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European Fish Species: Taxa and Guilds Classification Regarding Fish-Based Assessment Methods

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Abstract

The “European Fish Index” (EFI) is the output of the FAME project (Development, Evaluation and Implementation of a Standardised Fish-based Assessment Method for the Ecological Status of European Rivers) which was conducted from 2001 to 2004 based on the requirements of the European Union’s Water Directive Framework (WFD). The follow up project EFI+ (Improvement and Spatial Extension of the European Fish Index) will result in an improved version of the European Fish Index with regard to eastern European and mediterrenean rivers and streams and an improved cross-linkage to hydromorphological pressures. EFI+ will be completed in April 2009. In contribution to this project in the present thesis a comprehensive selection of fish species and their classification into guilds can be found. 339 fish species living in European running waters and belonging to 38 families are listed. Different names for the same species were discussed by experts and unified. The literature search was the basis for the classification of nearly 75% of the listed species into guilds of tolerance, feeding and reproductive guilds. Physiological and morphological parameters were also taken in account. More than 12 experts from 12 European countries (Austria, Finland, France, Germany, Italy, The Netherlands, Poland, Portugal, Romania, Spain, Switzerland, United Kingdom) contributed to the guild classification. Based on the literature search suggestions for classifications were made and experts reviewed the results and gave their own classifications. The new findings were collected. Mean values were calculated following the Delphi method and the results reviewd again by experts. This process continued until guild classifications were completed and agreed on by all project members. Additionally to the coordination of the classifications literature that is present in electronical sources (therefore approximately since 1997) examined and aggregated. About 200 papers, books, reports, thesis and dissertations were collected and more than 60 of them were described in detail by summarizing and analyzing them.

Finally the results of the guild classifications were described statistically on a family level and compared to references from the literature. Tolerance ranges corresponding to the families and physiological as well as morphological parameters were examined. Most of the species belong to the families Cyprinidae, Gobiidae and Cobititidae. Salmonidae and Petromyzonidae are mostly intolerant whereas numerous species of Cyprinidae, Gobiidae and Cobitidae are intermediately tolerant. Rheophilic species are intolerant and euryotpic species are tolerant. Problems that emerged during the classification process originate from a lack of information on ecological traits of endemic fish species and species which are not abundant.

Keywords: Fish, running waters, guilds, European Fish Index, Delphi method, WFD

Kurzfassung

Der „europäische Fisch Index“ ist das Ergebnis eines Projekts namens FAME bei dem es um die „Entwicklung, Bewertung und Einführung einer standardisierten Bewertungsmethode des ökologischen Zustandes europäischer Flüsse basierend auf Fischen“ ging. Das Projekt wurde im Hinblick auf die Wasserrahmenrichtlinie durchgeführt und 2004 abgeschlossen. Der Fisch Index wird jetzt in einem neuen Projekt bezüglich osteuropäischer und mediterraner Flüsse sowie betreffend eine bessere Vernetzung mit hydromorphologischen Einflüssen überarbeitet. Der Titel dieses Projekts lautet EFI+ (Verbesserung und räumliche Ausdehnung des europäischen Fisch Index). Es soll Ende April 2009 erfolgreich beendet sein. Als Beitrag zu diesem Projekt entstand mithilfe meiner Diplomarbeit eine umfassende Liste, in der 339 Fischarten, die in Fliessgewässern leben und 38 Familien zugehörig sind, aufgeführt sind. Artnamen wurden vorher in Expertendiskussionen vereinheitlicht. Die Literatursuche war die Basis für die Klassifizierung von fast drei viertel der Arten in ihre Toleranz-, Ernährungs- und Reproduktionsgilden. Auch physiologische und morphologische Parameter wurden zusammengefasst. Mehr als 12 Experten aus 12 europäischen Ländern (Deutschland, Finnland, Frankreich, Großbritannien, Italien, Niederlande, Österreich, Polen, Portugal, Rumänien, Schweiz und Spanien) trugen zu der Gildenklassifizierung bei. Basierend auf den Ergebnissen der Literatursuche wurden erste Vorschläge zur Klassifizierung gemacht. Die Experten beurteilten diese und nannten ihre eigenen Gildeneinstufungen. Die Ergebnisse wurden zusammengetragen, die Mittelwerte der Ergebnisse nach der Delphi-Methode ermittelt und nochmals an alle Experten zu deren Durchsicht ausgeschickt. Dieses Vorgehen wurde solange wiederholt bis alle den jeweiligen Ergebnissen zustimmten. Zusätzlich zu der Koordination dieses Prozesses wurde Literatur zum Thema Gilden überarbeitet, die hauptsächlich aus E-Journals entnommen wurde. Diese beschränkt sich daher hauptsächlich auf den Zeitraum von 1997 bis heute. An die 200 Publikationen, Bücher, Berichte, Diplom- und Doktorarbeiten habe ich auf diese Weise zusammengetragen. Etwa 60 davon habe ich im Detail beschrieben und deren Inhalte zusammengefasst.

Statistische Auswertungen auf Familienniveau sollen den Gildeneinstufungen Nachdruck verleihen und wurden mit Zitaten aus der Literatur verglichen. Die Darstellung des Toleranzverhaltens der Familien und der Zusammenhang zwischen Toleranzgrenzen und physiologischen und morphologischen Parametern, vor allem von Salmoniden, sind die Ergebnisse weiterer Analysen. Die meisten Arten gehörten zu den Familien der Cyprinidae, Gobiidae und Cobitidae. Salmoniden und Neunaugen sind größtenteils intolerant. Zahlreiche Arten der Cypriniden, Gobiiden und Cobitiden sind eher tolerant. Rheophile Arten sind intoleranter als eurytope Arten. Schwierigkeiten mit den Einstufungen sind auf einen Mangel an Information über Gilden zurückzuführen, vor allem was endemische und selten gewordene Fischarten betrifft.

Schlagwörter: Fische, Fließgewässer, Gilden, European Fish Index, Delphi-Methode, Wasserrahmenrichtlinie

CONTENTS

Index of Abbreviations

AIC	Akaike's Information Criterion
ANCOVA	Analysis of Covariance
ANOSIM	Analysis of Similarities
ANOVA	Analysis of Variance
AOV	Analysis of Variance
BOKU	Universität für Bodenkultur (University of Natural Resources and Applied Life Sciences)
CCA	Canonical correspondance analysis
CDF	Canonical discriminant function analysis
CPUE	Catch per unit effort
DA	Discriminant analysis
EFI	European Fish Index
EFI+	EFIplus - Improvement and Spatial Extension of the European Fish Index
FAME	Development, Evaluation and Implementation of a Standardised Fish-based Assessment Method for the Ecological Status of European Rivers
FAO	Food and Agriculture Organization of the United Nations
FIDES	Fish Database of European Streams
GSI	Gonadosomatic index
IBI	Index of Biotic Integrity
IUCN	International Union for Conservation of Nature
LC_{50}	Lethal acute concentration
LD_{50}	Lethal acute dosis
MCA	Multiple component analysis
MDA	Multiple discriminant analysis
NMDS	Non-metric multidimensional scaling
PCA	Principal component analysis
QQ plot	Quantile-quantile plot
SIMPER	Similarity percentages
STS	Simultaneous test procedure
SS-STP	Sum of squares simultaneous test procedure
WFD	Water Framework Directive
WHO	World Health Organization

1 Overview

The present thesis which is supervised by Andreas Melcher and Stefan Schmutz is a contribution to the EFI-plus project (http://efi-plus.boku.ac.at/) “Improvement and spatial extension of the European Fish Index” conducted by the Institute of Hydrobiology and Management of Waters of the University of Natural Resources and Applied Life Sciences (BOKU) in Vienna. The work is sponsored by the European Union’s sixth Framework Programme part of which is the research on sustainable development, global change and ecosystems. The European Fish Index originally results from the FAME (http://fame.boku.ac.at/) research project called “Development, Evaluation and Implementation of a Standardised Fish-based Assessment Method for the Ecological Status of European Rivers”.

The objective of the FAME project was to support the European Water Framework Directive (WFD) by developing, evaluating and implementing a fish-based assessment method for the ecological status of rivers in order to achieve a good ecological status. This method development was based on the Index of Biotic Integrity (IBI) introduced in the USA in the early 1980s. The basic principle was to describe fish assemblages by a set of different metrics, whereby these metrics correspond to human influences in a measurable manner. Two different development approaches were done in FAME: a type-specific spatially based approach and a site-specific approach. This ultimately yielded several methods for ecological status assessment. Statistical tests of the accuracy and consistency of FAME tools, along with comparisons between the FAME methods and existing regional/national methods, demonstrated that the site-specific method is as accurate as all other methods. Since it allows the ecological status to be assessed across Europe with a single, standardized method, it was selected as the final FAME assessment method: the European Fish Index (EFI) (FAME consortium 2008).

The above mentioned Index has to be improved regarding to eastern European and mediterranean regions and methods to assess waters with regard to hydromorphology. In the current project I collected information on Europe’s fish species and their ecological traits all of which was to be classified in reproductive, trophic and habitat guilds, also including other paramters like tolerance values and migration. Existing classifications that often reach back to Balon’s times in the 1970s had to be negotiated and new classifications had to be approved of. Experts all over Europe (table 3.2) were asked to contribute their own classifications on a list of species to which they could add guild classification derived from literature search or research projects. In my own extensive literature search on taxa and the classification of guilds of the observed fish species I tried to specify subject areas in relation to guild and the publication they can be found in. In the end all the findings had to be brought together to create a useful and comprehensive tool for assessing river ecosystem quality by applying the European Fish Index.

2 Scientific background

2.1 The guild approach

2.1.1 Multi-metric indices

Plenty of metrics that have already been used in IBIs assess similar aspects of a functional community but measure them in different ways. Ecological suitability, statistical robustness and methodological criteria are prevalent for each metric definition. An ecologically and statistically sensitive metric must be chosen in order to facilitate the use of an analytical technique, which is applicable in connection with the definition of the requirements of the fish-based index, the structure of the community being studied, a frame of reference classifying and scoring and the metric within the observed range of value figures. There are three levels of selecting a metric whereas at each level several criteria have to be fulfilled. Primarily there have to be ecological reasons for choosing the metric and a hypothesis for the reaction of the metric to degradation. Furthermore a statistical reason for the measurement used is needed and value figures need to be categorised and scored and compared to the frame of reference. Finally one has to understand the limitations of the sampling procedure used to assess the metric. The main criterion, however, should be that a candidate metric is proposed in relation to the expected variation with regard to the degradation and – in context of application to an European-wide fish-based IBI – the resulting guild must represent all ecoregions and an acceptable range of fish species (Noble et al. 2007).

When biological metrics are combined into a multimetric index for bioassessment purposes, individual metrics must be scored as unitless numbers to be combined into a single index value. Different multimetric indices apply methods of scoring metrics that vary widely in the type of scaling used and the way in which metric expectations are established. These differences among scoring methods may influence the performance characteristics of the final index that is created by summing individual metric scores (Blocksom 2003).

2.1.2 Index of Biotic Integrity

Biotic integrity is commonly defined as "the ability to support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity and functional organization comparable to those of natural habitats within a region" (Karr & Dudley 1981). Biological integrity is equated with pristine conditions, or those conditions with no or minimal disturbance (Environmental Protection Agency 2008). The Index of Biotic Integrity (IBI), a multi-metric index, was first developed by James R. Karr for use in small warmwater streams as a tool for assessing the biological integrity of stream resources and together with physical and chemical parameters provides a basis for ecological management. To have general utility and because human disturbance can affect riverine systems in many different ways a measure of bitotic integrity must have a broad ecological foundation. Therefore the IBI compares several observed metrics of fish communities with the attributes expected under minimal human influence, which include six metrics for species richness and composition, three metrics of trophic composition and three metrics dealing with fish abundance and condition. Angermeier and Karr (1986) outlined a manul for the calculation of the IBI:

> "Fish collections for which IBI scores are calculated are assumed to be "one-time" samples (i.e. not cumulative) in which related abundances of all species are accurate. Several steps precede the acutal IBI computation. First, all species included in the categories "intolerants", "omnivores", "insectivorous cyprinids", and "piscivores" are identified. Next, criteria are established for each metric whereby observed metric values are converted to scores of 5 (deviates only slightly from pristine situation), 3 (deviates moderatly from pristine situation) or 1 (deviates strongly from pristine situation). Both these steps are critical to a meaningful IBI assessment and require the input of expirienced biologists. Criteria used in scoring metrics, especially species-richness metrics, may vary with region, stream size and gradient. After all metric criteria are set, the 12 metric scores are assigned and added to yield a total IBI score between 12 and 60. Based on this score and the judgment of informed biologists, the fish community can than be classified as excellent, good, fair, poor or very poor."

2.1.3 Riverine ecosystem situation

Rivers have undergone huge modifications due to anthropogenic influences. Power plants, engineering of river channels, river straightening, channel deepening and isolation of the floodplain by poldering and levee construction have been causing changes to the morphology, hydrology and biology of river ecosystems. Flow regimes and floodplains are constantly changing because of dams and water extraction abstractions. Nowadays chemical pressures like, toxicity, heavy metals and waste water pollution should not be the biggest threat for inland waters anymore. Several environmental laws and a more or less strict monitoring system have led to stable conditions as to pollution of rivers and lakes. Damage that is caused by hydromorphological modifications like the ones mentioned above can, in the long run, be more severe but much more difficult to detect. Suitable indicator organisms for this kind of danger are supposed to be sensitive to changes in hydromorphology and hydrology, like fish (Spindler 1997). Schiemer and Waidbacher (1992) mentioned, for example, that the number of typical species of the Danube's upstream canyon zone like *Salmo trutta*, *Thymallus thymallus* and *Phoxinus phoxinus* had decreased in the impoundment area due to interruptions between the stream and its main tributaries. They believe that lateral connections are particulary important for many riverine species, as feeding grounds for some and as winter and flood refuge for others. The importance of inshore zones of rivers for species which prefer fast flowing waters during their early stages in life is recognized.

