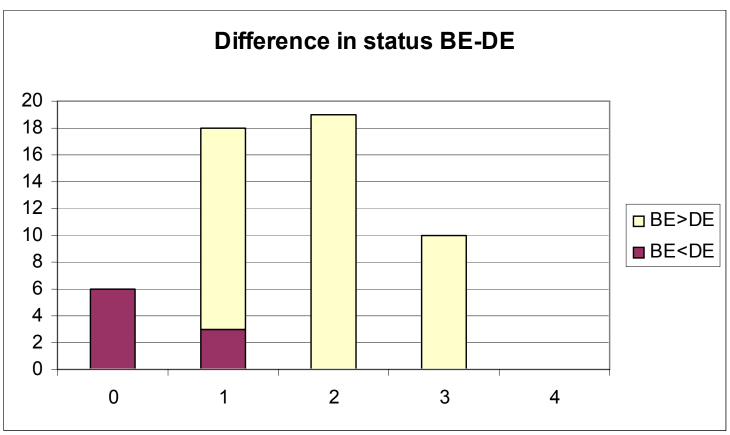
With the average value FIBS assessed the 47 sites as being the worst. Then the Dutch Index was most severe. EFI and IBI Flanders gave comparable average values.

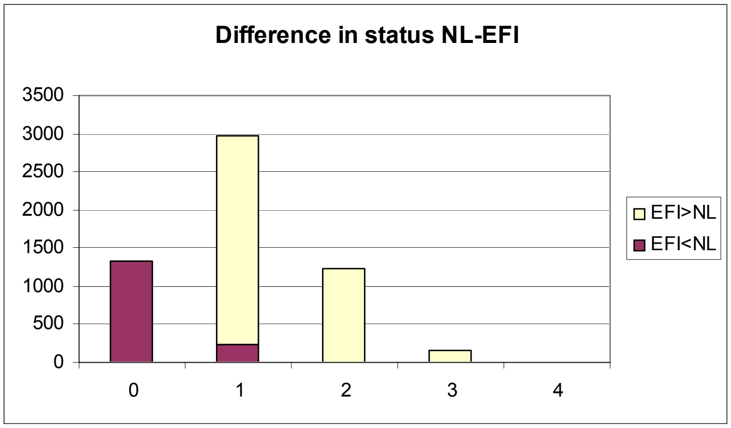
***B) Classification comparison between methods (pairwise)***

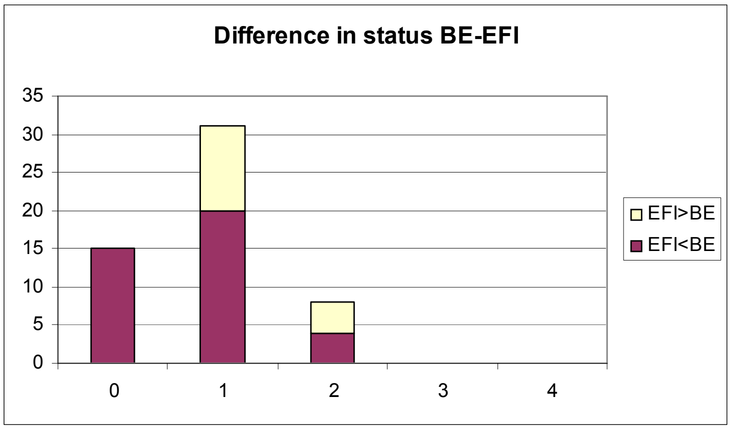
(On the y-axes the number of sites; on the x-axes the difference in status between two methods; the different colours indicate which method gave the best or the worst status)

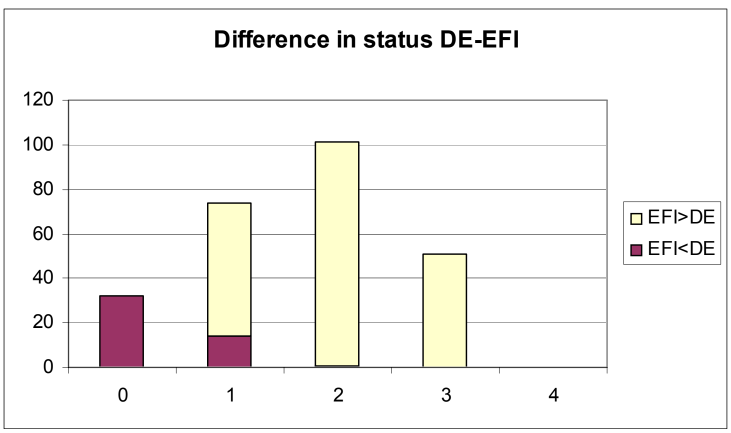





***Most sites which are calculated with the Dutch Index and FIBS differ only one status and in almost all cases the Dutch method gives a better status.***

***Regarding the EFI and the Dutch Index gives comparable results, but with the difference of EFI assessing the sites better and relatively more sites have the same status or differ more than one status.***

***The comparisons of the other methods show more variation and larger differences.***

Lowland Group report

| Number of sites | IBI Flanders | | | | | |
|---|---|---|---|---|---|---|
| FIBS | Bad | Poor | Moderate | Good | High | Total |
| Bad | | 4 | 18 | 10 | | 32 |
| Poor | | 3 | 10 | 1 | | 14 |
| Moderate | | | 1 | 1 | | 2 |
| Good | | | 3 | 2 | | 5 |
| High | | | | | | 0 |
| Total | 0 | 7 | 32 | 14 | 0 | 53 |

| Number of sites | Dutch Index | | | | | |
|---|---|---|---|---|---|---|
| FIBS | Bad | Poor | Moderate | Good | High | Total |
| Bad | 21 | 62 | 9 | 3 | | 95 |
| Poor | 4 | 20 | 20 | 2 | | 46 |
| Moderate | | 1 | 4 | 6 | 1 | 12 |
| Good | | 4 | 4 | 6 | | 14 |
| High | | | | | | 0 |
| Total | 25 | 87 | 37 | 17 | 1 | 167 |

| Number of sites | EFI | | | | | |
|---|---|---|---|---|---|---|
| FIBS | Bad | Poor | Moderate | Good | High | Total |
| Bad | 6 | 18 | 72 | 47 | | 143 |
| Poor | 11 | 8 | 30 | 23 | 4 | 76 |
| Moderate | | | 6 | 8 | 5 | 19 |
| Good | | 1 | 3 | 12 | 4 | 20 |
| High | | | | | | 0 |
| Total | 17 | 27 | 111 | 90 | 13 | 258 |

| Number of sites | EFI | | | | | |
|---|---|---|---|---|---|---|
| IBI Flanders | Bad | Poor | Moderate | Good | High | Total |
| Bad | | | | | | 0 |
| Poor | 2 | 2 | 3 | 1 | | 8 |
| Moderate | 2 | 10 | 10 | 7 | 3 | 32 |
| Good | | 2 | 8 | 3 | 1 | 14 |
| High | | | | | | 0 |
| Total | 4 | 14 | 21 | 11 | 4 | 54 |

| Number of sites | EFI | | | | | |
|---|---|---|---|---|---|---|
| Dutch Index | Bad | Poor | Moderate | Good | High | Total |
| Bad | 169 | 151 | 74 | 6 | | 400 |
| Poor | 98 | 323 | 565 | 390 | 148 | 1524 |
| Moderate | 8 | 81 | 616 | 1936 | 766 | 3407 |
| Good | | 1 | 46 | 216 | 89 | 352 |
| High | | | | | 1 | 1 |
| Total | 275 | 556 | 1301 | 2548 | 1004 | 5684 |

| Number of sites | | | | | | |
|---|---|---|---|---|---|---|
| | Bad | Poor | Moderate | Good | High | Total |
| Bad | | | 4 | | | 4 |
| Poor | | 4 | 19 | 8 | | 31 |
| Moderate | | 1 | 9 | 2 | | 12 |
| Good | | | 2 | 2 | | 4 |
| High | | | | | | 0 |
| Total | 0 | 5 | 34 | 12 | 0 | 51 |

# Description of local methods

**Flanders, Rivers**

Depending on the site dimension different techniques are applied. When applying electricity we fish in upstream direction.

*Table 1.* Description of the techniques used for fish stock analysis in Flandrian water bodies.

| Watertype | Techniques used |
|---|---|
| Running waters < 1.5 m | 100 m electric fishing with 1 anode |
| Running waters 1.5-4 m | 100 m electric fishing with 2 anodes |
| Running waters 4-6 m | 100 m electric fishing with 3 anodes |
| Running waters 6-8 m | 100 m electric fishing with 4 anodes |
| Running waters > 8 m | Combination of:<br>• 500 m boat electric fishing (2 x 250 m on both river banks)<br>• fykes and/or gill nets |

## Developed fish-based IBI's

## Bream and barbel type

We used data obtained during fish assemblage surveys carried out during the period 1993-1997. For the bream zone rivers in the Nete basin were selected and for the barbel zone the Herk river in the Demer basin the Abeek and Warmbeek were chosen as reference sites. For each water type metrics belonging to 3 categories (1. Species diversity; 2. Trophic composition; 3. Fish biomass and condition) were defined following the general IBI concept (Karr, 1981). The result is presented in table 2.

*Table 2.* Definition of metrics and scores for the calculation of the IBI for Flandrian water bodies of type C2 (river habitat corresponding to the bream zone) and type C3 (river habitat corresponding to the barbel zone).
* score is obtained by taking the mean of the species scores in italics
**: + recr. and - recr. stand for the presence and absence of natural recruitment.

| Metric | Type C2 | | | | | Type C3 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Score | 5 | 4 | 3 | 2 | 1 | 5 | 4 | 3 | 2 | 1 |
| Total number of species | | | | | | | | | | |
| *River width < 3m* | *≥7* | *6* | *5-4* | *3-2* | *1* | *≥5* | *4* | *3* | *2* | *1* |
| *River width 3-6.4m* | *≥12* | *11-9* | *8-6* | *5-3* | *≤2* | *≥7* | *6* | *5-4* | *3-2* | *1* |
| *River width 6.5-8.9m* | *≥13* | *12-10* | *9-7* | *6-4* | *≤3* | *≥10* | *9-8* | *7-6* | *5-4* | *≤3* |
| *River width ≥ 9m* | *≥14* | *13-10* | *9-7* | *6-4* | *≤3* | *≥12* | *11-9* | *8-6* | *5-4* | *≤3* |
| Mean tolerance | ≥2.4 | 2.39-2 | 1.99-1.6 | 1.59-1.2 | <1.2 | ≥2.4 | 2.39-2 | 1.99-1.6 | 1.59-1.2 | <1.2 |
| Mean typical species value | ≥3.3 | 3.29-3 | 2.99-2.7 | 2.69-2.4 | <2.4 | ≥3.1 | 3.09-2.8 | 2.79-2.5 | 2.49-2.2 | <2.2 |
| Type species* | ≥4.5 | 4.49-3.5 | 3.49-2.5 | 2.49-1.5 | <1.5 | ≥4.5 | 4.49-3.5 | 3.49-2.5 | 2.49-1.5 | <1.5 |
| *% Gasterosteus aculeatus* | | | | | | *<3* | *3-4.9* | *5-6.9* | *7-8.9* | *≥9* |
| *% Barbatula barbatula* | | | | | | *≥11* | *10.9-9* | *8.9-7* | *6.9-5* | *<5* |
| *% Leuciscus cephalus*** | | | | | | *>20<br>(+ recr.)* | *20-5<br>(+ recr.)* | *<5<br>(+ recr.)* | *≥25<br>(- recr.)* | *<25<br>(- recr.)* |
| *% Rutilus rutilus* | *10-25* | *25.1-35<br>7.5-9.9* | *35.1-45<br>5-7.4* | *45.1-55<br>2.5-4.9* | *>55<br><2.5* | | | | | |
| *% Scardinius erythrophtalmus* | *≥10* | *5-9.9* | *2-4.9* | *1-1.9* | *<1* | | | | | |
| *% Tinca tinca*** | *≥15<br>(+ recr.)* | *10-14.9<br>(+recr.)* | *<10<br>(+ recr.)* | *≥15<br>(- recr.)* | *<15<br>(- recr.)* | | | | | |
| Total biomass (kg/ha) | 100-349 | 350-499<br>75-99 | 500-649<br>50-74 | 650-799<br>25-49 | ≥800<br><25 | 250-349 | 350-449<br>100-249 | 450-549<br>60-99 | 550-649<br>20-59 | ≥650<br><20 |
| Weight % of non-native species | <1 | 1-3.99 | 4-6.99 | 7-9.99 | ≥10 | <1 | 1-3.99 | 4-6.99 | 7-9.99 | ≥10 |
| Trophic composition* | 5-4.3 | 4.29-3.5 | 3.49-2.5 | 2.49-1.7 | <1.7 | 5-4.3 | 4.29-3.5 | 3.49-2.5 | 2.49-1.7 | <1.7 |
| *% omnivorous species* | *<1* | | *1-5* | | *>5* | *<1* | | *1-5* | | *>5* |
| *% invertivorous species* | *>45* | | *45-20* | | *<20* | *>45* | | *45-20* | | *<20* |
| *% piscivorous species* | *3-5* | | *2.9-1<br>5.1-7* | | *<1<br>>7* | *3-5* | | *2.9-1<br>5.1-7* | | *<1<br>>7* |
| Natural recruitment (%) | ≥85 | 84.9-70 | 69.9-55 | 54.9-40 | <40 | ≥85 | 84.9-70 | 69.9-55 | 54.9-40 | <40 |

## Upstream IBI

The upstream IBI was developed using data from fish surveys executed between 1994 and 2000. No historical data were considered. This was done in another research project where we established for each water type a fish species reference list (presence frequency).
Table 3 gives an overview of the sequence of activities leading to the development of the upstream IBI.

*Table 3*. Overview of the activities involved in the development of the upstream IBI

| | Step | Description | Input | Methodology | Results |
|---|---|---|---|---|---|
| 1 | Composition of calibration data set | Decision: one or more indices? | Biotic and abiotic data from upstream brooks | FA + ANOVA | Pooled data set: one index (for grayling and trout zone) |
| 2 | Metric selection | Transformation of data into indicative biological variables | Literature and WFD | Guilds<br>PCA + cluster analysis | 28 candidate metrics<br>Selection of 9 metrics |
| 3 | Scoring | Standardisation into a scoring system (1, 3, 5) and aggregation into one biotic index | Descriptors | Trisection | Definition of thresholds<br>Integrity classes |
| 4 | Evaluation | Internal and External validation | Ecological quality class of calibration and independent data | Scoring discrepancy | Discrepancy distribution<br>Consistency evaluation |
| | | Consistency and redundancy | | Metric remainder correlation | |

The table below gives the upstream IBI.

*Table 4*. Fish-based IBI for upstream waters in Flanders (slope ≥3‰, river width ≤4.5 m): selected metrics and scoring criteria

| Metric | Metric score | | |
|---|---|---|---|
| | 1 | 3 | 5 |
| **Species richness and composition** | | | |
| Total number of species (MNSTOT) | | | |
| Slope class 1 (<4‰) | <4 | 4-7 | ≥8 |
| Slope class 2 (4-5‰) | <3 | 3-5 | ≥6 |
| Slope classes 3, 4 & 5 (>5‰) | 1 | 2-4 | ≥5 |
| Typical species value (MANTYP) | | | |
| Slope class 1 | <1.44 | 1.44-2.88 | >2.88 |
| Slope class 2 | <1.49 | 1.49-2.97 | >2.97 |
| Slope class 3 (>5-8‰) | <1.57 | 1.57-3.13 | >3.13 |
| Slope class 4 (>8-12.5‰) | <1.69 | 1.69-3.37 | >3.37 |
| Slope class 5 (>12.5‰) | <1.85 | 1.85-3.69 | >3.69 |
| Shannon-Wiener diversity index evenness (MANSWI) | <0.53 | 0.53-0.68 | >0.68 |
| Migrating species value (MANMIGV) | <2 | 2-4 | >4 |
| **Fish condition and abundance** | | | |
| Biomass (kg/ha) (MANBIOM) | | | |
| Slope class 1 | ≤130 | 130.1-250 | >250 |
| Slope class 2 | ≤80 | 80.1-150 | >150 |
| Slope class 3 | ≤46 | 46.1-100 | >100 |
| Slope classes 4 & 5 | ≤30 | 30.1-60 | >60 |
| Length classes value (MANCV) | <2 | 2-3.99 | 4-5 |
| **Trophic composition and habitat use** | | | |
| % invertivorous individuals (MPIINVT) | <26 | 26-45 | >45 |

| | | | |
|---|---|---|---|
| Lowland Group report | | | |
| Number of benthic species (MNSBEN) | 1 | 2-3 | >3 |
| % specialised spawners (individuals) (MPSSP) | | | |
| Slope class 1 | <8 | 8-15.9 | ≥16 |
| Slope class 2 | <10 | 10-20.9 | ≥21 |
| Slope class 3 | <12 | 12-30.9 | ≥31 |
| Slope class 4 | <24 | 24-47.9 | ≥48 |
| Slope class 5 | <35 | 35-69.9 | ≥70 |

The final appreciation is the IBI score (sum of metric scores) and is translated to an EQR ranging between 0 and 1. This holds for all river types and allocated IBI's.

*Table 5.* IBI score ranges and their appreciation, integrity classes, the colour code and EQR threshold values according to the WFD (EU Water Framework Directive, 2000).

| IBI score ranges | IBI appreciation | Integrity class = WFD quality classes | WFD colour code | EQR |
|---|---|---|---|---|
| >4.5-5 | Excellent | Very good | Blue | >0.8 |
| >4-4.5 | Very good | Good | Green | ≤0.8 |
| >3.5-4 | Good | | | |
| >3-3.5 | Fair | Fair | Yellow | ≤0.6 |
| >2.5-3 | Critical | | | |
| >2-2.5 | Critical-bad | Poor | Orange | ≤0.4 |
| >1.5-2 | Bad | | | |
| 1-1.5 | Very bad | | | |
| 0 | dead | Bad | Red | ≤0.2 |

A formula is applied to change the IBI values (unequal intervals) to EQR values with equal intervals.

## Description of the Dutch method for small and medium-sized rivers

Reference conditions and metrics for fish in The Netherlands were developed more or less simultaneously with the FAME project. In 2005 a validation exercise was conducted using FIDES (the FAME database). Rijkswaterstaat and STOWA (Dutch governemental organizations) gave commission to develop the references and metrics and the results are thus officially accepted. At this moment a draft report describes the references and metrics for the biological quality elements, including fish. The references and metrics for fish in small and medium-sized rivers will not change anymore and become finalized in the second half of 2007.
The general approach for the development of references is based on ecological guilds. The guilds used comprise degree of rheophily, migration and sensitivity to habitat degradation. For each guild a reference for species composition and abundance have been developed, resulting in the following metrics:

- Number of characteristic rheophilic species
- Number of characteristic eurytopic species
- Number of characteristic species that migrate regionally or to the sea
- Number of characteristic species sensitive to habitat destruction
- Relative abundance (%) of rheophilic species
- Relative abundance (%) of eurytopic species
- Relative abundance (%) of species that migrate regionally or to the sea
- Relative abundance (%) of species sensitive to habitat destruction

The references and metrics for species composition have been based on characteristic species. These species are considered to be characteristic for a particular river type.

On each metric the minimum score is 0 and the maximum score is 1. To determine the final result (index value) the scores for species composition and abundance are calculated separately as follows:

Score = [(rheophilic + eurytopic)/2 + (migration regional/sea) + (habitat sensitive)]/3

Subsequently the arithmetic mean of the score for species compositon and abundance gives the index value:

Index value = (score species composition + score abundance)/2

The index values correspond to the following ecological classes:

| | |
|---|---|
| 0-0,2 | Bad |
| 0,2-0,4 | Poor |
| 0,4-0,6 | Moderate |
| 0,6-0,8 | Good |
| 0,8-1 | High |

More information about the Dutch Fish Index can be found in "Description of references and metrics for fish in rivers in the Netherlands" (Buijse & Beers, 2006) which is published on JRC-EEWAI INTERCALIBRATION CIRCA FORUM.

*Description of the FIBS and the criteria for selection of reference sites in Germany can be found in the report of the Alpine Group*

## Netherlands reference criteria for fish in rivers

**By A.D. Buijse**

### GENERAL COMMENTS

There is no agreement on reference criteria in the Netherlands. The reason for that is there are no water bodies in an undisturbed state in the Netherlands. The quantification of reference conditions is thus based on a combination of historical data, descriptions of undisturbed conditions in and outside the Netherlands, models and expert judgment. The approach is in accordance with the EU guidance (REFCOND Guidance, 2003; Guidance on Ecological Classification, 2003).

The class boundaries are as much as possible based on ecological relevant boundaries i.e. transitions in fish community composition. The European dataset in FIDES has been used to validate the Netherlands dataset to set the class boundaries for small- and medium-size rivers. Occasionally expert judgment is applied to adjust the class boundaries to the situation in the Netherlands.

## METHOD TO DERIVE THE FISH COMMUNITY UNDER REFERENCE CONDITIONS

The basis was formed by two earlier studies (De Nie & Vriese, 1999; 2001). The following sources have been used: the atlas for fish in the Netherlands (De Nie 1996), various databases, data from foreign rivers under reference conditions and Habitat Suitability Index models.

The following approach was applied. Average occurrence under present conditions has been calculated for the various river types. By doing so an impression was obtained of poor and good sites to gain inside what are the differences in fish communities under various conditions and what may be the explanation. Subsequently using expert judgement the reference fish community has been determined i.e. reference conditions are an extrapolation of the difference between best and worst sites in the Netherlands supported by data from other countries as well. For this type-specific species were identified. Finally per species a ‘chance of occurrence’ was calculated for these reference conditions. The ’chance of occurrence’ is % of sites where a species should be recorded under reference conditions.

Per type of river type-specific species were identified. This is a subset of the whole fish community. Very rare species or species difficult to sample were not included to make the method more robust. Those list of type-specific species are relevant where it concerns the species composition i.e. there is a limited list of species used to judge the species composition. For abundance all species are considered though, but they are grouped within guilds (e.g. rheophilic, eurytopic). The description in the WFD at high status ‘all type-specific species sensitive for disturbance are present’ has been used to define the class ‘high’.

In addition the ‘chance of occurrence’ has been used to relate this to abundance acknowledging the fact there is a non-linear relationship between them.

| Abundance | Chance of occurrence |
|---|---|
| < 1% | 0,05 |
| 1-3% | 0,25 |
| 3-10% | 0,50 |
| 10-50% | 0,60 |

*Class boundaries*

To set the class boundaries expert judgement has been used taking account of the WFD requirements. In addition examples of IBI for fish in running waters have been consulted (e.g. Schmutz et al., 2000; Oberdorff et al., 2001; 2002). Regarding species richness as well as abundance the change is more or less linearly distributed over the classes while acknowledging that sensitive species disappear more rapidly than tolerant species.

## REFERENCE SITES FOR MACROINVERTEBRATES

As an example for the lack of reference sites the earlier work for intercalibration benthic invertebrates in running waters is here briefly summarised. Within the CB –GIG reference criteria has been applied to select reference sites for benthic invertebrates in rivers. This has resulted in the selection of only one stream (Hierdensche Beek) in the Netherlands (source: Rijkswaterstaat – Riza, 2006).

"Reference sites have been identified from sites with high ecological quality (WFDi-class 'high') according to the criteria defined by Wasson (April, 2006). Most of the Dutch waters could not meet these requirements as most of them have been hydromorphologically altered and do not correspond with the conditions set for nitrogen and phosphate. The selection criteria for the Dutch reference waters implied that the land use of the drainage basin meets: nature for at least 50% of the catchment, less than 4% urban area, less than 15 kilogram nitrogen per hectare, nor 1 kilogram phosphate per hectare in the catchment. The criteria for water chemistry are summarized in table 2. Furthermore, a reference site may not contain point sources and may not be hydromorphologically altered. Recreation or bio-manipulation must be restricted to a minimum. The stream Hierdensche beek is the only stream that meets all criteria set for a reference site."

## FOLLOW-UP

We may debate reference criteria, but the outcome of every choice will be that there are no or perhaps a very restricted number of reference sites in the Netherlands. The number will always remain too low to yield reliable results. We therefore advocate to use pair-wise comparisons with methods from neighbouring countries that do have reference sites or to use common metrics that do have a statistically sound basis to intercalibrate our national method with those of other EU member states. The first exercise within the lowland group has yielded promising results so far.

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## Description of the Lithuanian method

*Lithuania did not participate in the IC-exercise directly in any groups, but the Lithuanian method was used with data from the common database, so the description of the method and setting of reference criteria is presented here.*

## LTV (LZI) method

This method assesses deviation of metrics of specific ecological guilds and sentinel species from reference conditions. Classification of fish species to guilds is presented in Table 1. The list of metrics and their class boundaries for different fish types and their ecological status classes is presented in Table 2, fish-based typology of rivers is given in Table 3.

