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Management of Freshwater Fisheries on Bordering Rivers

EU-Regulations in the field of water and fish management

Norwegian Institute for Water Research
– an institute in the Environmental Research Alliance of Norway

REPORT

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Abstract

The report summarises the principles and regulations given in the EC Water Framework Directive (WFD) and the corresponding CIS-guidance documents (Common Implementation Strategy). In addition the reports gives the main findings from two EU-projects under DG-Research; the FAME project dealing with assessment of fish status, and the MANTRA EAST project dealing with water management of trans-boundary water bodies.

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Management of Freshwater Fisheries on Bordering Rivers

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Oslo 2005-04-05

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Preface

This report is a delivery from the Norwegian partners of the international project "Management of Freshwater Fisheries on Bordering Rivers", and it summarises EU-regulations and rules in the field of water management, with special reference to fish management in transboundary rivers.

The project is financed by the Norwegian Ministry of Foreign Affairs, and the client is the Croatian Directorate of Fisheries. The overall project leader is Tor-Jahn Herstad (M.Sc) from Akvaplan-niva AS. The project leader for the Balkan part is Dr. Ivan Katavic (Directorate of Fisheries), whereas the scientific part of the project is lead by Professor Milorad Mrakovcic, Univ. of Zagreb.

This report is written by M.Sc. Dag Berge at the Norwegian Institute for Water Research (NIVA) with inputs from Ph.D. Geir Dahl Hansen, Akvaplan-niva.

The report gives "a short version" of the Water Framework Directive and the corresponding guidance documents for the different CIS-groups (Common Implementation Strategy), and from two EU-research projects, the FAME project working with fish assessment methods, and the MANTRA EAST project that dealt with the problems of management of transboundary, and bordering water bodies.

It should be noted that the original documents, which form the basis for this report, are of more than 1000 pages. In the process of shortening these down to only 29 pages, some information has to be omitted (or lost). Being aware of this, we hope that the report will give the reader a good overview over the new European platform for water and fish management of inland waters.

Oslo, 2005-04-05

Dag Berge and Geir Dahl-Hansen

Contents

Summary

The report summarises the principles and regulations for water management given in the EC Water Framework Directive (WFD) and the corresponding CIS-guidance documents (Common Implementation Strategy). In addition the reports gives the main findings from two EU-projects under DG-Research; the FAME project dealing with assessment of fish status, and the MANTRA EAST project dealing with water management of transboundary water bodies.

No EU-Member State should be allowed to have an economical advantage of taking more easily on water pollution problems than other Member States. This was the original motivation of developing a common platform for water management (the WFD) in the European Union.

The new principle of water management given in the WFD, as compared to earlier practice, is that the water management now should be performed at river basin level, including also the marine influence area, whereas earlier the water management was performed according to administrative borders, at municipality, county, and country levels. The WFD also requires a co-operation between all the sectors with water management responsibility, and that those who use and impact the water also should take part in covering the cost of water management (polluter pay principle). The status of the water body should be evaluated according to the healthiness of the water biology, including fish. All surface water bodies shall have achieved good ecological status 15 years after the WFD has been put into force in a country. This time schedule applies for every Member State. For all river basins a water management plan that secures sustainable water use in the future, shall be developed. For bordering rivers and transboundary river basins, efforts should be made in developing one common international water management plan. The rules and the regulations given in the WFD are superior the national legislation in the different member countries. The national legislation has to be adapted to WFD, not the opposite.

The FAME project funded by DG-research has developed a method using the fish community to assess the ecological quality of European rivers, the European Fish Index. It is expected that the DG-Environment will use this as a basis for developing guidelines on how to use fish as an assessment parameter for ecological status in water management.

The MANTRA EAST project dealt with the different problems that arise in managing transboundary water bodies, the different legal platforms between the countries, the differences in water use, the lack of a common information platform, the upstream-downstream problems, etc. In the concluding remarks MANTRA EAST project group are particularly worried about the softness in the WFD in requiring a common international water management plan. They give several questions and recommendations to reach further progress in these difficult management tasks.

1. Introduction

During the 1990ies the European Parliament and The Council elaborated a directive for common practices in the Member States in the field of water policy. The full name of the directive is long and comprehensive: "Directive 2000/60/EC of The European Parliament and The Council establishing a Framework for Community Action in the Field of Water Policy." In short the directive is most often called "the Water Framework Directive" (WFD). The WFD was passed the EU Parliament and Council in October 2000, and adopted by the Member States later the same year. The WFD should also comprise the EEC countries, such as Norway and Iceland.

The WFD is, as the name says, a framework directive which comprises a number of more specific sub-directives, like e.g. The Drinking Water Directive, The Wastewater Directive, The Nitrate Directive, who regulate the different water uses more in detail. The WFD draws up the "rough management lines" which all water management in the member countries have to comply with. The WFD, with sub-directives, is superior the legislation in the different member countries, and the national legislation has to be adjusted to fit the WFD, not the opposite.

The WFD comprises all waters, lakes, rivers, ground waters, transitional waters (=estuarine waters), and coastal waters out to one sea (nautical) mile outside the territorial boundary of the different countries. The concept idea is that all water management shall be performed on a catchment's basis, i.e. the whole river basin should be regarded as a management unit, across the traditional administrative borders like municipality-, city-, county-, and country borders.

All Member States should take equally serious on problems of the deterioration of the water environment and the need for restoring and protection of water bodies. The aim of the WFD is in short to improve the situation in deteriorated water bodies, and prevent a negative development in the good water bodies. For all river basin districts water management plans shall be developed, including fish, which shall warrant good ecological status in all water bodies by 2015 and beyond (NB this applies for the countries that were EU-members in 2000. The time schedule runs from the date a country becomes member of the EU, so for e.g. Croatia, all water bodies should be in good ecological status by 2020? (21?, 22? depending on when they become full member).

In this Technical Paper we give a resume of the regulations within the WFD with particular emphasis on fish monitoring, and fish management, and on the problems confined with bordering and transboundary rivers. It should be noted that most of the regulations in the WFD is not yet made fully operational. This is still in process in, and among, the member countries. At the moment the so-called Characterisation is undertaken, which is an exercise using existing data to identify and map water bodies that are at risk of not reaching the WFD goals. In 2007, the monitoring starts, and in 2009 the first version of the water management plan shall be elaborated. This means that this report cannot describe in detail how the WFD regulations can be utilised, or adopted, to the bordering rivers of Balkan. However, it can give an update of the WFD work and draw different options for how you can implement the WFD regulations to the best of your rivers.

2. Source material

The source material for this technical paper is for the major part taken from the directive itself, from the guidances of the CIS-working groups on Common Implementation Strategies, and from two EU-research projects; the FAME (on fish methods) and the MANATRA EAST (on management of trans-boundary waters). In addition we have taken contact with the Commission (DG-Environment) and several of the participants in the CIS-working groups, as well as the two cited EU-research projects. All these documents can be found on the internet, see **Table 4** for Web-addresses.

3. The WFD and the CIS-guidance documents

3.1 WFD Goals

Very shortly the WFD goals can be compiled to the following:

- Achieve good ecological status and good chemical status in all surface water bodies by 2015
- Achieve good chemical status in all ground water bodies
- Achieve good ecological potential in heavily modified and artificial water bodies
- Improve the conditions in all deteriorated water bodies
- Prevent negative development in, and protect, water bodies with good status
- Develop, adjust and maintain sustainable water use through development of water management plans

It should be mentioned that it is possible to apply for exception from the goals of achieving good ecological status for special water bodies. However, such water bodies are relatively few compared to the total number of water bodies in a country.