Fish offer several advantages as indicator organism for human disturbances. They are present in most surface waters, their taxonomy and ecological requirements are generally better known than in other species and their longevity facilitates sensitivity to disturbance over relatively long time scales. Their life cycles are well documented and their responses to environmental stressors, like depressed growth and recruitment, are often known and easy to detect. Fish occupy a variety of habitats in rivers and use a wide range of food in distinct feeding habitats (FAME consortium 2004). Ecology and distribution of fish species are strongly influenced by habitat volume, current velocity, food availability and thermal regime, all of which are under hydrological influence (Poff & Allan 1995). However, not every single fish species can be classified seperately. It is necessary to move away from taxonomy and pay more attention to the formation and classification of ecological traits (Noble et al. 2007).

2.1.4 Assigning species to guilds

As far as rivers are concerned a species approach for assessing water quality is difficult to elaborate. Welcomme et al. (2006) indicate that even in temperate zones where there are relatively few species, a search for the indicator species that summarizes impacts for a wider group of species cannot be defined as numerous different habitats are occupied by many species. Additionally fish use distinct habitats during different stages of life. Groups of species behave in a sufficiently similar manner as to be classed into a common group and communities are structured by common ecological requirements.

“One key strength of the guild approach is that it provides an operational unit linking individual species characteristics with the community” (Noble et al. 2007). Root (1976) defines guilds as “a group of species that exploit the same class of environmental resources in a similar way”. Guilds reflect the presence of resources and biodiversity of a water body. The presence or absence of specific guilds is a good indicator for possible negative ecological conditions. The guild approach allows for the direct equation of riverine systems indepent from taxonomy and zoogeographic region.

Guilds have a major adavantage over species. They can be used even if the knowledge on the occurrence of singe species is incomplete (Schmutz et al. 2000).

A disadavantage in using taxonomy is that the same species often has different names in different countries but the guild of rheophilic species, for example, is the rheophilic guild anywhere. This is an important fact in view of a European-wide classification method.

2.1.5 Guilds as an assessment tool for the ecological status

Fish have specific requirements for breeding, feeding, growth, recruitment and survival. These characteristics have been used to classify them into ecological and functional groups. Balon (1975) created an extensive concept to classify fish species into ecological guilds which he based on spawning behaviour and spawning sites and which he called the “eco-ethological guilds”. With this concept Balon continued, to some extent, the work of Kryzhanovsky who had worked on some kind of ecological classification before, defining adaptations of fish for spawning and development as “not only essential factors of the embryonic period, but also essential factors of all the other intervals of life.” The subdivision in reproductive groups is so important because spawning behaviour and spawning grounds give useful hints about respiratory conditions and available protection from predators (Balon 1975). Balon considered other types of guilds like, for example functional groups based on feeding strategies and food composition of little importance. In his opinion single species of fish could switch from one feeding type to another. If one food resource had been left unutilized because of the removal of one taxon it would be utilized by another. Irrespective of the fate of a single taxon, nutrient load and production would remain constant in the end. Balon defined groups and associated sub-groups on the basis of spawning substrat, for example: Nonguarding open substratum spawners, nonguarding brood hiders, guarding substratum choosers, guarding nest spawners, external bearers and internal bearers.

Schiemer and Waidbacher (1992) took another approach to guilds (table 2.1) by concentrating on hydromorphological and hydrological requirements of fish. They intended to show the importance of lateral and vertical connectivity for fish species and defined habitat types and the resulting degree of rheophily. According to the preferred zones of occurrence of adults and their spawning and nursery grounds five types of habitat guilds are distinguished. In 1989 Schiemer and Spindler had created a similar definition of habitat types, also working with ecological groupings of rheophily. Waidbacher et al. (2003) reused this guild concept. Noble & Cowx (2002) for the FAME project collected all known guild classifications and ecological groups definitions.

***Table 2.1** Degrees of rheophily with the associated types of species (adapted from Schiemer & Waidbacher 1992 and Waidbacher et al 2003)*[1]

Denomination	Species and their type of habitat
rhitral	Riverine species dependent on connectivity as they require rhitral conditions for spawning and during their early life stages (e.g. *Hucho hucho, Lota lota*).
rheophilic a	Majority of species; riverine species with spawning grounds and nurseries in the inshore zone of the river itself (e.g. *Chondrostoma nasus, Barbus barbus, Gobio* spp.).
rheophilic b	Riverine species with a preference for low-flow conditions like in connected backwaters, for example, during certain periods in the adult stage, but spawning grounds and nurseries in the river (e.g. *Abramis ballerus, Aspius aspius*).
euryotopic	Habitat generalists found both in the river and various types of stagnant water bodies.
stagnophilic	Limnophilic species confined to various microhabitats of disconnected former river branches with a strong development of submerged vegetation.

2.2 Development of the European Fish Index

From 2002 to 2004 a project promoted by the European Union’s fifth Framework Programme was conducted by the Institute of Hydrobiology and Management of Waters. It was called FAME and aimed at developing, evaluating and implementing a standardized evaluation method for fish species which is based on the IBI. As a main result the EFI was created. The most important innovation of this Fish Index was that it had been worked on Europe-wide and that it was applicable to many types of running waters. Environmental parameters shall predict the reference conditions and an evaluation can be made comparing these reference conditions and the ones observed. EFI is based on West and North European rivers. Anthropogenic influences are taken into account. Although many kinds of waters can be evaluated large rivers, for example, are underrepresented in EFI. The European Fish Index is currently being tested in several European countries (FAME consortium 2008).

2.2.1 FAME[2]

The “Development, Evaluation and Implementation of a Standardised Fish-based Assessment Method for the Ecological Status of European Rivers” aimed at evaluating and implementing a fish-based assessment method for the ecological status of rivers based on the IBI created by Karr 1981. A large central database called FIDES (Fish Database of European Streams) which holds fish sampling data from 8.228 sampling sites in 12 European countries (Austria, Belgium, France, Germany, Greece, Lithuania, Poland, Portugal, Spain, Sweden, The Netherlands and the United Kingdom) provided a good foundation for the accomplishment of the project. Fifty-two variables were used to characterise fishing procedures in terms of abiotic criteria and human pressure; each of those variables was classified according to 5 different levels of impact on the fish fauna. Eight criteria described the sampling procedure and 9 the geographical position. Fish data were integrated, like the number of individuals, length or length class, number of 0+ individuals and, if available, biomass.

Data in FIDES implicate information on different type of water bodys, reference sites and different levels of degradation of European rivers. In order to identify reference sites and levels of degradation, each fishing

[1] Denomination of the habitat groups was used by Waidbacher et al (2003). Schiemer&Waidbacher (1992) did not mention any names for their habitat groups.

occasion was classified using a joint pressure variable. The latter was computed as the mean of 4 or 5 single pressure variables: morphological and hydrological conditions, nutrients/organic input, toxic substances/acidification and connectivity. Sites where none of the main pressures was classified higher than two (joint pressure status =1 or 2) were extracted as reference or “calibration” datasets.

Another basis for the index development was the calculation of so called metrics and the classification of fish species into functional guilds. In accordance with the WFD, the metrics selected in FAME refer to species composition, density and population structure. 45 species indicative of altogether about 450 metrics were computed. The standardized sampling procedure used in FAME was electric fishing, either by boat or wading, the only common sampling method regarding FAME partner countries.

Methodologically, two different approaches were tested: a site-specific and a type-specific one. The spatially-based approach aimed at developing type-specific methods on both the ecoregional and the European scale (Schmutz et al. 2000). The site-specific approach predicts reference conditions at the site level. The main task was therefore to identify those abiotic criteria that determine the natural variability of fish assemblages of European rivers and to integrate them adequately into the models. The site-specific approach resulted in the development of the European Fish Index, which enables ecological status assessment on a European scale.

The FAME consortium tested several fish-based assessment methods and the European Fish Index was the most suitable method to also meet the requirements of the WFD.

In view of the variable status of river classification methods and schemes across Europe and experts’ comments from FAME partner countries a standardised programme had to be developed. It was expected to meet the following criteria:

- description of the different river habitats
- a scheme which describes relatively homogenous river-types for the assessment of type-specific reference conditions
- recognition of different fish regions at ecoregion-, subecoregion- and catchment-level
- addressing the specific issues of FAME and the WFD (Noble & Cowx 2002)

FAME additionally respected plenty of zoogeographic factors like marine zones, altitude, latitude, geology and climate (FAME consortium 2008).

The site-specific European Fish Index works with a predictive model that compares reference conditions of the fish fauna with the observed ones for any site. The deviation between prediction and observation results in a probability that indicates an ecological status specified from 1 (high ecological status) to 0 (bad ecological status).

Data from single-pass electric fishing catches are used to calculate the assessement metrics which are part of single ecological functional groups like reproductive or trophic guilds. A theoretical reference value representing high or good ecological status (no or only little human disturbance) is predicted for each metric using environmental variables by means of a multilinear regression model calibrated with data from FIDES. Ten environmental factors and three sampling variables, relevant to the sampling site and strategy, are

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[2] http://fame.boku.ac.at

used to predict a reference level. One additional environmental variable, the river region, explains regional differences. The residuals of the multilinear regression models are used to quantify the level of degradation. This residuals scatter about the theoretical value figure. Affected sites exhibit a greater deviation from the theoretical value and thus are less likely to belong to the reference residual distribution than un-affected sites. The metrics used are based on different units therefore they have to be standardised through subtraction and division by the mean and the standard deviation of the residuals of the reference sites. Some standardised figures tend to increase with disturbance others decrease. They are transformed into probabilities so in the end the metrics vary between 0 and 1 and all metrics will react to disturbance in the same way. The final index is obtained by summing up the ten metrics and rescaling them from 0 to1.

After a validation with independent data the EFI was able to discriminate between non-impacted and impacted sites in about 80% of the cases (FAME consortium 2004).

2.2.2 Improvement and spatial extension of the European Fish Index (EFI+)[3]

Since 2007 further development and implementation of fish-based assessment tools and a methodology that can be used as a standard method in EU Member States as well as in candidate countries, is being executed. Under the new title EFI+ it implies improvement of the European Fish Index to correct its defects by:

- testing the applicability of EFI and urging its extension regarding mediterranean and eastern European countries
- incorporating large rivers into the evaluations
- analysing the correlation between fish communities and hydromorphological parameters to improve the accuracy of the Fish Index
- adapting the software and
- implementing and distributing the new European Fish Index.

[3] http://efi-plus.boku.ac.at

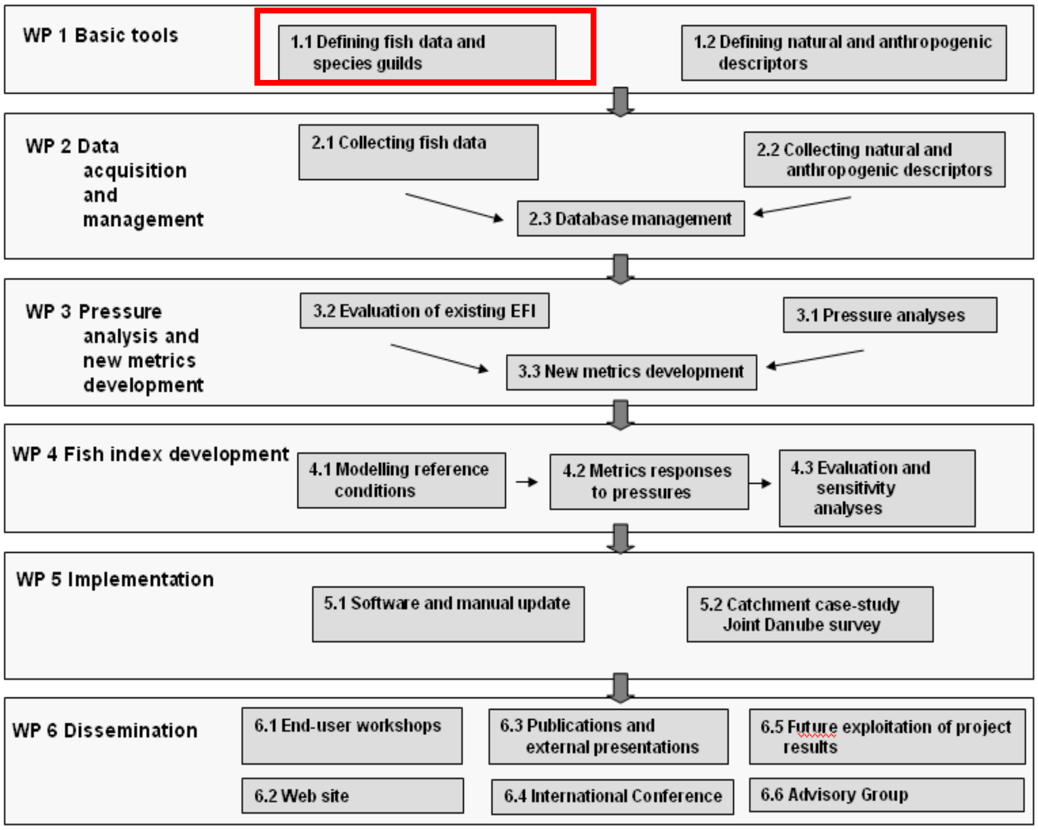

Figure 2.1 *The six workpackages of the EFI+ project with their different tasks — the red frame marks the part of the workpackage 1 that was the background of this thesis (adapted from http://efi-plus.boku.ac.at 2008)*

The EFI+ is being developed by following six levels of workpackages (figure 2.1) A basic tool is defining fish data and ecological traits of species to which this thesis contributes by creating a classification of taxa and guilds. Together with the definition of natural and anthropogenic descriptors and the collection of data it allows metric development. Metrics are later used for modelling the reference conditions. The software used is updated and a catchment case-study is conducted. Results will be discussed and information about the project and the application of the fish index will be spread. In the end evaluation of the ecological status can be conducted.