Table 1. Fish species and guilds in the rivers of Lithuania

| Species | Tolerance | Habitat_feeding | Habitat_rheo | Reproduction | Feeding | Migration | Longevity |
|---|---|---|---|---|---|---|---|
| Abramis brama | TOLE | B | EURY | | OMNI | POTAD | LL |
| Acipenser sturio | | B | RH | LITH | OMNI | LONG | LL |
| Alburnoides bipunctatus | INTOL | WC | RH | LITH | INSV | | SL |
| Alburnus alburnus | TOLE | WC | EURY | | OMNI | | SL |
| Alosa alosa | INTOL | WC | RH | | | LONG | |
| Alosa fallax | | WC | RH | | | LONG | LL |
| Anguilla anguilla | TOLE | B | EURY | | | LONG | |
| Aspius aspius | | WC | EURY | LITH | PISC | POTAD | |
| Barbatula barbatula | | B | RH | LITH | | | |
| Barbus barbus | | B | RH | LITH | | POTAD | LL |
| Blicca bjoerkna | TOLE | B | EURY | | OMNI | | |
| Carassius carassius | TOLE | B | LI | PHYT | OMNI | | |
| Carassius gibelio | TOLE | B | EURY | PHYT | OMNI | | LL |
| Chondrostoma nasus | | B | RH | LITH | | POTAD | |
| Cobitis taenia | | B | EURY | PHYT | | | SL |
| Cottus gobio | INTOL | B | RH | LITH | INSV | | SL |
| Cyprinus carpio | TOLE | B | EURY | PHYT | OMNI | | LL |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Esox lucius | | WC | EURY | PHYT | PISC | | LL |
| Gasterosteus aculeatus | TOLE | WC | EURY | | OMNI | | SL |
| Gobio gobio | | B | RH | | | | SL |
| Gymnocephalus cernuus | | B | EURY | | | | |
| Lampetra fluviatilis | INTOL | B | RH | LITH | | LONG | |
| Lampetra planeri | INTOL | B | RH | LITH | | POTAD | |
| Leucaspius delineatus | | WC | LI | PHYT | OMNI | | SL |
| Leuciscus cephalus | | WC | RH | LITH | OMNI | POTAD | |
| Leuciscus idus | | WC | RH | | OMNI | POTAD | |
| Leuciscus leuciscus | | WC | RH | LITH | OMNI | | |
| Lota lota | | B | EURY | LITH | PISC | POTAD | LL |
| Misgurnus fossilis | | B | LI | PHYT | | | |
| Perca fluviatilis | TOLE | WC | EURY | | | | |
| Perccottus glenii | | | LI | | OMNI | | |
| Petromyzon marinus | INTOL | B | RH | LITH | | LONG | |
| Phoxinus phoxinus | | WC | RH | LITH | | | SL |
| Pungitius pungitius | TOLE | WC | LI | | OMNI | | SL |
| Rhodeus sericeus | INTOL | WC | LI | | | | SL |
| Rutilus rutilus | TOLE | WC | EURY | | OMNI | | |
| Sabanejewia aurata | | B | LI | PHYT | OMNI | | |
| Salmo salar | INTOL | WC | RH | LITH | INSV | LONG | |
| Salmo trutta | INTOL | WC | RH | LITH | INSV | LONG | |
| Salmo trutta fario | INTOL | WC | RH | LITH | INSV | POTAD | |
| Sander lucioperca | | WC | EURY | | PISC | | LL |
| Scardinius erythrophthalmus | | WC | LI | PHYT | OMNI | | |
| Silurus glanis | | B | EURY | PHYT | PISC | | LL |
| Thymallus thymallus | INTOL | WC | RH | LITH | INSV | POTAD | |
| Tinca tinca | TOLE | B | LI | PHYT | OMNI | | LL |
| Vimba vimba | | B | RH | LITH | | POTAD | |

Table 2. The list of metrics and their class boundaries for different fish types and their ecological status classes (Perc.n - % of abundance, Perc.kg - % of biomass, Perc.sp. - % of number of species, N.sp.Mi.long – number of long distance migrating species)

| | | Ecological status classes | | | | |
|---|---|---|---|---|---|---|
| Fish metrics | Fish types | 1(high) | 2(good) | 3(moderate) | 4(poor) | 5(bad) |
| Perc.n.LITH | 1, 2 | >81 | 81-48 | 48-10 | <10 | 0 |
| | 3 | >78 | 78-46 | 46-9 | <9 | 0 |
| | 6 | >48 | 48-28 | 28-6 | <6 | 0 |
| | 4 | >50 | 50-29 | 29-9 | <9 | 0 |
| | 5 | >46 | >27 | >5 | <5 | 0 |
| Perc.kg.LITH | 1 | >85 | 85-50 | 50-10 | <10 | 0 |
| | 2, 3 | >79 | 79-47 | 47-9 | <9 | 0 |
| | 4 | >50 | 50-30 | 30-6 | <6 | 0 |
| | 6 | >48 | 48-28 | 28-6 | <6 | 0 |
| | 5 | >22 | >13 | >3 | <3 | 0 |
| Perc.n.TOLE | 1, 2, 3 | <10 | 10-31 | 31-60 | >60 | 100 |
| | 4, 6 | <35 | 35-50 | 50-71 | >71 | 100 |
| | 5 | <48 | 48-60 | 60-77 | >77 | 100 |
| Perc.kg.TOLE | 1-3 | <11 | 11-31 | 31-60 | >60 | 100 |
| | 4-6 | <35 | <50 | <71 | >71 | 100 |
| Perc.n.INSEV | 1 | >58 | 58-34 | 34-7 | <7 | 0 |
| | 2 | >43 | 43-25 | 25-5 | <5 | 0 |
| | 3 | >29 | 29-17 | 17-3 | <3 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 4-6 | >21 | 21-12 | 12-3 | <3 | 0 |
| | 2 | >67 | 67-51 | 51-27 | <27 | 0 |
| Perc.sp.LITH | 3 | >62 | 62-48 | 48-26 | <26 | 0 |
| | 4, 6 | >51 | 51-39 | 39-21 | <21 | 0 |
| | 5 | >41 | 41-28 | 28-16 | <16 | 0 |
| Perc.sp.EURY | 2, 3 | <24 | 24-41 | 41-66 | >66 | 100 |
| | 4 | <46 | 46-58 | 58-76 | >76 | 100 |
| Perc.sp.OMNI | 5, 6 | <38 | 38-52 | 52-72 | >72 | 100 |
| | 1 | >31 | <31 | 0 | | |
| Perc.n.*Salmo_trutta* | 2 | >21 | <21 | 0 | | |
| | 3 | >7 | <7 | 0 | | |
| | 2, 3 | >13 | 13-3 | <3 | 0 | |
| Perc.n.*Cottus_gobio* | 4 | >8 | 8-2 | <2 | 0 | |
| | 6 | >7 | 7-1 | <1 | 0 | |
| Perc.n.*Alburnoides_ bipunctatus* | 5, 6 | 9 | 9-2 | <2 | 0 | |
| N.sp.Mi.long | 3, 4 | 2 | 1 | 0 | | |
| | 6 | 4 | 2 | 1 | 0 | |

Table 3. Physiographic variables representing the fish community types (CS – catchment size, $km^2$; SLO – gradient slope, m/km)

| | Fish types | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| CS | < 50 | 50-100 | 100-600 | 100-600 | 100-600 | 600-5000 | >5000 |
| SLO | - | - | >1,1 | 1,1-0,6 | <0,6 | - | - |

Method assesses fish status on 1(high)-5(bad) scale. The final status class is calculated as average of sum of status classes of all fish metrics status. The range of average score per status class is as follows:

< 1.1 – high
1.1-2 – good
2.1-3 – moderate
3.1-4 – poor
> 4 – bad

## *Criteria for the selection of Reference stations for rivers in Lithuania*

**Procedure:**

1. Pre selection of reference sites in the rivers was based mainly on fish metrics. It was not possible to apply other biotic quality elements due to natural absence of macrophytes in some small river types, not enough data on macrophytes, and in some cases because of unexplained variation of Danish stresam fauna index for macroinvertebrates.

2. Selection of reference sites was based on fish metrics that form the newly established Lithuanian Fish index. The index encompasses the fish metrics that have shown to correlate well with chemical parameters from the Lithuanian dataset. Only those stations have been selected where chemical parameters are monitored monthly (12 times per year).

3. From the preselected possible High/Good status sites, those sites with fish metrics >75% (<25% for metrics, ascending with degradation) of total variance were selected as potential reference sites. 75-th and 25-th (for ascending fish metrics) percentiles derived from the data of reference sites were selected as thresholds, indicating high status (potentially reference status).

4. All river sites with absolute majority of fish metrics indicating high status were selected as final reference sites (for both fish metrics and water quality elements).

6. The average values of corresponding water quality elements, calculated at step 4 of following procedure appeared to be almost identical to those, identified by Central-Baltic GIG intercalibration group as “no effect thresholds” for benthic invertebrates. Therefore, we came to conclusion that our methods for reference sites selection seems to be correct.

# Annex VI: Report from the Mediterranean Group

EUROPEAN COMMISSION
DIRECTORATE GENERAL JRC
JOINT RESEARCH CENTRE
Institute of Environment and Sustainability

Report – River Fish Groups

| GIG | FISH- REGIONAL GROUP "MEDITERRANEAN" |
|---|---|
| Information provided by | Nuno CAIOLA (Spain), Frederic CASALS (Spain), Michele SCARDI (Italy), Adolf de SOSTOA (Spain), Lorenzo TANCIONI (Italy), Joao Manuel BERNADO (Portugal) |

**A – General approach**

1. Describe the common intercalibration types, specifying the countries participating for each type and the biological quality elements/ pressures that are intercalibrated (update 'types manual' tables

**River types:**
SPAIN - Catalonia
**Low Mediterranean Mountain**: Low to medium altitude (up to 500 m); Wide range of temperatures; Low / medium gradient; Low complexity; Some water deficit.
**Humid Mediterranean Mountain**: Medium / high altitude (up to 900 m); Relatively low temperatures; High slope; Low complexity; Permanent rivers; Low water deficit.
**Littoral rivers**: Low altitude; High temperatures; Low gradient; Low order; Intermittent rivers; Close to mouth.
**Ebro Main Rivers**: Low to medium altitude; Wide range of temperatures; Low slope; Complex rivers; Permanent rivers.
**High Mountain:** High Altitude (more than 900 m); Low temperatures; High slope; Low order; Permanent rivers; Close to source.

ITALY - Latium
No river types

FRANCE – Mediterranean region
No river types

PORTUGAL - groups of river types with fish index:

NE medium, low to medium altitude,
South, small, low altitude, temporary
South, medium, low altitude, temporary

**Biological quality element**: fish

5. Describe the general intercalibration approach
   - Approach for comparison (e.g. ICMi using common reference criteria), including statistical procedures
   - Approach for harmonisation (if applicable, e.g. use of common benchmark)

Specify which data was used to set the boundaries applying the BSP (e.g. common benchmark data [option 2], all MS data [option 3]

Data availability for the different assessment methods:

France: IPR and EFI (99 sites)

Italy: FIDESS (72 sites), EFI (72 sites)
and IBICAT (20 sites).

Spain: IBICAT, EFI and IPR (268 sites).

Portugal: PoFI (34 sites)

3. Identify the national methods that were intercalibrated (for all countries, if available); provide detailed description in Annex A

**IBICAT Catalan Index of Biotic Integrity:** Catalonia (Spain)

**FIDESS Fish Decission Support System:** Latium (Italy)

**IPR or FBI French Fish Based Index:** Mediterranean basin (France)

**PoFI Portuguese Fish Index**: Portugal

The above methods are officially accepted methods in their respective countries.

**EFI – EUROPEAN FISH INDEX** common method, used for all data

**B – Setting of Reference conditions**

Summarize the common approach for setting of reference conditions. Give a more detailed description of procedure and criteria, and identify reference sites for each country and type according to those criteria in Annex B

| |
|---|
| No common approach. |

| **C – Setting of Boundaries** |
|---|
| 4. Summarize how boundaries were set following the framework of the BSP for the HG and GM boundaries, demonstrating that this was done in accordance to WFD Annex V, normative definitions<br>a. For the benchmark (if applicable)<br>b. For the national methods (obligatory if no benchmark is used; also recommended if benchmark is used);<br>Provide a description of the full procedure in Annex C |
| No results. |

| **D – Results of comparison and harmonisation of boundaries between countries** |
|---|
| 1. Present the results of the comparison demonstrating comparability of class boundaries between the countries within the GIG for all types (if applicable) |
| Not applicable. |

| **E – Boundary EQR values** |
|---|
| Provide a table with HG and GM boundary EQR values for the national methods and the common metrics (where applicable) for each type as a table |
| Not available. |

| **F – Indicative work plan for the continuation of the intercalibration** |
|---|
| Indicate plans and appropriate timing for continuation of the intercalibration for types and quality elements not currently included |
| Strategy for the next 2 years<br><br>Spain, Italy and France are developing new versions of the indices. In the case of IBICAT (Spain) the following aspects will be considered in order to improve the |

method accuracy:
- to establish standard and more accurate procedures and criteria for the sites' pre-classification (impact variables) with special emphasis on the GM boundary;
- to test new fish based metrics;
- to enlarge the area of application for the local indices (IBICAT and FIDESS).

Portugal has recently developed an official fish index (PoFI) and intends to explore, for some particular subtypes, the relation of this index with IBICAT though no river types from Portugal and Spain-Catalonia match. Some outputs from EFI+ may possibly be usefull in a future stage of the intercalibration.

Although no resources from the MS are expected for IC during next years, regarding the high correlations found in the pilot IC exercise between the Spanish and Italian methods, both teams agreed in carrying out a more detailed IC exercise. This will be performed throughout complementary research actions, at least in the first phase of the IC process. Future work will be focused in gather a larger data set, establish common criteria for the pre-classification boundaries and developing a common strategy for Mediterranean rivers by means of the development of a common method or set of methods.

There is no perspective for the current EFI to work in the Mediterranean region.

The future Mediterranean Group could consist of the following countries:
Spain (Catalonia), Italy, France and Portugal.

**E – Comments and remarks**

- All the applied methods in the Mediterranean region must be related to the local fish fauna (WFD: Water district concept)
- At least at this moment, there are no possibilities to intercalibrate methods or to search common metrics
- The proposal is to work about impact evaluating criteria (preclassification)

The method must be used as benchmark (as diagnostic tool) and the final judgement should be issued by experts

**Annexes**

**Annex A – Description of national classification methods included in the intercalibration; please provide the reference to the method, the status of the method (officially accepted, finalized, under development), describe the metrics and approach.**

**A.1. IBICAT**
**A.2. FIDESS**

**Annex B – Reference criteria and reference sites**
**B.1. Catalonia – Spain**
**B.2. Italy**

**Annex C – First results of the pilot exercise.**

## Introduction

Three countries were involved in the Mediterranean group with data sets corresponding to: the Mediterranean basin of France, the Latium region of Italy and all rivers of Catalonia in Spain.

Four fish-based methods were compared: three national methods from France (IPR Indice Poissons rivières), Italy (FIDESS Fish-based Decision Support System) and Spain-Catalonia (IBICAT Index of Biotic Integrity of Catalonia) and the European Fish Index (EFI). The complete data set was distributed in the countries involved in the Mediterranean group: France: IPR and EFI (99 sites); Italy: FIDESS (72 sites), EFI (72 sites) and IBICAT (20 sites); Spain: IBICAT, EFI and IPR (268 sites); Portugal: PoFI (34 sites).

The fish fauna in Mediterranean rivers considered by the different indices was composed by a total of 85 species (Table 1). However, some of these species are not taken into account by the European Fish Index (only 75 are listed by EFI). It is important to mention that very few species are present in two or more countries. Many of those species are exotic for the original fauna, especially in Catalonia and Italy.

| Species | Catalonia | France | Italy | Portugal |
|---|---|---|---|---|
| *Total* | 37 | 28 | 41 | 34 |
| *Introduced* | 16 | 4 | 13 | 7 |
| *Native* | 21 | 24 | 28 | 27 |
| | | | | |
| Catalonia | | 16 (6/12) | 20 (8/8) | 13 (7/8) |
| France | | | 14 (11/3) | 6 (3/2) |
| Italy | | | | 11 (4/5) |

**Table 1. Fish fauna in Mediterranean rivers. Above, total number of introduced and native species. Below, number of shared species considered by the different applied indexes (in brackets, native and introduced species).**

**National methods**

France uses the IPR (Indice Poissons Rivières), a method developed by Oberdorff and col. within a national program between 1995 and 2000, and normalised in 2004 (AFNOR). It is a modelling approach that measures the deviation from the reference conditions. It is based on the use of seven metrics that are sensitive to human pressures and reflects species composition, trophic structure and species abundance (Figure 1).

The theoretical values of each metric is calculated from a combination of environmental characteristics, similar to those used for the EFI, and known as the factors controlling fish community structure. The result for each metric is expressed as the probability for the observed value to belong to the set of reference values. The final index is the sum of the probabilities of each metric. It ranges from 0 for reference sites to 100 and more for the most degraded sites.

**Indice poissons rivières (IPR) (NF T90-344)**

Outil de calcul de l'IPR - version 1.3 (Avril 2006)

Conseil Supérieur de la Pêche
Protection des milieux aquatiques

**Paramètres "milieux" utilisées dans le calcul :**

| Intitulé de la variable | Unité | Abréviation |
|---|---|---|
| Surface échantillonnée | m2 | SUF |
| Surface du bassin versant drainé | km2 | SBV |
| Distance à la source | km | DS |
| Largeur moyenne en eau de la station | m | LAR |
| Pente du cours d'eau | ‰ | PEN |
| Profondeur moyenne de la station | m | PROF |
| Altitude | m | ALT |
| Température moyenne inter-annuelle de l'air du mois de juillet | °C | $T_{JUILLET}$ |
| Température moyenne inter-annuelle de l'air du mois de janvier | °C | $T_{JANVIER}$ |
| Unité Hydrologique (8 modalités) | | UH |

| Modalités | Abréviation |
|---|---|
| Bassins Nord | NORD |
| Bassin Seine | SEINE |
| Bassins Manche | MANC |
| Bassins Atlantique | ATLA |
| Bassin Loire | LOIR |
| Bassin Garonne | GARO |
| Bassin Rhône | RHON |
| Bassins Méditerranée | MEDI |

**Abréviations utilisées pour les différentes métriques :**

| Métrique | Abréviation |
|---|---|
| Nombre total d'espèces | NTE |
| Nombre d'espèces rhéophiles | NER |
| Nombre d'espèces lithophiles | NEL |
| Densité d'individus tolérants | DIT |
| Densité d'individus invertivores | DII |
| Densité d'individus omnivores | DIO |
| Densité totale d'individus | DTI |

**Figure 1. Parameters and metrics used by the calculation programme for IPR.**

Portugal developed very recently a new official index, PoFI (Portuguese Fish Index). This index is multimetric and includes 5 or 6 metrics for 3 groups of river types. It does not apply in the following situations: < 30 km2 of drainage area, average depth < 0.2m, total density < 15ind/100m2. The index is calculated as follows:

A. Each metric scores *X* from 0 (minimum, high degradation) to 10 (maximum, low degradation).

B. Standardisation: the value for each metric (*Ms*) is calculated as

Ms = 10 x (*X* - Lim inf) / (Lim sup - Lim inf)

For the metrics decreasing with degradation, Lim sup = 50 %ile of reference sites and Lim inf = 5%ile of non-reference sites; for the metrics increasing with degradation, Lim sup = 50 %ile of reference sites and Lim inf = 90 %ile of non-reference sites.

C. PoFI = $(\sum Ms \times 10) / N$, where *Ms* is the value for each metric and *N* is the number of metrics of the index. Metrics which are included in the multi-metric indexes were selected from a large list of metrics of all types based on the responsiveness to pressures. PoFI values range from 0 to 100 and are transformed to EQR dividing by the median value of the reference sites. Metrics for the 3 types are.

- NE type: % endemic species, % pelagics, % limnophilics, % tolerant species, density of *Chondrostoma duriensis* (sentinel species).
- South medium temporary: % limnophilics, % lithophilics, % generalists, % tolerant species, % endemic species, total density.
- South small temporary: % limnophilics, % lithophilics, % generalists, % tolerant species, density of *Squalius pyrenaicus* (sentinel species).

Boundaries are set according to the so called REFCOND method: H/G boundary is the

25th %ile of the reference samples and all the other boundaries result from splitting the remaining gradient into 4 equal width classes.
In the comparison of this method with others, methods from France and Italy were considered as non applicable because of their particular character. Regarding IBICAT, the types of Catalonia do not match the river types of Portugal and IBICAT includes metrics which were tested in the Portuguese rivers and did not respond.
The Italian index (FIDESS, a FIsh-based DEcision Support System) is based on a neural network, which was trained to associate expert judgments to environmental and fish assemblage data (Figure 2). At present, a first version is available, which is based on data from the Tevere River and other minor river basins from Central Italy. However, the same method can be easily retrained. Therefore, updated versions of FIDESS will be issued as soon as data from other Italian regions are available and, in general, the method will be updated on a routine basis. Environmental data and fish assemblage composition are considered as input for FIDESS, while the output is a consensus expert judgment, i.e. the best estimate for ecological status.
Fish assemblage composition is recorded as presence/absence fish species. Only those species that occurred in more than 5% of the records were explicitly considered, whereas the remaining species are only taken into account when computing the overall species richness. A new version, based on quantitative data (relative abundance of fish species), is currently under development. Expert judgment in FIDESS is referred to a global evaluation of the ecological status sampling sites, not just to an evaluation of the fish fauna composition.

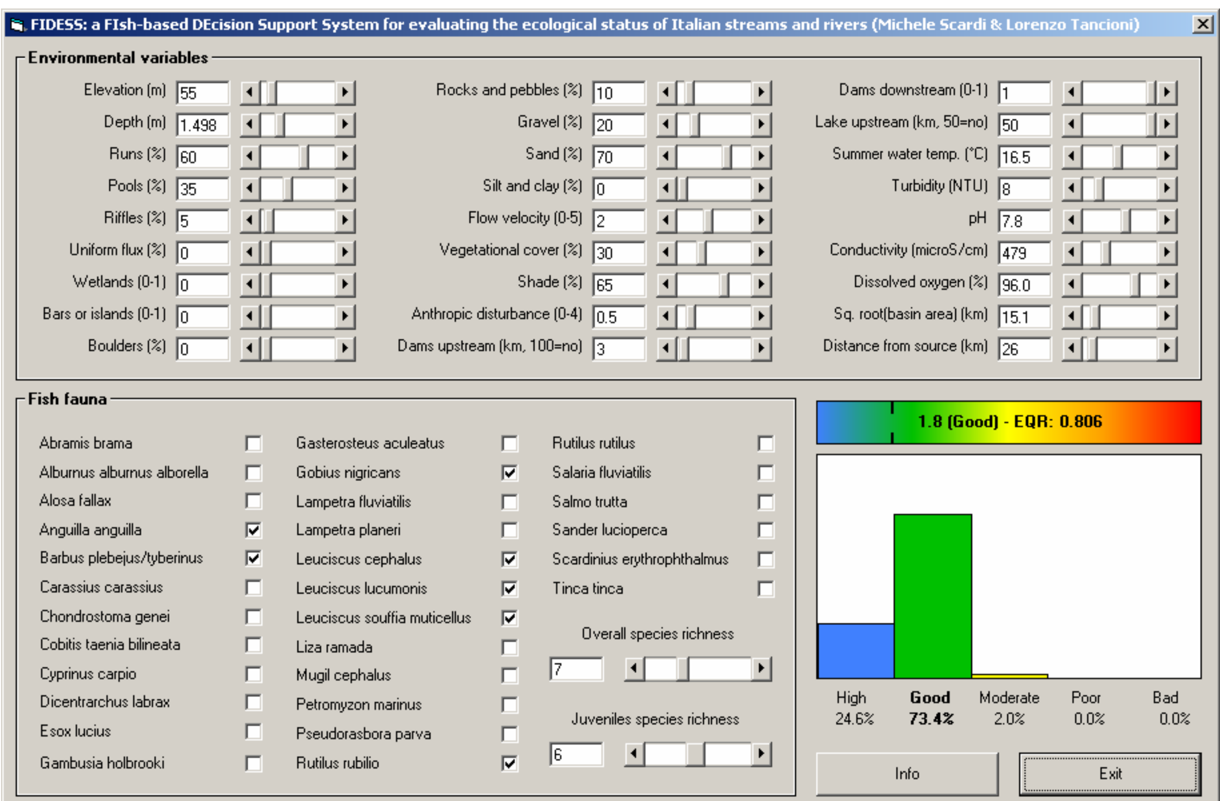



Figure 2. Input data (upper and lower-left panels) and output (lower-right panel) in FIDESS.

For the development of the IBICAT a spatially based approach was performed, that is to say, per river typology previously defined. The regionalization of rivers was performed based on the original geographical distribution of native fish species and its relationship with the environmental variables and as result 5 river types were established (Figure 3):

- Low Mediterranean Mountain: Low to medium altitude (up to 500 m); Wide range of temperatures; Low / medium gradient; Low complexity; Some water deficit.
- Humid Mediterranean Mountain: Medium / high altitude (up to 900 m); Relatively low temperatures; High slope; Low complexity; Permanent rivers; Low water deficit.
- Littoral rivers: Low altitude; High temperatures; Low gradient; Low order; Intermittent rivers; Close to mouth.
- Ebro Main Rivers: Low to medium altitude; Wide range of temperatures; Low slope; Complex rivers; Permanent rivers.
- High Mountain: High Altitude (more than 900 m); Low temperatures; High slope; Low order; Permanent rivers; Close to source.

A total of 528 potential metrics were proposed and tested, all of them fit in 8 categories (species composition; abundance; tolerance; habitat; reproduction; longevity; feeding; migration) describing the structural and functional species composition. After identify redundancy all the metrics with a clear response for the observed impacts. Since it was not possible to achieve good results with this approach, because the 5 impact classes were not represented in the dataset for each river type, a similar procedure was done for only impacted and non impacted sites. The IBICAT metrics for each river type are shown in Table 2.

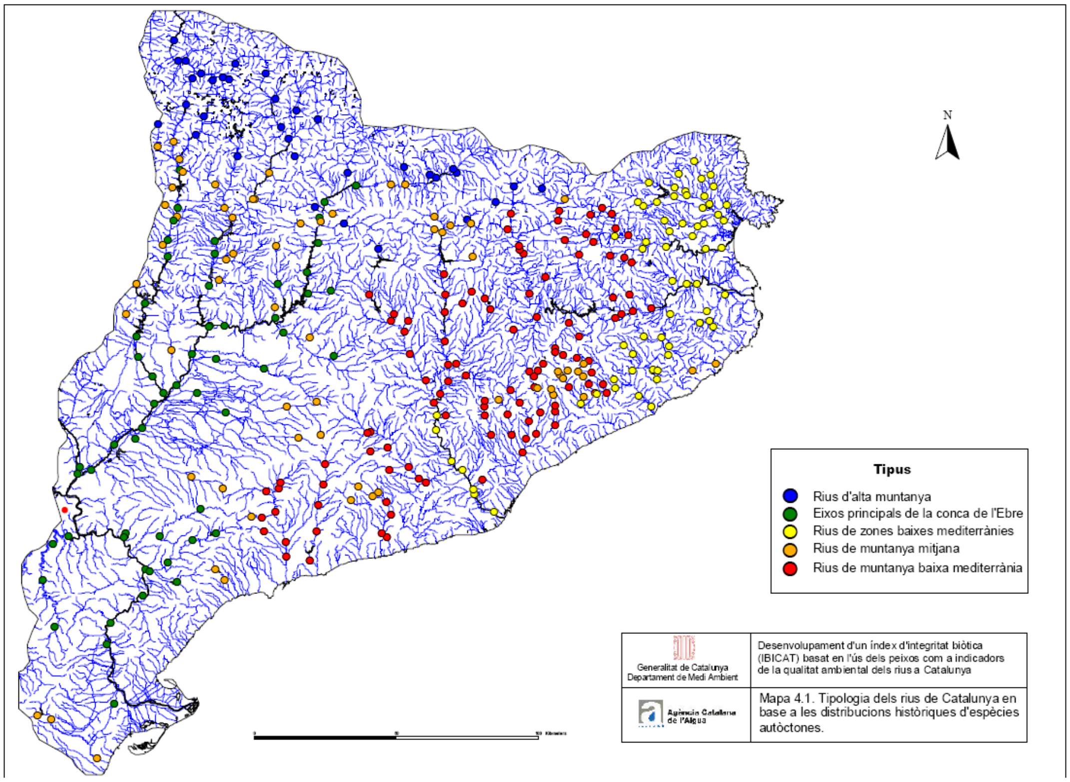



**Figure 3. River typology proposed by IBICAT.**

Table 2. Metrics and scores for the calculation of the IBICAT for the five river types.

| River Type | Metric | Score 1 | 3 | 5 |
|---|---|---|---|---|
| 1 | Nr. native species | 0 | 1 | >1 |
| | Nr. native insectivore species | 0 | 1 | >1 |
| | Density of intolerant natives (ind/ha) | 0 | <1500 | ≥1500 |
| 2 | % of native species | <20 | 20-80 | >80 |
| | % of intolerant species | <50 | 50-80 | >80 |
| 3 | % of native species | <40 | 40-80 | >80 |
| | % of density of insectivores (ind/ha) | <40 | 40-80 | >80 |
| | % of historical species present | <0.3 | 0.3-0.6 | >0.6 |
| 4 | Nr. native tolerant species | 0 | 1 | >1 |
| | Density of long lived natives (ind/ha) | <250 | 250-1750 | >1750 |
| | Density of introduced lithophilics (ind/ha) | <1000 | 1000-3000 | >3000 |
| 5 | Total density (ind/ha) | <400 | 400-1200 | >1200 |

1) “Low Mediterranean mountain”

2) “Humid Mediterranean mountain”

3) “Littoral streams”

4) “Ebro main rivers”

5) “High mountain”

Table 2. Metrics for the different river types applied by IBICAT.