3.2 Categories of water for which the WFD applies

The WFD applies to the following categories of water bodies

- Rivers
- Lakes
- Transitional waters (estuarine waters)
- Coastal waters
- Heavily modified water bodies
- Artificial water bodies
- Ground waters

A heavily modified water body (HMWB) is a water body that has been changed physically with the aim of supplying an important society good (e.g. drinking water supply, hydropower production, flood control), and it is anticipated that the physical alteration makes it impossible to reach good ecological status, or to achieve this is confined with unacceptable cost for the society. Therefore the goal is to reach good ecological potential which, however, is not yet clearly defined. However, it seems to something like this: “To make the ecological status as good as possible within the limits set by the physical regulation scheme”.

3.3 Principles for water management in the WFD

- The water management should be done in river basins, including also the marine influence area. This because all downstream localities are dependant on what happens upstream.

- The water management should be performed across administrative borders like county borders, municipality borders, and country borders. This requires co-operation between local, regional, and country authorities.

- There should be a co-ordinated co-operation between the environmental authorities and sector authorities with water responsibility, e.g. canal companies, ministry of energy (hydropower), agricultural authorities, industry.

- The "polluter pay" principle should be applied to the extent possible. This means that those who impact the water body should also contribute to cover the costs of the water management and the rehabilitation measures.

3.4 Water management units

River Basin Districts
Each Member State has to divide its country into River Basin Districts (Water Regions). In each River Basin District there shall be appointed a competent regional authority that is responsible for co-ordinating and executing the water management according to the WFD.

River basin including the marine influence area
Each river basin should have their separate water management plan (including fish management plan, monitoring programme). In international river basins the regional authorities in the different countries must co-operate on water management issues.

Water body
Water body is the smallest unit in the WFD. This is a naturally restricted body of water for which it can be set one (1) environmental goal. A river has to be divided into many water bodies (sections). For example with respect to fish: It is not possible to have the same goals for fish community structure in the trout region of a river as for the barbel-region. Another section can be heavily modified due to hydro-power development.

3.5 Practical water management tasks and time schedule for the WFD

The Member States of the European Union and the ECE commit themselves to undertake a series of water management tasks with certain deadlines. These are listed in **Table 1**.

Table 1. Practical water management tasks to be carried out by the Member States, and the deadlines for the different actions.

Task	Deadline	Rolling
Est. Riv. Basin distr., deciding the responsible athorities	2003	
Implementing the WFD into the national legislation	2003	
Characterization, incl identification of water bodies, Catergorisation, identify HMWB, Typification, Pressure-Impact anaysis, economical analysis of water use, assessment of status and reference conditions	2004-2005	2013
Register over protected areas	2004	Running
Monitoring programmes	2006	
Elaborate a work plan including time schedule for the water management plan	2006	2012
Publish a preliminary overview over the main water problems in the river basin district	2007	2013
Public hearing of draft water management plans	2008	2014
Elaboration of action plans	2009	
Publish the water management plans	2009	2015
Execute the action plans	2012	
Status report on the execution of the action programmes	2012	
Environmental Goals reached	2015	
Last deadline for reaching the Env goals if agreed extended deadline	2027	

Fish is included in several of these tasks; Characterisation, monitoring, water management plan. Again it should be noted that the time schedule runs from the date a country has become EU-member. The deadlines given above are for the countries that were members in the year 2000. A new EU-member has the same number of years to fulfil the different tasks.

3.6 The different types of impacts

A river is impacted by man in several ways:

- Pollution discharges
- Flood control
- Hydropower regulation
- Canalization
- Acid Rain
- Erosion
- Irrigation
- Introduction of new species
- Over-fishing
- Etc….

In the past, and at present, these impacts are from a management point of view, dealt with by different authorities, and administrative units, not only at the directorate level, but also different ministries are involved. Often the water management activities performed by the different ministries are not well co-ordinated.

The WFD concept is that in the future all impacts should be managed in a co-ordinated way. For example, hitherto, monitoring has mostly dealt with impact of nutrient discharges (eutrophication) and industrial discharges (environmental toxins). In the future, the monitoring should cover all impacts in an integrated way, and should also include the impacts from hydropower regulation, and all other significant impacts.

In the WFD the impacts are divided into 4 categories:

- Pollution (discharges, diffuse runoff, atmospheric deposition, etc.)
- Hydrological impacts (artificial water level fluctuations, artificial water flow regimes, etc.)
- Morphological impacts (damming, canalization, river bank strengthening, etc.)
- Biological impacts (fish diseases, introduced species, over-fishing, etc.)

3.7 The quality elements

The goal of all normal surface water bodies (lakes and rivers) is to achieve good ecological status. To be able to assess whether or not a body of water has good ecological status, the quality elements should be evaluated. In the WFD there are 3 main types of quality elements:

- Biological quality elements (phytoplankton, zoo-benthos, periphyton, macrophytes, and fish)
- Hydro-morphological quality elements (water level, water flow, degree of damming, strengthening works in the littoral zone, etc).
- Physico/Chemical quality elements (concentration of different chemical compounds, transparency, etc)

Under these 3 main categories of quality elements there are comprehensive sub-divisions all the way down to practical monitoring parameters. It will be too much to go into detail in these aspects in this short presentation of the WFD. It should be noted in relation to the ongoing project that fish is a mandatory parameter to be used in assessing the ecological status of rivers and lakes. In all water bodies that

don't have achieved good ecological status, the fish community should be monitored with test-fishing every third year (minimum frequency).

3.8 Establish water types (Typology) and reference condition

High-mountain rivers cannot be compared with low land rivers with respect to neither chemical constituents nor biological communities. This applies both for biomass and species composition. Humic lakes have considerably different chemistry and biology than clear water lakes, etc. As the degree of impact is defined as the deviation from natural conditions, the natural conditions has to be defined. Therefore, each Member State has to:

- Define their water body types and operational criteria for the types
- Define the reference conditions (natural back ground) for each water body type

3.9 Assessment of status

By 2015 (or 15 years of EU-membership) all surface water bodies should have achieved good water status. Water status consists of chemical status and ecological status, and is assessed after the poorer of the two. Chemical status refers to environmental toxins, like heavy metals and organic micro-pollutants. Nutrients and organic matter like (BOD, COD), and river regulation effects, are included in assessment of ecological status.

Depending on the deviation from the reference condition for the particular water type, the status should be given as one of the following five classes:

- High status
- Good status
- Moderate status
- Poor status
- Bad status

For assessment of ecological status, which shall be done for all surface waters, the 5 biological parameters (see quality elements above) should be the most important. One can also use physico/-chemical parameters that are indicative for the biological quality elements as complementary or supportive, but they can never replace them.

For fish the following community attributes should be evaluated as a minimum:

- Species composition
- Abundance
- Age structure

3.10 Economical analysis of water use

One of the ideas in the WFD is that there should be full recovery of costs for water services. The water users should pay what the use of water costs. This also includes expenditures for water management. The polluter-pay- (more correct, those who cause the impacts) -principle should be used as far as possible. As part of the characterisation each Member State shall perform economical analysis of water

uses – to elucidate what is the economic significance of water use in the river basin district, and what are the key economic drivers influencing pressures and uses.

Perform economic assessment of potential measures for reaching good water status – and carry out cost/effectiveness analysis of rehabilitation measures.

Assess the recovery of costs of water services – how much do current water cost – who pays for these costs – and what is the current recovery cost level.