Therefore the general aim of the project is to create a suitable fish index. The background, the application and the development of this index can shortly be explained by three steps:

<u>I. Assigning species to guilds</u>

To make sure that fish species data that were collected on electric fishing surveys can easily be worked with classifications had to be found and the taxa and guilds table was created (ANNEX II) as a help table for the EFI+ database. According to the WFD the guilds had to be connected with data on lifestyle of fish like trophic composition, reproduction and age-length structure (Beier et al. 2007). Assignment of species into guilds is necessary for calculating metrics (Noble et al. 2007) which would be for example density of “insectivorous species” or “species intolerant to habitat degradation”.

<u>II. Calculating metrics</u>

When species are assigned to guilds the number of individuals belonging to the different guilds is expressed in individuals per hektar, in absolut numbers or in percentage – depending on the area which was sampled and the total number of individuals. This figure values then are called the “observed metrics” and are needed for calculation of the index. The influence of human pressures is also reflected by reaction metrics e.g. the number of rheophilic species is supposed to decrease when influenced by anthropogenic disturbances.

III. Fish index development

Those resulting observed metrics are compared to predicted metrics with regard to environmental descriptors like for example the two main factors river size and altitude. Predicted values are theoretical reference values, indicating no or only slight human disturbances. Deviation of the observed metrics from the predicted ones is calculated. The resulting residuals are standardised and transformed to probabilities. Probabilities of all metrics used are summed up and rescaled from 0 to 1 in order to create classes of ecological status from 0 to1 (1 means the best ecological status possible).

The index provides assessment on a guild instead of a species level and implies the possibility to combine different guilds for assessment of the ecological status of water bodies.

3 Methods

3.1 Taxonomy

The zoogeography of European freshwater fish species is determined by the post-glacial dispersal characteristics of the individual species, hydrological, physical and morphological conditions and by climatic and human-induced events. Freshwater fish fauna is more diverse in Central and Southern Europe than in the northern parts of Europe as glaciations during the Pleistocene era eliminated species there.

Freshwater fish mainly belong to the super class Gnathostomata with the super order Teleostei except for lamprey that belongs to the super class Agnatha. Most fish are either Cyprinidae or Salmonidae. They can also be classified in game (e.g. salmon, trout, charr, grayling) and coarse fish (e.g. roach, dace, chub, common bream, silver bream, barbell, rudd, tench, common carp, bleak, gudgeon, pike, perch, ruffe, pike-perch) (Noble & Cowx 2002).

3.1.1 Selection of species

In the beginning of the FAME project a list included all European freshwater fish species recorded in specific literature. Later only species that are known to occur in rivers and euryhaline species (typical for estuaries) were retained. As spreadsheets often returned with no data for single species, only fish species known to occur within rivers that are included in the FAME project were retained (Noble & Cowx 2002).

However, the new EFI+-version again attaches great importance to species representing mediterrenean and eastern rivers.The resulting list contains 339 fish species, including the most familiar ones, but also species that are considered taxonomically “new” or are endemic. All species listed belong to 38 different families. The family affilities are adapted from Kottelat & Freyhof (2007).

3.1.2 Denomination

The names of several species have changed in the course of the development of my thesis (table 3.1) and of the final species list – some more than once. Initially taxonomy followed Kottelat (1997) but for a number of species there were disagreements or recent changes (Noble & Cowx 2002).

The resulting nomenclature is a compromise between Kottelat’s publication and names that are most recent and widely accepted. New species which were often introduced by experts and considered useful for classification are also included.

The latest nomenclature of European freshwater fish which follows Kottelat & Freyhof (2007) but could not be adapted for this thesis due to opinion divergences can be found in ANNEX III.

Table 3.1 *Modification of nomenclature for EFI+*

new EFI+ name	old FAME name	
Achondrostoma arcasii	*Rutilus arcasii*	changed
Achondrostoma occidentale	—	new species
Achondrostoma oligolepis	*Rutilus macrolepidotus*	changed
Alburnus alburnus alborella	—	unique in Switzerland
Gasterosteus gymnurus	—	new species
Gobio lozanoi	—	new species
Herichthys facetum	*Cichlasoma facetum*	changed
Iberochondrostoma almacai	—	new species
Iberochondrostoma lemingii	*Chondrostoma lemingii*	changed
Iberochondrostoma lusitanium	*Chondrostoma lusitanium*	changed
Pseudochondrostoma duriense	*Chondrostoma duriense*	changed
Pseudochondrostoma polylepis	*Chondrostoma polylepis*	changed
Pseudochondrostoma wilkommii	*Chondrostoma wilkommii*	changed
Salmo trutta marmoratus	*Salmo marmoratus*	new species
Salvelinus umbla	*Salvelinus alpinus*	changed (partial)
Squalius ardanensis	*Leuciscus ardanensis*	changed
Squalius carolitertii	*Leuciscus carolitertii*	changed
Squalius pyrenaicus	*Leuciscus pyrenaicus*	changed
Squalius torgalensis	*Leuciscus targolensis*	changed

Polymorphism and speciation have become important regarding fish taxonomy and although these issues were not expected to influence the classification system strongly some species were assumed to exhibit different ecological traits depending upon their geographic location and local adaptation. Brown trout (*Salmo trutta fario*) and sea trout (*Salmo trutta trutta*) are no longer recognised as distinct species but they are both retained in the classification list because of the adult sea-run trout being a good indicator of longitudinal connectivity within river basins (Noble & Cowx 2002).

3.2 Literature search

The aim of the literature search was to collect as much information as possible about guilds. The search mainly focused on literature which is available online but also took advantage of a collection of papers at the IHG institute. Online search covers the time between 1997 and today as most publishers started making articles available online at around 1997. Older publications were only included when they were essential for guild classifications like for example literature by Balon, Schiemer, Spindler or Waidbacher or when experts insisted on references on guilds and taxonomy. With my literature search I focused on recent literature and therefore lots of the publications collected are summaries from older literature or based on a selection of works by different scientists. I intended to use only a few books and publications about fish species in particular and the ecology of single species to underline the focus on the guild approach.

Few older publications or publications that are restricted by publishers were either found in journals or were provided by the authors themselves. Other articles and papers that had been published before 1997 or are restricted in journals for both BOKU and University of Vienna library users were not accounted for or only mentioned by title if they contain relevant information.

The literature search was conducted between May and December 2007. By means of Web of Science[4] the journals of the following publishers were systematically searched with pre-defined keywords: Blackwell Pub-

[4]http://isiwebofknowledge.com

lishing, Elsevier Science, Kluwer, Springer and Wiley. Additionally scholar google[5] was searched. Pdf-files were downloaded. Numerous authors sent their publications directly to me. Citations were added to an online Endnote[6] library. I checked the reference lists of papers for additional relevant publications. Over time I found the collected references to be intensively cross-linked and redundant.

The initial evaluation of papers was based on information contained in the title, the abstract and keywords. I selected the literature according to its capability to classify species into guilds and its information on physiological and morphological parameters. Only publications dealing with freshwater fish were taken in account. Basically I paid attention to papers which study areas are limited to European countries but I also included literature from other continents with similar zoogeographic regions. No difference was made between studies working with quantitative or qualitative analysis. I analysed each paper as to relevant guild criteria like feeding behaviour of fish species or reproduction, information on assessment methods or temperature tolerances.

References concerning literature that was either restricted by publishers or written in any other language than German, English, French and Spanish were collected for an additional literature list (see ANNEX I). Older references and references suggested by experts but too numerous to be analyzed can also be found in the additional literature list.

I summarized 68 papers that were relevant for guild classification. The guild explained, the type of paper, a geographic location, the type of the water body, the spatial and the temporal scale, the study design, the biotic variables mentioned, the taxa studied, the statistical methods used and possible redundances with other guilds were mentioned.

3.3 Classification table

To provide a unified classification and to prepare a comprehensive table displaying the final classification all species present in the process had to be listed. The number of species constantly changed during literature search and expert judgement since new species were described or single species had different names. In contrary there were also different species which were unified to one single species by experts.

In the beginning the project team wanted to retain hybrid species and different morphs in the list. In the end they were left out from classifications. As a consequence I had to change the species list and the classification table several times until in the end 339 species were retained.

3.4 Expert Judgement

Prepared tables of all species and suggestions for their classifications into guilds were sent to all cooperating experts (table 3.2). They were asked to classify all species they knew or found literature about and return the data sheets. All the data was collected and used to create new tables which were then compared to the data resulting from the literature search. A resulting list was again sent to all experts for reevaluation. In some cases and if necessary the process of elaborating and adapting classifications was repeated. The

[5] http://scholar.google.at
[6] http://www.endnote.com

final decisions about the classifications were either made by calculating the mean value or, in case of doubt, taken from the literature.

The whole process was conducted following the Delphi method which is a systematic, interactive forecasting method. It relies on a group of independent experts who are asked to answer questionnaires in two or more rounds. After each round, a coordinator provides an anonymous summary of the experts' forecasts from the previous round as well as the reasons they provided for their judgments. Responses are collected and analyzed. Common and conflicting viewpoints are identified. Participants get encouraged to revise their earlier answers in light of the replies of other members of the group. The method aims at allowing experts to freely express their opinions, encouraging open critique and admitting errors done in earlier judgements.

During this process the range of the answers is supposed to decrease and the group will converge towards the most plausible result. Finally the process is stopped after a pre-defined stop criterion (achievement of consensus in the classification process) and the mean scores of the final rounds determine the results (wikipedia 2008).Twelve European experts and their collegues contributed to the project and in the classification process.

Table 3.2 *List of responsible experts who had cooperated in the development of EFI+ by classifying fish species (in alphabetical order)*

Name	Institution	Country
Battes Klaus	The Bacău University, Faculty of Sciences,	Romania
Belliard Jerome	Cemagref, Anthony	France
Buijse Tom	DELTARES,Department of Freshwater Ecology & Water Quality, Utrecht	The Netherlands
Ferreira Teresa	Instituto Superior de Agronomia, Lisbon	Portugal
Garcia de Jalon Diego	Universidad Politécnica de Madrid	Spain
Holzer Susanne	University of natural resources and applied life sciences, Vienna	Austria
Maio Guiseppe	AQUAPROGRAM s.r.l., Vicenza	Italy
Melcher Andreas	University of natural resources and applied life sciences, Vienna	Austria
Noble Richard	Hull International Fisheries Institute (HIFI), University of Hull	United Kingdom
Pont Didier	Cemagref, Aix en Provence	France
Schager Eva	EAWAG, Swiss Federal Institute of Aquatic Science and Technology, Kastanienbaum	Switzerland
Schotzko Nikolaus	Federal Agency for Water Management, Institute for Water Ecology, Fisheries and Lake Research, Scharfling/Mondsee	Austria
Segurado Pedro	Instituto Superior de Agronomia, Lisbon	Portugal
Sutela Tapio	Finnish Game and Fisheries Research Institute, Uleåborg	Finland
Vehanen Teppo	Finnish Game and Fisheries Research Institute, Uleåborg	Finland
Wiesner Christian	University of natural resources and applied life sciences, Vienna	Austria
Wisniewolski Wieslaw	Inland Fisheries Institute, Olsztyn	Poland
Wolter Christian	Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin	Germany

3.5 Statistical methods

During first analyses classified species were added together according to their families. Guild modalities were displayed in graphs as to the percentage of species of the different families. For every figure I separately chose families which I expected to follow clear trends with regard to the guild modalities concerned in the graph.

To analyze tolerance ranges and their explanation capability for species and families descriptive statistics were applied. A hierachical cluster analyses of the five revision groups water quality in general, oxygen concentration, temperature, habitat tolerance and habitat and the corresponding 14 binary variables (intolerant, intermediately tolerant, tolerant) was conducted based on the tables in ANNEX II (using average linakge distance and the Jaccquard method). Then another hierarchical cluster analyses for one variable explaining tolerance and all species was conducted. By displaying the results with the Ward Euclidean distance physiological and morphological parameters were also taken in account.

4 Definition of guilds

Within the FAME project and the work on EFI and EFI+ suitable guilds had to be tested and finally applied for a pan-European IBI method. Modalities for traits and guilds had to be generalized to make classification easy and assessment possible but the modalities had to be strict enough so that the results would be appropriate and useful for ecological monitoring. Given that classification and understanding is necessary for the development of any IBI, the development of a standardised ecological assessment tool to aid implementation of the WFD requires that European fish species are classified in a harmonised way (Noble et al. 2007). Therefore there are guild modalities for each of the five main ecological functions, identified in the previous IBIs (trophic, reproduction, habitat, longevity and tolerance), as well as migratory guilds and the corresponding salinity which are both considered important, too.

To include ontogenetic discussions and data for juvenile development of fish species which would be far too complex, modalities of guilds and traits only refer to adults. The classification also includes parameters like maximum fish length, shape factor or number of oocytes (just to mention a few) which should be used to create applicable mean values or calculate biomasses. Tolerance guilds are divided in more specified groups to underline the diversity of possible disturbances.