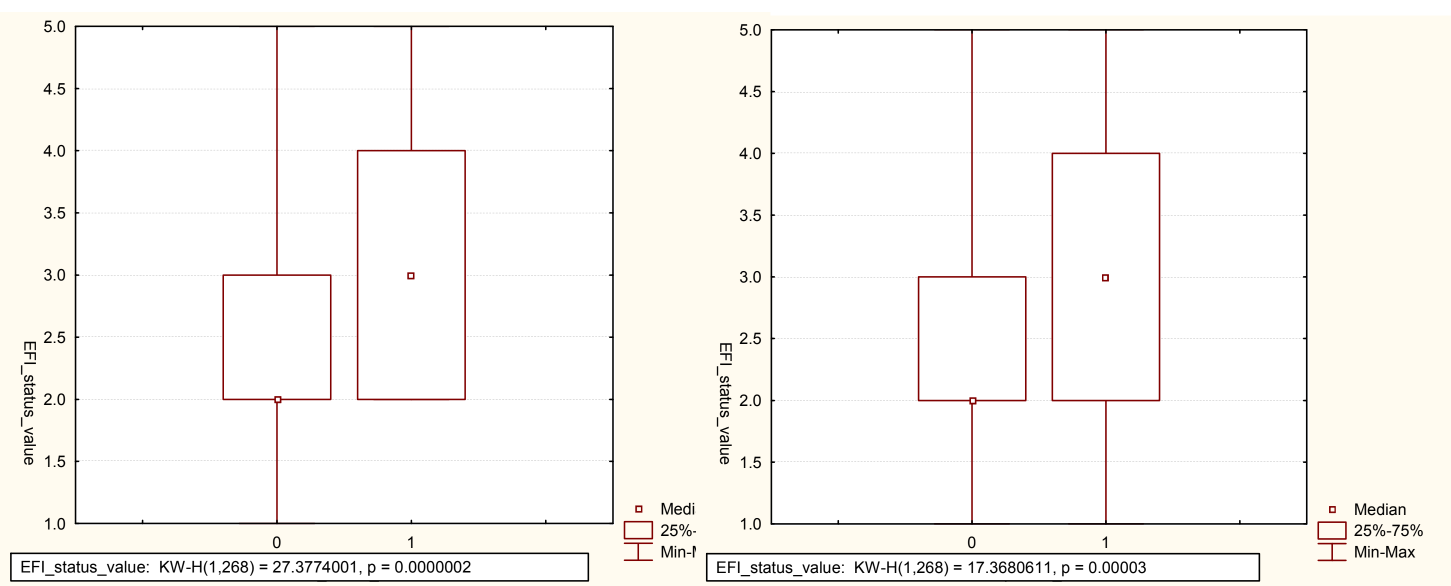
**Catalonia - Spain**

Due to the structure of the dataset, using the first version of IBICAT it is only possible to classify rivers' ecological status in 2 categories: Impacted (High and Good DMA status) and Non impacted (Moderate, Poor and Bad). A comparison between pre-classification of sites by human impact and IBICAT score of more than 300 sites is shown in figure 4, with a significant discrimination for the two considered categories. The overall agreement is highly good, with 57% of the Non impacted sites and 80% of the reference sites classified as the same status for IBICAT and considering the observed human impact. The percentage of classification agreement changes between the considered rivers types and being the best agreement in Humid Mediterranean Mountain rivers with 81% for Non impacted sites and in Ebro Main Rivers and High Mountain rivers with 89% for reference sites.

| | Estacions | Referència | No impactades | Validació | Referència | No Impactades |
|---|---|---|---|---|---|---|
| Tipus 1 | 120 | 87% | 45% | 10 | 80% | 60% |
| Tipus 2 | 47 | 45% | 81% | 10 | 40% | 80% |
| Tipus 3 | 69 | 84% | 55% | 10 | 90% | 30% |
| Tipus 4 | 44 | 89% | 68% | 10 | 90% | 70% |
| Tipus 5 | 37 | 89% | 59% | 10 | 90% | 70% |
| Total | 317 | 80% | 57% | 50 | 78% | 62% |

**Figure 4. Box-plots of the values of IBICAT (0=Non impacted and 1=Impacted) versus the mean human impact (Non impacted=1 and 2 and Impacted=3 to 5). In the table (left), percentage of well classification of reference and non impacted sites applying IBICAT at different river types.**

The European Fish Index (EFI) gives significant different status for sites classified as Impacted and Non impacted by IBICAT (Figure 5), but has no discrimination for the boundary between those categories, i.e. between Good and Moderate. In the same way, EFI scores increases in relation to high human impacts, but with no clear separation for the five WFD classes.



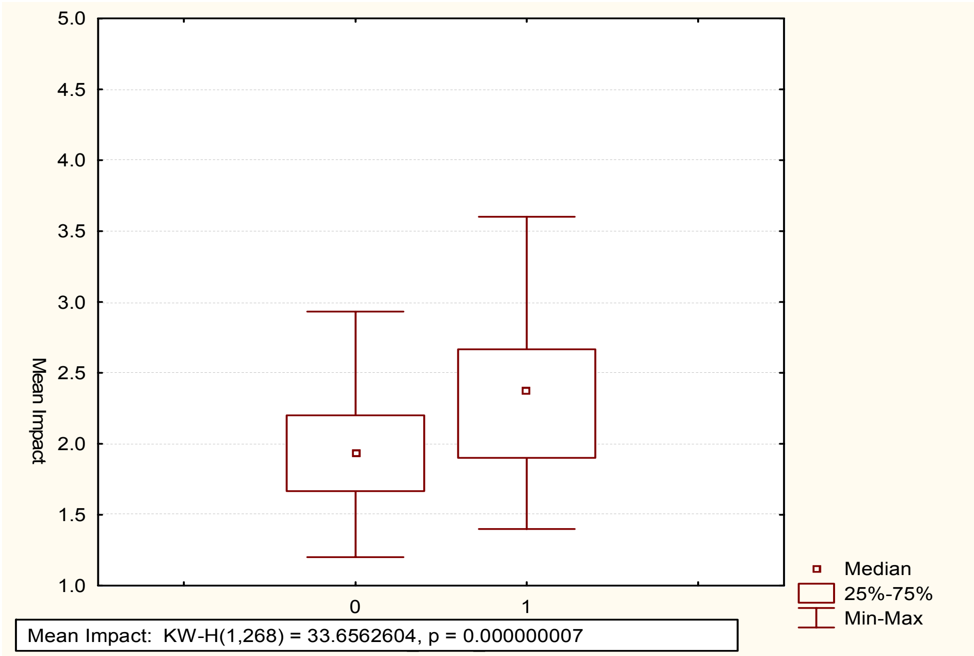



**Figure 5. Box-plots of the values of IBICAT (0=Non impacted and 1=Impacted) versus EFI scores (1=Very good to 5=Very bad), left; and EFI (0=High and Good and 1=Moderate, Poor and Bad) versus the mean human impact (Non impacted=1 and 2 and Impacted=3 to 5), right.**

There is no significant difference in the values of IPR for the classified Impacted and Non impacted sites by IBICAT, giving similar status for all sites (Figure 6). The main reason seems to be related to fish community composition. The expected values for the total number of fish species of IPR model is more than the double of the fish species present at our sites. The French index is not sensitive to the human impact observed during the preclassification process.

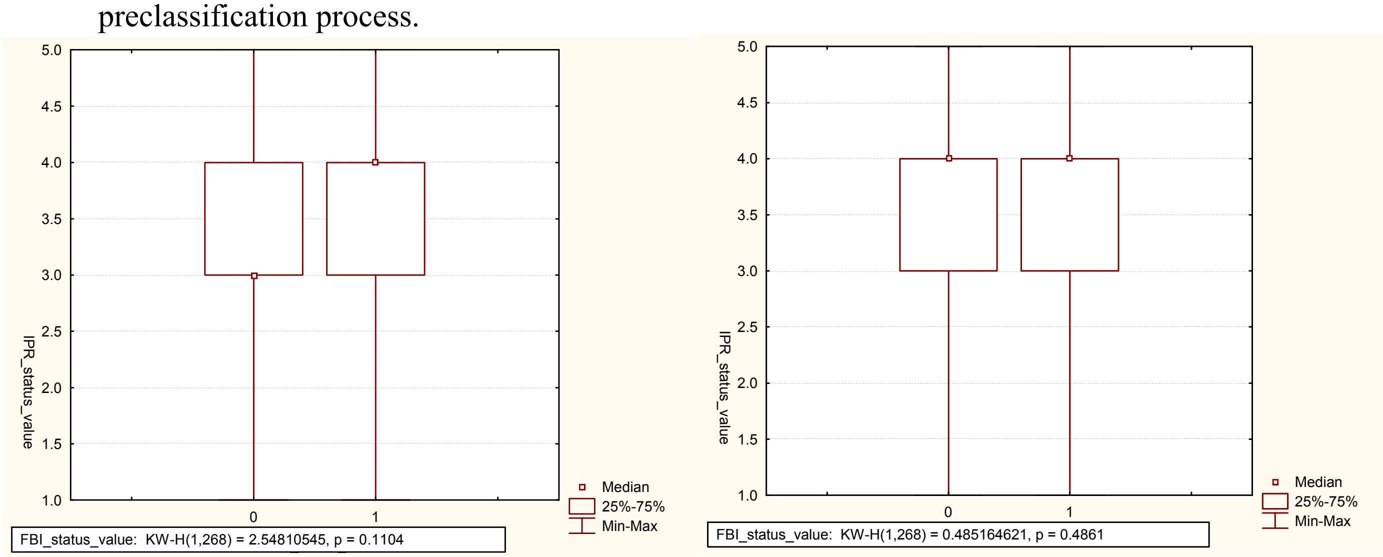



**Figure 6. Box-plots of the values of IBICAT (0=Non impacted and 1=Impacted) versus IPR scores (1=Very good to 5=Very bad), left; and IPR (0=Very good and Good and 1=Moderate, Poor and Bad) versus the mean human impact (Non impacted=1 and 2 and Impacted=3 to 5), right.**

**Latium – Italy**
A comparison between IBICAT and FIDESS was carried out at 46 test sites from Central Italian rivers, in spite of differences in fish fauna composition between Italy and Catalonia. These differences did not allow applying FIDESS to Catalonian rivers, because it relies upon fish assemblage composition data (i.e. upon taxonomic information, which is obviously region-specific). On the other hand, we were able to compute IBICAT, which takes into account functional groups rather than a species list, for Italian rivers.

In spite of differences in the rationale supporting the two methods, and in spite of the non-optimal environmental and faunistic context for IBICAT application, we found a quite good agreement between the two approaches. In figure 7 IBICAT scores are compared to FIDESS scores and it can be clearly seen that they are consistent with each other, although their scales are opposite (1=best in FIDESS, 1=worst in IBICAT). Spearman rank correlation is therefore negative, but quite high and highly significant ($r=-0.764$, $p<0.00001$).

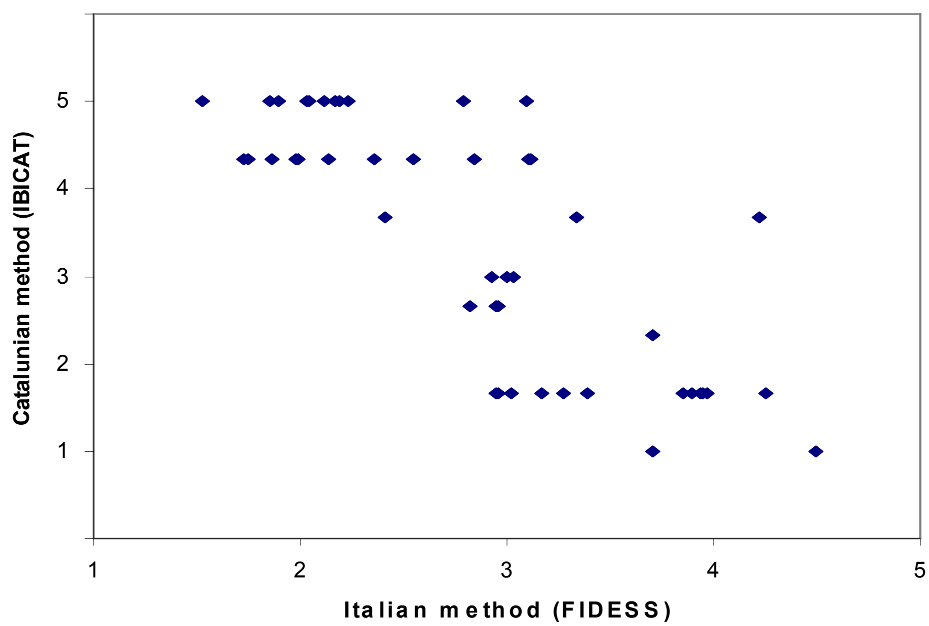



**Figure 7. IBICAT vs FIDESS (Spearman's rank correlation: r=-0.764, p(r)<0.00001).**

Continuous scores have to be discretized in practical applications, and therefore the agreement between evaluation methods must be also checked taking into account discrete classes of ecological status. A comparison between FIDESS and IBICAT classifications of the 46 Italian test sites is shown in figure 8. Exact matches are on green background (21 out of 46 cases), close misses (i.e. misclassifications by only a single class of ecological status, 22 out of 46 cases) are on yellow background, and wrong classifications are on orange background (3 out of 46 cases).

**IBICAT (Catalunia)**

| FIDESS (Italy) | High | Good | Moderate | Poor | Bad |
|---|---|---|---|---|---|
| High | 0 | 0 | 0 | 0 | 0 |
| Good | 2 | 7 | 0 | 1 | 0 |
| Moderate | 0 | 6 | 6 | 5 | 2 |
| Poor | 0 | 0 | 0 | 8 | 9 |
| Bad | 0 | 0 | 0 | 0 | 0 |

**Figure 8. Agreement between IBICAT and FIDESS status classes (weighted kappa = 0.49091 p(kappa) < 0.00001).**

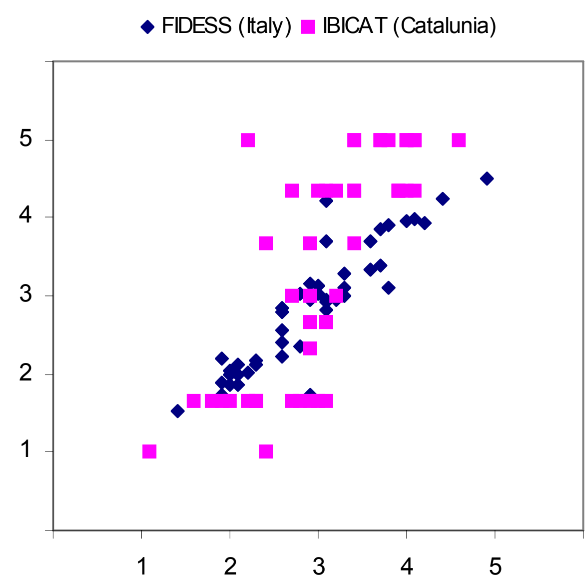



**Figure 9. IBICAT and FIDESS vs expert judgement, comparison based on Italian sites only (Spearman's rank correlation: For FIDESS values r= 0.90***; For IBICAT values r = 0.77***).**

## Conclusion

It is very clear that the overall agreement is very good, even though the range of FIDESS estimates (Good to Poor) is somewhat narrower than the range of IBICAT estimates (High to Bad). At the critical boundary between Good and Moderate some inconsistencies emerged: while 9 out of 10 sites that were evaluated as High-Good by FIDESS are evaluated at the same level by IBICAT, 6 sites out of 15 among those that were evaluated as High-Good by IBICAT are in a Moderate state according to FIDESS.

Therefore, it seems that FIDESS is slightly more conservative as far as the Good/Moderate boundary is concerned.

The overall agreement between IBICAT and FIDESS discrete classes, however, is quite good and the value of the weighted Kappa statistics, a very common inter-observer agreement statistics, is quite large and highly significant ($K=0.49091$, $p<0.00001$).

Finally, we compared both IBICAT and FIDESS scores for the 46 test sites to the expert judgment evaluations, which are issued by Italian experts as fuzzy (i.e. as probabilities of) memberships to each ecological status class. Fuzzy expert judgments were defuzzified into a continuous score (1 to 5) and IBICAT scores were reversed (from 1=worst to 1=best) in order to allow make the comparison easier.

FIDESS, which was developed on purpose to match the expert judgments, is very highly correlated to the expert judgment scores (Spearman's rank correlation: $r=0.90$, $p<0.001$), but also IBICAT, although out of context in Italian rivers, performs surprisingly well ($r=0.77$, $p<0.001$).

*Sostoa A., de; Caiola, N. & Casals, F. 2004. A new IBI (IBICAT) for local application of the E.U. water framework directive. In: D. Garcia de Jalón & P. Vizcaíno (eds.). Aquatic Habitats: Analysis and Restoration, pp. 187-191. IAHR, Madrid.*

## A new IBI (IBICAT) for local application of the E.U. Water Framework Directive

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**Conclusions**

A real comparison between method aimed at evaluating the ecological status of streams and rivers only makes sense when methods that were developed in the same ecoregion are concerned. Other comparisons, although theoretically possible, are certainly biased because of the problems that arise when evaluation methods are applied out of their original ecological context. Basically, such comparisons imply the same kind of inconsistencies that are observed when a text is translated by the word to two different languages.

Given this caveat, the comparison between IBICAT and FIDESS showed a very good agreement between the two methods in a set of 46 Italian test sites. The overall agreement certainly exceeded the expectation and it was even more surprising in the light of the preliminary state of development of both methods. Obviously, some inconsistencies were detected at the Good to Moderate boundary, where IBICAT was slightly less severe than FIDESS.

As for other comparisons, nor EFI or IPR application to Catalonia rivers seems to give good results with problems related to the fish fauna considered during the index construction and with no sensivity related to increased human impact on the rivers.

Even though no river basins are shared between Mediterranean Group countries, we plan to continue to compare our approaches, not only in the light of the intercalibration exercise, but especially as far as the underlying methodological and ecological issues (e.g. pre-classification of sites) are concerned. Therefore, we do not aim at direct interoperability of national methods, but we certainly want to build and improve them on a common theoretical ground.

## Introduction

Integrated management of aquatic ecosystems is a common concern for water resources managers as well as for researchers (Cohen 1998). The 2000 European Union Water Framework aims to preserve the biotic and ecological integrity of aquatic ecosystems as part of water management schemes, creating needs for new methodologies for studying these systems. The fish based assessment Index of Biotic Integrity (IBI) created by Karr (1981), is one of the used methods. In order to increase the accuracy of such method, a spatially based approach should be carried out. The principle behind this approach is that rivers are understood as a sequence of distinct segments with homogeneous abiotic and biotic characteristics. Thus, the entire river network is classified into distinct types. For each river type, the basic functional unit, undisturbed conditions are formulated and the deviation from these conditions provides the measure of the ecological status.
A river regionalization and an IBI, suitable for each river type, are proposed for its application on rivers from a NE region of the Iberian Peninsula (Catalonia, Spain).

## Sampling

A total of 333 sites from 158 rivers belonging to 15 river basins were sampled. To assess fish fauna composition, electro fishing was performed according to the CEN directive for water analysis – sampling of fish with electricity (Work Item 230116, revision of PrEN 14011, October 25, 2001). The specific gears and strategies used are region and site dependent. Fish were identified and some measurements were taken from a representative sample of the captured specimens: fork or total length (depending on the shape of the caudal fin) to the nearest mm; total wet weight to the nearest 0.1 g; external aspect concerning wounds, parasites and deformities. At the end, all specimens were returned alive to the river.
Each site was characterized with 26 environmental variables linked to climate, geomorphology and location in the drainage basin and with 28 human impact variables. These variables were collected either *in situ* or from Geographical Information Systems developed by the Ebro Hydrological Confederation and the Catalonian Water Agency for the Ebro basin and the south-eastern Pyrenees watershed, respectively. The human impact variables were scored from 1 (no impact) to 5 (high impact). Finally, a mean impact was calculated for each site. This way, sites could be classified in impacted (3 to 5) and non impacted (1 and 2).

# Fish species classification and river typology

Fish species were classified according to their requirements with regard to reproduction and longevity (Balon 1975, 1981a, b), feeding (Goldstein & Simon 1999), habitat (Mann 1996), migration (McDowall 1997, Northcote 1999) and tolerance capacity (Cowx 2001). These ecological guilds were then used for determine similarities between species and establish fish eco-types that play identical roles in a determined community. This was achieved by means of adequate cluster analysis for qualitative data, in this case Jaccard coefficient followed by neighbor joining consensus tree, performing bootstrap with 500 iterations (Sneath & Sokal 1972). The significantly robust groups of species were considered as one single species for the river typology assessment.

The regionalization of rivers was performed based on the original geographical distribution of native fish species and its relationship with the environmental variables. The potential natural distribution of fish species was established using data from 1996, a time series from 1984 to 1988 and historical information (Aparicio et al. 2000).

Cluster analysis was performed in order to define groups of sites based on historical presence of native fish. For this purpose adequate algorithms for presence absence data were used: square Euclidean distance coefficient and Ward's minimum variance linkage method (McGarigal 2002). In order to determine redundancy between environmental variables, a Spearman correlation analysis for non parametric data (Sokal & Rohlf 1995) was carried out. Discriminant analysis was performed to predict fish based group membership of sites (McGarigal 2002) based on non redundant environmental data. A discriminant classification function, based on 11 environmental variables (Table 1) was defined, being 79% of the sites well classified:

$S_i = C_i + Y_{i1} \times V_1 + Y_{i2} \times V_2 + ... + Y_{in} \times V_n$

In this formula, the subscript i denotes the respective group; the subscripts 1, 2, n denote the variables; $C_i$ is a constant for the i'th group, $Y_{ij}$ is the weight for the j'th variable in the computation of the classification score for the i'th group; $V_j$ is the observed value for the respective case for the j'th variable. $S_i$ is the resultant classification score. The application of this function allows an easy and precise classification of new sampled sites.

As result 5 river types were established: 1) “Low Mediterranean mountain”; 2) “Humid Mediterranean mountain”3) “Littoral streams”; 4) “Ebro main rivers”; 5) “High mountain”.

Table 1. Parameters of the discriminant classification function.

| Variable | River type | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Altitude | 0.252 | 0.256 | 0.238 | 0.251 | 0.267 |
| T_air | 16.308 | 17.400 | 16.120 | 17.472 | 16.898 |
| Jan_t_air | 5.056 | 4.296 | 5.391 | 3.873 | 6.680 |
| Jul_t_air | 18.924 | 18.404 | 19.045 | 17.676 | 16.602 |
| Jul_max | 10.969 | 10.769 | 9.951 | 11.288 | 10.399 |
| Slope | 0.132 | 0.164 | 0.117 | 0.152 | 0.167 |
| Riv_ord | 2.122 | 1.667 | 2.460 | 2.328 | 2.704 |
| Dist_s | -0.042 | -0.035 | -0.047 | -0.030 | -0.041 |
| Dist_m | -0.078 | -0.050 | -0.070 | -0.040 | -0.017 |
| Jul_rain | 0.311 | 0.258 | 0.340 | 0.256 | 0.267 |
| Wat_def | -0.116 | -0.105 | -0.118 | -0.088 | -0.088 |
| Constant | -534.40 | -533.99 | -506.23 | -538.57 | -514.92 |

T_air = mean air temperature; Jan_t_air = mean air temperature in January; Jul_t_air = mean air temperature in July; Jul_max = maximum temperature in July; Riv_ord = order of river; Dist_s = distance from source; Dist_m = distance to mouth; Jul_rain = rainfall in July; Wat_def = water deficit.

## Development of the IBICAT

For the development of the IBICAT a spatially based approach was performed, that is to say, per river typology previously defined. A total of 528 potential metrics were proposed and tested. Most of these correspond to the original or modified metrics proposed by Karr (1981). In addition, some new metrics were proposed as an attempt to reflect the fish communities of Catalonian rivers and streams. All the metrics fit in 8 categories: species composition; abundance; tolerance; habitat; reproduction; longevity; feeding; migration. The previous species classification was used for metrics describing the structural and functional species composition.

Firstly a Spearman correlation analysis (Sokal & Rohlf 1995) was used to identify redundancy between the potential metrics, and, thus, reduce its number. Two metrics were considered redundant for a correlation coefficient absolute value higher than 0.8. The non redundant metrics are the candidate ones. To evaluate the response of the candidate metrics a graphical analysis supported by statistical test was performed. For this purpose, box plots for the distribution of metric values for each of the 5 impact values, followed by non parametric ANOVA, Kruskal-Wallis (Sokal & Rohlf 1995) was carried out. Since it was not possible to achieve good results with this approach, because the 5 impact classes were not represented in the dataset for each river type, a similar procedure was done for only impacted and non impacted sites (Fig. 1). Therefore, metrics' scoring was performed with only 3 values: 1 – impact / high impact; 3 – moderate impact; 5 – without / low impact. The scoring criterion is shown in Figure 1. The IBICAT metrics for each river type are shown in Table 2.

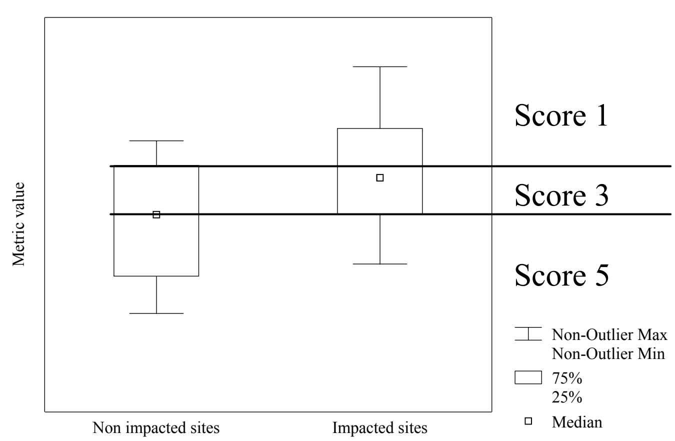


Figure 1. Box-plots of the values of a hypothetical metric with a clear response for impacted and calibration sites and respective scoring.