The motivation for the economical analysis is that no Member State should be allowed to have an economical advantage of taking less care of the water environment than the other members.

3.11 The characterisation

This task is ongoing right now in all Member State countries. The main goal of the characterisation is to identify the water bodies that are at risk of not meeting the goal of good water status now, and in 2015. More specific the tasks included in the characterisation are:

- Identification of all the water bodies in each country (name, restriction, geographical co-ordinates, shown on GIS-map).
- Categorize all water bodies (lake, river, coastal water, transitional water, HMWB)
- Designate all water bodies to the appropriate water type.
- Economic analysis of water use, including driver identification and their pressure implication, and trend analysis towards 2015
- Pressure analysis (i.e. evaluate the threat from human activity in the catchment area)
- Water status assessment (i.e. assess the water status based on available data from the water body)
- Risk assessment (i.e. assess the risk of not meeting the goals of good water status both today, and in 2015).

The results from the characterisation shall be reported to the commission by 15 March 2005 (or the fifth year of membership).

3.12 The monitoring

Monitoring is central in water management within the WFD. Monitoring results are regarded as the safest way of assessing the status of a water body, as well as discovering trends in the status development. The WFD operates with three types of monitoring:

- Surveillance monitoring
- Operational monitoring
- Investigative monitoring

Of these the operational monitoring is likely to be the most important, and should be conducted in all water bodies that are not in good ecological status. First after they have reached the good ecological status, and there is no risk of negative development in the future, the monitoring can be stopped.

Surveillance monitoring should be used if the pressure analysis indicates that there is most likely a problem in a specific water body, but there are no monitoring data from the locality. If the surveillance monitoring confirms the suspicion from the pressure analysis, the water body should be included in the

operational monitoring programme. Surveilance monitoring should also be performed in reference water bodies to register any long term trends in the nature (e.g. effects of climate change).

Investigative monitoring should be used when data indicate that there is a problem in a water body, but the reason is unknown. For example if one discovers brominated flame retardants in the fish filets, but nobody knows where they come from; from the sediments, from ongoing industrial discharges, from atmospheric fall out, or other reasons.

For heavily modified water bodies and protected areas, special montitoring programs shall be designed adapted to each case.

For all surface water bodies the biological quality elements should be monitored, along with chemical elements that are indicative for the biological quality elements. The indicative parameters cannot replace the biological parameters, only be supplementary and supportive. This means in effect that the magnitude of biological monitoring will increase in the future, as compared with the to day's monitoring activity in most countries.

With respect to fish, abundance, species composition, and age structure, shall be monitored as a minimum. The main goal is to monitor the ecological status of the water body. Data on fish community is regarded as an important parameter to assess the ecological status, along with other parameters. This means that a water body which is at risk, shall be monitored every year, but not necessarily for all parameters every year. It has been set a minimum frequency for the different parameters. Frequencies should be chosen so as to achieve an acceptable level of confidence and precision.

For river monitoring the WFD requires studies of fish community every 3. year (species composition, abundance and age structure, as minimum parameters).

3.13 Water management plan

Member States shall ensure that a River Basin Management Plan is produced for each River Basin District lying entirely within their territory.

In the case of an international River Basin District falling entirely within the Community, Member States shall ensure co-ordination with the aim of producing a single International River Basin Management Plan. If this is not possible, the plan shall at least cover the portion of the international River Basin District lying within the territory of the Member State concerned.

In case of an international River Basin District extending beyond the boundaries of the community, Member States shall endeavour co-ordination to produce a single River Basin Management Plan for the river and its catchment. If this is not possible, the plan shall at least cover the portion of the international River Basin District lying within the territory of the Member State concerned.

The River Basin Management Plan shall be published at the latest nine years after the date of entering into force of the WFD. For the Original Member States and EEC countries this means by 2009.

4. What does the WFD say about fish management

4.1 Monitoring

WFD states that fish is one of the main Biological Quality Elements to be used for assessing the ecological status of a river. The other quality elements are periphyton, zoo-benthos, aquatic macro-phytes, and phytoplankton.

Fish is said to be one of the best parameters to assess impact of hydrological and morphological changes in the rivers, as well as impact of acidification, and low oxygen. However, additional research is needed to assess the fish reaction towards other pollutants. For some unwanted pollutants, e.g. mercury, fish is very resistant.

Fish community is a mandatory element that shall be monitored in rivers. The frequency of monitoring is minimum every 3rd year, preferably every year. The fish parameters that are decided used for assess-ment of ecological status are as a minimum:

- Species composition
- Abundance
- Age structure

Particular emphasis should be put on assessing the parameter values (scorings) of the fish community that are believed to be the natural background for that river. In the WFD terminology this means that the observed community, with respect to the above three parameters, should be compared with the "river type specific" community (i.e. natural background, in WFD called "reference condition").

4.2 Fish management

By 2015 (or 15 years after the WFD is put into force) all quality elements (Biological Quality Elements, Hydromorphological quality elements, and Physicochemical quality elements) shall be in good status. Fish community is one of the biological quality elements. In practical terms this means that 1) the species composition, 2) the abundance and 3) the age structure of the different fish populations shall only deviate slightly from what is regarded as natural conditions in the different water bodies.

The welfare of fish is included in the River Basin District Management Plan. There is no requirement to have a separate management plan for fish. The water management plan shall, when the necessary measures are taken, secure that the fish community of a given stretch of Sava and Donau River should be in good ecological status. This is close to what is anticipated to be the natural, or reference condition.

From Annex V in the WFD good fish status means:
"There are only slight changes in species composition and abundance from the type specific communities attributable to anthropogenic impacts on physico/chemical and hydromorphological quality elements. The age structure of the fish communities show signs of disturbance attributable to anthropo-genic impacts on physicochemical or hydro morphological quality elements, and, in a few instances, are indicative of a failure in the reproduction or development of a particular species, to the extent that some age classes may be missing."

So far this is a verbal, qualitative, statement and additional effort is needed to develop this into an operational framework with quantifyable parameters.

4.3 How to assess the ecological status

The assessment procedure is described in the CIS-guidance no 2.3: Guidance on establishing reference conditions and ecological status class boundaries for inland surface waters. The ecological status is divided into 5 classes, see below. Good status or better is the goal for most water bodies.

Ecological status classification	Color code
High	Blue
Good	Green
Moderate	Yellow
Poor	Orange
Bad	Red

The ecological status should be assessed separately for all the 5 biological quality elements (peri-phyton, phytoplankton, aquatic macrophytes, benthic animals, and fish). The principle is "one out-all out", which means that the overall ecological status of a certain river stretch is set after the poorest score. The physicochemical and hydromorphological elements shall be supportive to assess the ecological status.

4.4 Sampling

The sampling should be done in the way that is commonly used in fish population assessment studies in each member country. This varies a great deal among the Member States. A project under DG-Research has focused on this for rivers, The FAME project. They have just now finished a three year study with the aim of establishing a common method of using fish data as a tool for assessing ecological quality in European rivers. Their findings and recommendations will be very helpful in developing the fish assessment procedures in EU. However, their results are not yet adopted by the DG-Environment. It is believed that there will be issued a guidance document on how to assess the ecological status by fish methods. All countries use the electro fishing method in small rivers and in near shore areas, whereas in more central parts of large river parts drag-nets or drift-nets are often used. Several countries also use seine. For the central parts of large rivers it is very difficult to perform sampling that reflects the real populations in a good manner. It is often recommended to use some kind of standardised catch per unit effort (CPUE).