4.1 Tolerance capacity

Within an IBI it is necessary to use tolerance parameters to identify the presence or absence of intolerant species. This provides information on the state of a riverine ecosystem. Whittier et al. 2007 worked on human disturbances and the corresponding tolerance ranges.They used site-scale chemical and physical habitat data and catchment-scale disturbance measures to evaluate fish and amphibian tolerances. By calculating species tolerance values and using relative abundances of species they defined an assemblage tolerance index score for each site.

On the one hand, the capacity of a species to tolerate pollution or hydromorphological degradation depends on its genetic and physiological characters. On the other hand it varies to the extent a species is specified, e.g. with regard to factors like habitat or reproduction. Of course the degree and type of degradation is another important influence. Responses to water quality degradation, habitat degradation and temperature were identified as key parameters. Parameters such as tolerance to acidification were considered important by some partners at a national level. Tolerance to low oxygen concentrations is closely linked to temperature. Tolerance to toxic contamination is an additional category.

4.1.1 Water quality tolerance

Classification concerning tolerance to water quality in general, acidification, toxic contamination and oxygen concentration is limited to a three-group scheme – tolerant, intermediate and intolerant (table 4.1). Only the tolerance to low oxygen concentration is numerically expressed in oxygen concentration in milligrams per litre. Estimations and observations are the basis for the classifications of the other tolerance variables in the water quality group since it is not easy to express parameters like habitat degradation in numbers.

4.1.2 Temperature tolerance

For Lappalainen (2001) temperature is the most important abiotic factor for fish as poikilothermal animals. Water ecosystems appear to have three temperature levels that can be important for fish: a limit of lethargy due to cold temperatures, the optimum temperature for growth and the lethal temperature level. Generally an increase of water temperature alters the life cycle of fish (e.g. age at maturity, food supply). To determine the lethal temperature level it is necessary to know the history of the adaptions to unfavourable temperature (Klee 1991). Body temperature of fish follows closely that of water and changes in temperature affect, either directly or indirectly their physiology and behaviour. Another aspect is that, due to thermoreceptors, they can detect temperatures where the amount of energy available for movement, growth and development of gonads is at an optimum (Lappalainen 2001). To a certain extend fish can even regulate water temperature themselves what was tested in shuttleboxes by Wootton (1998). The studied individuals regulated the water temperature by moving between chambers what initiated either cooling or warming of the water.

Parameters of temperature tolerance are reduced to two classifications – eurythermal and stenothermal (table 4.1). Fish are either classified in species withstanding a wide range of temperature or in species which tolerate only a narrow range of temperature. This definition does not differentiate between cold and warm water adapted species.

4.1.3 Tolerance to habitat degradation

Species can be classified as tolerant, intermediately tolerant or intolerant to the degradation of their habitat (table 4.1). The guild implies the connection of guilds to hydromorphological parameters and investigates the tolerance capacities of species towards hydromorphological pressures of any kind.

Table 4.1 *Description of modalities concerning water quality used in EFI+ to classify European fish species into guilds*

Guild	Modality	Abbreviation	Definition EFI+
Water quality tolerance general	tolerant	TOL	Species are in general tolerant to the usual national water quality parameters.
	intermediate	IM	Species are intermediately tolerant to the usual national water quality parameters.
	intolerant	INTOL	Species are in general intolerant to the usual national water quality parameters.
Water quality tolerance O2	tolerant	O2TOL	Tolerance against low oxygen concentration is observed. Concentrations of 3 mgL^{-1} or less can be coped with.
	intermediate	O2IM	Relatively tolerant to low oxygen concentration (O2)
	intolerant	O2INTOL	Species are intolerant to low oxygen concentration. Their physical constitution requires a concentration of more than 6 mgL^{-1}.
Water quality tolerance toxicity	tolerant	TOXTOL	General tolerance against toxic contamination
	intermediate	TOXIM	Species are intermediately tolerant to toxic contamination.
	intolerant	TOXINTOL	Species are generally intolerant to toxic contamination.
Acid tolerance	tolerant	ATOL	Tolerance of acidification
	intermediate	AIM	Species are intermediately tolerant against acidification.
	intolerant	AINTOL	Clear intolerance to acidification has been observed.
Temperature tolerance	eurythermal	EUTHER	Fish tolerate a wide range of temperature.
	stenothermal	STTHER	Species that can only tolerate a narrow temperature range.
Habitat degradation tolerance	tolerant	HTOL	Fish species that do not react too sensitive to degradation of their habitat.
	intermediate	HIM	Species show an intermediate tolerance of habitat degradation.
	intolerant	HINTOL	Fish that cannot compensate any degradation of their habitat.

4.2 Habitat

Optimal habitat requirements of fish species result in typical community structures alongside the horizontal gradient of a river and the classification into different river zones. Number, vitality and spatial distribution of species depend to a great extent on the quantity and quality of their habitat. For the assessment of hydro-morphological conditions within IBIs habitat guilds which are best-represented by flow preferences are necessary.

4.2.1 Degrees of rheophily

The habitat guild is classified by the distinction of three groups of rheophily (table 4.2) as proposed by Schiemer and Spindler (1989) (chapter 3.1). Adult fish prefer fast flowing conditions, stagnant waters or can cope with a combination of both. The species living in lakes are not considered in the guild classifications. Floodplain species will be classified as limnophilic. If exhibiting tolerance of relatively high flows they are eurytopic (Noble & Cowx 2002).

The effects of impoundment and channelisation of rivers alter the magnitude and variability of flow and can be measured by the abundance of limnophilic and rheophlic species. Reductions in water velocity caused by channelisation and impoundment favour limnophilic and eurytopic species over those with rheophilic preferences. On the other hand the separation of the floodplain from the river reduces habitats of limnophlic and eurytopic species. The latter need secondary channels and floodplain water bodies for their reproduction (Noble et al. 2007).

Table 4.2 *Description of modalities concerning habitat used in EFI+ to classify European fish species into guilds*

Guild	Modality	Abbreviation	Definition EFI+
Habitat	rheophilic	RH	Degree of rheophily: Fish prefer to live in a habitat with high flow conditions and clear water.
	eurytopic	EURY	Degree of rheophily: Fish that exhibit a wide tolerance of flow conditions, although are generally not considered to be rheophilic.
	limnophilic	LIMNO	Degree of rheophily: Fish prefer to live, feed and reproduce in a habitat with slow flowing to stagnant conditions.

4.3 Feeding

4.3.1 Feeding habitat

Species can feed in the water column or from the bottom (table 4.3). How and where fish obtain their food from (water column or benthos) helps to discriminate between trophic guilds (Poff & Allan 1994). Classification systems that consist of elements of dietary preference together with complementary feeding habitat information potentially overlap with other guild classifications in particular those of habitat (Noble et al. 2007). For the classification process the guild of benthivorous species was replaced by the benthic feeding guild.

Table 4.3 *Description of modalities concerning* *<u>feeding habitat</u>* *used in EFI+ to classify European fish species into guilds*

Guild	Modality	Abbreviation	Definition EFI+
Feeding Habitat	water column	WC	Species that live and feed in the water column. They usually do not go to the bottom to search for food.
	benthic	B	Fish prefer to live near the bottom from where they obtain food. They usually do not go to the surface for feeding purposes.

4.3.2 Adult trophic guilds

Trophic guilds have been consistently used in IBIs (Noble *et al.* 2007) although stream fish are known to be flexible in their diet, they feed based on the availability of food and undergo ontogenetic shifts in their feeding role (Poff & Allan 1994). They use a wide range of food sources, species can be detritivorous as well as predators. Additionally omnivores are able to feed on a large variety of food and are as a consequence supposed to be more tolerant to perturbation of the aquatic environment as opposed to species with specialist feeding requirements. The assessment criterion for trophic guilds is in fact defined by the dominant food item in the diet (table 4.4). For species that do not fall in discrete categories and are neither considered true omnivores a classification into joint groups is valid (e.g. piscivorous/insectivorous). Although this capability of shifting from one feeding behaviour to another may mask the response of metrics to degradation, it is necessary to separate the species within specific feeding guilds from those which are more plastic in their trophic ecology (Noble et al. 2007).

Table 4.4 *Description of modalities concerning* *<u>trophic behaviour</u>* *used in EFI+ to classify European fish species into guilds*

Guild	Modality	Abbreviation	Definition EFI+
adult trophic guild	detritivorous	DETR	Adult diet consists of high proportion of detritus, the digestive tract is unspecialised. Combinations with other modalities are possible, if explained.
	herbivorous	HERB	Terminal or subterminal mouth with bony slashing jaw for clipping and tearing aquatic vegetation; diet of adult fish consists of more than 75% plant material. Often the digestive tract is as long or longer than the total length of the individual. Combinations with other modalities are possible, if explained
	insectivorous	INSV	Adult diet consists of more than 75% insects. Individuals have a terminal or supraterminal mouth, take aerial, drifting or swimming insects and invertebrates. The largest and most diverse trophic guild. Combinations with other modalities are possible, if justified.
	omnivorous	OMNI	Adult consists of more than 25% plant material and more than 25% animal material. Species are typical generalists. Combinations with other modalities are possible, if justified.
	parasitic	PARA	Fish that exhibit a parasitic feeding mode. Combinations with other modalities are possible, if justified.
	piscivorous	PISC	Other fish represent more than 75% of adult's diet. Individuals have a wide mouth aperture with needle-like teeth and a strong jaw with marginal and palatal bones. They pursue prey by stalking, chasing, ambushing or lying-in-wait approach. Combinations with other modalities are possible, if justified.
	planktivorous	PLAN	Adult diet consists of more than 75% zooplankton and/or phytoplankton. Fish have fine gill-rakers and elongated pharyngal teeth, they do not have a stomach but an elongated, undifferentiated intestine. Combinations with other modalities are possible, if justified.

4.3.3 Migration guild and salinity

During their life time some fish species migrate – from fresh to marine waters or only a few kilometres within a river segment – others don’t. The detection of some form of change in migratory behaviour can be proof of environmental degradation through obstruction to migratory movement.

Longitudinal migration takes place up and down the main river channel, generally between breeding, feeding and refuge locations. Potamodromous species migrate between river zones (e.g. from large lakes up rivers) while diadromous species migrate at maturity either down rivers to spawn in the sea (catadromy) or up rivers to spawn (anadromy). McDowall’s suggestion of amphidromy (1997) which refers to fish that spend parts of their lifes in both fresh and sea waters and do not migrate for reproductive purposes was not included in the EFI+ since as an ecological trait it is not common within or throughout Europe. However, three major migratory guilds and one guild concerning residency have been included (table 4.5). These classifications provide information about habitat and reproduction but are, above all, closely linked with salinity. Four guilds of salinity show in which habitats species at a certain ontogenetic stage can be found (freshwater, brackish, marine).

Considerations concerning drift and lateral migration are not expressed trough guilds. Downstream drift consisting of eggs and larvae of migrating species is an important component of their life cycles (Welcomme et al. 2006) but can hardly be documented and neither measured nor located. Lateral migration or movement taking place from the main river channel to and from the floodplain and its waterbodies manifests differently to longitudinal migration. Lateral migration requirements are difficult to asses, given a lack of understanding and the no longer intact nature of many European floodplains. In the EFI+ presence of limnophilic or eurytopic species is considered to be adequate for assessing lateral connectivity, too.

Table 4.5 *Description of modalities concerning migration used in EFI+ to classify European fish species into guilds*

Guild	Modality	Abbreviation	Definition EFI+
Migration guild	resident	RESID	Species that only move within a particular river segment.
	potamodromous	POTAD	Species migrate between river zones or more than 5-10 km (more than a river segment)
	long catadromous	LONG-LMC	Refers to fish that have lived their early life in fresh water – feeding and growing - and at maturity migrate down rivers to spawn in the sea.
	long anadromous	LONG-LMA	Refers to fish that live as older juveniles and sub-adults in the sea but at maturity migrate up rivers to spawn.
Salinity	freshwater	FRE	Fish that exclusively live in freshwater habitats
	estuary - brackish	FRESAL	Fish that spend life periods both in freshwater and brackish habitats.
	marine	MAR	Fish that spend life periods mainly in marine habitats
	anadromous /catadromous	ANCA	Fish that spend life periods in freshwater, brackish and marine habitats (i.e. long migratory species)

4.4 Reproduction

4.4.1 Reproductive guilds

Fish exhibit diverse forms of reproduction using different spawning grounds and substrata. IBIs apply reproductive guilds to make changes in the availability of habitats visible. Again, species within a community that require specific spawning niches or substrata (e.g. lithophils or phytophils) are expected to be placed at a disadvantage compared to species with more flexible spawning requirements (e.g. phytolithophils or polyphils). For FAME and the EFI as well as the EFI+ and for the purpose of developing a typology for European riverine fishes, a simplified system of reproductive guilds was developed based on the classification proposed by Balon (1975) and his concept modified by Chadwick (1976), Balon *et al*. (1977), Balon (1981a, b), Mahon (1984), Berkman & Rabeni (1987), Bruton & Merron (1990), Oberdorff & Hughes (1992), Boet et al (1999) and Cowx (2001). The resulting proposition which had been primarily based on preferred spawning habitats to fit the requirements of the IBI was minimally modified for the EFI+ (table 4.6) by members of the project team.

4.4.2 Habitat spawning preference

The preference for a spawning habitat with either fast flowing or stagnant conditions is closely linked to the habitat guilds as well as to the reproductive guilds. If species exhibit no clear preference for a spawning habitat they are classified as eurypar (table 4.6).