Table 2. Metrics and scores for the calculation of the IBICAT for the five river types.

| River Type | Metric | Score 1 | Score 3 | Score 5 |
|---|---|---|---|---|
| 1 | Nr. native species | 0 | 1 | >1 |
| | Nr. native insectivore species | 0 | 1 | >1 |
| | Density of intolerant natives (ind/ha) | 0 | <1500 | ≥1500 |
| 2 | % of native species | <20 | 20-80 | >80 |
| | % of intolerant species | <50 | 50-80 | >80 |
| 3 | % of native species | <40 | 40-80 | >80 |
| | % of density of insectivores (ind/ha) | <40 | 40-80 | >80 |
| | % of historical species present | <0.3 | 0.3-0.6 | >0.6 |
| 4 | Nr. native tolerant species | 0 | 1 | >1 |
| | Density of long lived natives (ind/ha) | <250 | 250-1750 | >1750 |
| | Density of introduced lithophilics (ind/ha) | <1000 | 1000-3000 | >3000 |
| 5 | Total density (ind/ha) | <400 | 400-1200 | >1200 |

## Conclusions

A first attempt to develop a fish based assessment index of biotic integrity, for the application of the E.U. water framework directive in Catalonia (IBICAT) is presented. For this purpose, a spatially based approach was performed.

The river regionalization resulted in the classification of rivers in five types. For each river type a fish based index is proposed. Due to the structure of the dataset it was only possible to classify rivers' ecological status in 3 categories. Although the presented IBICAT is suitable to assess ecological status of Catalonian Rivers, it can be improved by means of increasing the number of metrics. This can be achieved by proposing and testing new metrics.

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## Italy: FIDESS: a FIsh-based DEcision Support System for evaluating the ecological quality of streams and rivers

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### Introduction

Fish species have been regarded as very effective biological indicators of environmental quality in different aquatic ecosystems (Fausch et al., 1990; Whitfield, 1996), not only because their iconic value, but also because of their sensitivity to subtle environmental changes (Karr, 1981). Obviously, fish responses to environmental disturbances, including hydromorphological ones, are different in time and space from those of simpler organisms, as they tend to be integrated over larger intervals (Scardi et al., 2006).
The relevance of fish species as biotic indicators has been explicitly mentioned not only in scientific studies (e.g. Karr & Dudley, 1981; Oberdorff & Hughes, 1992), but also in European and American laws and regulations (European Commission, 1992; European Union, 2000; Kurtz et al., 2001) as well as in those from other countries. In particular, fish are explicitly mentioned among the "quality elements" that are to be considered to assess the ecological status of surface waters according to the European Water Framework Directive (WFD) (European Union, 2000).
Therefore, several environmental assessment methods based on fish have been developed during the last two decades, mostly inspired to the seminal work by Karr (1981), who developed the Index of Biotic Integrity (IBI). The IBI is a multimetric index, i.e. it combines different variables that are supposed to respond to environmental disturbance (i.e. *metrics*) into a single score. It takes into account twelve ecological attributes of the fish assemblage related to species richness, assemblage composition and abundance, trophic guilds and fish condition.
The multimetric IBI approach is very flexible, as different metrics can be selected according to regional ecological conditions, and this is certainly the main reason why it has been adapted to a number of countries and river basins, not only in North America (e.g. Karr and Dudley, 1981; Karr et al., 1986; Plafkin et al., 1989; Fausch et al., 1990), but also in Europe (e.g. Hughes and Oberdorff, 1999) and in other continents (e.g.

Steedman, 1998; Lyons et al., 1995; Kleynhans, 1999; Harris, 1995; Hugueny et al., 1996; Hay et al., 1996; Kamdem Toham & Teugels, 1999; An et al., 2002).

While many IBI clones and other biotic indices were developed during the last two decades, other methods were also proposed. Although they may differ from the IBI paradigm because of more complex scoring criteria or because they take into account not only the fish assemblage composition, but also some environmental attributes (e.g. geomorphological types), in most cases they are still based on a multimetric approach. The European Fish Index (EFI) is a recent example of such a second generation multimetric index (FAME Consortium, 2004).

Finally, a few attempts have been also made at evaluating the environmental quality of streams and rivers by comparing observed fish assemblages to those modeled on the basis of relevant physical variables, thus obtaining indices based on deviation from expectation of the fish fauna (e.g. Oberdorff et al., 2002).

Although (multimetric) biotic indices have become ordinary ecological tools, even the most successful ones are often criticized by the same people who apply them routinely, because the way they classify streams and rivers is not consistent with other ecological evidences.

This is not surprising, as no model (or method, or index, in this case) can be simple, general and accurate at the same time. In order to be simple (and indices are designed to be inherently simple), a method can be general, but not accurate, or it can be accurate, but not general.

Indices are not exceptions to this rule, and this is the reason why they usually have to be calibrated at regional scale or at river basin scale in order to provide good results. The original IBI, for instance, has been adapted to a number of different (eco)regions or river basins and a very large number of different implementation are now available. Obviously these implementations share a common rationale, but the metrics that are taken into account change from case to case. On the other hand, indices which are aimed at generality always fail when applied to many different ecoregions. The problems that have been experienced with the EFI in several European countries demonstrate the impaired accuracy of an index that was designed to be both general and simple.

The simplicity versus accuracy (or generality) tradeoff is not the only reason why a multimetric approach is not optimal. In fact, most metrics, although carefully selected, are linked to ecological status by relationships that are not linear, nor monotonic and not even simple, while all multimetric approaches are based on at least one of these assumptions.

The case of species richness, a very common metric, is a typical example of such a problem. While in multimetric indices species richness (overall or referred to a specific taxonomic group or guild) is assumed to be positively and monotonically related to the ecological status, it is well known that a moderate disturbance usually favors an increase in species richness, and the intermediate disturbance hypothesis is the formal expression of this familiar evidence (Connell, 1978). Moreover, competition between species may induce even more complex responses to environmental disturbance.

Another problem with (multimetric) biotic indices is the lack of computational optimization. In fact, they usually take into account only a handful of metrics, thus causing an information loss, while the selected metrics are heuristically processed. For instance, in many cases indices are obtained by summing up scores assigned to each metrics, under the assumption that all metrics have the same weight, that no metrics are redundant and that no interactions between metrics exist. It is obvious that these assumptions are quite simplistic and seldom compliant with reality.

As a matter of fact, (multimetric) biotic indices are often conceptually sound as far as the underlying ecological rationale is concerned, but they exploit only part of the available information, and in a suboptimal way.
In spite of these problems, the index-based approach is very popular. In fact, by converting biotic responses to environmental disturbance into scores and combining these scores into indices some ecologists assume that ecological clues may be turned into hard facts and that (multimetric) scores are closer to hard science than expert judgments. The same ecologists usually forget that in any case expert judgments are the basis for metrics selection as well as for the definition of thresholds in index scoring scale, i.e. for setting ecological status class boundaries.
Basically, expert judgment is the key for any environmental assessment, evaluation or diagnosis. In fact, the very concept of ecological status (or environmental quality, etc.) is at the same time very clear in the field and absolutely vague when it has to be translated into a set of rules, or into a concise definition. Of course, this problem does not depend on ecologists. In fact, ecological status is not an emergent property of ecosystems, nor a property that can be univocally defined: on the contrary, it is nothing more than a personal interpretation of the natural phenomenology. Nevertheless, ecologists usually agree in ranking a set of sites according to their ecological status, because they share a common theoretical background (a common ecological aesthetics?).
Although it plays a fundamental role, expert judgment cannot be regarded as the solution to environmental assessment problems. For instance, it might fail in practical applications that involve not only ranking, but also other tasks that require a finer resolution in the expert judgment. For instance, experts not always agree with each other in case undisturbed or slightly disturbed sites (i.e. in high or good ecological status according to the European WFD) have to be recognized and separated from more seriously impaired sites.
We tried to address this problem by developing a Decision Support System (DSS) based on a neural network, which was trained to associate expert judgments to environmental and fish assemblage data. In essence, this solution is based on the assumption that the complex biotic relationships that link fish assemblage composition to environmental conditions can be implicitly embedded into a neural network and that such a neural network can be trained to reproduce expert judgments.
The outcome of this approach is FIDESS, a FIsh-based DEcision Support System. At present, a first version is available, which is based on data from the Tevere river and other minor river basins from Central Italy. However, the same method can be easily retrained and we are actually planning to add data from other Italian regions as soon as they are available and, in general, to update FIDESS on a routine basis.

**Data sets and methodological details**

Environmental data and fish assemblage composition were recorded in Central Italian streams and rivers during 386 sampling occasions. Sampling sites were located in the Tevere river basin as well as in other minor river basins. Most sampling sites were wadable, and sampling was performed by means of standard electrofishing gear.
Fish assemblage composition was recorded as the number of fish caught in the sampling stretch for each species, while pictures were taken for later biometric analyses. However, only binary presence/absence data have been used in FIDESS so far, because we aimed at maximum compatibility with previous qualitative data sets. A new version of FIDESS based on quantitative data, whose relevance is explicitly stated in the WFD, is under development at the time of this writing.

Although 43 species were identified in our samples, only 30 of them, i.e. those which occurred in more than 5% of the records, were explicitly considered (Table 1), whereas the remaining species were only taken into account when computing the overall species richness. A separate species richness value was computed for juveniles (young of the year) only. Information about 27 environmental variables (Table 2) was also recorded during fish sampling. Most of these variables were selected because they had been already considered in previous studies, but some of them might be discarded in future implementations of the expert system on the basis of a sensitivity analysis.

*Table 1. List of the fish assemblage descriptors: 30 fish species and 2 species richnesses (overall and juveniles only) are included. Species that are not explicitly mentioned are taken into account in species richnesses.*

| **Species/Faunistic variable** | |
|---|---|
| *Abramis brama* | *Leuciscus cephalus* |
| *Alburnus alburnus alborella* | *Leuciscus lucumonis* |
| *Alosa fallax* | *Leuciscus souffia muticellus* |
| *Anguilla anguilla* | *Liza ramada* |
| *Barbus plebejus/tyberinus* | *Mugil cephalus* |
| *Carassius carassius* | *Petromyzon marinus* |
| *Chondrostoma genei* | *Pseudorasbora parva* |
| *Cobitis taenia bilineata* | *Rutilus rubilio* |
| *Cyprinus carpio* | *Rutilus rutilus* |
| *Dicentrarchus labrax* | *Salaria fluviatilis* |
| *Esox lucius* | *Salmo trutta* |
| *Gambusia holbrooki* | *Sander lucioperca* |
| *Gasterosteus aculeatus* | *Scardinius erythrophthalmus* |
| *Gobius nigricans* | *Tinca tinca* |
| *Lampetra fluviatilis* | Overall species richness |
| *Lampetra planeri* | Juveniles species richness |

Finally, the expert judgments were recorded. They were meant as a global evaluation of the ecological status the sampling sites, not just as an evaluation of the fish fauna composition. When possible, more than a single expert judgment was recorded at each sampling site, thus associating more than a single expert judgment to the same environmental and fish assemblage data.

The expert judgments were expressed as fuzzy sets, i.e. a membership value was recorded for each ecological status class in the *high*, *good*, *moderate*, *poor* and *bad* range. This way of coding ecological status is very flexible, as it also allows expressing uncertainty. For instance, in case it was not possible to discriminate between *moderate* and *good* (a very difficult task and a very relevant problem in European countries because of the WFD) a 50% *good* and 50% *moderate* expert judgment was issued.

At present, the number of available field data records is not large enough to properly train a multilayer perceptron neural network and it certainly will not become large enough in the near future. Therefore, more information was added to the training set by simulating changes to real records that could affect the expert judgment. In other words, the same experts who evaluated the ecological status of the sampling sites were requested to think about species whose presence or absence would change their judgment or to environmental variables that, if changed in value, would affect their evaluation, and to translate their thoughts into new data records.

*Table 2. List of the environmental descriptors: 27 variables are included. Units and notes for each variable are shown in the right column.*

| Environmental variable | Unit/Notes | |
|---|---|---|
| Elevation | m | |
| Depth | m | |
| Runs | % of the wetted surface | |
| Pools | % of the wetted surface | |
| Riffles | % of the wetted surface | $\sum_{i=1}^{4} p_i = 100\%$ |
| Uniform flux | % of the wetted surface where the water flow is apparently uniform at surface (relevant in larger rivers) | |
| Wetlands | presence or absence of wetlands connected to the river in normal flow conditions (binary variable) | |
| Bars or islands | presence or absence (binary variable) | |
| Boulders | % of the sampling site surface | |
| Rocks and pebbles | % of the sampling site surface | |
| Gravel | % of the sampling site surface | $\sum_{i=1}^{5} p_i = 100\%$ |
| Sand | % of the sampling site surface | |
| Silt and clay | % of the sampling site surface | |
| Flow velocity | semiquantitative score in the [0,5] range | |
| Vegetational cover | % of the surface of the sampling site covered by aquatic macrophytes | |
| Shade | % of the surface of the sampling site shaded at noon | |
| Anthropic disturbance | semiquantitative score in the [0,4] range | |
| Dams upstream | distance in km (use 100 in case there are no dams) | |
| Dams downstream | presence or absence (binary variable) | |
| Lake upstream | distance in km (use 50 in case there are no lakes) | |
| Summer water temperature | °C (mid-June to August) | |
| Turbidity | NTU | |
| pH | | |
| Conductivity | ($\mu S\ cm^{-1}$) | |
| Dissolved oxygen | % saturation | |
| Basin area | square root of the area, in km | |
| Distance from source | km | |

For instance, given a site in which the fish assemblage included both adults and juveniles of the species that are supposed to be present on the basis of the environmental information, the overall evaluation would certainly become less positive in case less or no juveniles were found. Basically, such virtual records were used to add relevant information that was not found in the available real records, but they are obviously based on ecological scenarios that are very likely to occur. At present about 600 virtual records were added to our data base. We also tried to balance the number of records that were associated to each class of ecological status, adding virtual records to this end. This way no class of ecological status included less than 100 records.
Before training the neural network, the available records were divided into two subsets for training and test. Records were assigned to training or test subset on the basis of a stratified procedure, taking into account simultaneously expert judgment and elevation and selecting random records for each subset from each stratum.

The overall number of input variables in our data set was 59, including 27 environmental variables, 30 species and 2 values for species richness (overall and juveniles), whereas the output variables were 5, corresponding to membership values for each class of ecological status defined by the European WFD.
The best architecture for the multilayer perceptron was selected on the basis of a heuristic test. In fact, we trained neural networks with a number of nodes in the hidden layer ranging from 10 to 50 and then we selected the one which provided the best results. On the basis of this procedure, the final architecture of the multilayer perceptron neural network was set to 59-25-5.
All the environmental variables and the species richness values were normalized into the [0,1] interval. Obviously, binary data for species occurrence did not require normalization. Sigmoid activation functions were selected in the hidden layer nodes [$f(x)=1/(1-e^{-x})$], whereas *softmax* activation functions (Bridle, 1990) were used in the output layer nodes. The *softmax* function scales the neural network outputs so that their sum is 1 and that each output can be regarded as a probability, i.e. the membership value for each class of ecological status.

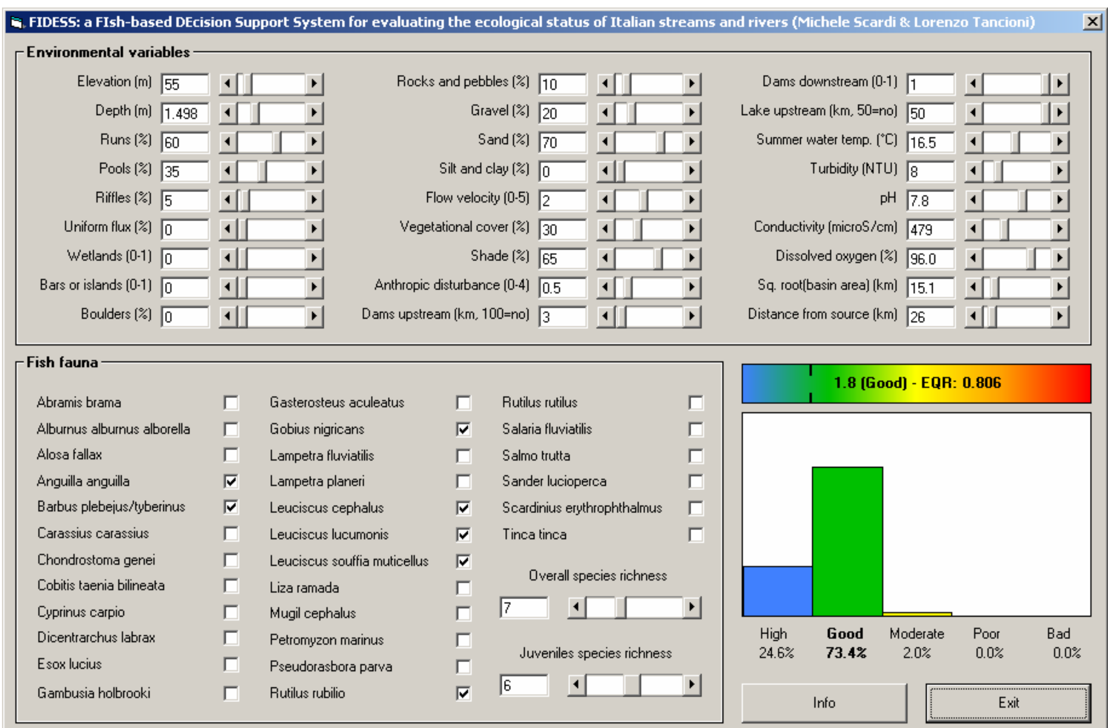


*Figure 1. The Graphical User Interface (GUI) of the expert system. The classification results are shown in the lower right corner both graphically and alphanumerically: the histogram shows the membership values for each class of ecological status, while the values in the horizontal bar indicate the ESS and the EQR. In the histogram, the ecological status class selected by the winner-take-all criterion has boldface labels. The GUI is fully interactive and the classification is instantly updated at each change in the input data. (N.B. Ecological status classes are color-coded in the real GUI).*

The neural network training was performed by means of the most common algorithm, i.e. the error back-propagation (Rumelhart et al., 1986). A constant value was set for both the learning rate (0.9) and the momentum (0.1), while overtraining was avoided using an early stopping strategy. The neural network training was performed according to a "learning per pattern" paradigm. Moreover, training patterns were submitted to the neural network in random order at each learning epoch, thus avoiding that memorization of the submission order could adversely affect the training. Finally, jittering, i.e. addition of a small amount of noise to input patterns at each epoch (Györgyi, 1990), was performed during the training phase. Gaussian noise with $\mu = 0$ and $\sigma = 0.01$ was used. Jittering helps neural network generalization by providing a virtually unlimited number of artificial training patterns that are closely related, even though not exactly identical, to the original ones.

The confusion matrix obtained from the neural network output using a *winner-take-all* strategy for the classification of the test records was analyzed by means of the weighted Kappa statistics (Cohen, 1960; Fleiss et al., 1969). Neural network output was also analyzed after conversion into a continuous variable by weighted average. In this case a linear correlation coefficient was computed to evaluate the neural network performance (Pearson, 1896).

Finally, a Graphical User Interface (GUI) was wrapped around the trained neural network, thus providing a user-friendly and interactive access to FIDESS (Figure 1). The GUI was designed in order to make the neural network completely transparent to the user, who can interact with FIDESS in real time, observing changes in classification while input data are modified.

## Results

In spite of the problems related with the *curse of dimensionality*, the synaptic weights of the trained 59-25-5 multilayer perceptron did not grow too large (88% of the weights were <0.5 and 97% of them <1.0) and the overall response of the neural network to changes in input data was very smooth. Given the small ratio between the number of training patterns and the number of synaptic weights, a proper training was theoretically impossible, but ecological problems are often exceptions to this rule. In fact, their real dimensionality is usually much smaller than expected, especially due to associations between species whose response to environmental variables is similar and to tight relationships between environmental variables.

For instance, the 30 species that were selected as neural network binary inputs might combine in $2^{30}$ different ways, i.e. in more than one billion of different fish assemblages. In practice, about a hundred different fish assemblages were found in our data records. Together with appropriate training strategies (jittering, early stopping, random selection of training patterns at each epoch) these ecological constraints to the theoretical dimensionality of the problem minimized the effects of the *curse* and made it possible to properly train a neural network. An indirect evidence of training stability was also provided by the very small differences that were observed between neural networks with different numbers of nodes in the hidden layer.

The comparison between neural network outputs and expert judgments can be carried out in different ways, depending on the defuzzyfication method. In fact, the *softmax* activation functions of the output layer nodes returned output values that sum up to 1, which could be regarded as memberships for each ecological status class. These membership values, however, are relative to ordered categorical variables and therefore they can be either used to compute a continuous score, or to define the most probable class.

The first solution is the most straightforward, as a continuous ecological status score (*ESS*), ranging from 1 (best) to 5 (worst), can be easily obtained as a weighted average of the class membership values:

$$ESS = \sum_{k=1}^{5} k \cdot p_k$$

where $k$ is the class rank and $p_k$ is the class membership value.
In the FIDESS GUI the ESS can be found in the horizontal bar that is located above the histogram in the lower right corner. The ESS is 1.8 in the screenshot shown in Figure 1. Next to the ESS another numerical value is also shown, i.e. the Environmental Quality Ratio (EQR), which is 0.807 in Figure 1. The EQR is explicitly required by the European Water Framework Directive as the basis for classifying the ecological status. It ranges from 1, in case of an ecological status close to pristine, to 0, in case of a heavily disturbed ecological status. In theory, the EQR is to be computed with respect to some pre-defined reference conditions, but in our expert system the reference conditions are implicitly defined by the expert judgments used for training the neural network, and therefore the EQR can be easily obtained by reversing the ESS and scaling it into the [0,1] interval.

In Figure 2 the *ESS* values obtained from the neural network are compared to the *ESS* values computed on the basis of actual expert judgments. Both the training (white squares) and the test (black triangles) data subsets are shown. Differences between the two data subsets are minimal, and the linear correlation between neural network outputs and observed values is very high in both cases ($r$=0.978$^{***}$ for the training data subset and $r$=0.932$^{***}$ for the test data subset). While extreme *ESS* values are very accurately estimated by the neural network, a few larger errors are associated to intermediate *ESS* values. This is not surprising, as the characterization of intermediate classes of ecological status is inherently more controversial.

Even though the *ESS* assessment seems very accurate, a classification into discrete levels of ecological status is required in most practical applications. Such a classification can be obtained from the neural network output according to different criteria. The most straightforward solution is to round off the *ESS* to the closest integer value, but this solution is also potentially biased, because the *ESS* might be influenced by an asymmetrical distribution of the neural network outputs around the most probable ecological status class. In this case, even small membership values for extreme classes might bias the overall estimate of the *ESS*.
A safer alternate solution is the classical *winner-take-all* strategy. In other words, each pattern is classified according to the highest class membership value in the neural network outputs. This strategy seems more robust in case of asymmetrical class membership distributions and it also has the advantage of being more intuitive than others. From a theoretical point of view, it can be affected by bimodal (or trimodal) distributions of class membership values, but such particular cases were never observed while classifying real records.
A confusion matrixs based on the *winner-take-all* strategy was computed for a test data subset (n=69) and is shown in Table 3. Data in the test subset were never used in the training phase, and therefore they could be safely used to assess the ability of the neural

network to reproduce the way expert judgments are issued. The percentage of Correctly Classified Instances (CCI) in the test data subset (66.7%) is not very different from the one in the training data subset (73.5%). Basically, if only test data were taken into account, 2 out of 3 cases were exactly classified, while the remaining cases were misclassified by only one class of ecological status.

*Table 3. Confusion matrix obtained from the winner-take-all classification of the test data subset. Correctly Classified Instances (CCI) were 66.7%, while the weighted Kappa statistics was Kw=0.775 (p<0.001).*

| | | Neural network | | | | | |
|---|---|---|---|---|---|---|---|
| | | High | Good | Moderate | Poor | Bad | |
| Expert judgment | High | **5** | 7 | | | | *12* |
| | Good | 2 | **15** | 1 | | | *18* |
| | Moderate | | 5 | **6** | 2 | | *13* |
| | Poor | | | 2 | **11** | | *13* |
| | Bad | | | | 4 | **9** | *13* |
| | | *7* | *27* | *9* | *17* | *9* | ***69*** |

The agreement between expert judgments and neural network outputs was tested by means of the weighted Kappa statistics. The weighted version of the Kappa statistics was selected because of the ordered categorical nature of the classification and the following weighting scheme was adopted:

$$w_{i,j} = \frac{|i-j|}{r-1}$$

where $w_{i,j}$ is the weight for the $j$-th element of the $i$-th row of the confusion matrix and r is the rank of the confusion matrix.

The weighted Kappa statistics for the confusion matrix obtained from the test data subset was highly significant ($K_w$=0.775, $p$<0.001) and the overall agreement between expert judgments and neural network outputs could be considered as “good” according to the Landis & Koch (1977). The same statistics for the confusion matrix obtained from the training data subset was only slightly higher ($K_w$=0.822, $p$<0.001).

It is worth noticing that the weighted Kappa statistics for the confusion matrix based on the alternate classification criterion for the ecological status, i.e. on the rounding off of the ESS to the closest integer value, was lower, although still highly significant ($K_w$=0.715, $p$<0.001) for the test data subset.

## Conclusions

Relationships between environmental variables and fish assemblage composition in streams and rivers are quite tight, and they have been already successfully modeled using statistical approaches (e.g. Oberdorff et al., 2001) as well as neural networks (e.g. Boet & Fuhs, 2000; Joy & Death, 2002; Mastrorillo et al., 1997; Olden & Jackson, 2001; Scardi et al., 2004, 2005). FIDESS, however, goes a step farther, because it leverages an Artificial Intelligence approach in the strict sense, i.e. for reproducing as closely as possible the behavior of human experts.