The FAME project recommends using the electro-fish method for sampling in all rivers, as given in the European Standard EN 14011: Water Quality - Sampling of Fish with Electricity.

As a minimum the data on species composition, abundance and age structure should be used to assess, the ecological status with respect to fish. In addition one should collect some habitat describing data such as, latitude, longitude, altitude, slope, substrate type, current velocity, river depth, river width, oxygen concentration, temperature, turbidity. It should be noted that the use of indexes (which is recommended in the WFD) requires normally collection of more parameters, e.g. fish condition factor, data on recruitment, parasites, as well as designation of fish species to functional guilds, reproductive guilds, habitat guilds.

4.5 Assessment of ecological status.

One should apply a kind of index, for example the IBI (Index of Biotic Integrity, Karr 1981) on the data from the given river stretch and compare it with the index value of the reference condition for this type of

river stretch. See **Figure 1**. The indices used are calibrated in such a way that they give values from 0-1, where 1 represent natural conditions (high ecological status) and 0 represent a highly deteriorated fish community.

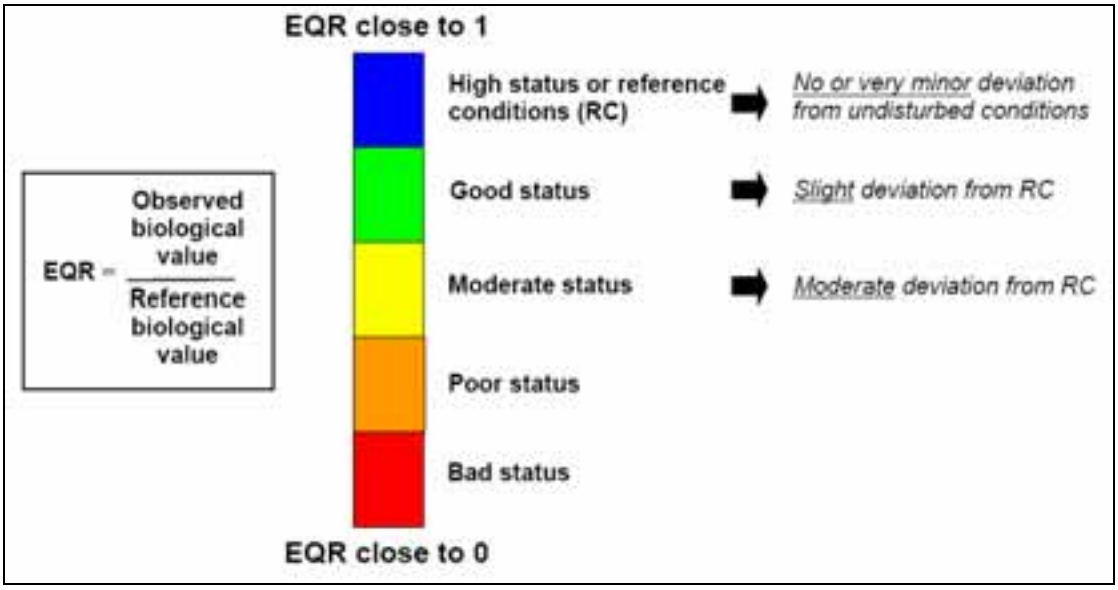

Figure 1. Basic principle of assessment of ecological status by use of EQR, Environmental Quality Ratio (from CIS-Guidance from Working Group 2.7).

The same index cannot be used throughout Europe. The IBI is difficult to use e.g. in mountain streams in Western and Northern Europe due to few species. In mountain streams in Norway, for example, there are often only on species present, the brown trout. The IBI-type of indexes should, however, be more suitable in the barbel region of Donau with tributaries. Each Member State is free to decide the kind of index system they will use.

For population of key species like the Atlantic salmon (*Salmo salar*) in Western Europe, there are catch statistics for more than 100 years. Thus these statistics give a good impression of the development of the stock. Catch statistics also exist for some key species in the Danube and tributaries. However, the catch statistics do not provide information about the age structure or the species composition.

5. The FAME project

The FAME project (DG-Research) is dealing in detail with questions related to the use of fish samples to assess the ecological status of rivers, and gives many good recommendations for fish monitoring and fish management. The reports from the project can be found on the internet ((http://fame.boku.ac.at). It is believed that DG-Environment will adopt many of their findings and recommendations and elaborate a guidance document on the use of fish to assess the ecological status.

A short review of the recommendations in the FAME project is provided below.

The total project name of FAME is: *Development, Evaluation, and Implementation of a Standardized Fish-based Assessment Method for the Ecological Status of European Rivers – A Contribution to The Water Framework Directive.*

The WFD stipulates that the rivers should be managed in such a way that the biological quality elements show good ecological status. This is achieved when the biological quality elements are equal to, or only slightly different from what is expected to be the natural condition (or reference condition) in that type of river stretch. Fish is one of these quality elements.

5.1 Development of a river typology

The first work packages in the FAME project dealt with how to classify rivers into types, and how to assess the reference conditions for the different river types with respect to fish community. Here there are great differences between the species rich rivers in South Eastern Europe and the species poor rivers in North Western part of Europe. Europe is first divided into eco-regions. **Figure 2** shows eco-regions covered by the FAME project.

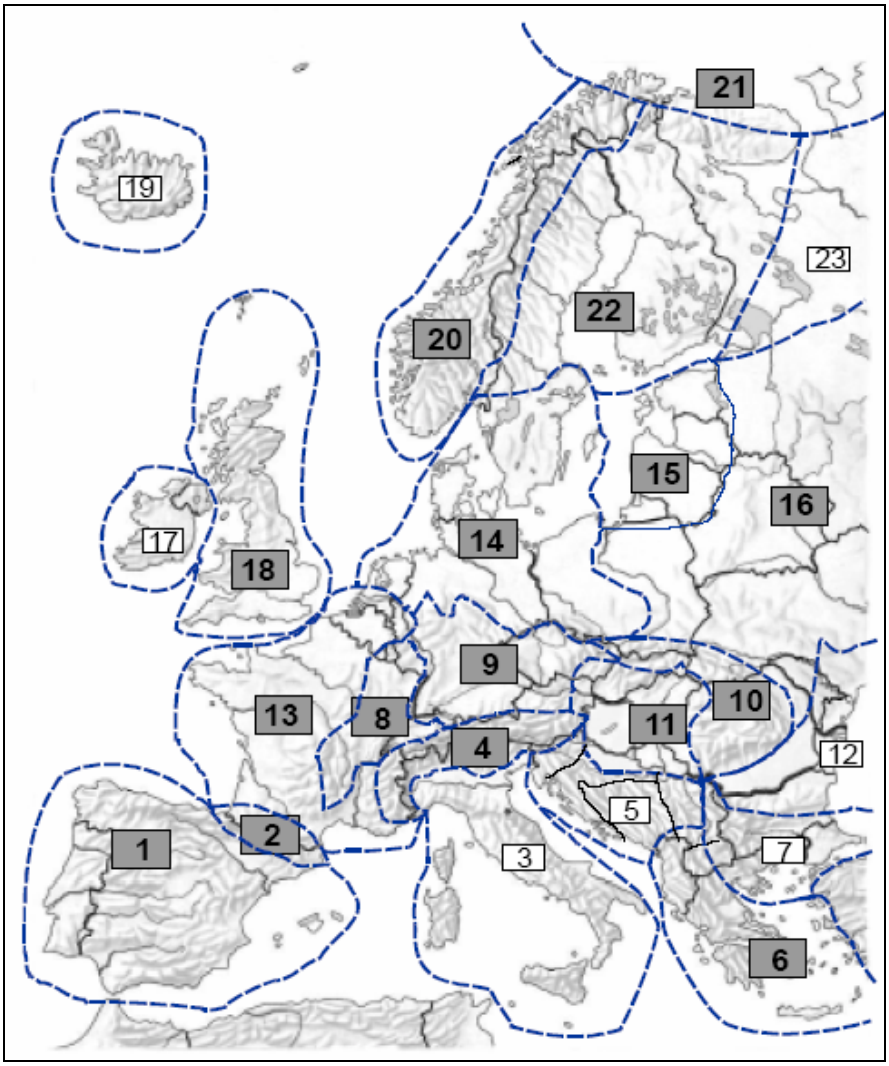

Figure 2. Eco-regions covered by the FAME project (fame.boku.ac.at)