4.4.3 Reproductive behaviour

Spawning events can be either repeated during the spawning season or different parts of the population spawn at different times. They can occur at only one time during the potential season or last over a long period (table 4.6).

4.4.4 Parental care

Reproductive guilds are closely linked to parental care. How and where fish spawn constitutes the basis for the protection of the eggs. Balon (1975) suggests three forms of parental care types: nonguarders, guarders and bearers. “Nonguarders” can be open substratum spawners or brood hiders. The so called “guarders” would choose their substratum explicitly or build nests. “Bearers” breed externally or internally.

Parental care in EFI+ is already given if a fish hides its eggs. This would be, according to Balon, include every group except the open substratum spawners. The EFI+ definition does not make a distinction between parental care in the form of hiding eggs or by building nests – nevertheless in combination with the reproductive guild this information creates a clear picture of the species’ reproduction habits (table 4.6).

Table 4.6 *Description of modalities concerning reproduction used in EFI+ to classify European fish species into guilds*

Guild	Modality	Abbreviation	Definition EFI+
Reproductive guild	lithopelagophilic	LIPE	Rock and gravel spawners with pelagic free embryos
	lithophilic	LITH	Fish spawn exclusively on gravel, rocks, stones, rubbles or pebbles. Hatchlings are photophobic.
	ostracophilic	OSTRA	Spawning takes place in shells of bivalve molluscs.
	pelagophilic	PELA	Fish spawn into the pelagic zone.
	phytophilic	PHYT	Fish deposit eggs in clear water habitats on submerged plants.
	phyto-lithophilic	PHLI	Fish deposit eggs in clear water habitats on submerged plants or on other submerged items. Larvae are photophobic.
	polyphilic	POLY	Non-specialised spawners
	psamnophilic	PSAM	Fish spawn on roots or grass above sandy bottom or on the sand itself.
	speleophilic	SPEL	Fish spawn in interstitial spaces, crevices or caves.
	viviparous	VIVI	Live bearers
	ariadnophilic	ARIAD	Specialised nest building fish that may exhibit some form of parental care.
Habitat spawning preferences	rheopar	RHPAR	Preference to spawn in running waters.
	euryopar	EUPAR	No clear spawning habitat preferences
	limnopar	LIPAR	Preference to spawn in stagnant waters.
Reproductive behaviour	single	SIN	Spawning events occur at only one time in the season
	fractional	FR	Repeated spawning events within a season or different groups of the population spawn at different times.
	protracted	PRO	Spawning takes place over a long period during the potential season.
Parental care	no protection	NOP	No protection or parental care of eggs or larvae. Nest or eggs are not hidden in any manner.
	protection	PROT	Protection of eggs and/or larvae, including hiding of nest or eggs.

4.5 Physiological and morphological parameters

These definitions were designed to simply address the requirements of a number of IBI metrics commonly used to reflect longevity, shape and length of different species. Physiological and morphological parameters are often taken from fishbase.org[7].

4.5.1 Length variables

Length is a numeric figure, maximum lengths defined by experts or found in literature were specified in the classification spreadsheet. Length relation a and length relation b are mathematical expressions that consider the weight of a fish in terms of its length i.e. length-weight relation (table 4.7). The length relations a and b which can be found in literature and often in fishbase.org help to calculate weight or length if only one of those two physiological parameters is known.

If the bodyshape is defined biomass can be calculated using the specific length relations for each type of bodyshape (see chapter 4.5.9).

Table 4.7 *Formula for calculating length or weight by using relation coefficients a and b*

	Formula	Units
length-weight regression	$w = a*L^b$	w[g] = weight; L[cm] = length; a, b…length relation coefficients

4.5.2 Shape factor and swimming factor

Fish body morphology varies among different lotic habitats. According to Scarnecchia (1988) and Poff & Allan (1995) two morphological ratios that are expected to vary with hydrological environments were examined. The shape factor is defined by the minor ratio of the largest to the smallest part of the body. In most cases this means total body length divided by maximum body depth. The “fineness ratio”, as it is called by Scarnecchia (1988) describes the hydrodynamic profile of fish and informs about the energy needed for the maintenance of a certain position.

The ratio of minimum depth of the caudal peduncle to the maximum caudal fin depth defines the swimming factor (table 4.9). Fish that are capable of strong, sustained swimming, like thunniform fishes, are supposed to have a small swimming factor (Poff & Allan 1995).

4.5.3 Longevity

The parameter is numeric, when classified it is necessary to refer to the reported maximum age (table 4.9). Longevity can also be a reflection of the natural geographic location of the population within its natural range and the stability and adaptativeness of the habitat.

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[7] www.fishbase.org

4.5.4 Fecundity and relative fecundity

The maximum number of oocytes defines the parameter of fecundity. The maximum number of oocytes per 100 gramm informs about the relative fecundity. Exceptional cases should not be included (table 4.9).

4.5.5 Egg diameter

Information on the egg diameter is provided (table 4.9). Some species produce large numbers of small eggs and other produce few eggs of large diameter (Noble & Cowx 2002). Egg size can play an important role in juvenile survival and fitness. Hutchings (1991), for example, determined experimentally relationships between egg size and juvenile survival in the brook trout, *Salvelinus fontinalis*, at two levels. Food abundance was then incorporated into a model that related maternal fitness to egg size and food supply. The effects of egg size and food abundance on juvenile survival were not additive. Decreased food abundance significantly increased mortality among the smallest eggs but had a negligible effect on the largest eggs. As a result Hutchings provided empirical support for the hypothesis that selection favours an increase in offspring size with reductions in resource abundance. On the contrary in studies egg sizes of the Atlantic sturgeon did not provide any advantage for survival of young fish (Gisbert et al. 1999)

4.5.6 Age at maturity

The age of maturation is defined (table 4.9). It can be a reflection of the geographical location of the population and the stability and nature of the habitat but it has to be kept in mind that for survival some species are able to adapt their ontogenetic development to different conditions (Noble et al. 2007). Within many taxa the age of maturity is not simply positively correlated with the adult lifespan; the two variables are proportional to each other whereas the proportionality constant becomes something to be predicted by life history theory (Charnov & Berigan 1990).

4.5.7 Incubation

The parameter of incubation time is defined as a phase which designates the time from commencement of incubation to hatching (table 4.9). During incubation stable temperature and humidity conditions should prevail (Encyclopedia Britannica 2008). For the egg stage of a fish's life history the effect of temperature on the rate of metabolism has an important consequence. The time between fertilization and hatching decreases sharply with an increase in temperature. Therefore at low temperatures a fish spends longer in what is often the most vulnerable stage of its life history (Wootton 1998).

4.5.8 Catch occurrence

The catch occurrence simply informs about the fact that a certain species has already been present in an EFI database (table 4.9).

4.5.9 Body shape

Taking a first superficial look on a fish's morphology the body can be spindle-shaped, high-backed, very slender or eel-shaped. Together with the length relation variables a and b it is possible to calculate the biomass of species with characteristic body shapes (table 4.8).

To define bodyshape codes for the species listed bodyshape explanations were searched for in Kottelat & Freyhof (2007).

Table 4.8 *Codes of body shapes, their values of length relations and characteristical species*

Shape	Length relation a	Length relation b	Species	Codes
1	0,0190551	2,956236	*Salmo trutta*	1=spindle-shaped
2	0,0052	3,2382	*Abramis brama*	2=high-backed
3	0,00250	3,334413	*Zingel Zingel*	3=very slender (bottom living)
4	0,001161	3,1166	*Anguilla anguilla*	4=eel-shaped

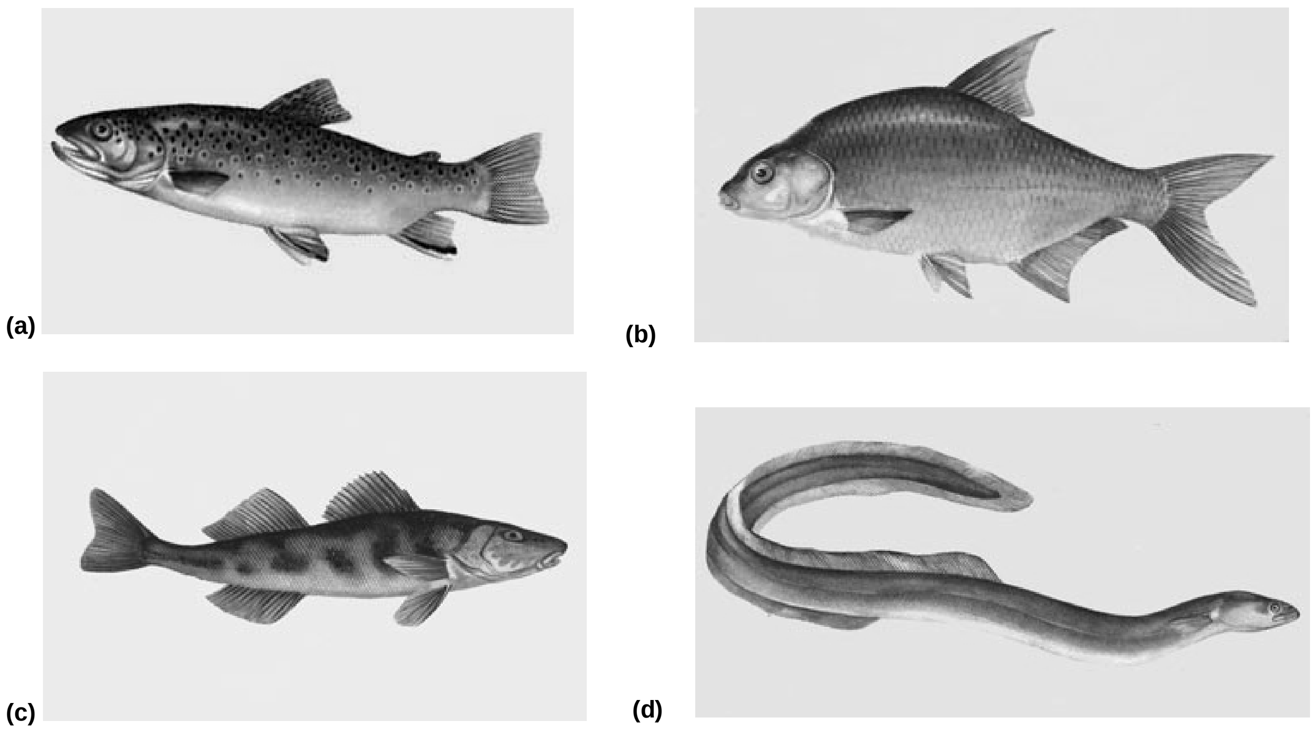


Figure 4.1 *The four types of body shapes and corresponding typical fish species* ***(a)*** *Salmo trutta* ***(b)*** *Abramis brama* ***(c)*** *Zingel zingel* ***(d)*** *Anguilla anguilla (adapted from www.angelprofi.at)*

In table 4.9 all physiological and morphological are explained in detail and defined. If numbers are used units of measurement are defined.

Table 4.9 *Description of physiological and morphological parameters used to classify fish species*

Parameter	Modality	Abbreviation	Definition EFI+
Length	numeric	LENG	Figures for maximum fish lengths [mm] without exceptional cases.
Length relation a	numeric	LWa	Length weigth relationship; From fishbase.org or other sources. Mathematical formula for the weight of a fish in terms of its length. When only one figure is known, the formula can be used to determine the other. Typically given as w=a*L^b; w[g]= weight, L[cm]=length.
Length relation b	numeric	LWb	Length weigth relationship; From fishbase.org or other sources. Mathematical formula for the weight of a fish in terms of its length. When only one is known, the formula can be used to determine the other. Typically given as w=a*L^b; w[g]=weight, L[cm]=length.
Shape factor	numeric	SHAF	Minor ratio of the largest to the smallest part of the body (in general total body length divided by maximum body depth).
Swimming factor	numeric	SWF	Defined as the ratio of minimum depth of the caudal peduncle to the maximum caudal fin depth. Fish having a small ratio are capable of strong swimming (thun-niform fishes). Adapted from Poff & Allan (1995) initiated by Scarnecchia (1988).
Longevity	numeric	LONG	Maximum longevity of a species in years but without any exceptional cases.
Fecundity	numeric	FEC	Maximum number of oocytes, exceptional cases should not be included.
Relative fecundity	numeric	RFEC	Maximum number of oocytes per 100 grams, no exceptional cases
Egg diameter	numeric	EGG	Average egg diameter [mm]
Age at maturity	numeric	MATU	Average age at maturity of female fish in years
Incubation	numeric	INCU	Average incubation time of eggs in days at common temperatures
Catch occurence	binary	0, 1	indicates wheter a species was present in the EFI database or not
Body shape	description	1, 2, 3 or 4	1=spindle shaped, 2=high backed, 3=very slender (bottom living), 4=eel-shaped

5 Results of the literature search and their discussion

In this chapter I list the results of the literature search according to the guilds defined in chapter 4. The sources of relevant literature are compared and the citations are grouped according to the guild modalities. Additionally summaries of 68 publications can be found.

5.1 Frequency of responses

More than 300 papers, reports, reviews, theses, dissertations and books were revised during the literature research. About 200 contained relevant information to identify and classify guilds or provide information on physiological and morphological parameters. However, in most of the publications guilds were only mentioned as additional information and were not the objectives of the research.

20 papers were found concerning habitat degradation tolerance, 29 concerning habitat, 11 concerning feeding habitat and 34 concerning trophic guilds (table 5.1). Those are modalities that are prominent for research. Whereas water quality in general, salinity and parental care are issues that are not yet well described since only 3 publications could be found concerning all three parameters. It could be that water quality in general is somewhat redundant to the other water quality parameters (like oxygen concentration or toxicity) and that the modalities of salinity are too similar to the migration guild modalities. Authors may refer to those closely linked topics more often.