Conventional strategies for evaluating the ecological status of streams and rivers include biotic (multimetric) indices and comparisons between observed and expected fauna (either modeled or found in reference sites). Although useful in some cases, all these methods rely upon expert judgments and subjective choices, while they are often assumed as entirely objective.
On the contrary, selection of sampling scale, diagnostic variables (metrics), similarity or distance coefficients or thresholds in the scoring scale is inherently subjective, exactly like the very concept of ecological status (or environmental quality, etc.). Nevertheless, recent developments in environmental laws and regulations of most countries demand ecological status classification procedures to be applied in routine environmental monitoring activities.
Although we are fully aware that such a request implies an oversimplification of the underlying ecological problems, FIDESS is aimed at obtaining the best classification procedure by focusing on expert judgments at the earliest step and then processing all the relevant biotic and abiotic information as objectively as possible. In short, we aim at mimicking the way human experts issue their judgments as closely as possible.
In fact, the multilayer perceptron neural network we trained provided very good results, accurately reproducing the expert judgments, even though we were only aiming at demonstrating the feasibility of an Artificial Intelligence approach and therefore training data set was not nearly as large as needed. In spite of these limits, the neural network classification of test cases closely matched the expert judgments, with a limited number of misclassifications (1 out of 3 cases), which were never worse than a single ecological status class. Moreover, the similarity in terms of CCI and weighted Kappa statistics between the results obtained with training and test data subsets showed that the neural network was properly generalized.
The software implementation of FIDESS is not a minor feature in our opinion, and the GUI that makes the neural network transparent to users plays a major role as far as the acceptance of FIDESS is concerned. Most users are already acquainted with biotic indices, while they are not comfortable with a "black box" approach, even though they realize it makes sense from a theoretical point of view. Interacting with FIDESS through the GUI, on the other hand, is very intuitive. For instance, the sliders, that are not strictly needed or convenient for data input, help users to learn how FIDESS reacts to changes in diagnostic variables. In other words, they help users to understand the way of reasoning of FIDESS and to recognize similarities with their own point of view.
A recurrent criticism to an Artificial Intelligence approach to the evaluation of ecological status is that a lot of data are needed and that other methods are therefore more feasible in data-limited situations. Although the need for data is absolutely true, it is certainly false that other approaches need less data to be fully developed. In fact, collecting enough relevant information is the basis for any evaluation procedure, from the simplest, i.e. expert judgment, to the most complex ones. And biotic indices cannot be regarded as exception to this rule.
However, information is available in many different forms, and not only data can be considered as useful information. Knowledge is equally (and probably even more) important, for instance in expert judgment. And knowledge can be converted in virtual records that may contribute relevant information to the training data set for a neural network. Basically, simulating changes in real records that might affect the expert judgment is a very effective way for eliciting experts' knowledge and transferring it into a neural network with no filters or reinterpretations. Of course, the role of such virtual

records will become less important as soon as more data will be available, but they will always play a useful role.
In conclusion, a reductionist, index-based approach to such a complex problem as the evaluation of ecological status of streams and rivers (assuming that this very concept really makes sense) cannot be successful, except in particular cases like a single river basin or a very homogeneous ecoregion. The only sensible way to evaluate the overall state of an ecosystem is by expert judgment, which can integrate all the available information and provide a competent diagnosis. Of course, expert judgment is subjective by definition and, due to our limited grasp of ecological processes, potentially flawed. Therefore, FIDESS, a Decision Support System based on a typical Artificial Intelligence approach may assist human experts or, if none available, it may successfully surrogate them.

### Downloading and installing FIDESS

The current version of FIDESS, aimed at Central Italian streams and rivers, is available for download at *http://www.michele.scardi.name/FIDESS_setup.zip*
Unzip the file in any temporary folder, then launch *setup.exe* to install. When installation is complete, FIDESS will be available in the Start/Programs menu. Use Add or Remove Programs in the Control Panel to uninstall.
FIDESS runs under Microsoft Windows 9x/NT/Me/2000/XP, but it has not been tested under Windows Vista at the time of this writing.

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## CATALONIA - SPAIN

### Definition criteria to select reference sites - Fish

Multicriteria analysis is used to select reference sites by the intercalibration exercise group of Spain. Pressures and impacts are evaluated at three spatial scales : catchment scale, reach scale (i.e. the water body – between 5-15 km.), and at sampling site scale. In order to select reference stations, the fulfilment of 2 criteria were required. The 3 criteria used are listed below:

**1)** At watershed and reach scales, pressure analysis is performed to select potential reference water bodies (reach level):

Sixteen (16) pressure indicators (diffuse and point sources, etc.) were measured in order to define reference water bodies (at reach level using watershed and reach scale information):

- **Dams and weirs**:
  - Number of physical retention infrastructures (dams and weirs) per water body (< 0.5 weirs /km).
  - No weirs with high river discontinuity in the water body (using ICF index)
  - No dams which significantly modify the natural hydrological flow regime (flow regulation) upstream: < 20% modification of the natural monthly minimum flow discharge,
  - The total storage capacity of the reservoirs upstream is < 5% of the mean annual discharge at the site
- **River canalisation** (< 10% of the water body)
- **Water abstractions**: The calculation was performed annually. The objective implies fulfilment of the environmental flows (about 20-30% of the natural flow regime).
- **Floodplain occupation by urban uses**: (< 10% of the water body)
- **Floodplain occupation by extractive activities**: (< 20% of the water body)
- **Floodplain occupation by rapid-growth forest planting**: (< 25% of the water body)

- **Biodegradable discharges from sewage systems**: Discharges from urban areas and industries is assessed based on the organic (DQO) and total phosphorus (P) loads discharged with respect (corrected) to the natural flow regime (dilution). The cumulative effect of biodegradable discharges is calculated based on the sum of all discharges into each water body. To quantify the effect of the biodegradable discharges that occur upstream, an exponential extinction coefficient is applied, and the length of the fluvial system is considered. Reference water bodies selected implies an increase of < 5 mg/L in the DQO of the river caused by biodegradable discharges. On the other hand, the objective for total P is fixed at an increase of < 1 mg/L.
- **Untreated biodegradable discharges**: Sewage discharges from untreated population is quantified based on the equivalent population for municipalities, and the reference water bodies selected is assessed as the ratio between the organic load from the untreated sewage in each water body with respect (corrected) to the natural flow regime (dilution) flowing in the water body. Reference water bodies selected implies an increase < 20 mg/L in the DQO of the river caused by the discharges. This objective was determined under the assumption that not all of the organic load produced by the untreated populations reaches the fluvial systems. The cumulative effect of biodegradable discharges is calculated based on the sum of all discharges into each water body. To quantify the effect of the biodegradable discharges that occur upstream, an exponential extinction coefficient is applied, and the length of the fluvial system is considered
- **Discharges from sewage storm waters**: Discharges from sewage storm waters represent a considerable point source of pollution for fluvial systems. The volume of urban surface runoff and the average concentrations of pollutants (DQO) are considered. Reference water bodies selected implies an increase < 20 mg/L in the DQO of the river caused by the sewage storm water discharges.
- **Dumps for urban solid waste**: For the diffuse pollution sources, the magnitude of the pressure is weighted based on the rain discharges and runoff of drainage area in each sub-basin associated with a water body. (Urban waste < 1 % of the sub-basin).
- **Dumps for mixed solid waste (industrial and urban)**: For the diffuse pollution sources, the magnitude of the pressure is weighted based on the rain discharges and runoff of drainage area in each sub-basin associated with a water body. (Urban waste < 0.1 % of the sub-basin).
- **Agricultural land uses**: grazing < 30 %, intensive farming of cereal and fodder crops (non irrigation) < 25 %, farming in rainy zones, intensive farming of vegetables, flowers, fruit trees, vineyards < 15 %, rice fields and irrigation < 10 %.
- **Urban land uses**: urban uses < 2 %
- **Mining zones**: The pressure due to mining and extraction zones is considered based on the occupied surface area and the weighting coefficient for the rain discharges in the associated sub-basin. Mining areas < 5 %
- **Surpluses of nitrogen from agriculture and farm**: Reference water bodies are considered based on the nitrogen load per hectare. Reference water bodies selected is set at < 10 kg N / ha. of the drainage area per water body. The reduced value of the objective is due to the fact that the surplus is that fraction which is not assimilated in any biological compartment and which can reach the aquatic systems directly
- **Invasive species**: the number of non native species is considered as an indicator of pressure. At the reach scale (water body) absence of invasive species is required to select reference water bodies, but non native species not in invasive stage are tolerated.

**2)** At site scale, reference stations were selected using the criteria described below:
**Table 1.** Criteria for reference sites for fishes

| Criteria | Reference values |
|---|---|
| Hydrological regime of site<br>(deviation from natural flow pattern) | Natural flow pattern and water level > 90%<br>or<br>Mean annual flow > 90% |
| Global connectivity | No barriers |
| Morphological condition of site<br>(deviation from natural stage of channel and bank of the river in the site) | No morphological changes or negligible |
| Toxicity – Acidification of site | pH > 7<br>$O_2$ > 7<br>Ammonio < 0,2 mg/l<br>Nitrits < 0,01 mg/l |
| Nutrient organic input of site<br>(including farm, humic substances, etc.) | Concentraciones de P, N y TOC concentration below 150% of the natural levels |

**3)** Additional criteria: In some cases, it was also been used the additional criteria described below:

**Table 2.** Metrics and reference values for IBICAT.

| River type* | Metric | Reference value |
|---|---|---|
| Low Mediterranean mountain | Number of native species (N) | > 1 |
| | Number of native insectivore species (N) | > 1 |
| | Density of intolerant natives (n/ha) | > 1.500 |
| Humid Mediterranean mountain | Percentage of native species (%) | > 80 |
| | Percentage of intolerant species (%) | > 80 |
| Littoral streams | Percentage of native species (%) | > 80 |
| | Percentage % of density of insectivores (% de n/ha) | > 80 |
| | Percentage of historical species present (%) | > 60 |
| Ebro main rivers | Number of native tolerant species (N) | > 1 |
| | Density of long lived natives (% de n/ha) | > 1750 |
| | Density of introduced lithophilics (n/ha) | > 3000 |
| High mountain | Total density (n/ha) | > 1.200 |

*Not corresponding with the official river typology of Catalunya adopted by the Catalan Water Agency (ACA).

**Selection of reference stations in order to use fish data for intercalibration:**

1. To be in reference water body (point 1) and have local reference conditions (point 2).
2. To be in reference water body (point 1) and have additional criteria (point 3).
3. To have local reference conditions (point 2) and additional criteria (point 3).

**ITALY**

The FIDESS (Fish-based Decision Support System) relies upon reference conditions, although in a broader sense than other methods. In fact, all the available data records are considered as reference by FIDESS, which is specifically aimed at reconstructing the human expert judgment.

In case conventional reference conditions are to be defined, those that correspond to sites whose ecological status was "high" according to human expert judgment in the FIDESS data base could be used (NB: expert judgment is one of the methods that are mentioned in the WFD for defining reference conditions). At the time of this writing, there are 47 sites in "high" ecological status in the Central Italy fish data set.

From a more general point of view, defining reference conditions and then measuring deviations from such conditions is not a procedure that allows assessing ecological status. In fact, in order to quantify the magnitude of a deviation, a single reference (i.e. pristine, or undisturbed, or "high") is not enough and at least two different references are needed. In other words, if two or more different references (e.g. "high" and "bad") are not available, no scale can be defined and no evaluation can be obtained, unless expert judgment is also taken into account. Therefore, the only way to calibrate methods for the evaluation of ecological status is to compare their results with some kind of independent classification. As no objective criteria exist for measuring ecological status, expert judgment is the only viable solution, provided that it is referred to more than a single level of ecological status conditions (a complete spectrum of ecological conditions is the best option).

## New National Assessment Method- Portugal

New Method (PoFI, Portuguese Fish Index) includes different metrics for each river type. Does not apply in the following situations:
- < 30 km2 of drainage area,
- average depth < 0.2m
- total density < 15ind/100m2.

*Sampling*:
Electrofishing and stop nets when necessary, During spring, all types of existing habitats, fished areas according to CEN standards.

*Indexes*:

The index PoFI is calculated as follows:

A. Each metric scores *X* from 0 (minimum, high degradation) to 10 (maximum, low degradation).

B. Standardisation: the value for each metric (*Ms*) is calculated as

Ms = 10 x (*X* - Lim inf) / (Lim sup - Lim inf)

for the metrics decreasing with degradation

Lim sup = 50 %ile of reference sites

Lim inf = 5%ile of non-reference sites

for the metrics increasing with degradation

Lim sup = 50 %ile of reference sites

Lim inf = 90 %ile of non-reference sites

Negative values are transformed to zero and values higher than 10 are transformed to 10.

C. The Index PoFI is calculated as

$$PoFI = \frac{\sum Ms \ \text{x} \ 10}{N}$$

where *Ms* is the value for each metric and *N* is the number of metrics included in the index for that river type.

Metrics which are included in the multi-metric indexes were selected from a large list of metrics of all types based on the responsiveness to pressures.

PoFI values range from 0 to 100 and are tranformed to EQR dividing by the median value of the reference sites.

Considering the IC types in which Portugal intercalibrates, the metrics included in the indexes are:

- R-M1: no index available (no responsive metrics were found)
- R-M2: % endemic species, % pelagics, % limnophilics, % tolerant species, density of *Chondrostoma duriensis* (sentinel species).
- R-M5 (Temporary): % limnophilics, % lithophilics, % generalists, % tolerant species, density of *Squalius pyrenaicus* (sentinel species).

The ecological character of the fish species is presented in Table 1.

Table 1. Classification of species: B (benthic), PELG (pelagic), GEN (generalist), RF (reophilic), LIM (limnophilic), FIT (phytophilic), LIT (lithophilic), OMNI (omnivorous), INSV (insectivorous), POTAD (potamodrous), LONG (long migrations), LL (long life), TOL (tolerant), INTOL (intolerant), NAT (native), END (endemic), EX (exotic)

| ESPÉCIES | guild habitat | guild habitat (grau de reofilia) | guild reprodutiva | guild trófica | migração | longevidade | tolerância | tipo ecológico |
|---|---|---|---|---|---|---|---|---|
| *Alosa alosa* | PELG | RF | | | DIAD | | INTOL | |
| *Alosa fallax* | PELG | RF | | | DIAD | | | |
| *Ameiurus melas* | B | LIM | LIT | OMNI | | | TOL | EX |
| *Anaecypris hispanica* | PELG | LIM | | | | | INTOL | END |
| *Anguilla anguilla* | B | GEN | | | DIAD | | TOL | |
| *Atherina boyeri* | PELG | LIM | FIT | | | | | NAT |
| *Barbus bocagei* | B | LIM | LIT | OMNI | POTAD | LL | TOL | END |
| *Barbus comizo* | PELG | LIM | LIT | OMNI | POTAD | LL | TOL | END |
| *Barbus microcephalus* | B | LIM | LIT | OMNI | POTAD | LL | | END |
| *Barbus sclateri* | B | LIM | LIT | OMNI | POTAD | LL | TOL | END |
| *Barbus* spp. | PELG | RF | LIT | OMNI | POTAD | LL | | END |
| *Carassius auratus* | B | LIM | FIT | OMNI | | | TOL | EX |
| *Chondrostoma arcasii* | PELG | RF | FIT | OMNI | | | | END |
| *Chondrostoma duriensis* | B | RF | LIT | OMNI | POTAD | LL | | END |
| *Chondrostoma lemmingii* | PELG | LIM | LIT | OMNI | | | | END |
| *Chondrostoma lusitanicum* | PELG | LIM | LIT | OMNI | | LL | TOL | END |
| *Chondrostoma macrolepidotus* | PELG | LIM | FIT | INSV | | | TOL | END |
| *Chondrostoma polylepis* | B | RF | LIT | OMNI | POTAD | LL | | END |
| *Chondrostoma willkommii* | B | RF | LIT | OMNI | POTAD | LL | | END |
| *Cobitis calderoni* | B | RF | LIT | INSV | | | INTOL | END |
| *Cobitis paludica* | B | LIM | | INSV | | | TOL | END |
| *Cyprinus carpio* | B | LIM | FIT | OMNI | | | TOL | EX |
| *Gambusia holbrooki* | PELG | LIM | | INSV | | | TOL | EX |
| *Gasterosteus gymnurus* | PELG | GEN | | OMNI | | | TOL | NAT |
| *Gobio gobio* | B | RF | | INSV | | | | EX |
| *Herichtys facetum* | PELG | LIM | | OMNI | | | TOL | EX |
| *Lampetra planeri* | B | RF | LIT | OMNI | POTAD | | INTOL | |
| *Lepomis gibbosus* | PELG | LIM | | INSV | | | TOL | EX |
| *Liza ramada* | | GEN | | | DIAD | | TOL | |
| *Micropterus salmoides* | PELG | LIM | FIT | | | | TOL | EX |
| *Mugil cephalus* | | | | | DIAD | | | |
| *Petromyzon marinus* | B | RF | LIT | | LONG | | INTOL | |
| *Platichthys flesus* | B | LIM | | | DIAD | LL | | |
| *Salaria fluviatilis* | B | RF | LIT | INSV | | | | NAT |
| *Salmo trutta* | PELG | RF | LIT | INSV | | | INTOL | |
| *Squalius alburnoides* | PELG | GEN | LIT | INSV | | | | END |
| *Squalius aradensis* | PELG | GEN | LIT | INSV | | LL | | END |
| *Squalius carolitertii* | PELG | GEN | LIT | INSV | | LL | | END |
| *Squalius pyrenaicus* | PELG | GEN | LIT | INSV | | LL | | END |
| *Squalius torgalensis* | PELG | GEN | LIT | INSV | | LL | | END |

# Annex VII: Report from the Midland Group

EUROPEAN COMMISSION
DIRECTORATE GENERAL JRC
JOINT RESEARCH CENTRE
Institute of Environment and Sustainability

## Report – River Fish Groups

## MIDLAND GROUP

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**General approach**

Three countries were involved in the Midland group: the Walloon region of Belgium, France and Luxemburg. We used electrofishing fish data and environmental characteristics of a selection of sites belonging to the Meuse and Rhine basins and located in the Luxemburg, the Northeast part of France and the Southwest region of Belgium. Three fish-based methods were compared : two national methods from France and Belgium-Wallonia and a European index.

**National methods**

Among the three member states (MS) involved in the midlands group, only France and Wallonia use a national fish-based index. It is important to note that these national methods are still provisonial and will probably be updated to meet completely the requirement of the WFD:

- species composition and abundance,
- sensitive species
- age structure.

**Belgium-Wallonia :**

The IBIP (Integrity Biotic Index based on Fish) is the fish assessment tool applied in the Walloon part of the River Meuse basin. This method was developed at the University of Namur for the Meuse basin only by adapting the principles of the North American IBI to the lower diversity rivers of Belgium –Wallonia (DIDIER, 1997).
It is based on the following 6 metrics scored from 1 to 5 :

- Number of natives species;
- Number of benthic species;
- Proportion (%) of intolerant individuals;
- Bullhead / (Bullhead +Loach) ratio;
- Proportion (%) of individuals as specialized spawners;
- Presence of fry, juveniles and adults.

As one can see in the metrics list above, the method is not fully WFD compliant but the three under elements are at least partially covered
The final index score ranges from 6 (worst quality) to 30 (higher quality). For the index development, the reference conditions were defined on the ground of the best sites in the data set. With those reference sites, a “maximum value line - MVL ” was found that shows the highest expected value for the “High” class. The boundaries were set by a pentasection method, considering the relation between fish community watershed area and the Huet zonation.
Considering the type and region of rivers used as reference, the index can be applied for the trout, grayling and barbel zones. Although it showed some limitations, the « IBIP » is the only method developed specific to the Walloon part of the River Meuse basin. The metrics are calculated from the captures of a single run of electrofishing sampling. The site length required is 150 m and the habitats should be as diverified as possible. Non native species, non native species in the fish zone (Huet) and species coming from ponds or restocking are not taken into account.

The list of species used for this index and their ecological characteristics (native species, benthic species, tolerence guild, specialised spawners) was clearly identified in the method (Didier, 1997).

**France :**
France uses the FBI (French fish-based index), a method developed by Oberdorff and col. within in a national program between 1995 and 2000, and normalised in 2004 (AFNOR). It is a modelling approach that measures the deviation from the reference conditions. It is based on the use of the following seven metrics that are sensitive to human pressures and reflects species composition, trophic structure and species abundance:

- Total number of species;
- Number of rheophilic species;
- Number of lithophilic species;
- Density of Tolerant individuals;
- Density of Invertivorous individuals;
- Density of Omnivorous individuals;
- Total density of individuals

The theoretical values of each metric is calculated from a combination of environmental characteristics, similar to those used for the EFI, and known as the factors controlling fish community structure. The result for each metric is expressed as the probability for the observed value to belong to the set of reference values.
The final index is the sum of the probabilities of each metric. It ranges from 0 for reference sites to 100 and more for the most degraded sites.
The metrics are calculated from the results of a single run of electrofishing sampling following the European norm EN 14011.

**Luxembourg :**
So far, Luxembourg has no national classification method according to the fish biological element. A project is scheduled during the next years in order to intercalbrate some of the different national methods used in the neighbouring countries. The results of the fish intercalibration process will also be taken into account to develop a national fish-based method for the classification of watercourses in Luxembourg. In the meantime, electrofishing fish data and environmental characteristics of a selection of 20 sites are provided for the intercalibration pilot exercise for the Midland group.

**Setting of Reference conditions**

The first important issue was to select enough reference sites to be able to compare the different methods according to the Refcond protocole.

**Belgium-Wallonia**
The Belgian midlands reference sites have been selected among 77 sites pre-selected by expert judgement. From those 77 pre-selected sites, at the end of the process, 24 were considered as references sites on the ground of 110 criteria that can be summarized in the following categories:

- Morphological alterations
- Hydrological alterations-

- Water quality alterations
- Biological pressures
- Recreation uses

The exhaustive list of criteria used and the associated values are detailed in Annex 3.

**France**

For the intercalibration pilot exercise, the French reference data come from two sources:

- “reference” data used in the European Fame project. For several pressure type encompassing both hydro-morphological and physico-chemical perturbations, sites were classified into five quality classes. Sites with no score higher than two for the four main pressure criteria (hydrology, morphology, toxic and nutrient) were selected as “reference” calibration data;
- sites from the national reference monitoring network specially designed for the implementation of the WFD. A list of criteria is proposed in Annex 3. They encompass hydrology, sediment transport, land use, water quality (toxic, industrial and domestic waste, eutrophication), morphology and connectivity considered at different spatial scales (watershed, river reach and sampling site).

**Luxembourg**

Reference sites were chosen according to the REFCOND guidance. Detailed criteria and type-specific concentrations of key chemical parameters were proposed and agreed by the CBGIG (Central Baltic Geographical Intercalibration Group) for the macroinvertebrate intercalibration process. About 300 sites distributed all over the country were screened to select reference sites against agreed catchment land use limits, and when proposed reference sites were over agreed limits, a validation with physico-chemical parameters threshold at the site scale were used.

An exhaustive check list indicating which of the GIG defined reference criteria were used for the screening exercice and what sources of information were available for this process are detailed in Annex 3.

RQ : considering the methods used for selecting reference sites, the reference data set should not be considered as pristine (i.e. without human activity or influence) but as sites with no significant impact.

**Method for the intercalibration exercice**

**General objectives**

1.3. The intercalibration exercise doesn’t aim to test nor compare the national indices, since each of them have been developed, validated at a national or regional scale, and are consequently applicable at this scale.

1.4. The objective is to intercalibrate the boundaries values to find correspondence between the national classification of ecological status. The main thresholds of interest are the limits between “High and “Good” and “Good” and “Moderate” ecological status.

**Midland Data set**

Data were compiled to allow the calculation of the different fish-index of interest in the midland regions: the European fish index (EFI) developed at a European scale during the Fame project, the French fish-based index (FBI) and the Belgium-Wallonia IBIP.

The complete data set for the midlands was made of 349 fishing occasions distributed in the 3 countries involved in the midlands group (FR: 234; BE_W:95; LUX:20). Among those 349 fishing occasions, 120 were located on 100 different references sites.

RQ For some sites; some of the data required for the calculation of the national index was extrapolated when not available. For example, some of the Luxemburg river depth was extrapolated from other sites of the same type and other environmental characteristics. Moreover, individual fish data were not available for France, so the corresponding IBIP metric was extrapolated by expert judgment.
In a first step, due to the significant difference between countries concerning the number of fishing occasions, and to overcome the problems of temporal variations, only one fishing occasion by site was randomly selected leading to a set of 265 fishing occasions, for which the EFI was calculated; the IBIP was calculated for 235 ones (32 french samples were not calculated, particularly because the method is not adapted to non wadable rivers), and the FBI was calculated for all but 3 samples (N° BE230015, BE232008b and LUX184).
After selection of one fishing occasion per site, the reference data set include 100 sites (73 from France, 25 from Belgium and 2 from Luxemburg).

| Number of sites | Ref sites | Total |
|---|---|---|
| Belgium - Wallonia | 24 | 94 |
| France | 73 | 234 |
| Luxembourg | 2 | 20 |

**Data handling**
While the range of index scores is different between IBIP, FBI and EFI, it was necessary to make them comparable, by forcing them to vary between 0 and 1. This was achieved by subtracting from each value (IndexScore) the lowest value of the index (MinScore), and dividing the result by the difference between the highest (MaxScore) and the lowest (MinScore) of the index :

*Rescaled index= (IndexScore-MinScore) / (MaxScore-MinScore)*

*Following the recommendations of the intercalibration guidance (Common Implementation Strategy for the Water Framework Directive (2000/60/EC) - Guidance Document No. 14), each rescaled index score was transformed into EQR (Equivalent Quality Ratio) by dividing by the median value of reference sites (reference value). The following reference values were calculated on the midland reference data set : 0.56 for the EFI ; 0.79 for the IBIP ; and 1.023 for the FBI.*

***IndexEQR=Rescaledindex/MedianRefMidland***

**Setting of Boundaries**
For Belgium-Wallonia, a first exercise was done to set new boundaries following the framework of the BSP. Since the method used to define the IBIP classes (Didier, 1997) was not WFD and BSP compliant (see "national methods"), the first step was to define the boundary between High and Good status. This goal could be achieved by taking the 95%tile value of the index for the reference sites. Some values of the index were missing

in the reference sites data set. The raw result was a score value slightly below two score values that were not present in the reference sites data set. Above those two missing values there was a higher one (IBIP: 23/30) that was finally chosen as H/G boundary in a way to fit as well as possible to the EFI. The other boundaries were defined dividing the remaining values in four equal classes.
For France, the present GM threshold is based on the statistical study of the difference between a "reference" (both H and G status) and a disturbed (several types and intensity level of degradation) data set. It corresponds to the equal probability to classify a site as "reference" while it is degraded and to classify a site as degraded while it is unaltered. As a first step, other limits (GM, MP, PB) were defined subjectively. Thus these values are provisory and will be updated based on recent study.
After transforming the index into EQR, boundaries for the different indices are :

| | EFI-EQR | IBIP-EQR | FBI-EQR |
|---|---|---|---|
| HG Boundary | 1.19 | 0.89 | 0.89 |
| GM Boundary | 0.8 | 0.68 | 0.78 |
| Reference | 1 | 1 | 1 |

**Results of the comparison of boundaries between countries**

During this first midlands group intercalibration exercise for fish, the comparisons were run at the member states level and at the "midlands region" by comparing the scores and boundaries of several indices. The comparisons were carried out in term of correspondence of boundaries, indexes scores correlation and correlation between ecological status classification. First we consider only the reference data set to focus on the good and high status boundary. Then we further study the correlation between index and ecological status classification on the whole data set.