Within each eco-region a zonation of the rivers should be made, dividing the rivers into river stretches where one can expect the same fish fauna. Most rivers run through different zones, from the high mountain fast flowing streams – via-the the foot-hill region to the low land region, and at last the brackish part at the entrance into the sea. This is also done in different ways in different countries. **Figure 3** shows the classical fish based river zonation scheme by Huet (1949, 1954).

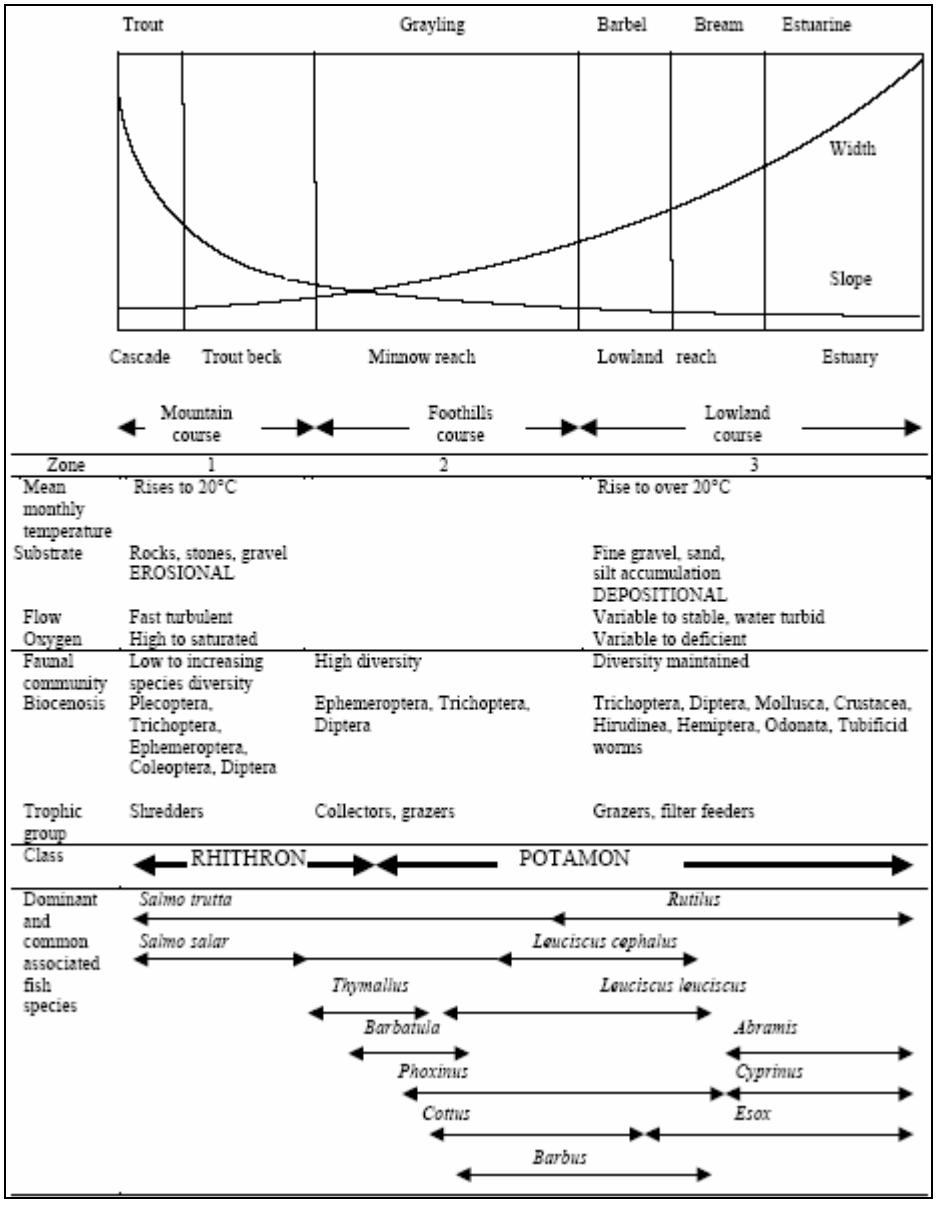

Figure 3. Zonation in rivers according to Huet (1949, 1954)

The water body is the operative water management unit in the WFD. Each river basin has to be divided into distinct water bodies. For a river, a water body is an unbroken river stretch of the same type, with the same biology, and where it is possible, and naturally logic, to have the same environmental goal. The water bodies should then be designated to the correct water type. The natural fish fauna for each water type is assessed in advance as the "reference condition". The test fishing results for a given river stretch should be compared with the reference condition; what is the anticipated type specific fish fauna for that river stretch (=water body).

The FAME project concluded that it is very complicated to get the abiotic typology criteria in the WFD (size of the river, eco-region, elevation, geology) to correspond with the biocoenotic zonation criteria often used when fish fauna is used to split a river into practical management units. Nor the FAME project, neither DG-Environment has not yet found a final and simple solution on this problem.

5.2 What kind of fish metrics should be used?

What attributes of the fish fauna should be measured to be able to use fish as a practical tool for assessing the ecological quality of a given river stretch (water body). The WFD says that the fish population as a minimum should be evaluated according to

- Species composition
- Abundance
- Age structure

The FAME project has reviewed the metrics used in each of the Member States, as well as in the USA, and are trying to make an integrated assessment method. It has been a great challenge to develop one Fish Index that can be used throughout Europe due to large variation of the species richness in the fish fauna. The Danube catchment is the most species rich in Europe with approximately 140 fish species, while rivers in North Western part of Europe have only 1-4 fish species.

Table 2 shows the metrics tested in the FAME fish database. The selection is based on the large review mentioned above. The table also shows how the metrics is believed to change when the water body becomes degraded. It is quite clear that the number of metrics is much greater than the three main required in the WFD. Most systems have found it useful to group the fish fauna into functional and behavioural groups (called guilds). For example in a river damming project it is the lithophilic spawners and the migratory species that are most heavily affected. It is therefore practical for the IBI – index that these species are sorted out in separate guilds. These guilds can be put under the main WFD group of Species composition.

5.3 Fish sampling

The FAME project has reviewed the different fish sampling techniques used in river surveillances in the member countries, and come up with a general suggestion that electro fishing according to the CEN-standard is the best method. All countries use electro fishing device in rivers. In small rivers this is the main, and often the only method applied.

In larger rivers, electro fishing is often used along the shoreline, but in deeper areas there are a variety of methods used, like drift nets and drag nets, trawlers, and seines. In fact in the mid sections of larger rivers, it is very difficult to do any representative fishing, and very little data existed from such areas among EU-countries.