Literature originated mainly from typical fish research and aquatic ecology or hydrobiological journals. It is clear that for almost every issue there can be found a book but since the search focused on recent publications their number is less important for analyses. However, in terms of completeness the few books used are included in the following tables.

Table 5.1 *Frequency and sources of papers concerning <u>guilds</u> (feed. hab =feeding habitat)*

Guild	Modality	Number of papers	Ecology	Hydrobiologia	Journal of Fish Biology	Ecology of Freshwater Fish	Aquatic Ecology	Can. Journal Fisher. Aqu. Scie.	River Research & Applications	Bull. franc. de lapê che et de la pisciculture	Environmental Biology of Fishes	Thesis- Dissertation	Reports	Books
tolerance	water quality tolerance in general	1												1
	water quality tolerance – oxygen concentration	8	1					1	1					
	water quality tolerance – toxicity	6		1										1
	acid tolerance	2												
	temperature tolerance	7					1					1	1	1
	habitat degradation tolerance	20		1		2			3		2	1		1

Table 5.2(continued) *Frequency and sources of papers concerning* <u>*guilds*</u>

Guild	Modality	Number of papers	Ecology	Hydrobiologia	Journal of Fish Biology	Ecology of Freshwater Fish	Aquatic Ecol-ogy	Can. Journal Fisher. Aqu. Scie.	River Research & Applications	Bull. franc. de lapê che et de la pisciculture	Environmental Biology of Fishes	Thesis- Disser-tation	Reports	Books
habitat	rheophilic	10		1										
	euryotopic	9		1										
	limnophilic	10									1			
feeding habitat	water column	1												
	benthic	10		1		2	1						2	
adult trophic guild	detritivorous	7		1								1		
	herbivorous	3					1						1	
	insectivorous	3					1							
	omnivorous	5					1						1	1
	parasitic	1												
	piscivorous	5				1	1						1	
	planktivorous	10					2			1			2	
migration guild	resident	2		1					1					
	potamodromous	2		1									1	
	long catadromous	1												1
	long anadromous	4							1	1				
salinity	freshwater	0												
	estuary - brackish	0												
	marine	0												
	catadro-mous/anadromous	1		1										
reproductive guild	lithopelagophilic	3												1
	lithophilic	4												1
	ostracophilic	4				1								1
	pelagophilic	5											1	1
	phytophilic	5												1
	phyto-lithophilic	5												1
	polyphilic	4												1
	psamnophilic	5											1	1
	speleophilic	8			1			1				1	1	1
	viviparous	2												1
	ariadnophilic	3												1
spawning habitat	rheopar	3												1
	eurypar	2												1
	limnopar	4			1									1
reproductive behaviour	single	1												1
	fractional	8			1			1				1	1	1
	protracted	1												1
parental care	no protection	1												
	protection	2												

Publications where information on physiological and morphological parameters is provided are rare (table 5.3). Four papers were found concerning relative fecundity of single species, 2 papers and 2 books revealed numbers of longevity. For each one of the parameters of length, length relation a and b, the shape factor, the swimming factor, the egg diameter and age at maturity there was only found one publication. The literature search focused on guilds and therefore physiological and morphological parameters were mainly simply taken from fishbase.org.

Still, there were few publications which revealed their results in detail in connection with physiological and morphological parameters and if they did there were only examined some species or some parameters at one time.

Table 5.3 *Frequency and sources of literature concerning* *<u>physiological and morphological parameters</u>*

Parameter	Number of sources	Ecology	Hydrobiologia	Journal of Fish Biology	Ecology of Freshwater Fish	Aquatic Ecol-ogy	Can. Journal Fisher. Aqu. Scie.	River Research & Applications	Bull. franc. de lapê che et de la pisciculture	Environmental Biology of Fishes	Thesis- Disser-tation	Reports	Books
length	1												
length relation a	1												
length relation b	1												
shape factor	1												
swimming factor	1												
longevity	4												2
fecundity	2												1
relative fecundity	6									1	1		2
egg diameter	3												2
age at maturity	2												1
incubation	1												1

The experts who cooperated in the classification process relied on books and personal information. Additionally they suggested 160 papers from different journals. 10 of them were thesis and dissertations and 6 were congress reports (table 5.4). Literature that was recommanded by experts but not available or written in any other language than English, German, Spanish or French can be found in an additional literature list (see ANNEX I).

Table 5.4 *Frequency and sources of papers used by* *<u>experts</u>* *for classification*

Additional literature	Number of papers	Ecology	Hydrobiologia	Journal of Fish Biology	Ecology of Freshwater Fish	Aquatic Ecol-ogy	Can. Journal Fisher. Aqu. Scie.	River Research & Applications	Bull. franc. de lapê che et de la pisciculture	Environmental Biology of Fishes	Thesis- Disser-tations	Reports	Books	others
all guilds and parameters	160		6	17	2		3		1	6	10	6	22	87

5.2 Selected literature

As a result of the literature search all guild classifications could be specified except for salinity. Publications that contain information about guilds or physiological and morphological parameters often refer to more than one modality (e.g. habitat, trophic guild and migration guild) consequently they are cited and mentioned several times. For information on a few issues it was necessary to refer to older literature as there could not be found anything new about it.

Numerous publications exist concerning tolerance to habitat degradation whereas most of the papers found suggest an intermediate tolerance for the fish species they threated, and only three authors and groups of authors worked with species they believe are tolerant to habitat degradation. As far as I can tell tolerance of water quality in general and tolerance to acidification are underrepresented in research as I could only find one paper concerning water quality and two papers concering acidification (table 5.5). I did not read anything about an intermediate tolerance or intolerance to acidification. Probably the issue of water quality is too general and the issue of acidification too specific to find something in literature during a limited time scale like the one provided for this thesis.

Table 5.5 *Selected literature grouped according to its contribution to classify species into <u>tolerance guilds</u>*

trait	modality	citation
tolerance to water quality in general	tolerant	(Philippart & Vranken 1983)
	intermediately tolerant	(Philippart & Vranken 1983)
	intolerant	(Philippart & Vranken 1983)
tolerance to low oxygen concentration	tolerant	(Blanck *et al.* 2007) (Žarski *et al* 1995) (Welcomme *et al*. 2006) (Fisher & Willis 2000) (Philippart & Vranken 1983)
	intermediately tolerant	(Welcomme *et al*. 2006) (Ribeiro *et al*. 2008) (Morman *et al*.1980) (Philippart & Vranken 1983)
	intolerant	(Blanck *et al*. 2007) (Dušek *et al.* 2004) (Philippart & Vranken 1983)
tolerance to toxic contamination	tolerant	(Langston *et al*. 2002) (Dušek *et al*. 2004)
	intermediately tolerant	(Langston *et al*. 2002) (Lindholm *et al.* 1999) (Santos *et al*. 2002) (Santos *et al*. 2004)
	intolerant	(Fent 2007)
tolerance to acidification	tolerant	(Pusch & Hoffmann 2000) (Schjolden *et al*. 2007)
	intermediately tolerant	
	intolerant	
temperature tolerance	eurythermal	(Küttel *et al*. 2002) (Philippart & Vranken 1983)
	stenothermal	(Ovidio *et al*. 2007) (Zambrano *et al*. 2006) (Lappalainen 2001) (Küttel *et al*. 2002)
habitat degradation tolerance	tolerant	(Cucherousset *et al*. 2006) (Verneaux 1981) (Grandmottet 1983)
	intermediately tolerant	(Quintella 2006) (Almeida *et al.* 2002) (Quintella *et al.* 2003) (Andrade *et al*. 2007) (Herrera & Fernández-Delgado 1994) (Granado-Lorencio *et al*. 1985) (Santos *et al*. 2004) (Santos *et al*. 2006) (Torralva *et al*. 1999) (Carmona *et al.* 1999) (Filipe *et al.* 2002) (Verneaux 1981) (Grandmottet 1983)
	intolerant	(Verneaux 1981) (Grandmottet 1983) (Ovidio *et al*. 2007) (Lamouroux & Cattanéo 2006) (Welcomme *et al*. 2006) (Schiemer & Waidbacher 1992) (Carmona *et al*. 1999) (Elvira 1996)

Habitat guilds are well discussed in literature as far as it concerns the literature search (table 5.6).

Table 5.6 *Selected literature grouped according to its contribution to classify species into <u>habitat</u> guilds*

trait	modality	citation
habitat	rheophilic	(Blanck *et al*. 2007) (Aarts & Nienhuis 2003) (Irz *et al.* 2007) (Waidbacher *et al*. 2003) (Schiemer & Waidbacher 1992) (Zauner & Eberstaller 1999) (Ribeiro *et al*. 2000) (Grandmottet 1983) (Keith & Allardi 2001) (Oberdorff *et al*. 2002)
	eurytopic	(Spindler 1997) (Aarts & Nienhuis 2003) (Irz *et al.* 2007) (Waidbacher *et al*. 2003) (Schiemer & Waidbacher 1992) (Zauner & Eberstaller 1999) (Grandmottet 1983) (Keith & Allardi 2001) (Oberdorff *et al.* 2002)
	limnophilic	(Spindler 1997) (Blanck *et al*. 2007) (Irz *et al*. 2007) (Waidbacher *et al*. 2003) (Schiemer & Waidbacher 1992) (Zauner & Eberstaller 1999) (Godinho & Ferreira 1998) (Grandmottet 1983) (Keith & Allardi 2001) (Oberdorff *et al*. 2002)

Feeding habitat and adult trophic guild are also well documented although only one reference for species feeding in the water column and fish exhibiting a parasitic feeding behaviour could be found. In most of the literature found species are classified as benthic feeding and as planktivorous. The question whether this correlates with the number of species classified as benthic feeders or plantivores in the resulting classification table is answered in chapter 6.2.2.3.

Table 5.7 *Selected literature grouped according to its contribution to classify species into* <u>*trophic guilds*</u>

trait	modality	citation
feeding habitat	water column	(Oberdorff *et al.* 2002)
	benthic	(Winkelmann *et al*. 2007) (Spindler 1997) (Herzig *et al*. 1994) (Zambrano *et al*. 2006) (Klemetsen *et al*. 2005) (Grossman & Sostoa 1994) (Rodriguez Jimenez 1987) (Lafaille *et al*. 2002) (Torras *et al.* 2000) (Oberdorff *et al*. 2002) (Langston *et al.* 2002)
adult trophic guild	detritivorous	(Lobon *et al*. 1994) (Almeida 2003) (Torras *et al*. 2000) (Bellido *et al.* 1989) (Coelho 1987) (Lobón-Cerviá & Elvira 1981) (Elliot *et al*. 2007)
	herbivorous	(Herzig *et al*. 1994) (Zambrano *et al.* 2006) (Elliot *et al*. 2007)
	insectivorous	(Zambrano *et al*. 2006) (Elliot *et al*. 2007)
	omnivorous	(Spindler 1997) (Zambrano *et al*. 2006) (Scott & Crossman 1973) (Robalo *et al*. 2003) (Elliot *et al* 2007)
	parasitic	(Elliot *et al*. 2007)
	piscivorous	(Herzig *et al*. 1994) (Zambrano *et al.* 2006) (Smith 2006) (Elliot *et al*. 2007)
	planktivorous	(Spindler 1997) (Herzig *et al.* 1994) (Zambrano *et al*. 2006) (Alajärvi 2004) (Klemetsen *et al.* 2005) (Vinyoles *et al*. 2007) (Vasek & Kubecka 2004) (Correia *et al.* 2001) (Vinni *et* al. 2000) (Elliot *et al*. 2007)

With regard to migration I found mainly literature by Welcomme et al*.* (2006) and McDowell (2007). Salinity does not seem to be a prominent topic in scientific publications since I could not find any referencens in connection with it. However, it is surely true that the guild of salinity strongly overlaps with the migration guild.

Table 5.8 *Selected literature grouped according to its contribution to classify species into* <u>*migraton guilds*</u>

trait	modality	citation
migra-tion guild	resident	(Aarts & Nienhuis 2003) (Welcomme *et al.* 2006)
	potamodromous	(Aarts & Nienhuis 2003) (Ovidio & Philippart 2005)
	long catadromous	(McDowell 2007)
	long anadromous	(McDowell 2007) (Welcomme *et* al. 2006) (Schiemer & Waidbacher 1992) (Costa *et al*. 2001)
salinity	freshwater	
	estuary-brackish	
	marine	
	anadro-mous/catadromous	

Guild modalities concerning reproduction are nearly as popular for research as trophic guilds. For every modality except viviparous species at least one reference could be found. The basic for all reproductive guilds classification is still constituted by Balon (1975). His schemes are often adapted and discussed.

In contrary, for parental care I only found one publication by Marshall et al*.* (1998) as only reference apart from Balon (1975).