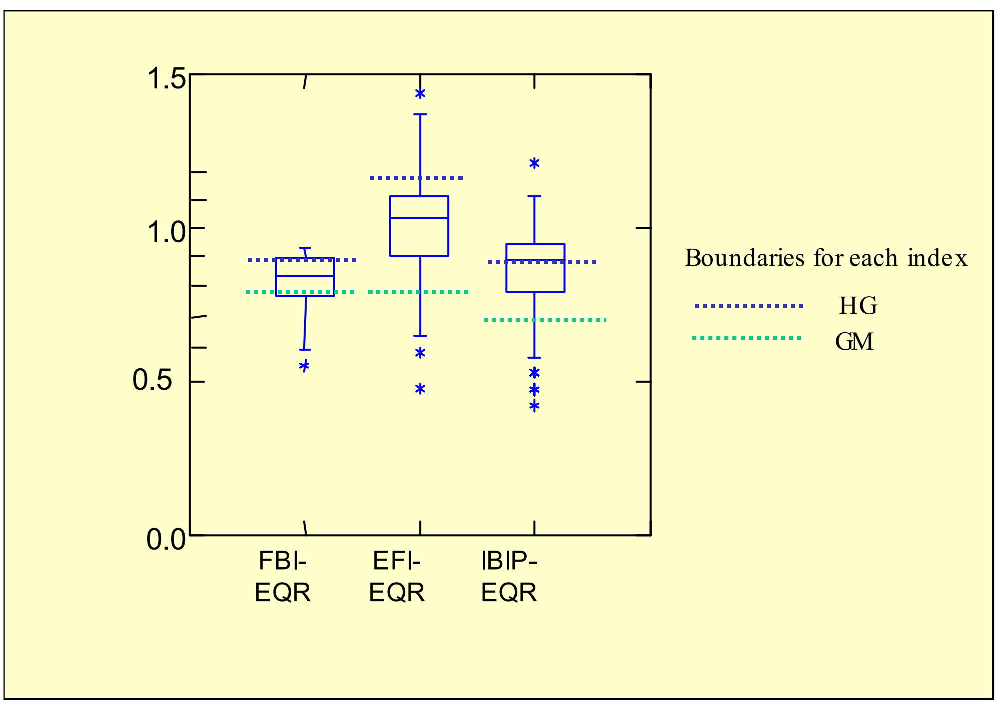


**Figure 1: Box and whisker plots for each fish index applied to reference data**

**Reference data set**

Applying the three indices and the corresponding boundaries to reference sites shows that EQR values are similar between FBI and IBIP (median values=0.85 and 0.9 respectively), while EFI values are higher (median=1.05). The HG boundary is quite the same for IBIP and FBI and higher for EFI. The GM boundary is quite the same for FBI and EFI while it is lower for IBIP.

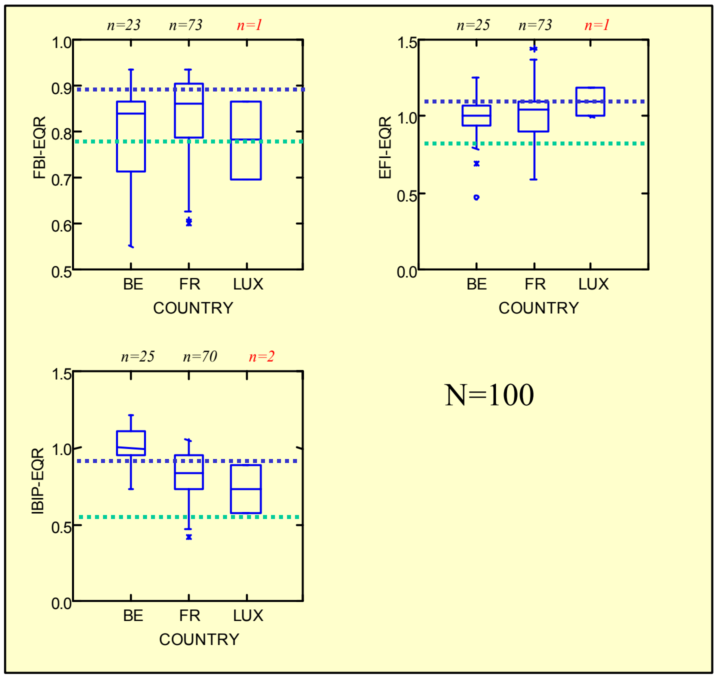


**Figure 2 : Box and whisker plot for each fish-index applied to reference data in each country**

If we consider the results of each index by country (
Figure ) we can observe different trend depending on the country where they are applied. The variance of FBI values for reference sites is higher than other indices whatever the number of samples considered.

While there is no statistical difference between values given by EFI and FBI in the different countries, the IBIP values for reference sites in Belgium are higher than in France and Luxemburg.

Correlations between indices are low (Fig. 2). The highest correlations are observed between EFI and the two national indices (r=0.3). The lowest correlation is observed between FBI and IBIP (r=0.1).

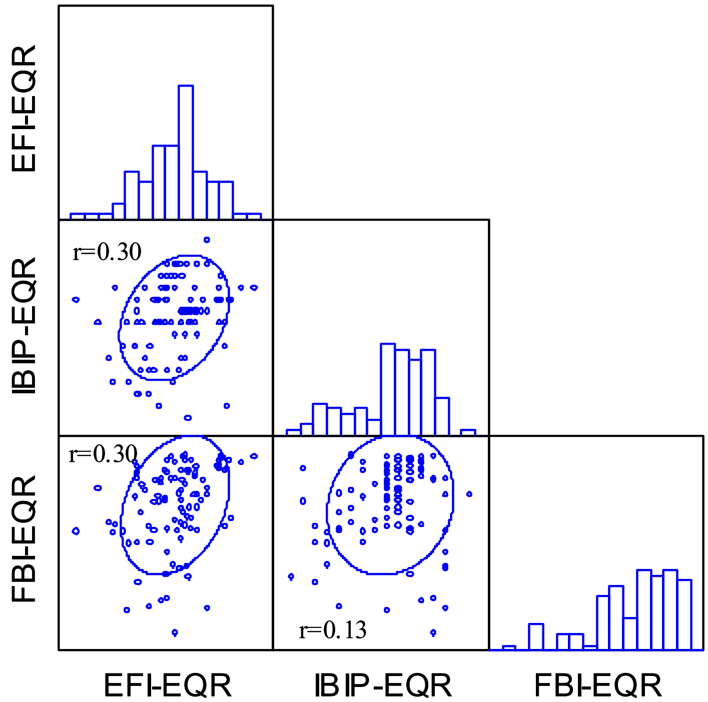


**Figure 3. Pearson correlation between fish indices and distribution of scores**

Considering the ecological status, indices give different classification of the "reference" sites. A higher proportion of sites are classified as "Good" by the EFI. A higher proportion of sites are classified as "High" by the IBIP. At a lesser extend, a higher proportion of sites are classified as moderate or bad by the FBI.

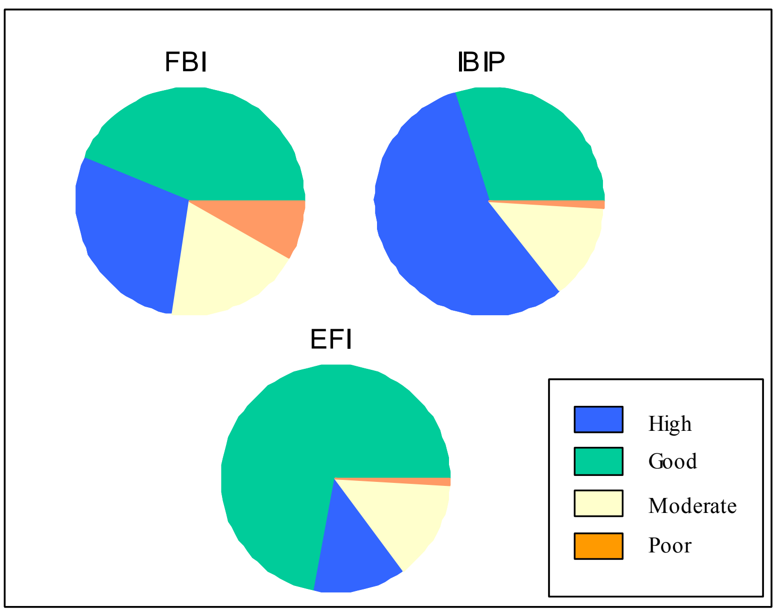


**Figure 4. Proportion of sites in the different ecological status for the three indices**

Spearman correlation coefficient was calculated on index class ranked from 1 to 5 (Table 1). The highest correlation is observed between FBI and EFI classes (r=0.36), followed by FBI and IBIP classes (0.27). But the values are low.

| | EFI-CLAS | IBIP-CLAS | FBI-CLAS |
|---|---|---|---|
| EFI-CLAS | 1 | | |
| IBIP-CLAS | 0.23 | 1 | |
| FBI-CLAS | 0.36 | 0.27 | 1 |

**Table 1. Spearman correlation matrix between index classes**

The cross-proportions of quality classes given by the three indices (2 by 2) are given in the annex.

### Whole data set

Considering the whole data set, we can observe that each index discriminates reference and impacted sites, but the difference between both categories is weak (

Figure 6). The figure also confirms that GM boundary is different between index (the difference is lower between IBIP and FBI comparing to EFI vs. IBIP and EFI vs. IBIP), and give information on how it could affect the classification of degraded sites. It is also interesting to note that IBIP and EFI exhibit similar boundaries for the differences between classes 3 / 4 and 4 / 5.

The correlation between EQRs is higher than for reference sites, but the distributions of scores are still different particularly for the EFI (Figure 8). The highest correlation is observed again between FBI-EQR and IBIP-EQR (0.71), and correlation between EFI and the two national indices is similar (0.69 and 0.65 respectively for IBIP and FBI).

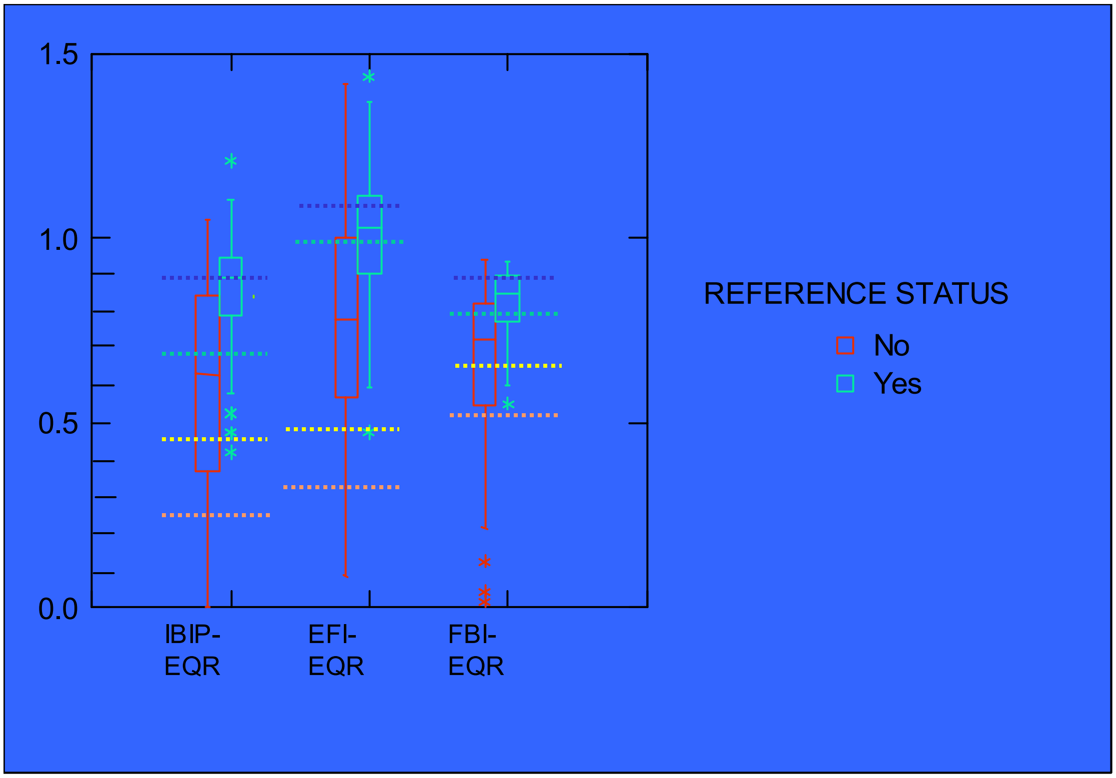


**Figure 5. Box and whisker plot for each fish-index applied to the whole data set**

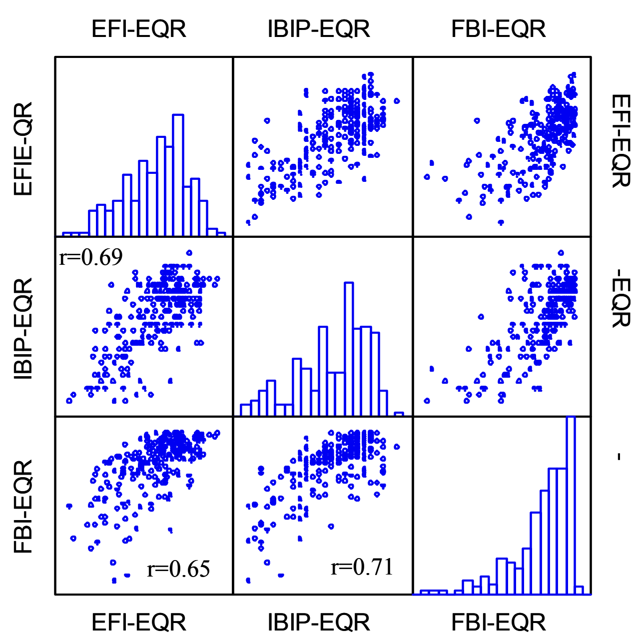


**Figure 6. Pearson correlation between Indices-EQR and distribution of scores**

The classification of sites into the different ecological status is different between indices, but this difference is lower for moderate, poor and bad status than for high and good status (Figure 10).

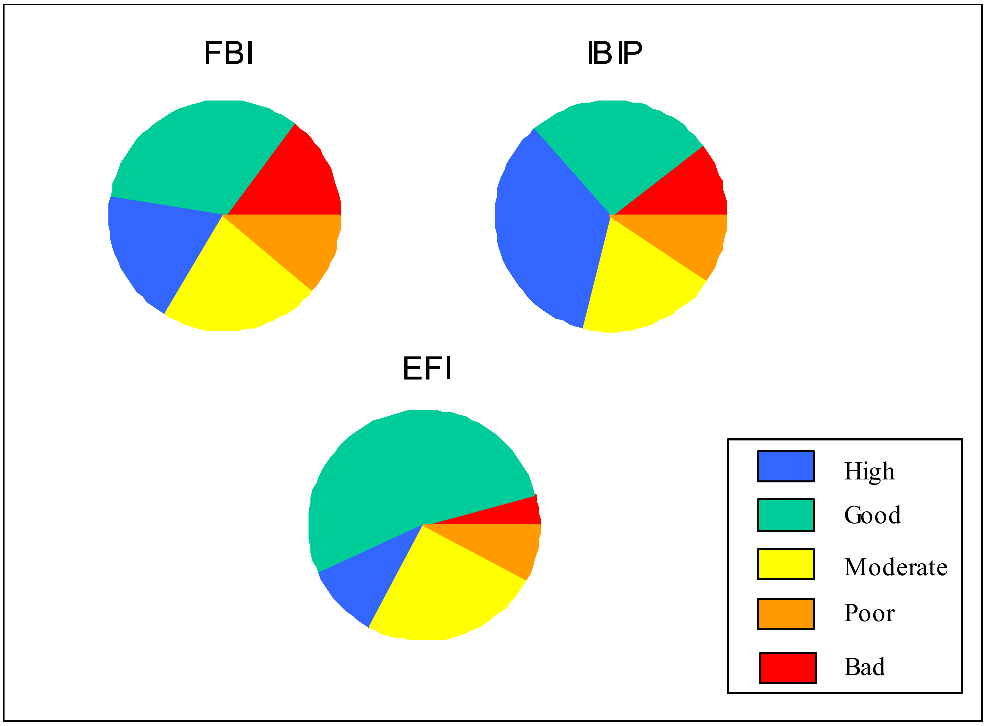


**Figure 7 Proportion of sites in the different ecological status for the three indices**

Spearman correlation coefficient was calculated on index class ranked from 1 to 5 ( Table 2). The highest correlation is observed between FBI and IBIP classes (r=0.66) while correlations between EFI classes and the national classes are similar (r=0.59 and 0.61 respectively with IBIP and FBI classes).

| | EFI-CLAS | IBIP-CLAS | FBI-CLAS |
|---|---|---|---|
| EFI-CLAS | 1 | | |
| IBIP-CLAS | 0.59 | 1 | |
| FBI-CLAS | 0.61 | 0.66 | 1 |

**Table 2. Spearman correlation matrix between index classes**

## Conclusion and indicative work plan for the continuation of the intercalibration

Due to very short timetable, the full intercalibration process couldn't be achieved for the midlands. Some indexes are still under development, do not exist or are applicable only to some of river types or region. There was also a big difference in the number of data provided by the countries which limit the conclusions. The provisional results are interesting and show that the three indexes compared, gave different classification status. Considering the reference data set, the three indices (EFI, IBIP and FBI) identify in a comparable way the reference sites as good or high quality status, but there are strong differences between indices concerning the HG boundary. For the moment it seems that criteria for selecting reference sites are not fully comparable. Moreover, indices

developed at a regional scale are not expected to be applied elsewhere, this extrapolation could explain a part of the divergences observed.
Considering the whole data set, there is a better correspondence between the three classification methods, and some boundaries seem easier to intercalibrate.
For the moment, the EFI does not constitute a highly consistent intercalibration tool, since it does not exhibit better results than direct national indices comparison ; but in the perspective of joining lowland and midland, EFI and a fortiori the EFI+ version could be really helpful.

Indeed, for the future work, it seems possible to group Midland and Lowland rivers, since these two regions are geographically very close together and share similar fish fauna, and they reflect more river types than distinct biological regions. Involving more countries and data would undoubtedly increase the insights and enrich the conclusions.

A further program of two years at least seems necessary to progress in data handling and analysis. Such a time table would allow including future developments on national indices and improvement of the European fish index (EFI+ project).

**References for national index**

Belgium

Didier, J., Kestemont, P. & Micha J.-C. (1997) : Indice Biotique d'Intégrité Piscicole (IBIP) pour évaluer la qualité écologique des écosystèmes lotiques, Convention MRW (DGTRE) 2095 : rapport final, 100 pp.

Kestemont, P., Didier, J., Depiereux, E,. & Micha J.-C. (2000) : Selecting ichthyological metrics to assess river basin ecological quality. – *Arch. ;Hydrobiol. Suppl.* 121/3-4, Monogr. Stud., p. 321-348.

France

T. Oberdorff, D. Pont, B. Hugueny, J.P. Porcher(2002) Development and validation of a fish-based index for the assessment of 'river health' in France. *Freshwater Biology* 47 : 1720-1734

T.Oberdorff, D. Pont, B.Hugueny, J.Bélliard, R.Berrebi dit Thomas, J.P. Porcher (2002) Adaptation et validation d'un indice poisson (FBI) pour l'évaluation de la qualité biologique des cours d'eau français. *Bull. Fr. Pêche Piscic.* 365/366 : 405-433.

AFNOR (2004) Qualité de l'eau - Détermination de l'indice poissons rivière (IPR) / *Water Quality standard* –Calculation of the French fish-based index (FBI)

**Annex 1: Cross-proportion of the ecological status given by the three indices for reference sites**

EFI vs. IBIP

| | | IBIP | | | |
|---|---|---|---|---|---|
| | | High | Good | Moderate | Poor |
| EFI | High | **10.7** | **1.3** | **1.3** | **0.0** |
| | Good | **42.7** | **20.0** | **5.3** | **1.3** |
| | Moderate | **4.0** | **6.7** | **5.3** | **0.0** |
| | Poor | **1.3** | **0.0** | **0.0** | **0.0** |

EFI vs. FBI

| | | FBI | | | |
|---|---|---|---|---|---|
| | | High | Good | Moderate | Poor |
| EFI | High | **14.7** | **1.3** | **1.3** | **0.0** |
| | Good | **18.7** | **48.0** | **16.0** | **8.0** |
| | Moderate | **4.0** | **6.7** | **5.3** | **2.7** |
| | Poor | **0.0** | **1.3** | **0.0** | **0.0** |

IBIP vs. FBI

| | | FBI | | | |
|---|---|---|---|---|---|
| | | High | Good | Moderate | Poor |
| IBIP | High | **16.0** | **25.3** | **9.3** | **5.3** |
| | Good | **2.7** | **20.0** | **4.0** | **1.3** |
| | Moderate | **1.3** | **1.3** | **6.7** | **5.3** |
| | Poor | **0.0** | **0.0** | **0.0** | **1.3** |

**ANNEX 2 – Description of national classification methods included in the intercalibration**

*France*

The FBI method (Oberdorff et al. 2002a and b and AFNOR 2004) is officially used for national monitoring and first step of WFD implementation. This index will be revised to fully meet the requirement of the WFD and adjust boundaries thank to recent studies. A description of the method can be found in the Alpine Group report.

*Belgium-wallonia*

1. Although it shows some limitations of applicability, the « IBIP » (Integrity Biotic Index based on Fish) is the only method until now that has been developed speciciffically for the Walloon part of the River Meuse basin. The metrics are calculated on the ground of a single run electrofishing. The site length required is 150 m and the habitats should be as varied as possible.The index is used for the trout, the grayling and the barbel zone. Non native species, non native species in the fish zone (Huet), species coming from ponds or restocking are not taken into account. The IBIP is calculated on the ground of 6 metrics (see below). Each metric scores from 1 to 5. The index is obtained by adding the result of the 6 metrics.

2. Metrics calculation. Number of natives species. The theoretical maximum number of native species (Y) is a function of the catchment class ( varies from X=1 : 0-3.1 km2 to X=14 : 3160-5620 km2). The maximum number of species for each catchment class is defined by the following equation : Y= 1.38x + 3.62. ($r^2$= 0,97).The five quality classes

of this metric are obtained by deviding into 5 equal classes the theoritical maximum number of native species (Y). Number of benthic species The principle to establish the five quality classes for this metric is the same as the previous one. The maximum number of benthic species for each catchment class is defined by the following equation : Y= 0.49x + 2.77. r2= 0,88. Proportion of intolerant individuals A tolerance guild has been set to classify each fish species (taken into account by the method) according to its tolerance to water quality degradation. The number of individuals is mutiplied by 0.8 for class 4 and by 1 for class 5 (to most intolerant species). The total number obtained for individuals of class 4 ans 5 divided by the total number of caught individuals considered by the method, multiplied by 100 provides the value used to calculate this metric. The principle to establish the five quality classes for this metric is the same as the previous one. The maximum proportion of intolerant species for each catchment class is defined by the following equation : Y= -0.57x2 + 3.02x + 91.61. (r2= 0,75). Bullhead/bullhead +loach ratio This metrics is scoring from 1 if the ratio shows a value lower than 0.2 to 5 for values above 0.8. Proportion of individuals as specialized spawners Each fish species (taken into account by the method) is classified as specialized spawners or not. The percentage of individuals classified as specialized spawners leads to the metric value 1, 3 or 5. Presence of fry, juveniles and adults The goal is to check if the three age classes (fry, juvenile and adult) are present in the most abundant intolerant species of the fish zone. i.e. trout in the trout zone, trout or grayling in the grayling zone (depending on the abundance) and trout, grayling, barbel or nase in the barbel zone (depending on the abundance).The score depends on the number of classes (1, 2 or 3) but also of the number of individuals in each class (0, 1-50 or >50).
The index score varies from 6 to 30.
After setting the boundaries on the ground of the boundary setting protocol the new boudaries for quality classes are (provisionally):

| | IBIP | Rescaled IBIP | EQR IBIP |
|---|---|---|---|
| Maximum value | 30 | 1.00 | 1.26 |
| Reference value | 25 | 0.79 | 1.00 |
| HG | 23 | 0.71 | 0.89 |
| GM | 19 | 0.54 | 0.68 |
| MP | 15 | 0.38 | 0.47 |
| PB | 11 | 0.21 | 0.26 |
| Minimum value | 6 | 0.00 | 0.00 |

**National criteria for the selection of reference sites**

**FRANCE : Summary of the criteria for selecting reference monitoring sites**

Watershed level

*Land use*
Threshold for agriculture cover : reference < 10 % of watershed area
Vineyard: reference < 1% of watershed area
Urban land< 2% of watershed area
In agricultural area:
10 à 50% of watershed = cultivated area ; reference sites could be found where :
- no erosion nor siltation
- part of watershed is “natural”
- parts of the valley is grassland and riparian zones are preserved.

*Hydrology*
No dam modifying significantly hydrology (no sites with frequent flood suppressed (Q5), or low flow discharge lowered).
Flood <5 years frequency not modified
Low flow: no more than 50 % of inter-annual low flow lowering (
No increase of discharge >30%
*Sediment transport*
No dam modifying significantly sediment transport
Incision and erosion are the criteria considered for dam >5m high

<u>River reach scale</u>

*Toxic pollution*
No toxic effluent for smal rivers
No impact of known industry for larger rivers

*Domestic and industrial pollution*
For small rivers no effluent or very local moderate impact
For larger rivers: low impact considering auto-epuration (level <3 for water organic parameters from national water assessment method)

*Eutrophication*
No obvious vegetation development and/or value <3 for phosphorus parameters of the French national water assessment method
Nitrogen : < 5 mg /l de NO3
or if higher, no other source of pollution

*Hydrology*
flushing discharge / natural discharge < 2, water abstraction <20% low flow discharge

*Morphology*
Proportion of artificially lowered water flow < 30% of reach length;
Strong modification of morphology<20% of reach length (strengthening; impounding; deepening, banks artificialisation…
Light local modifications <40% of reach length
No sign of siltation of spawning habitats
*Land use and riparian corridor*
In cultivated areas, riparian corridors should be preserved: altered or absent riparian vegetation < 30% of the reach length
Riparian buffer: 10 –50 m

<u>Sampling site</u>

RQ : Sampling site length > 12 to 18 fold river width
No close polluted effluents
No close morphological modifications
Presence of riparian vegetation, at least for small and medium size rivers
Avoid high livestock, angling, tourist…area and presence of invasive species

*<u>BELGIUM (Wallonia): criteria for selecting reference monitoring sites</u>*

A list of 110 single criteria according to the REFCOND- guidance is used to select reference sites. This list can be found in the Original report from the Midland Group (CIRCA).