Table 2. List of metrics proposed to be tested on the FAME database, and expected trend in the different metrics on degradation of the water body.

METRICS	CALCULATION	ALTERNATIVES	TREND
DIVERSITY			
Species richness	Total number of species	minus exotic	↗ (↘)
Diversity index	Shannon, Simpson…	minus exotic	↗ (↘)
NATIVE/EXOT	Number of species		
	Number of individual or biomass (CPUE)		
	% of Total number of species		
	relative abundance (% total number of individuals, biomass)		
HABITAT PREFERENCE			
Benthic	Number of species	minus exotic AND OR Tolerant	↘
	Number of individual or biomass (CPUE)	minus exotic AND OR Tolerant	↘
	% of Total number of species	minus exotic AND OR Tolerant	↘
	relative abundance (% total number of individuals)	minus exotic AND OR Tolerant	↘
Rheophilic	Number of species	minus exotic AND OR Tolerant	↘
	Number of individual or biomass (CPUE)	minus exotic AND OR Tolerant	↘
	% of Total number of species	minus exotic AND OR Tolerant	↘
	relative abundance (% total number of individuals)	minus exotic AND OR Tolerant	↘
SPAWN HABITAT			
Lithophilic	Number of species	minus exotic AND OR Tolerant	↘
	Number of individual or biomass (CPUE)		↘
	% of Total number of species	minus exotic AND OR Tolerant	↘
	relative abundance (% total number of individuals)	minus exotic AND OR Tolerant	↘
TROPHIC GUILD			
Omnivorous	Number of species	minus exotic AND OR Tolerant	↗
	Number of individual or biomass (CPUE)	minus exotic AND OR Tolerant	↗
	% of Total number of species	minus exotic AND OR Tolerant	↗
	relative abundance (% total number of individuals, **biomass**)	minus exotic AND OR Tolerant	↗
Invertivorous	Number of species	minus exotic AND OR Tolerant	↘
	Number of individual or biomass (CPUE)	minus exotic AND OR Tolerant	↘
	% of Total number of species	minus exotic AND OR Tolerant	↘
	relative abundance (% total number of individuals, **biomass**)	minus exotic AND OR Tolerant	↘
TOLERANCE			
Tolerant	Number of species	minus exotic	↗
	Number of individual or biomass (CPUE)	minus exotic	↗
	% of Total number of species	minus exotic	↗
	relative abundance (% total number of individuals, biomass)	minus exotic	↗
Intolerant	Number of species	minus exotic	↘
	Number of individual or biomass (CPUE)	minus exotic	↘
	relative species richness (% of total species richness)	minus exotic	↘
	relative abundance (% total number of individuals, biomass)	minus exotic	↘
Abundance			
CPUE	Number or biomass per 100 m2		↘
	Number or biomass per sampling duration		↘
Age - length structure	PRESENCE of several Trout OR Pike lenght classes (2 or 3 categories)		Absence
	PRESENCE of several Intolerant AND Dominant species lengt	minus exotic	Absence
	PRESENCE of several Dominant species lenght classes (2 or 3	minus exotic AND Tolerant	Absence
MIGRATION			
Long-distance specie	presence	site, reach, basin scale??	Absence
	number of species	site, reach, basin scale??	↘
	% of species	site, reach, basin scale??	↘

The FAME recommends the use of electro fishing in small rivers, and in the shoreline areas of large rivers. With respect to the electro fishing method the FAME recommends to follow the CEN standard (EN 14011). They recommend fishing a stretch 3 times with some time interval in between, and using the data on reduced catch in the successive samplings to both evaluate the abundance of fish and the

efficiency of the methods 1st survey. If there is established a relatively good estimate of the percentage caught in the first survey, only one survey should be used. The catch per unit effort (CPUE) can be used for the estimation of abundance.

In the central parts of large rivers the FAME project provides no clear recommendations, but indicates that some kind of drift nets and drag nets of variable mesh size could be used. They admit however, that it is very difficult to get representative catch from these areas of large rivers. The problem with using nets is that they under-represent the smaller stages, and then do not provide correct information about the age structure of the population, which is one of the mandatory metrics in the WFD.

5.4 The European Fish Index (EFI)

5.4.1 Metrics and methodology

The European Fish Index is the main result from the FAME project. Based on statistical testing from a large database (FIDES = Fish Database of European Streams) the FAME project concluded that Fish status could be assessed using **only 10 metrics**. These are shown in **Table 3**.

Table 3. The 10 metrics used by the EFI and their response to human pressures.

Selected metrics	Response to pressure
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 migration over long distances	↓
10. Number of potamodromous species	↓

1. The first step in assessing the EFI is to use data from single-pass electric fishing catches to calculate the assessment metrics, see **Figure 4**, (1).

2. In the second step a theoretical reference value, indicating no or only slight human impacts (equals good or high status) is predicted for each metrics using environmental variable by means of multi-linear regression model calibrated with FIDES reference data, see Figure 4 (2).

3. The residuals of the multi-linear regression models are used to quantify the level of environmental degradation. Residuals are calculated as observed metric values minus theoretical (predicted) metric values, see Figure 4 (3).

4. Residual metric values scatter around the theoretical value. Impacted sites show a greater deviation from the theoretical value and thus are less likely to belong to the reference residual distribution than unimpacted or slightly impacted sites, see Figure 4 (4).

5. The metrics in the EFI are based on different units. 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, see Figure 4 (5).

6. As some standardised residuals values tend to increase with distrurbance, whereas others decrease, they are transformed into probabilities. This transformation presents two main advantages. Firstly, all metrics will vary between 0 and 1, whereas the standardised metrics 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 classes. A site that fits perfectly with the prediction (the reference condition) will have a final metric value of 0.5, see Figure 4 (6).

7. The final EFI is obtained by summing the ten metrics, and then by rescaling the score from 0 to 1, see Figure 4 (7).

8. The final step is to assign the index scores to ecological status classes, see Figure 4 (8).

The EFI was validated within the FAME project with indipendant data sets. The EFI was also validated against a pre-classification of site status based on assessment of human impacts 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.

5.4.2 Soft-ware for calculating EFI and assessment of status

An Excel-based soft ware has been developed to calculate the EFI and assessment of ecological status. The software can be downloaded from the internet free of charge, at http://fame.boku.ac.at website.

5.4.3 Limitations of the EFI

The EFI is a statistical method and requires a certain minimum catch of approximately 30 specimens at each site. The EFI can only use input data from single pass elecro-fishing. The EFI should be used with caution in the lowland reaches of very large rivers like the Rhine and Donau as no reference sites from these reaches have been used for the calibration of the EFI. The EFI will not function in undistrurbed areas with very low fish density, or heavily disturbed areas where fish is almost extinct.

The WFD requires use of species composition, abundance, sensitive species, age structure and reproduction within the assessment criteria. The 10 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. In mountain rivers of northern Europe, e.g. in Norway, the brown trout (Salmo trutta) is often the only species present. To be able to say something about the health of the fish population, growth rate, age structure, fish condition (length/weight-relationship), and spawning success, are very important parameters. These metrics could be integrated in a future version of the EFI.