Table 5.9 *Selected literature grouped according to its contribution to classify species into reproductive guilds*

trait	modality	citation
reproductive guild	lithopelagophilic	(Balon 1975)
	lithophilic	(Irz *et al*. 2007) (Balon 1975)
	ostracophilic	(Balon 1975) (Smith *et al*. 2006)
	pelagophilic	(Spindler 1997) (Irz *et al*. 2007) (Balon 1975)
	phytophilic	(Irz *et al*. 2007) (Balon 1975) (Bartulovic *et al*. 2006)
	phytolithophilic	(Irz *et al*. 2007) (Balon 1975)
	polyphilic	(Simon 1999) (Balon 1975)
	psamnophilic	(Spindler 1997) (Irz *et al*. 2007) (Balon 1975)
	speleophilic	(Carbonero *et al*. 2006) (Vlaming & Vodicnik 1978) (Rinchard & Kestemond 1996) (Fox & Crivelli 1998) (Villa-Gispert 1996) (Villa-Gispert & Moreno-Amich 2002)
	viviparous	
	ariadnophilic	(Balon 1975)
spawning habitat	rheopar	(Zauner & Eberstaller 1999) (Collares-Pereira *et al*. 1999)
	eurypar	(Zauner & Eberstaller 1999)
	limnopar	(Balon 1975) (Gante & Santos 2002) (Copp & Horsfield 2004)
reproductive behaviour	single	(Keith & Allardi 2001)
	fractional	(Carbonero *et al*. 2006) (Vlaming & Vodicnik 1978) (Rinchard & Kestemond1996) (Fox & Crivelli 1998) (Villa-Gispert 1996) (Villa-Gispert & Moreno-Amich 2002) (Keith & Allardi 2001)
	protracted	(Keith & Allardi 2001)
parental care	no protection	(Balon 1975)
	protection	(Balon 1975) (Marshall *et al*.1998)

Physiological and morphological data are often taken from fishbase.org and books which were suggested by experts. The only recent publication I found during my literature search contatining concrete numbers of physiological and morphological parameters is Blanck et al. (2007). Bodyshapes were on purpose exclusively taken from one single author (Kottelat & Freyhof 2007) to guarantee standardised biomass calculations. Catch occurrence data are found in EFI databases.

Table 5.10 *Selected literature concerning physiological and morphological parameters*

modality	citation
length	fishbase.org
length relation a	fishbase.org
length relation b	fishbase.org
shape factor	fishbase.org
swimming factor	fishbase.org
longevity	(Blanck *et al*. 2007) (Pedroli *et al*. 1991) (Keith & Allardi 2001) (Maitland 2004)
fecundity	(Blanck *et al*. 2007) (Keith & Allardi 2001)
relative fecundity	(Boughida 1992) (Bănărescu,1999) (Keith & Allardi 2001) (Spillman 1961) (Changeux & Pont 1995)
egg diameter	(Blanck *et al*. 2007 (Bănărescu & Paepke 2001) (Maitland 2004)
age at maturity	(Banarescu & Paepke 2001) (Rosecchi *et al*. 2001)
incubation	(Banarescu & Paepke 2001)
catch occurence	FAME, EFI+
bodyshape	(Kottelat & Freyhof 2007)

5.3 Paper summaries

Publications relevant for classification were examined with regard to content, type of paper, geographical location, type of water body, spatial scale, temporal scale, statistical approaches, taxa studied, biotic variables and study design. Most attention was paid to guild classification and morphological and physiological parameters.

The papers differ according to their study objectives which are either fish itself or distinct issues conncected to fish like, for example, hydromorphology or drifting behaviour of makrozoobenthos. Additionally a clear distinction can be made between literature that focuses on one single species and authors who are surveying life strategies of several different fish species.

The publications are sorted according to their guilds and therefore are sometimes repeated on the following pages dependent on how much information about different guilds they deliver.

5.3.1 Tolerance

guild	tolerance to low oxygen concentration
paper	Blanck et al. 2007
type of paper	study report
summary	The report focuses on the "habitat template theory" and the hierachical "landscape filters concept". The relationship between life-history traits of European freshwater fish and their habitat preferences helps to detect the strategies adopted by fish to cope with their current habitat. The study supports the idea that microhydraulics play a more important role than temperature regime and oxygen concentration.
geographic location	Europe
type of water body	fast flowing and shallow habitats
spatial scale	unknown
temporal scale	unknown
study design	The use of multivariate analyses to classify survival strategies and examine the relationship between those strategies and published data about habitat preferences
modality information	tolerant + intolerant
biotic variables	microhabitat hydraulics, oxygen level, temperature preferences
taxa studied	*Abramis brama, Alburnoides bipunctatus, Alburnus alburnus, Barbatula barbatula, Barbus barbus, Abramis bjoerkna, Carassius carassius, Chondrostoma nasus, Cottus gobio, Cyprinus carpio, Esox lucius, Gobio gobio, Gymnocephylus cernuss, Lepomis gibbosus, Leuciscus cephalus, Leuciscus leuciscus, Phoxinus phoxinus, Rhodeus sericeus, Rutilus rutilus, Salmo trutta, Sander lucioperca, Scardinius erythrophthalmus, Thymallus thymallus, Tinca tinca*
statistics	PCA, MCA, ANOVA
other modalities concerned	limnophilic, rheophilic

guild	tolerance to low oxygen concentration
paper	Welcomme et al. 2006
type of paper	theoretical
summary	Neglecting the fact that reliance on a single indicator species would be useful the paper proposes the use of environmental guilds based on common patterns of response by fish species to changes in river flow and geomorphology. A general framework consisting of two upland stream guilds, three lowland lentic guilds, four lowland lotic guilds, two generalist guilds and five estuarine guilds is proposed which aims at describing general trends in fish population and assemblage structure occurring during river development.
geographic location	Europe
type of water body	any
spatial scale	unlimited
temporal scale	unlimited
study design	According to criteria determined (location in river system, migration and movement, reproduction, resistence to anoxia) environmental guilds are created.
guild information	tolerant + intermediately tolerant
biotic variables	hydrology, reproduction, migration, oxygen level tolerance, pool/riffle, river reaches
taxa studied	*Tinca tinca, Ameiurus melas, Misgurnus fossilis, Salmo salar, Onchorhynchus* spp., *Rutilus rutilus, Abramis brama, Esox lucius, Cyprinus carpio, Scardinius erythrophthalmus, Rhodeus sericeus, Carassius carassius*
statistics	none
other modalities concerned	ostracophilic, intolerant to habitat degradation, resident, long anadromous

guild	tolerance to low oxygen concentration
paper	Fisher & Willis 2000
type of paper	study report
summary	The Missouri river floodplain historically contained numerous wetlands but flood-pulse processes have reduced due to alterations of the corridor. The objective of this study was to survey aquatic fauna and basic habitat characteristics in a small perched wetland before, during and after a connection period within a naturally functioning section of the Missouri river. Fish, macroinvertebrates, zooplankton and habitat parameters were sampled. No significant differences in densities or catch-per-unit-effort among sample periods were detected for macroinvertebrates. Copepoda nauplii, calanoid Copepoda and *Bosmina* spp. densities exceeded other regional means by as much as 900%. Twenty-four fish species were documented in the wetland. The black bullhead, *Ameiurus melas*, dominated the fish assemblage. Wetland depth and surface area increased during the connection period and contributed woody debris and terrestrial grasses. A reduced level of dissolved oxygen was measured and fish preferred to use the upper water column since the lower water column was nearly anoxic. Presence of juvenile fish and high densities of zooplankton establish the importance of the wetlands for the Missouri river ecosystem.
geographic location	USA – river Missouri
type of water body	river and wetlands
spatial scale	30 ha
temporal scale	3 months
study design	The flow volume near the study site was indexed contionously using the combined flow data from gauging stations. Data on several habiat parameters, all life stages of fishes, benthic and limnetic macroinvertebrates and zooplankton before, during and after the peak flow connection were collected. During each period the surface morphometry of the wetland was roughly mapped and sample transects were randomly selected.
guild information	tolerant
biotic variables	wetland, native fish, zooplankton, oxygen concentration, woody debris
taxa studied	*Ameiurus melas, Esox lucius, Cyprinus carpio, Semotilus andromaculatus, Pimephales promelas, Notemigonus crysoleucas, Lepomis cyanellus, Lepistosteus platostomus, Ameiurus natalis, Ictiobus bubalus, Ictiobus cyprinellus, Platygobio gracilis, Lota lota, Hybognathus* sp., *Rhinichthys cataractae, Carpiodes carpio, Moxostoma macrolepidotum, Sander canadense, Ameiurus punctatus, Hiodon alosoides, Catostomus commersoni, Perca flavescens*
statistics	Shapiro-Wilkes test, one-way AOV, Tukey's multiple range test, Chi-square test for homogeneity, Kruskal-Wallis test, Mann-Whitney U test
other modalities concerned	none

guild	tolerance to low oxygen concentration
paper	Žarski et al. 1995
type of paper	study report
summary	The aim of this study was to determine the degree of mercury contamination in the tissue of the bream, *Abramis brama*. Taking into account the reduction in Polish industry production, reduced use of chemicals in agriculture and the installation of several waste water plants in the Vistula River basin, it was interesting to determine possible mercury contamination changes in water and in fish. In 1993 the range of Hg concentration in muscles of bream was about two times lower than in 1990. The observed level of bream muscle contamination does not exceed the acceptable norms for mercury content established by FAO/WHO as well as the Polish Ministry of Health.
geographic location	Poland – river Vistula
type of water body	river
spatial scale	unknown
temporal scale	2 years
study design	The study was performed in the middle course of the Vistula River, where 30 individuals of bream were caught (15 in each year of sampling). The mercury concentration in muscle tissue was determined.
guild information	tolerant
biotic variables	mercury contamination, muscle tissue, bioaccumulation
taxa studied	*Abramis brama*
statistics	none
other modalities concerned	none

guild	tolerance to low oxygen concentration
paper	Ribeiro et al. 2008
type of paper	theoretical
summary	The paper offers a first approach to determine characteristics of non-native fish in a mediterranean-climate area. Three stages of the invasion process are examined: establishment, spread and integration. Prior invasion success was a good predictor for all the stages of the invasion process. Biological variables relevant for more than one stage of invasion were maximum adult size and size of native range. Despite these common variables, all models demonstrated that successful invaders have a combination of biological traits that may favor success at all invasion stages. However, characteristics of the ecosystem which gets invaded are as relevant as the characteristics of the invading species.
geographic location	Iberian peninsula
type of water body	any
spatial scale	unknown
temporal scale	unknown
study design	The use of general linear models revealed the characteristics which are most important for success at each stage of invasion. A non-native fish species was considered successful when it was known to have reproducted in the wild. Ten species variables were adopted for analysis: trophic status of adults, size of the species' native range, degree of parental care, maximum fecundity, maximum adult size, maximum lifespan, physiological tolerance, distance from nearest native source, past invasion success and propagule pressure. An additional variable considered in the study was the introduction effort, which measures the number of times that each species was introduced.
guild information	intermediately tolerant
biotic variables	invasive species, fecundity, parental care, reproduction, maximum size, maximum age
taxa studied	*Oncorhynchus mykiss, Salvelinus fontinalis, Esox lucius, Blicca bjoerkna, Alburnus alburnus, Carassius auratus, Cyprinus carpio, Gobio lozanoi, Pseudorasbora parva, Rutilus rutilus, Scardinius erythrophtalmus, Cobitis bilineata, Ameiurus melas, Silurus glanis, Fundulus heteroclitus, Gambusia holbrooki, Poecilia reticulate, Australoheros facetus, Lepomis gibbosus, Micropterus salmoides, Perca fluviatilis, Sander lucioperca, Acipenser baerii, Hucho hucho, Oncorhynchus kisutch, Abramis brama, Alburnoides bipunctatus, Ctenopharyngodon idella, Misgurnus anguillicaudatus, Leuciscus idus, Ameiurus punctatus, Aphanius fasciatus, Astronotus ocellatus, Pygocentrus nattereri, Piaractus brachypomus, Salmo trutta, Chondrostoma arcasii, Chondrostoma miegii, Chondrostoma polylepis, Phoxinus phoxinus, Squalis alburnoides, Squalis pyrenaicus, Tinca tinca, Cobitis paludica, Barbatula barbatula*
statistics	Kendall's tau-b correlation coefficient, Wald's test
guild modalities concerned	none

guild	tolerance to low oxygen concentration
paper	Morman et al.1980
type of paper	review
summary	The sea lamprey is widely distributed in the Great Lakes but it is scarce in large parts of the watershed. Individuals of sea lamprey living as parasites occur everywhere in the Great Lakes basin following suitable host fish but do not inhabit the western and central basins of Lake Erie during the summer. The water temperature affects most the survival of juveniles and embryos while the distribution of larval sea lamprey is limited primarily by barriers that block adult spawning runs, warm temperatures, low and unstable flow conditions, hard bottom substrate and pollution. Nevertheless, larvae were found in habitats whit such unstable conditions what is probably resulting from interconnecting waterways and attachment of larval sea lamprey to fishes and boats.
geographic location	Canada – Great Lakes
type of water body	lakes and streams/rivers
spatial scale	unknown
temporal scale	unknown
study design	Based on the review and analysis of available publications and the unpublished records of the American and Canadian control agents, life stages, water quality analysis, migratory behaviour, feeding and habitat of sea lamprey are discussed.
guild information	intermediately tolerant
biotic variables	reproduction, spawning, larvae development, migration, water quality
taxa studied	*Petromyzon marinus, Lampetra fluviatilis, Coregonus clupeaformis, Coregonus artedii, Lota lota, Salvelinus namaycush, Oncorhynchus nerka, Lampetra richardsoni*
statistics	none
other modalities concerned	none