# Annex VIII: Report from the Nordic Group

EUROPEAN COMMISSION
DIRECTORATE GENERAL JRC
JOINT RESEARCH CENTRE
Institute of Environment and Sustainability

Report – River Fish Groups

| GIG | **FISH- REGIONAL GROUP “ Nordic”** |
|---|---|
| Information provided by | Ulrika Beier, Alan Starkie, Teppo Vehanen |

## A – General approach

No specific type according to the WFD “system A or B” for the intercalibration has been applied. Participating countries in the Nordic group are Finland, Ireland, Northern Ireland, Norway, Scotland, Sweden Wales and parts of England. An overview regarding the distribution of some environmental variables, available data and other information is listed in Table 1. A common feature for the participating countries is that salmonid fish, i.e. trout (*Salmo trutta*) and salmon (*Salmo salar*) are frequently occurring and often the dominant group in the fish community at sites reported by the participating countries in the Nordic group. Trout and salmon are also important species in the metrics within the indices of both national methods used in the comparison.

There is fundamental difference between the two national methods compared. With FIFI, classifications of status are made on the basis of the outcome of the index for reference sites in each country. The status classification VIX, on the other hand, does not directly refer to the status for sites classified as reference. Instead, the focus during the development of VIX was, as clearly as possible, to separate between good and moderate status.

The approach for comparison is to provide each fishing occasion with a) index values for FIFI and VIX (see below) and b) class values based on FIFI and VIX, respectively. Comparisons of the outcome of both indices will be made with respect to preclassified human impact for connectivity, chemical pressure and type, hydrological pressure, morphological pressure, whether sites are classified as official national references, and whether sites are classified as fish references by expert judgement. The data for Scotland could only be compared against preclassification for water quality pressures at the time of collecting data for the intercalibration. Sites in Scotland were therefore neither classified as being fish reference sites (by expert judgement) nor national reference sites.

The relationship between index values of both methods was compared using linear regression. The outcome of classifications using both methods was demonstrated using a pivot table, stacked bar diagrams as well as error bar diagrams.

To set the boundaries between status classes for FIFI, datasets from each country were used, using the reference classification of sites to set the boundary between high and good status. (The original typology of FIFI was not applied.) Boundaries between status classes for VIX were set according to the dataset originally used for developing the VIX index in Sweden, where preclassified impact determined the main boundary between good and moderate status.

The intercalibration within the Nordic group includes a comparison of two national methods to classify ecological status in running waters from electric fishing data; the Finnish FIFI and the Swedish VIX methods. The two methods have different approaches. FIFI has a reference based approach with the main focus being on the boundary between high and good status. The class boundaries in FIFI are determined according to the distribution of index values, assuming that 75% of the references are within class 1 (high status). VIX has a site based approach, setting class boundaries originally based on the Swedish dataset used for developing VIX, with the main focus on the boundary between good and moderate status. The boundary between class 2 and 3 (good and moderate status) was set where the probabilities for making Type I and Type II errors were equal, i.e. the risk of erroneously classifying a site which according to preclassified human impact should be 1- 2 (high or good status) as 3-5 (moderate, poor or bad status) is equal to the risk of erroneously classifying a site which should be 3-5 as 1-2. More detailed descriptions of the methods are provided in Annex A.

**Table 1.** Statistics of environmental variables, number of fish species, trout type, references and amounts of supplied data for the countries participating in the Nordic intercalibration group for fish in running waters. FI=Finland, IR=Ireland, NI=Northern Ireland, NO=Norway, SC=Scotland, SE=Sweden and UK=subset of the United Kingdom including Wales and parts of England.

| | | FI | IR | NI | NO | SC | SE | UK |
|---|---|---|---|---|---|---|---|---|
| Altitude | mean | 74 | 70 | 66 | 345 | 195 | 82 | 132 |
| | **median** | **54** | **64** | **65** | **309** | **145** | **27** | **115** |
| | min | 1 | 4 | 5 | 63 | 2 | 1 | 6 |
| | max | 397 | 263 | 237 | 715 | 505 | 870 | 541 |
| Wetted width | mean | 26,8 | 4,2 | 3,9 | 6,1 | 3,1 | 7,5 | 5,1 |
| | **median** | **15** | **3,8** | **4** | **5** | **2,6** | **4,2** | **4,3** |
| | min | 3 | 1 | 1 | 1 | 1 | 1 | 1 |
| | max | 130 | 30 | 6 | 20 | 8 | 135 | 18 |
| Slope | mean | 2,2 | 14,2 | 3,4 | 86,8 | 17,3 | 13,6 | 18,4 |
| | **median** | **1,9** | **8** | **2,3** | **52,2** | **12** | **7,7** | **11** |
| | min | 0,3 | 0,3 | 0 | 12,2 | 1 | 0,2 | 0 |
| | max | 10 | 283 | 15 | 325 | 95 | 100 | 131 |
| Mean year temp. | mean | 2,3 | 9,4 | 12,6 | 6 | 8,5 | 5,5 | 9,5 |
| | **median** | **2,2** | **9,3** | **12,5** | **5,6** | **8,4** | **7** | **9,6** |
| | min | -2 | 8,8 | 12,1 | 4,3 | 8,3 | -1 | 7,7 |
| | max | 5,3 | 10,4 | 12,9 | 8,2 | 9,1 | 8 | 10,6 |
| Catchment size class | <10 | | 232 | 6 | **66** | 41 | 29 | 88 |
| (no. sites per class) | <100 | 5 | **247** | **32** | 3 | **90** | **98** | **133** |
| | <1000 | 29 | 15 | 2 | | 2 | 35 | 8 |
| | <10000 | **36** | 2 | | | | 16 | |
| | >10000 | 1 | | | | | | |
| Catchment geology** | Calcareous | 5 | **306** | **22** | | 40 | 34 | |
| (no. sites per class) | Siliceous | 6 | 190 | 18 | **69** | **93** | **144** | **229** |
| | Organic | **60** | | | | | | |
| No. of fish spp. | mean | 4,7 | 2,9 | 3,2 | 1,1 | 2,3 | 2,8 | 3,9 |
| | **median** | **5** | **3** | **3** | **1** | **2** | **3** | **4** |
| | min | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| | max | 10 | 8 | 7 | 2 | 5 | 10 | 8 |
| Trout type | resident | 58 | 325 | 40 | | 14 | 60 | 229 |
| (no. sites per class) | lake migrating | 2 | 168 | | 69 | 22 | 10 | |
| | sea migrating | 11 | 3 | | | 97 | 108 | |
| National reference site | No | 62 | 488 | 40 | | 133 | 172 | |
| | Yes | 9 | 8 | | | | 6 | |
| | Information lacking | | | | 69 | | | 229 |
| Fish reference site | No | 63 | 469 | 34 | | 133 | 164 | |
| (expert judgement) | Yes | 8 | 27 | 6 | | | 14 | |
| | Information lacking | | | | 69 | | | 229 |
| Sites | No. of cases | 71 | 441 | 40 | 69 | 125 | 178 | 152 |
| Fishing occasions | | 71 | 496 | 40 | 69 | 140 | 1280 | 229 |
| FIFI index | | 71 | 496 | 40 | 69 | 121 | 1280 | 229 |
| FIFI status | | 71 | 496 | 40 | | | 1280 | |
| VIX index + status | | 71 | 495 | 39 | 66 | 121 | 1276 | 229 |
| Pressure data | | 71 | 496 | 40 | | 140 | 1280 | 229 |

# B – Setting of Reference conditions

Table 2. National approaches for determining national references and fish references. Further information is available in Annex B.

| | No of national reference sites in the Nordic dataset | National reference criteria | No of fish reference sites in the Nordic dataset | Fish reference criteria |
|---|---|---|---|---|
| FI | 9 | Morphology of the river base (1 natural state, 2 restored, 3 dredged), human disturbance effects (expert judgement, scale 0-10) and water quality. PCA. (Annex B) | 8 | Morphology of the river base (1 natural state, 2 restored, 3 dredged), human disturbance effects (expert judgement, scale 0-10) and water quality. PCA. (Annex B) |
| IR | 8 | * | 27 | * |
| NI | * | * | 6 | * |
| NO | * | No official national classification system for references yet. | | Suggested criteria: Morphology of river bed / basin (normal, restored or dredged), human impact; land use, hydraulic engineering or point source pollution (expert judgement), water quality (a=toxic substances, b=eutrophication and c=acidification [pH > 6,0, alkalinity > 10 µekvL-1 and labile Al < 10 µg L-1], stocking (0 or 1) and introductions of alien or species non-native in catchment (0 or 1). |
| SC | * | All macroinvertebrate REFCOND criteria (Annex B). | * | |
| SE | 6 | REFCOND guidance with additions and modifications (Annex B). | 14 | Information available in the Swedish electrofishing register regarding human impact (expert judgement). Separate, more detailed information for a study regarding coastal sites (HÖL). |
| UK | * | * | * | * |

* Not reported

# C – Setting of Boundaries

a. A common benchmark dataset was not used. Data from all countries was used to compare the two methods FIFI and VIX.
b. To set the boundaries between status classes for FIFI, datasets from each country was used, using the reference classification of sites to set the boundary between high and good status. The original typology of FIFI was not applied due to an insufficient number of sites for each type. The whole dataset from each country was used instead, and the FIFI index value where 75% of the references (fish references) were above the index value, was used to determine the border between high and good status (HG). The remaining three boundaries below, i.e. between good and moderate (GM), between moderate and poor (MP), and between poor and bad status (PB), were then set in equal intervals from the HG border towards zero. In this manner, the borders between status classes with differ slightly between countries (Table 3). Furthermore, for countries which had not classified fish references, FIFI could be calculated but not categorized into status classes, as this procedure depended on the outcome of FIFI scores for the national references.

Boundaries between status classes for VIX were set according to the dataset originally used for developing the VIX index in Sweden, where preclassified impact determined the main border between good and moderate status. The border between good and moderate status was chosen where the probabilities of making type-I and type-II errors were equal, i.e. where the risks of classifying an impacted site (preclassified impact 3-5) as unimpacted (preclassified impact 1-2), or vice versa, were equal. The border between high and good status (“HG”) was chosen so that the probability of classifying an unimpacted site (preclassified impact 1-2) as impacted (preclassified impact 3-5) was less than 5%. The border between poor and bad (”PB”) was chosen so that the probability of classifying an impacted site (preclassified impact 3-5) as unimpacted (preclassified impact 1-2) was less than 10%. The border between moderate and poor was set midway between the GM and PB borders. The borders for status classes of the index values are: class 1 (high) ≥0.749, class 2 (good) ≥0.467, class 3 (moderate) ≥0.274, class 4 (poor) ≥0.081, and class 5 (bad) <0.081.

## D – Results of preliminary comparison of boundaries between countries using FIFI and VIX

The FIFI method appears consistently to class sites higher than the VIX method. This is illustrated in Figure 1, where the regression line is significantly below a line drawn from the origin to the end points of the x- and y-axes. Figure 2, showing classes of FIFI and VIX, also demonstrates that FIFI generally classifies sites more "generously" than VIX. Table 3 also demonstrates that there are considerably more sites classified as high or good status using FIFI than using VIX. Furthermore, the outcome in the FIFI and VIX indices appear to be clearer regarding chemical impact, especially impacts from increased nutrient input (Figure 3) compared to hydrological or morphological impact (Figure 4 & 5). However, it is still apparent that FIFI generally gives a higher index value compared to VIX.

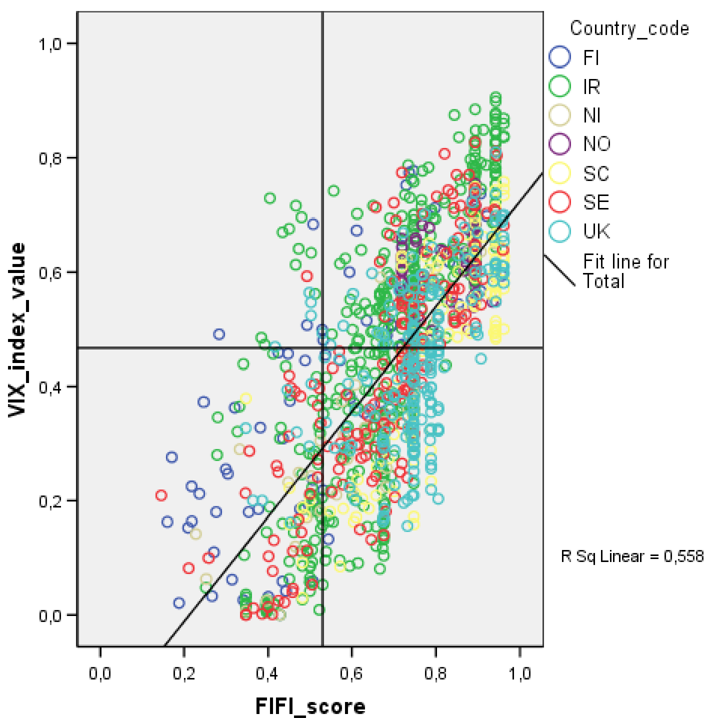


Figure 1. Scatterplot of scores of index values for FIFI and VIX for the last fishing occasion of sites, fitted with linear regression (P<0.001, R2=0.558, N=1216). The horizontal line shows the GM border for FIFI (Finnish sites) and the vertical lie the GM border for Swedish sites.

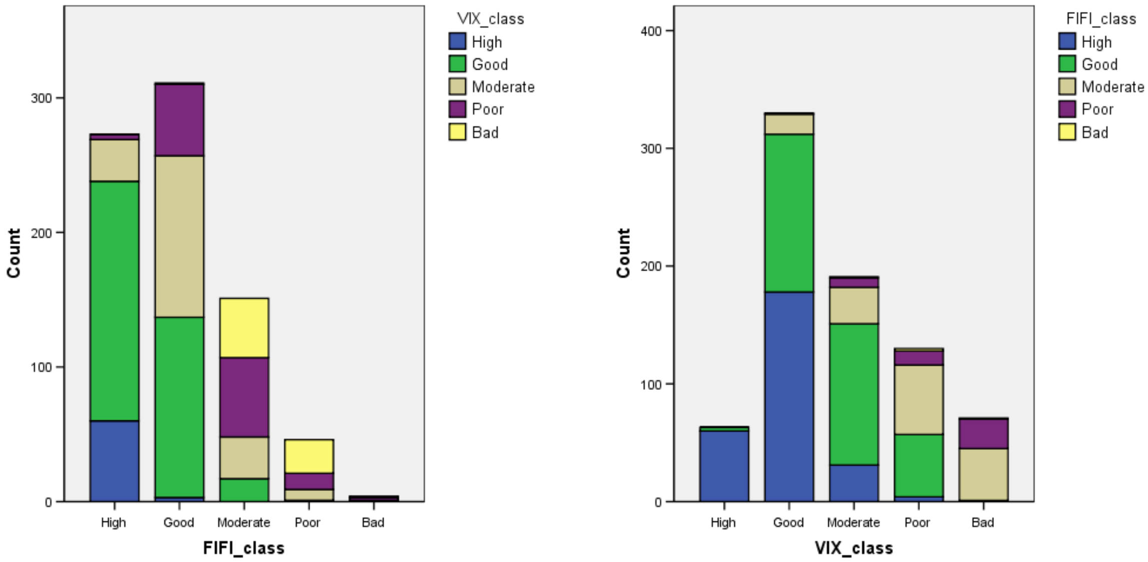


Figure 2. Histogram of a) FIFI class split in VIX classes and b) VIX class split in FIFI classes. The dataset used is the most recent fishing occasion at 1216 sites in Finland, Ireland, Northern Ireland, Norway, Scotland, Sweden and the United Kingdom (sites in Wales and England).

Table 3. Pivot table of status classifications using FIFI and VIX. The numbers are the number of cases (based on the most recent fishing occasion at each site).

| Country | | FIFI status | | | | |
|---|---|---|---|---|---|---|
| | VIX status | High | Good | Moderate | Poor | Bad |
| | High | 3 | 0 | 0 | 0 | 0 |
| FI | Good | **12** | **10** | 3 | 1 | 0 |
| | Moderate | 0 | 6 | 6 | 2 | 1 |
| | Bad | 0 | 0 | 6 | 3 | 1 |
| | Poor | 0 | 1 | **7** | **8** | 1 |
| IR | High | 50 | 3 | 0 | 0 | |
| | Good | **91** | **119** | 13 | 0 | |
| | Moderate | 2 | 79 | 17 | 5 | |
| | Poor | 0 | 35 | **36** | 1 | |
| | Bad | 0 | 1 | 24 | 20 | |
| | High | - | | | | |
| NI | Good | **8** | 2 | 0 | 0 | |
| | Moderate | 5 | **7** | 1 | 1 | |
| | Poor | 0 | 5 | **6** | 1 | |
| | Bad | 0 | 0 | 2 | 2 | |
| SC | - | 16 | | | | |
| | High | 1 | | | | |
| | Good | **77** | | | | |
| | Moderate | 16 | | | | |
| | Poor | 22 | | | | |
| | Bad | 1 | | | | |
| | High | 7 | 0 | 0 | 0 | 0 |
| SE | Good | **67** | 3 | 1 | 0 | 0 |
| | Moderate | 24 | **28** | 7 | 0 | 0 |
| | Poor | 4 | 12 | 10 | **2** | **1** |
| | Bad | 0 | 0 | **12** | 0 | 0 |
| UK | High | 1 | | | | |
| | Good | 96 | | | | |
| | Moderate | **109** | | | | |
| | Poor | 23 | | | | |
| | Bad | - | | | | |

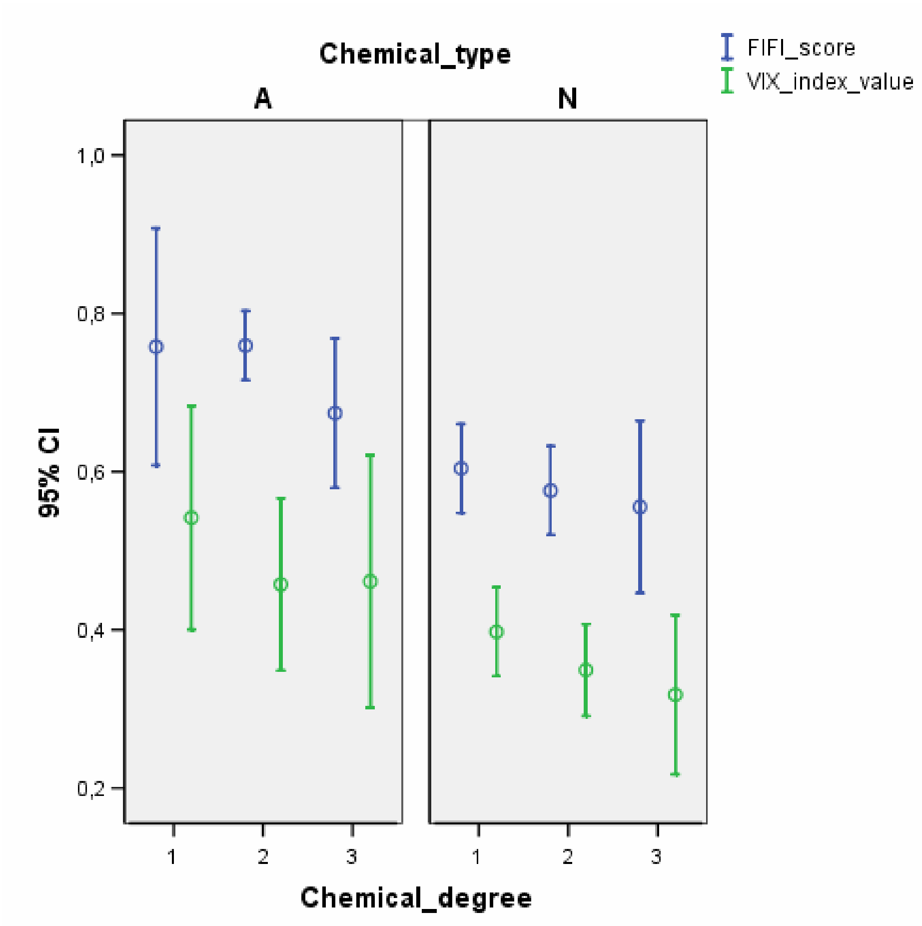


Figure 3. Error bar (95% confidence limits) of FIFI index scores and VIX index scores, in different categories of increasing chemical pressure (chemical degree). The different types of chemical pressures have been separated into mainly acidification pressure (A) and nutrients/organic input (N) where 1 = low pressure and 3 = high pressure.

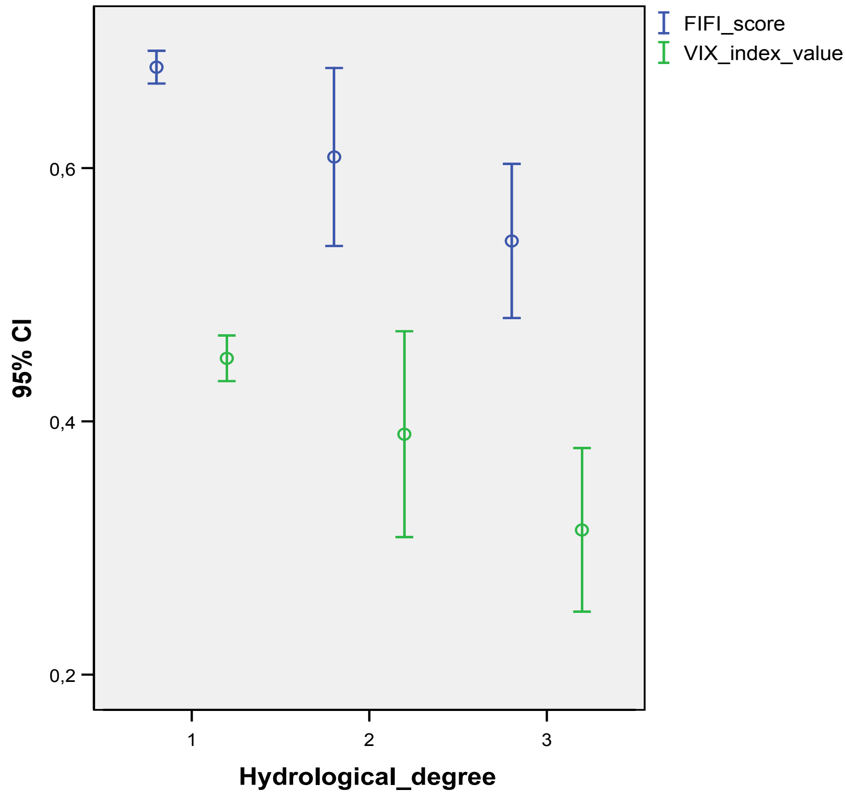


Figure 4. Error bar (95 % confidence limits) of FIFI index scores and VIX index scores, in different categories of increasing hydrological pressure (hydrological degree).

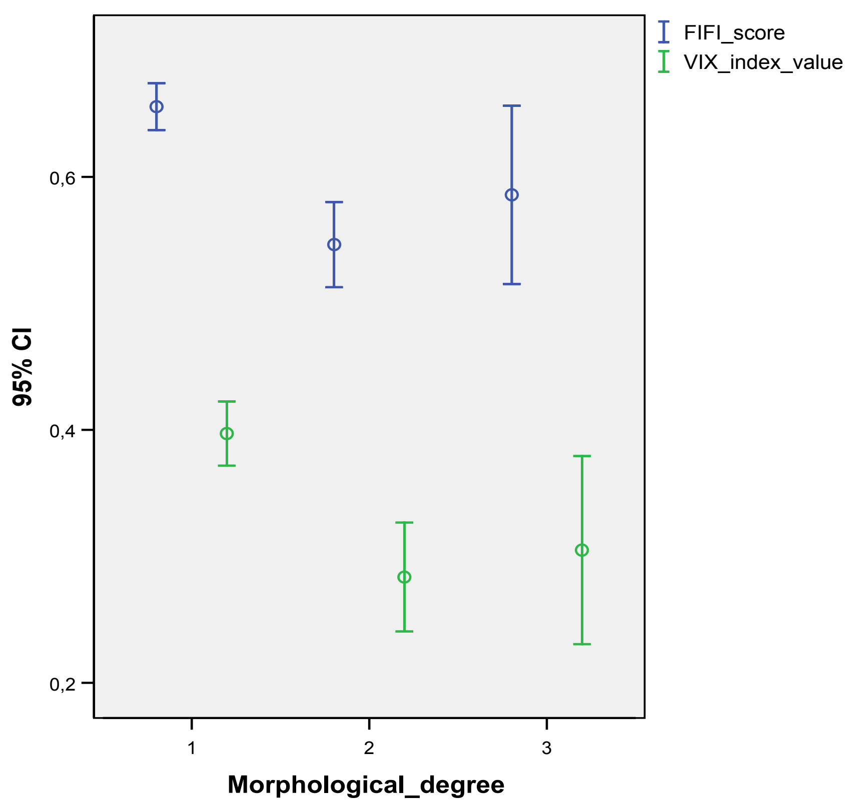


Figure 5. Error bar (95% confidence limits) of FIFI index scores and VIX index scores, in different categories increasing morphological pressure (morphological degree).

The altitude values for Northern Ireland used in the calculations for FIFI and VIX were unfortunately incorrect, as they had been given in yards instead of metres. Therefore index values for Northern Ireland will have to be recalculated. Correct altitude values were supplied 2007-04-27 and were incorporated into the overview of environmental variables in Table 1.

## E – Boundary EQR values

Table 3. Borders between status classes for FIFI and VIX.

| | FIFI | | | | | | | VIX (all countries) |
|---|---|---|---|---|---|---|---|---|
| | FI | IR | NI | NO | SC | SE | UK | |
| High | 0,71 | 0,76 | 0,73 | n.a. | n.a. | 0,68 | n.a. | 0,749 |
| Good | 0,53 | 0,56 | 0,56 | | | 0,51 | | 0,467 |
| Moderate | 0,35 | 0,38 | 0,40 | | | 0,34 | | 0,274 |
| Poor | 0,21 | n.a. | n.a. | | | 0,21 | | 0,081 |

## Annex A

**Description of the Finnish Fish Index (FIFI)**

The Finnish Fish Index (FiFI) is currently published in Finnish. The report can be downloaded from the web-pages of the Finnish Fisheries Research Institute: www.rktl.fi/?view=publications&cat=41 . The report is "Vehanen, T., Sutela, T. & Korhonen, H. 2006. Kalayhteisöt jokien ekologisen tilan seurannassa ja arvioinnissa. Alustavan luokittelujärjestelmän perusteet. Kala- ja riistaraportteja nro 398."

There has been no official decision of the methods used in the ecological classification in Finland. Therefore the status of the FIFI method is "under development".