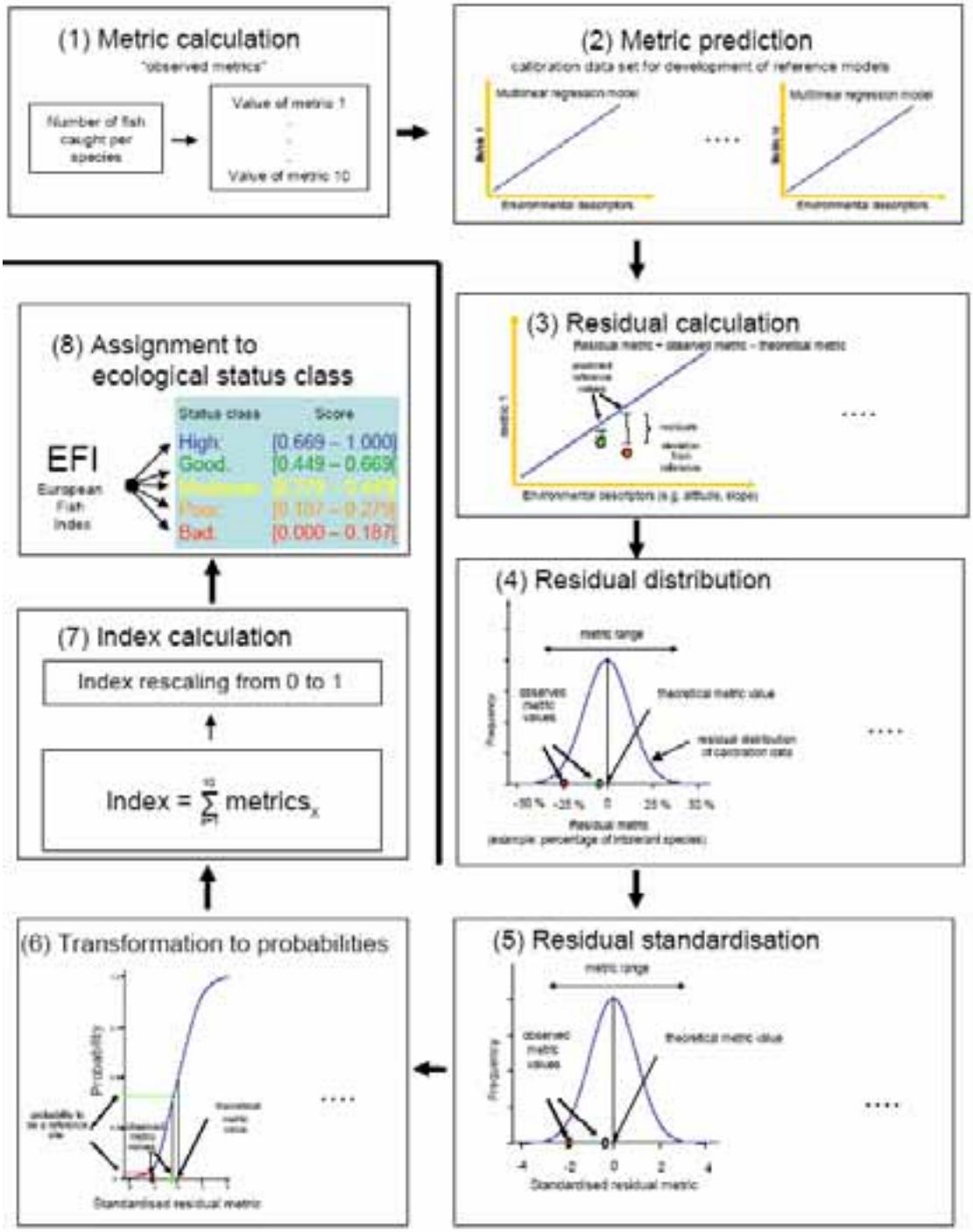

Figure 4. The methodology for assessing the ecological status of a water body using the European Fish Index developed by the FAME project. See preceding text for explanation.

6. What does the WFD say about Management of fish in bordering and trans-boundary rivers

6.1 From the WFD and the CIS-guidances

The WFD is a framework for integrated water management. This is a step forward compared to the traditional sector-wise water management; i.e. one plan for irrigation managed by the Ministry of Agriculture, one for hydropower driven by the Ministry of Energy, one for fisheries by the Ministry for Fishery, etc. Now they should all be linked together. In many fish management plans it can already be seen that it is not only the fishery and fishing rules that are the problems for the fish community health in many rivers, but impacts from other sectors, from pollution discharges, low water levels and low water flows in critical periods, migration barriers like dams, etc. With respect to fish, the WFD says that the rivers should be managed in such a way that the fish communities show only small or negligible deviation from what is believed to be the natural fish community conditions for that river type.

Another step forward by the WFD is that it states that the rivers should be managed on a catchment basis. This should also apply for bordering- and trans-boundary rivers. For international river basins within the EU, the Member States are obliged to take contact with the other countries in the catchment and co-ordinate the water management. Preferably, they should make a common water management plan for the whole river basin. This could be achieved by using existing over-national organisations such as the Danube Commission or the Rhine Commission. If this is not possible, each Member State shall make a water management plan for their own part of the catchment and co-ordinate this with the others.

7. The Mantra East Project

A research project under the DG-research (Mantra East) studied the problems confined with management of trans-boundary waters in Europe. One of their conclusions is that the WFD is very "soft" with respect to require establishment of a common water management plan for international rivers. The MANTRA East project experts formulated the following list of issues important in their view for the management of trans-boundary waters that was proposed for discussing at a workshop organised 26th November 2004 in Brussels. As a result of the discussion, possible specific measures and projects' proposals could be formulated to promote IWRM approaches in transboundary water basins on the EU borders and in the EU Water Initiative regions. Their concerns (written in italic) are listed below:

7.1 Major issues that concern management of trans-boundary waters in Europe (as identified by the MANTRA East project experts)

Establishment of formal arrangements and detailed procedures for the cooperation
Formal arrangement and procedures should be established between the riparian governments as well as between the governments and the stakeholders are important. Their responsibilities and procedures of work should be clearly described in the part that concerns implementation of the WFD on those trans-boundary waters.

The political process of the trans-boundary cooperation should be taken more seriously into account
Water management in a trans-boundary context is much more complex than water management within one state. There is not one government to manage the trans-boundary waters; there are different states with their distinct political and economic interests, different histories and cultures; all management aspects become very political. The political will from the governments of all riparian countries is a prerequisite for a successful start and continuation of any trans-boundary cooperation. Actions should

be taken to promote political commitments of the states to the international cooperation on trans-boundary waters. This could be done through special communication events, etc.

Stakeholders - the key to successful implementation of water policies?
The study of theoretical models and a review of experiences of stakeholder and public participation in trans-boundary water management confirmed that involving multiple stakeholder groups in the development and implementation of the EU and national water policies is critically important. However, this is not always feasible for various reasons. Usually in trans-boundary water basins only few organised stakeholder groups are in some way involved in the planning and implementation of water policies. Many local stakeholders are not sufficiently aware of regional water management issues and therefore are not interested to get involved. Traditionally, a major bottleneck in the implementation of environmental policies is created when experts produce a highly technical body of information that becomes incomprehensible to those local stakeholders and laypersons.

Innovative approaches and technologies to disseminate water management information (e.g., semantic webs, citizen juries) were tested and found to be valuable to be implemented in trans-boundary water basins in order to increase awareness of local stakeholders in trans-boundary water issues. One important tool in the Lake Peipsi Basin is a regional Internet portal (www.peipsi.org) that uses knowledge management technological solutions to provide all interested parties with comprehensive information and news on environmental and regional development issues in the lake basin. The Lake Peipsi portal is available in Estonian, English and Russian. It is important to use the mother tongue of local stakeholders for this kind of communication tools.

Promote involvement of stakeholder in work of Trans-boundary Water Commissions
Seven case studies examining the use of various aspects of environmental information from both theoretical and empirical perspectives for Nemunas River, Bug River, Odra River, Lake Neusiedl, Lake Constance, Elbe River and Spanish –Portuguese Rivers were conducted. The results of this comparative assessment show that trans-boundary commissions are largely expert/technical commissions. The socio-economic connotation of water management decisions may as a consequence be underestimated. One consequence is the lack of attention of trans-boundary commissions to an active involvement of stakeholders in the management process.

Address differences in water management competences between countries on the new EU-border
Investigations during the MANTRA East project illustrated in particular that there is a growing gap in the formal frameworks (different administrative structures, norms and standards), practices, information and levels of funding towards water protection measures on the different sides of the border – an EU member or accession state and a non EU state. This present a major challenge for the trans-national implementation of EU water policy such as the WFD.

Simplistic nutrient modelling tools efficient for pollution prevention strategies
In trans-boundary river basins, riverine load modelling and source apportionment estimation is more difficult than in other situations, because the required administrative statistics and GIS (spatial) data are often not harmonized between the countries. This is especially the case for the Lake Peipsi basin, which can be regarded as data-rich for the Estonian part (and to a lesser extend to the Latvian part), and data-poor with respect to the Russian part. In the project, two models (MESAW and POLFLOW) were applied to assess the source, retention and transport of nutrients. Both models have proved to be complementary and useful tools to assess the nutrient loads of the past, present and future in trans-boundary drainage basins. With a minimum of large-scale maps and calibration of the model using data from a relatively data-rich part (Estonia), plausible nutrient emission estimations and load simulations can be obtained for an entire basin, including data-poor parts (Russia/Latvia). The modelling of nutrient emissions and loads for future scenarios enables decision makers to identify priorities for water management, and evaluate the effect of various developments (see next bullet point). The same situation concerns the Vistula Lagoon basin, which can be regarded as data-poor with respect to the Russian part and slightly data-richer for the Polish part. In the project, the MIKE BASIN model was

applied to the Pasleka River to assess the sources and loads of nutrients. These estimates were extrapolated to other rivers discharging into the Vistula Lagoon.

Need in comparative policy science studies to promote efficient water management planning
A review of existing trans-boundary water management structures and practices in trans-boundary water basins in Europe demonstrated a lack of well developed research and analysis on the implementation of water management policies and plans. It was also shown that organizational and institutional aspects of implementing EU water policy (political, research, administration etc) and problems of communication and information exchange between different levels of governance as well as across borders present major difficulties for policy implementation.

Use of environmental and socio-economic information is crucial for trans-boundary water management
A very wide spectrum of information is required to support decision-making and to evaluate the effects of water resources management decisions. Within the project, it was found that information production lags behind needs in well-informed developments in the water management. Although integrated water management was introduced more than a decade ago, information about trans-boundary water basins still focuses mostly on hydrological and ecological components of water bodies and largely ignores the importance of socio-economic data and processes. Among the reasons that hinder production of such improved information are (1) strong boundaries between different disciplines that are not easily over-come; (2) the variety of information needs are underestimated and the knowledge and perception of goals of information dissemination prior to producing the information is insufficient; (3) differences in institutional behavior between representatives of different organizations involved in the cooperation hinder the collaboration between these institutions.

Socio-economic information is important in the water management decision-making process
Environmental data is rarely used in the decision-making process unless it shows a direct and clear connection between and impact of the physical-chemical and biological conditions on changes in the economic and social situation in a given trans-boundary water region. Information for decision making, especially the analysis of the problem, needs to fall within the scope of expectations of the decision makers. For a trans-boundary water management situation this implies that, to be effective, an existing problem should be described from the viewpoints of the countries involved. Furthermore, the information should also allow different solutions in the different countries concerned.

Financing of water protection measures
Implementation of water protection measures requires considerable financial resources, usually much higher than are usually available in a trans-boundary water basin. It is important to take into account that trans-boundary areas, especially the ones shared by countries in transition, consist of peripheral and usually less economically developed regions of neighbouring countries where the budgets of local authorities are poor and not many private entrepreneurs are present in those border areas who are willing to provide their resources into water protection – market for businessmen is much wider in capital areas where most of the wealth of countries is concentrated. In this context, especially in trans-boundary water basins shared by countries in transition, the ***environmental objectives of*** *water management plans* ***should be co-ordinated with economy.***

The MANTRA East is a research project under DG-Research and their findings and recommendations are not yet adopted by the DG-Environment which forms the official rules and regulations.

It should be noted that a finalised Water Management Plan is not required according to the WFD before 9 years after the WFD came into force, i.e. in year 2009 for the first EU-members. Most likely there will be elaborated a guidance document on water management planning.

8. Literature

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Huet, M. 1954: Biologie, profiles en long et en travers des aux courantes. Bulletin Fransais de Pisciculture 175: 41-53.

Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries, 6, 21-27.

For the WFD and CIS-guidance documents, and reports from the two EU-research projects referred to, see the web-site references given in **Table 4** on the next page.

Table 4. EU documents regulating water management (Water framework directive with different guidance documents)

Doccuments	Web site link where the documents can be found
The water framework directive	http://www.sft.no/arbeidsomr/vann/vanndirektiv/vannrammedirektivet_engelsk.pdf
Guidance for the analysis of Pressures and Impacts In accordance with the Water Framework Directive	http://www.sft.no/arbeidsomr/vann/vanndirektiv/vannrammedirektiv_veiledning21.pdf
Guidance document on identification and designation of heavily modified and artificial water bodies	http://www.sft.no/arbeidsomr/vann/vanndirektiv/vannrammedirektiv_veiledning22.pdf
Guidance on establishing reference conditions and ecological status class boundaries for inland surface waters	http://www.sft.no/arbeidsomr/vann/vanndirektiv/vannrammedirektiv_veiledning23.pdf
Guidance on typology, reference conditions and classification systems FOR transitional and coastal waters	http://www.sft.no/arbeidsomr/vann/vanndirektiv/vannrammedirektiv_veiledning24.pdf
Towards a guidance on establishment of theIntercalibration network and on the process of the Intercalibration exercise	http://www.sft.no/arbeidsomr/vann/vanndirektiv/vannrammedirektiv_veiledning25.pdf
Economics and the environment, the implementation challenge of the water framework directive - a guidance document	http://www.sft.no/arbeidsomr/vann/vanndirektiv/vannrammedirektiv_veiledning26.pdf
Guidance on Monitoring for the Water Framework Directive	http://www.sft.no/arbeidsomr/vann/vanndirektiv/vannrammedirektiv_veiledning27.pdf
Statistical aspects of the identification of groundwater pollution trends, and aggregation of monitoring results	http://www.sft.no/arbeidsomr/vann/vanndirektiv/vannrammedirektiv_veiledning28.pdf
Guidance on Public Participation in relation to the Water Framework Directive - Active involvement, Consultation and Public access to information	http://www.sft.no/arbeidsomr/vann/vanndirektiv/vannrammedirektiv_veiledning29.pdf
Guidance document on Implementing the GIS Elements of the WFD	http://www.sft.no/arbeidsomr/vann/vanndirektiv/vannrammedirektiv_veiledning31.pdf
Fish Assessment Methods (FAME), European Fish Index (EFI)	http://fame.boku.ac.at
Management of Transboundary Waters (MANTRA EAST)	http://www.mantraeast.org/