FIFI index is based on the reference conditions approach. We began from the promise that rapids are key habitats that characterize the condition of an entire river. Fish data was collected from wadeable rapids and stream areas that had been electro fished in fishery surveys. Electrofishing is a CEN-standardised method for collecting fish data (Water quality – Sampling of fish with electricity, EN 14011). The data was collected from studies using 1-3 pass removals in fish sampling. To maintain comparability between sites, we used the results of the catch of the first run from all the studies. We recorded the fish species caught, their density (fish per 100 $m^2$) and biomass (g). The age-0+ brown trout and salmon were recorded separately from the older age classes. We utilized electrofishing results only from late July to October when the age-0+ fish were a catchable size.

Information about the location (coordinates), water width of the river at the electrofished site and the catchment area above the site were recorded. The condition of the river bed was categorised as natural state, dredged or restored. Water chemistry data (oxygen %, pH, brown colour, phosphorus, COD, suspended solids) was collected from a national database and long-term averages were calculated. The effect of human disturbance was estimated using expert judgement (scale 0 to 10) to measure the effects of land use in the catchment (ditching, peat production, agriculture and forestry), hydraulic engineering and point source pollution.

The 19 fish species present in the electrofishing catch were classified into different ecological and functional groups based on their habitat use, feeding and tolerance level. Rainbow trout was the only alien species present in the data and its existence was restricted to one river area in southern Finland. The WFD requires an assessment of fish species composition and abundance and the age structure of the fish community. We tested the ability of several fish-community-based candidate metrics to distinguish between the impacted and reference sites. We used the entire data set (impacted vs. reference sites) and also tested separately three river types where both reference and impacted sites existed. Metrics selected for the index were selected according to two principles. First the response

with the human pressure was examined: metric had to show significant correlation with the magnitude of human pressure throughout the data (Figure A1). Then Discriminant Function Analysis (DFA) was used to calculate apparent error rate (APER), the error rate how accurately the classification of sites was made according to each metric. Those metrics with the lowest APER were selected. Finally, the correlations between the selected metrics were examined to remove metrics with similar response to human pressure. If correlations between too metrics were high, the other was removed based on expert judgement.
According to the results five metrics were selected for the fish index: number of fish species, proportion of intolerant species, proportion of tolerant species, density of cyprinid individuals, and density of age-0+ salmonids individuals.

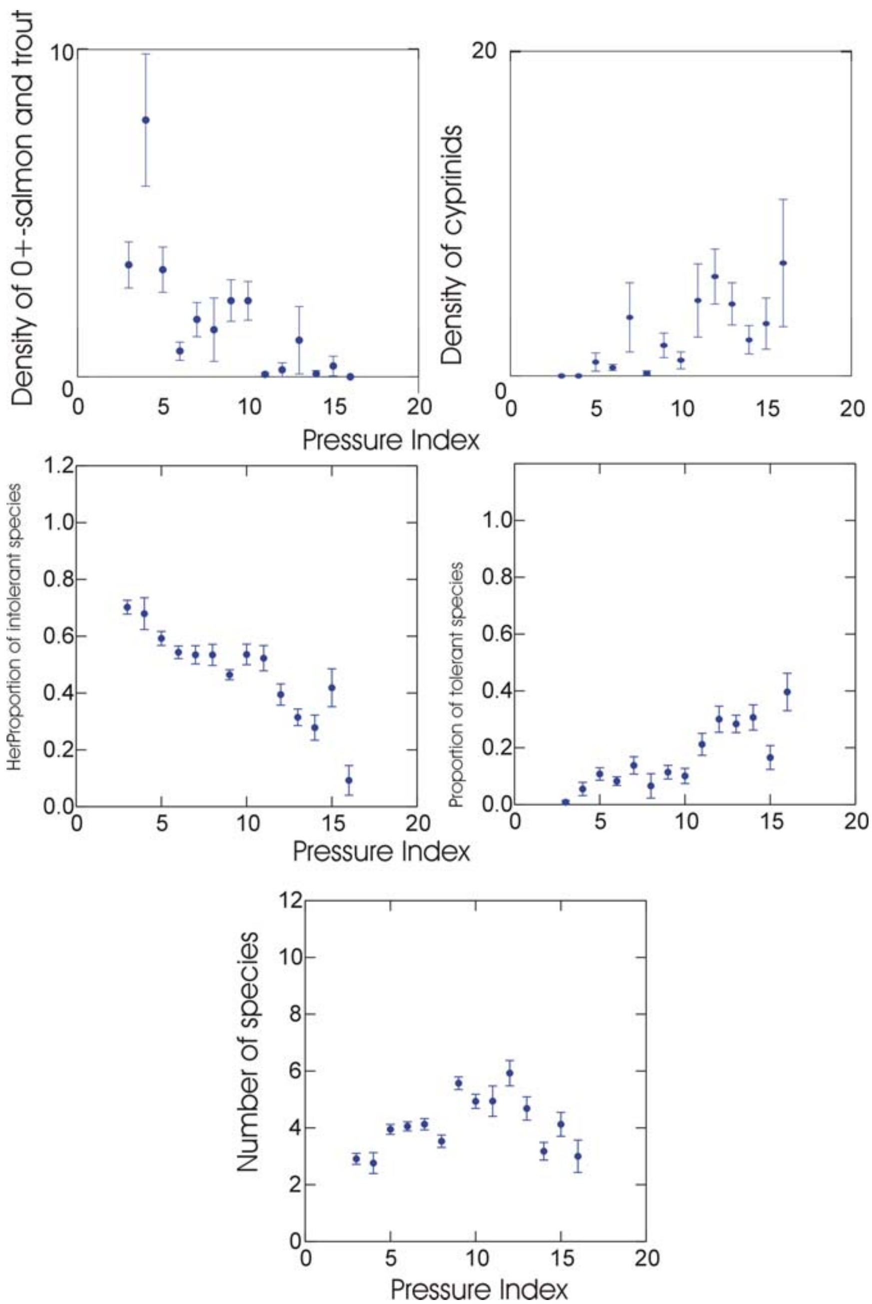


Figure A1. Responses of the selected metrics to human pressure.

The IBI-index score is typically calculated in categories (e.g. 1, 3, 5). We believe that a continuous scoring system is more flexible and effective. Each variable was plotted against the magnitude of human disturbance effects in the study area (measured from water quality, human disturbance and morphology as explained above) to visualise the response of each metric used against the stressor variables. Cumulative frequency distributions were used to characterise the distribution of candidate metrics. Maximum scores were set near the 95th percentile. Linear or simple curves were fitted according to the shape of the response plot. The value of each metric was calculated according to the fitted equation, and the final index value was obtained as a sum of these variables divided by the number of variables used in calculations. The response curves for each metric are shown in Figure A2.

Table A1. Finnish river types and FIFI-index reference value for river types with reference data (situation 1.1.2007), together with calculated EQR-boundaries for ecological status classes.

| Catcment size | Geology | Fish Index Reference Value | EQR H/G Boundary | EQR G/M Boundary | EQR M/P Boundary | EQR P/B Boundary |
|---|---|---|---|---|---|---|
| <100 $km^2$ | Organic | N/A | N/A | N/A | N/A | N/A |
| <100 $km^2$ | Siliceous | N/A | N/A | N/A | N/A | N/A |
| <100 $km^2$ | Clay-soils | N/A | N/A | N/A | N/A | N/A |
| 100-1000 $km^2$ | Organic | 0.77 | 0.95 | 0.71 | 0.47 | 0.24 |
| 100-1000 $km^2$ | Siliceous | 0.74 | 0.89 | 0.67 | 0.45 | 0.22 |
| 100-1000 $km^2$ | Clay-soils | N/A | N/A | N/A | N/A | N/A |
| 1000-10 000 $km^2$ | Organic | 0.70 | 0.77 | 0.58 | 0.38 | 0.19 |
| 1000-10 000 $km^2$ | Siliceous | 0.72 | 0.94 | 0.71 | 0.47 | 0.24 |
| 1000-10 000 $km^2$ | Clay-soils | N/A | N/A | N/A | N/A | N/A |
| > 10 000 km2 | Organic | N/A | N/A | N/A | N/A | N/A |
| > 10 000 km2 | Siliceous | 0.73 | 0.94 | 0.71 | 0.47 | 0.24 |

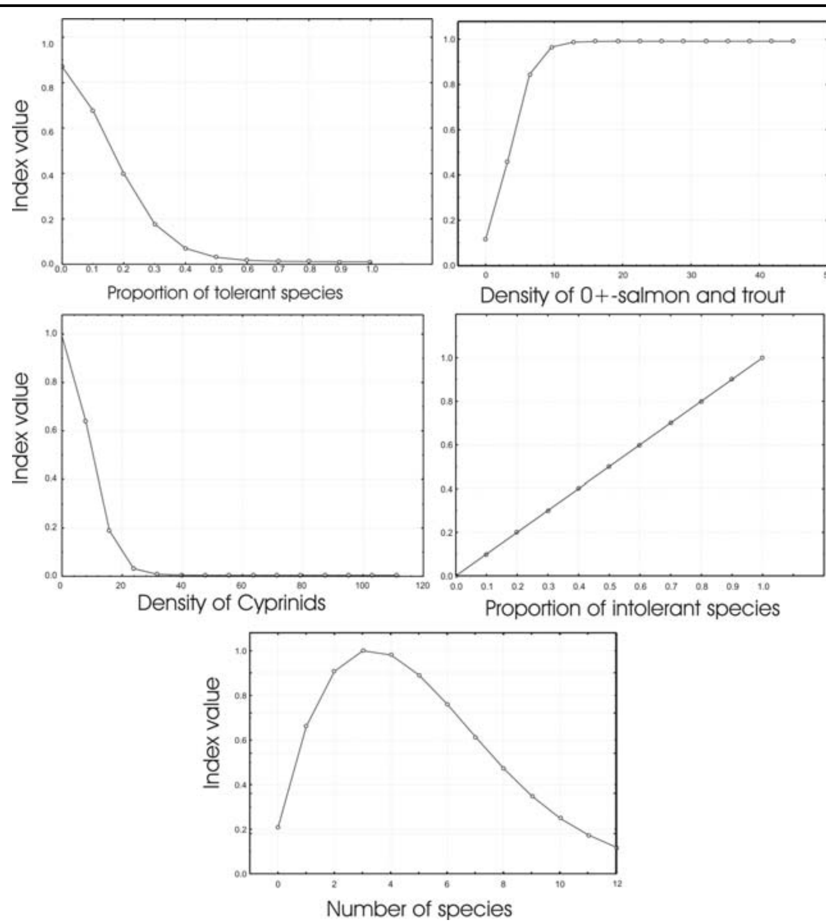


Figure A2. Response curves between the metric value and index value in the Finnish Fish Index.

**Description of the Swedish method (VIX)**

An index for classification of ecological status based on fish data from running waters was developed in Sweden in 2006. The report "Environmental quality criteria to determine the status of fish in running waters - development and application of VIX" (Beier et al. 2007) is published at www.vattenportalen.se and www.fiskeriverket.se (see "Service / Publikationer / Finfo"). The new environmental quality criteria are presently (2007-04-27) on a final enquiry to authorities in Sweden. They are expected to be officially accepted in May 2007.

To apply VIX (VattendragsIndeX = running water index) standardised data from electric fishing are needed. In Sweden, the period of sampling is restricted to July-October to be able to catch YOY fish and to avoid periods with flooding.Only native species have been considered when calculating the index. Abundances are based on estimations from one or more electric fishing runs, i.e. all electrofishing runs are included to calculate the metrics. Environmental variables needed are 1) size class of catchment upstream of the sampling site, 2) class of proportion of lake area in the catchment, 3) least distance to the closest lake upstream or downstream the sampling site (up to 10 km), 4) altitude above sea level, 5) slope, 6) yearly average air temperature, 7) average air temperature during July, 8) wetted width of the stream and 9) sampled area. Additionally, migration type of the trout (resident, lake migrating or sea migrating) is used to adjust the index accordingly.

The main principles and statistical procedures for developing the EFI (European Fish Index) were applied for developing VIX. Reference sites were identified using maximum values (1 or 2 out of 5) of four impact categories (toxic or acidification impact, nutrient or organic input, morphological as well as hydromorphological impact). Theoretical expected values for each metric are calculated using multivariate regression incorporating relevant environmental variables (transformed values). The residuals between expected values and observed values are transformed in two steps. First, the residuals are transformed to Z-values by dividing the residual with the standard deviation of the residuals for each metric. The Z-values are transformed to P-values, which are probabilities for the observed value to represent impacted conditions, adjusted for the direction of the expected change in the metric with increased impact (the lower the P-value, the higher probability that the site is impacted). The index consists of the mean of these P-values.

The main focus was to find the clearest possible separation between "impacted" and mainly "unimpacted" sites, i.e. the "GM" border between good and moderate status (class 2 and 3 out of 5) according to the Water Framework Directive. As with the method used for developing the EFI, the border between good and moderate status was chosen where the probabilities of making type-I and type-II errors were equal, i.e. where the risks of classifying an impacted site (preclassified impact 3-5) as unimpacted (preclassified impact 1-2), or vice versa, were equal. The border between high and good status ("HG") was chosen so that the probability of classifying an unimpacted site (preclassified impact 1-2) as impacted (preclassified impact 3-5) was less than 5%. The border between poor and bad ("PB") was chosen so that the probability of classifying an impacted site (preclassified impact 3-5) as unimpacted (preclassified impact 1-2) was less than 10%. The border between moderate and poor was set midway between the GM and PB borders. The borders for status classes, set according to the Swedish dataset used for developing VIX, of the index values are: class 1 (high) ≥0.749, class 2 (good) ≥0.467, class 3 (moderate) ≥0.274, class 4 (poor) ≥0.081, and class 5 (bad) <0.081.

Twenty-four potential metrics were considered during the index development. These were the metrics from the existing Swedish index for fish in streams (FIX); metrics from HÖL, an index especially developed for salmonid coastal streams and metrics from the European Fish Index (EFI). out Of these, six metrics were retained in the final index (VIX), which distinguishes the degree of general human impact. The VIX metrics are 1) abundance of salmon and trout, 2) proportion of salmonid species reproducing, 3) proportion of tolerant species, 4) proportion of intolerant species, 5) proportion of lithophilic individuals and 6) proportion of tolerant individuals. The metrics 3-5 are also used in the EFI, but then only incorporating data from the first run of electric fishing.

In the dataset used for the index development, VIX was found to classify 66% of the Swedish sites correctly when comparing scores with the preclassified impact status. When applying the index on an independent dataset containing preclassified impact, 73% of the sites were correctly classified as either belonging to the preclassified impact groups ‘unimpacted’ (class 1-2) or ‘impacted’ (class 3-5). In the Swedish electric fishing data (August 2006), 50% of the sampling sites were classified to good status, and 23% to moderate status, i.e. the majority of sites were in the crucial interval of good and moderate status. There was a significant positive relationship between EFI and VIX. However, EFI estimated the status class higher compared to VIX approximately eight times more often than the reverse case. Especially small streams with sea migrating trout were estimated comparatively higher with EFI than with VIX.

## Annex B

*Reference criteria and reference sites*

### Finland

A national reference network of reference sites has been established in Finland. Collection of reference data from these sites was started in 2006. The least disturbed sites were selected for fish reference sites. The analysis was based on three factors: morphology of the river base (1 natural state, 2 restored, 3 dredged), human disturbance effects (expert judgement, scale 0-10) and water quality. Principal component analysis (PCA) was used to summarise the variation in the water quality parameters into principal components. The condition of each survey area was calculated as the sum of these three factors and the best 20% fractal was set as reference areas.

### Norway

A national reference network of reference sites for fish in running waters has not yet been established in Norway. Information is available for some sites but additional data needs to be obtained to cover other ecoregions. Furthermore, the protocol for setting reference conditions has yet to be determined. No index has been developed either to set reference conditions or to set boundaries between the different status classes. For this work, the indexes from Sweden and Finland will probably be adopted, and should be based on the reference condition approach.
The least disturbed sites will be selected for fish reference sites across the country. We assume that such locations should be relatively easy to identify, at least for some parts of Norway. However, in southern Norway many fish populations are still affected by acidification and liming has been used to mitigate against this damage. A large proportion of Norwegian lakes have been regulated for the purpose of producing hydroelectric power. The hydrology in their outflowing rivers has been substantially changed, with a strong reduction in their water flow. Many rivers with anadromous fish have also been regulated for the purpose of producing hydroelectric power. Changes in fish abundance due to eutrophication and toxic substances are less evident in Norwegian waters. Widspread stocking and the spread of native fish species, as well as introductions of non-native or alien fish species, are now occurring at an increasing rate. These activities may also cause negative effects on native fish populations. Reference conditions will be basedon these five criteria: (i) morphology of the river bed or basin (1=normal state, 2=restored and 3=dredged), (ii) human disturbance effects from land use, hydraulic engineering or point source pollution (expert judgement, scale 0-10), (iii) water quality (a=toxic substances, b=eutrophication and c=acidification [pH > 6,0, alkalinity > 10 $\mu ekvL^{-1}$ and labile

Al < 10 μg $L^{-1}$], (iv) stockings to restore or enhance natural stocks (0 or 1) and (v) introductions of species that are non-native to that specific catchment or introduction of alien species (0 or 1).

**Scotland**

Reference sites were initially chosen by Scotland, as in other Member States, using REFCOND guidance (Working Group 2.3 - REFCOND Guidance Document No 10.). A list of the more detailed criteria and type-specific concentrations ("reference thresholds") of key chemical parameters were developed by the macro-invertebrate working group.

For the screening exercise, both mean values and 90-percentile values were proposed as reference thresholds for some chemical parameters. The mean is the most robust statistic when few data are available, as is frequently the case for new reference sites. The 90-percentile would only be used when sufficient data are available (at least 12 monthly chemical samples).

The proposed reference thresholds allow the same criteria to be applied to the selection of all reference samples used in the intercalibration exercise and were intended for use in conjunction with other general pressure criteria. The thresholds aim to interpret the WFD requirement of "very minor anthropogenic impact".

The thresholds were principally derived from datasets linking invertebrates to general chemical elements. In general, the available information was not sufficient to derive type-specific reference thresholds for all types.

During the intercalibration process, representatives from each Member State were asked to screen reference sites, chosen using REFCOND guidance, against agreed catchment landuse and chemical reference thresholds. Tables have been compiled detailing this for the Rivers NGIG and can be found in the *NGIG Rivers milestone report 6, ECOSTAT update October 2006.* All macroinvertebrate refcond criteria submitted for Scotland for the NGIG fish intercalibration process is taken from the above report and tables B1 and B2.

References:

Working Group 2.3 - REFCOND Guidance Document No 10. Rivers and Lakes – Typology, Reference Conditions and Classification Systems. Common Implementation Strategy For The Water Framework Directive (2000/60/EC).

NGIG Rivers Milestone Report 6, ECOSTAT update October 2006. http://forum.europa.eu.int/Public/irc/jrc/jrc_eewai/library

Table B1. Physical and chemical criteria for classifying references in Scotland

| | | |
|---|---|---|
| | | **Urban areas:** should be minimal in the catchments upstream of reference sites |
| All | Point Source | No significant point source pressures |
| All | Direct Morphological Alteration | Level of direct morphological alteration, e.g. artificial instream and bank structures, river profiles, and lateral connectivity compatible with ecosystem adaptation and recovery to a level of biodiversity and ecological functioning equivalent to unmodified, natural water bodies. No major dams or control structures upstream of reference condition site. The river should not have been subject to any arterial drainage schemes that affect lateral connectivity or cause changes in the natural time of residence. River substratum should be appropriate to the catchment geology and river slope at the point of substratum assessment. |
| All | Water Abstraction | Abstraction of water from the river upstream of a site regarded as being at reference condition should not **reduce** the 95 percentile discharge flow ($m^3/s$) by more than 10%. (The 95 percentile flow or discharge is that which is exceeded 95% of the time over the hydrological year). |
| All | Flow Regulation | Levels of regulation resulting in only very minor reductions in flow levels having no more than very minor effects on the quality elements. As a guideline low flow alteration should be less than 20% of monthly minimum flow. There should be no major dams or control structures upstream of the reference condition site. Dams located downstream should not affect the flow regime at the reference site and should not impede the passage of migratory fish |
| All | Introductions of alien speci | Introductions compatible with very minor impairment of the indigenous biota by introduction of fish, crustacea, mussels or any other kind of plants and animals. No impairment by invasive plant or animal species.No recent introductions (<15 years) that are still causing major ecological changes within a river ecosystem. |
| All | Fisheries and aquaculture | There should be no commercial fishing operations or fish farming which affects the biological quality elements or water quality of the river system. No significant stocking of non-native species or stocking of 'put and take' fish for angling purposes. |
| All | Biomanipulation | No biomanipulation or liming of the system in response to acidity pressures. |

Table B2. Intercalibration types for Scotland.

| *Type* | *River characterisation* | *Catchment area (of stretch)* | *Altitude & geomorphology* | *Alkalinity (meq/l)* | *Organic material (mg Pt/l)* |
|---|---|---|---|---|---|
| ***R-N1*** | *Small lowland siliceous moderate alkalinity* | 10-100 $km^2$ | < 200 m and HC* | 0.2 - 1 | < 30** |
| ***R-N3*** | *Small lowland organic* | 10-100 $km^2$ | < 200 m and HC* | < 0.2 | > 30 |
| ***R-N4*** | *Medium/large lowland siliceous moderate alkalinity* | 100-10000 $km^2$ | < 200 m and HC* | 0.2 - 1 | < 30 |
| ***R-N5*** | *Small mid-altitude siliceous* | 10-100 $km^2$ | Between lowland and highland | < 0.2 | < 30 |

## Sweden

28 localities are at present (2007-04-27) defined as national references where both chemical and biological monitoring will be carried out. The list of references is a compromise where objective criteria as well as opinions and viewpoints regarding sites from key persons representing chemical, hydromorphological and biological status (mainly fish and benthic algae) have been taken into

account. At present, there has been no inventory of streams in Sweden to make a full list of available reference sites. This list would probably be quite long, although sites in the lowlands and in the south would be very scarce if any at all. Apart from eutrophication and hydrological impact (all but four rivers in Sweden are more or less exploited for hydropower), there is also frequent impact from acidification and liming, especially in the south, as well as forestry all over the country.

The following criteria have been used to determine Swedish reference sites. There is an official "reference filter" concerning mainly chemical (tot-P and pH) impact to determine reference quality (Table B3). However, this filter has not been followed exactly when finally putting together the list of national reference localities to be monitored for the Water framework directive. Compromises have been made with respect to the total number of sites (the available amount of money for monitoring), geographical coverage and types. In other words, in the north, there may be very many references, and in the south, perhaps hardly any. Therefore, the reference sites in the south occasionally do not meet all criteria in the official reference filter.

Table B3. Common criteria in the "reference filter" to define reference localities in running waters in Sweden based on the REFCOND guidance (http://www-nrciws.slu.se/REFCOND/index.html).

| **Zone** | **Impact** | **Reference criteria, conc.** | **Reference criteria, land use** |
|---|---|---|---|
| Illies 20 (arctic alpine) | N and P (agriculture) | tot-P<8 (modified according to organic substances) | |
| Illies 14 and 22 (central plains and boreal) | N and P (agriculture) | tot-P<10 (modified according to organic substances and yearly flow pattern) | <10% agricultural land in the catchment |
| Illies 14 and 22 (central plains and boreal) | N and P (forestry) | tot-P<10 (modified according to organic substances and yearly flow pattern) | <10% clearcut forest area in catchment with 5 year time lag in the south and 10 years in the north |
| all | Acidification | yearly mean pH ≥6 | |
| all | Effluents, point sources | | <1% urban land use |
| all | Hydromorphological impact | Common criteria not complete - expert judgement for each case | |
| all | Introduced species | Common criteria not complete - collection of information and expert judgement for each case | |

Apart from the official reference filter (Table B3), the following criteria have also been used to classify Swedish references:

- Objects considered were already within regional or national monitoring programs, i.e. background information and/or time series of chemical and biological data were available.
- With respect to fish, objects where at least 5 individuals of brown trout per 100 $m^2$ had been caught with electric fishing were considered. This figure was somewhat adjusted according to latitude (lower northwards and higher southwards). The purpose of this was to exclude sites with little or no fish, although they may be excellent concerning for example chemical status.
- The range in catchment area was set to 10 - 600 $km^2$.
- The ambition was to cover Swedish fish regions (5 + high mountains), as defined during the FAME project. This was not entirely possible.
- The proportion of forest or high mountain should be >60%.
- The watercourses should neither be acidified (mean year pH ≥6), neither affected by liming upstream.

**England and Wales**

A national network of **reference sites for fish** in running waters has, unfortunately, not yet been established for England and Wales. Work is ongoing to produce such a list but, unfortunately, it will not be available in time for inclusion in this report.

For the record, there is an English and Welsh list of reference sites for invertebrates that was established during the Invertebrate Intercallibration Exercise, in a similar way to that described above for Scotland. The 835 highest invertebrate scoring sites in the Environment Agency's General Quality Assessment Classification (RIVPACS) database for England and Wales were screened to remove those sites known to be subject to chemical, land use and flow pressures. The remaining 299 highest scoring sites formed the list of Invertebrate Reference sites used in the Central Baltic Invertebrate GIG. At least some of these sites are, however, known not to be reference sites for fish as they have, for example, barriers to migratory fish downstream of the site or are subject to other pressures. The decision was therefore taken not to use this invertebrate refcon site list for the present fish intercalibration exercise.

Whilst fish reference sites are to be expected from those English and Welsh sites intercalibrated within the Nordic Fish Intercal Group (typically salmonid dominated sites) it is considered very unlikely that genuine reference sites will be found in the Lowland river types being intercalibrated within the Lowland Fish Intercal Group (typically the cyprinid dominated sites). This may result in problems for a future intercalibration exercise.

European Commission

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## Abstract
To become functional tools in the implementation of the water framework directive, national methods must be intercalibrated. This task has not yet been carried out for the ecological quality element FISH. As national monitoring networks has been established and different methods developed during the last years, a first attempt to compare and intercalibrate the quality boundaries set by the different methods has been done.
This report is mainly based on results and descriptions submitted from each of 7 IC-groups. We have tried to draw some main conclusions and recommendations based on the work done by all the people involved and also some editing of the reports and other documents to make the information more accessible and clearer for the reader, however the contend is unaltered and expresses the experience and views from the groups.
Each group report is placed as an annex. To limit the variation, these group reports are organised in a similar way, first answering a set of questions, then describing in more detail the process and the results, then descriptions of the national methods used and finally the criteria used for setting reference conditions.
Since the first meeting in May 2006, much effort has been put into this pilot exercise by a number of people from more than 20 Member States. We have been working with 3 categories: 1) MS with an accepted/approved national method, 2) MS with methods under development/approval and 3) MS without any national method (planning to use common metrics or other countries methods).
The results of the comparisons between different regions and methods demonstrate that more work is needed before intercalibration with boundary setting can be achieved. Especially the lack of common criteria for reference conditions is an obstacle in the progress of this work, so a future workplan is proposed.

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