guild	tolerance to low oxygen concentration
paper	Dušek et al. 2004
type of paper	monitoring study
summary	At 13 geographical sites that can be regarded as crucial points for an ecotoxicological assessment fish muscle tissues were monitored for mercury contamination. Predators were significantly contaminated compared to the other fish species in all sites. Omnivorous and planktivorous species ended up to be the least sensitive to Hg pollution. Time-related comparisons of sampling procedures revealed no significant trend changes, in sediment samples of fish tissue. Thus, the analyses documented an evidently rather stable Hg pollution in the Elbe river environment. Benthivorous species displayed discrimination capacity towards contaminated sites, omnivorous species corresponded with their weak bioindicator power.
geographic location	Czech Republic – Elbe river
type of water body	river
spatial scale	whole reach of the Elbe river in the Czech Republic
temporal scale	5 years
study design	Hg concentrations in muscle tissue of different fish species were monitored at 13 sites along the Czech part of the river Elbe. Multivariate statistics revealed differences between fish species and between trophic guilds in sensitivity concerning heavy metal pollution.
guild information	intolerant
biotic variables	heavy metals, bioaccumulation, fish as bioindicators, trophic guilds
taxa studied	*Perca fluviatilis, Abramis brama, Rutilus rutilus, Leuciscus cephalus, Alburnoides bipunctatus, Anguilla anguilla, Aspius aspius, Barbus barbus, Abramis bjoerkna, Carassius auratus, Esox lucius, Gobio gobio, Gymnocephalus cernuus, Ameiurus nebulosus, Leuciscus leuciscus, Salmo trutta, Scardinius erythrophthalmus, Silurus glanis, Sander lucioperca, Thymallus thymallus, Vimba vimba*
statistics	ANOVA, Tukey’s multiple-range test, Pearson’s correlation coefficient, Spearman’s rank, PCA
other modalities concerned	tolerant to toxic contamination

guild	tolerance to toxic contamination
paper	Langston et al. 2002
type of paper	study report
summary	The purpose of the study was to examine the role of metallothioein in the detoxification and regulation of metals in the livers of eels by monitoring hepatic levels. Hepatic metallothioein concentrations highly correlated with metal pollution notably reflecting Cu and Ag enrichment. Thus, despite causing induction of metallothioein excess bioavailable Cu, Ag and Cd appear to be successfully detoxified in eels no matter how intense the environmental contamination is. Therefore, determination of hepatic MT (and associated metals) in eels could be useful for monitoring responses to metal exposure and environmental quality on a much broader basis.
geographic location	England
type of water body	estuary
spatial scale	100 km
temporal scale	6 months
study design	Measurement and correlation of hepatic metallothioein levels and estuarine metal concentrations
guild information	tolerant + intermediately tolerant
biotic variables	bioavailability, pollution, adaption
taxa studied	*Anguilla anguilla*
statistics	ANOVA
other modalities concerned	planktivorous, benthic

guild	tolerance to toxic contamination
paper	Dušek et al. 2004
type of paper	monitoring study
summary	At 13 geographical sites that can be regarded as crucial points for an ecotoxicological assessment fish muscle tissues were monitored for mercury contamination. Predators were significantly contaminated compared to the other fish species in all sites. Omnivorous and planktivorous species ended up to be the least sensitive to Hg pollution. Time-related comparisons of sampling procedures revealed no significant trend changes, in sediment samples of fish tissue. Thus, the analyses documented an evidently rather stable Hg pollution in the Elbe river environment. Benthivorous species displayed discrimination capacity towards contaminated sites, omnivorous species corresponded with their weak bioindicator power.
geographic location	Czech Republic – Elbe river
type of water body	river
spatial scale	whole reach of the Elbe river in the Czech Republic
temporal scale	5 years
study design	Hg concentrations in muscle tissue of different fish species were monitored at 13 sites along the Czech part of the river Elbe. Using multivariate statistics revealed differences between fish species and between trophic guilds in sensitivity concerning heavy metal pollution.
guild information	tolerant
biotic variables	heavy metals, bioaccumulation, fish as bioindicators, trophic guilds
taxa studied	*Perca fluviatilis, Abramis brama, Rutilus rutilus, Leuciscus cephalus, Alburnoides bipunctatus, Anguilla anguilla, Aspius aspius, Barbus barbus, Abramis bjoerkna, Carassius auratus, Esox lucius, Gobio gobio, Gymnocephalus cernuus, Ameiurus nebulosus, Leuciscus leuciscus, Salmo trutta, Scardinius erythrophthalmus, Silurus glanis, Sander lucioperca, Thymallus thymallus, Vimba vimba*
statistics	ANOVA, Tukey's multiple-range test, Pearson's correlation coefficient, Spearman's rank, PCA
other modalities concerned	intolerant to low oxygen concentration

guild	tolerance to toxic contamination
paper	Lindholm et al. 1999
type of paper	monitoring study
summary	The brackish-water Lake Vargsundet was affected by multiple algal toxins and extensive fish mortality in July 1997. Dense populations of the ichthyotoxic haptophyte *Prymnesium* sp. and the hepatotoxic cyanobacterium *Planktothrix agardhii* were observed simultaneously, but usually in distinct layers. Fish died in the relatively clear epilimnion while they survived in the metalimnion dominated by the hepatotoxic *P. agardhii*. The deeper layers were anoxic. The *Prymnesium*-rich water remained ichthyotoxic until the end of August. As a result the authors suggested the reconsideration of safety and monitoring measures as even inconspicuous haptophyte blooms with low chlorophyll a concentrations may be harmful.
geographic location	SW Finland
type of water body	coastal lake
spatial scale	unknown
temporal scale	2 months
study design	During the period of fish mortality phytoplankton samples were taken. Secchi depth, chlorophyll a, water pH and nutrient concentration content were identified. Newly caught individuals belonging to three species were exposed to water taken from the lake. Mortality rates were observed. Additional mortality rates of brine shrimp larvae *Artemia salina* were tested. Information on weather conditions, nutrient load and phytoplankton composition made assessment of the situation possible.
guild information	intermediately tolerant
biotic variables	ichthyotoxicity, toxic algae, nutrient load, temperature
taxa studied	*Perca fluviatilis, Rutilus rutilus, Alburnus alburnus*
statistics	none
other modalities concerned	none

guild	tolerance to toxic contamination
paper	Santos et al. 2002
type of paper	study report
summary	An upstream fish passage was continuously monitored by video tape analysis at the fish lift Touvedo dam. A total of 1194 individuals from 7 species were transferred by the lift. Cyprinids were the dominant group. Their movement was mostly observed in spring and therefore connected to reproduction.
geographic location	Portugal – river Lima
type of water body	river
spatial scale	unknown
temporal scale	11 months
study design	In order to monitor fish passage through the fish lift two video cameras and an automatic video recorder system were installed. One camera was placed on the top of the fish lift, allowing the collection of lift cage images. Another camera was placed outside the lift, enabling the recording of fish passage as the fish were transferred to the channel which goes into the reservoir. Data on turbine and spillway discharges, as well as head and tailwater levels, were hourly and daily collected in oder to determine water velocities of the fish lift entrances.
guild information	intermediately tolerant
biotic variables	fish lift, migration, obstacles, reproduction
taxa studied	*Barbus bocagei, Chondrostoma polylepis, Rutlilus arcasii, Leuciscus carolitertii, Salmo trutta fario, Petromizon marinus, Anguilla anguilla, Salmo salar, Alosa alsoa, Alosa fallax*
statistics	ANOVA, STS, Mann-Whitney Rank Sum Test, Durbin-Watson statistic, Tukey's multiple range test
other modalities concerned	none

guild	tolerance to toxic contamination
paper	Santos et al. 2004
type of paper	study
summary	The microhabitat use of the Iberian nase *Chondrostoma polylepis* and the Iberian chub *Squalius carolitertii* is studied in three small streams. Both species move to shallow and slow flowing microhabitats in summer and autumn, what mainly reflects the seasonal variation in the microhabitat availability. Larger individuals of both species inhabit deeper areas and areas which are less covered. Significant ontogenetic differences are found for the behaviour towards water velocity. Different patterns of a nonrandom microhabitat use are displayed by both cyprinids. There is no evidence of interspecific competition for the microhabitat.
geographic location	North West Portugal – Lima basin
type of water body	small warm-water streams
spatial scale	1500 m
temporal scale	12 months
study design	Measurements were made for 210 and 248 individuals distributed in two size classes based on fish ages. The procedures took place during winter, spring, summer and autumn 1998. Hypothesis were: Do species display seasonal or size-related (ontogenetic) differences in microhabitat use? Do species exhibit nonrandom microhabitat use? and Do species make af difference in microhabitat use and, if yes, is it indicative of resource partitioning?
guild information	intermediately tolerant
biotic variables	microhabitat use, habitat competition, water velocity, cover
taxa studied	*Chondrostoma polylepis, Squalius carolitertii, Salmo trutta, Anguilla anguilla*
statistics	DA, PCA, Mann Whitney U-test, Pearson's correlation, Tukey's pairwise comparison
other modalities concerned	intermediately tolerant to habitat degradation

guild	tolerance to toxic contamination
paper	Fent 2007
type of paper	book
summary	Effects of anthropogenic chemical inputs in ecosystems are suggested and consequences on a variety of biological levels as well as correlations are discussed. Recent findings in environmental chemistry, toxicology and ecology are linked and introduced. New threats to ecosystems like nanoparticles, pharmaceuticals and synthetics are taken in account. Handling of chemicals as well as exploitation of resources, greenhouse effect and global warming are important topics in this book.
geographic location	any
type of water body	any
spatial scale	any
temporal scale	any
study design	The mechanism of action with regard to substances which are toxic to the environment are explained and systems of testing are introduced.
guild information	intolerant
biotic variables	toxins, environmental chemistry, LC_{50}, LD_{50}, metabolism, global resources
taxa studied	*Anguilla anguilla, Phoxinus phoxinus, Onorhynchus mykiss, Rutilus rutilus, Cyprinus carpio, Gobio gobio, Abramis brama, Pimephales promelas, Brachydario rerio, Platichthys flesus, Solea solea, Lophius piscatorius, Coregonus* sp.
statistics	none
other modalities concerned	none

guild	tolerance to acidification
paper	Pusch & Hoffmann 2000
type of paper	study/theoretical
summary	In the Lusatia region of northeastern Germany, dewatering for mining activities resulted in an 8 km³ deficit in the groundwater balance. In order to refill aquifers and empty lignite pits, water was abstracted for several decades from the River Spree which, as a consequence, drained the region. Ecological consequences are shown for fish, the aquatic invertebrate fauna, the retention of suspended matter and oxygen concentrations. The use of a multiple compartment method (MCM) for the assessment of flow requirements in extended river sections was suggested. Using the MCM, it can be shown that the minimum discharge that is required to preserve the river ecosystem is largely influenced by ambient channel morphology and nutrient concentration. This means that the ecological impact of water abstraction could be abated by the measures of morphological restoration of the river as well as by the restriction of nutrient input. Also, instream minimum flow requirements would be reduced, so that more river water could be abstracted
geographic location	NE Germany
type of water body	lowland river
spatial scale	230 km
temporal scale	unknown
study design	Fish, invertebrate fauna, retention of suspended matter and oxygen concentration were examined. The results were examined regarding their adaptiveness to one of the methods for assessing flow requirements in streams.
guild information	tolerant
biotic variables	minimum flow requirements, dissolved oxygen
taxa studied	*Rutilus rutilus, Alburnus alburnus, Gobio gobio, Scardinius erythrophtalmus, Perca fluviatilis, Leuciscus cephalus, Leuciscus idus, Cobitis taenia*
statistics	none
other modalities concerned	none

guild	tolerance to acidification
paper	Schjolden et al. 2007
type of paper	experimental study
summary	Crucian carps were exposed to a Cu rich medium and their mortality was determined after 13 days of exposure. Significant changes in the haematocrit level, the level of plasma chloride and plasma sodium and the water content in muscles after two days were observed After 14 days of exposure the haematocrit level and the water content in muscle tissue had increased and the level of plasma chloride and plasma sodium had decreased. No apparent changes in blood ethanol level, and minor changes in plasma lactate level had taken place. Analyses of the gills revealed an increasing concentration of copper. Through both, lamellar and filamental fusion, the respiratory area was reduced. The O_2 uptake did not change but the critical oxygen tension level was elevated. This study shows that the crucian carp has a higher tolerance to copper compared to other freshwater fish species. Results suggest that this tolerance is based on the ability of the crucian carp to avoid becoming hypoxic as well as an extreme tolerance to severe loss of plasma ions.
geographic location	Norway - Oslo
type of water body	pound
spatial scale	unknown
temporal scale	14 days
study design	Individuals of crucian carp, ranging from 25 to 80g in weight and 10 to 15cm in total length, were exposed to a Cu rich medium. Untreated department water was used as a control liquid. Mortality as well as changes in the level of haematocrit, plasma chloride and plasma sodium as well as in the water content in muscles were observed. The fish were not fed during the acclimation period or the experiments to avoid the influence of food on blood parameters.
guild information	tolerant
biotic variables	copper contamination, pH, toxicity, fish mortality and physiology
taxa studied	*Carassius carassius*
statistics	ANOVA, Tukey-Kramer post hoc test
other modalities concerned	none

guild	temperature tolerance
paper	Küttel et al. 2002
type of paper	literature study
summary	The study presents the results of the literature research for optima and limits of temperature for 32 fish species living in Swiss waters, differentiating between eggs, juveniles, adults and reproduction. The obtained data were compared to anthropogenic alterations of temperature focusing on the influence of stowages. Increased temperatures in winter enhance the development of salmonid eggs, decreased temperatures slow down the development. Low temperatures place disadvantages at warmwater-adapted taxa like cyprinids and percids.
geographic location	Switzerland
type of water body	anthropogenic modified rivers
spatial scale	unknown
temporal scale	unknown
study design	A report on the effects of stowages to water temperature is followed by a theoretical study on fish species with regard to their optimum- and critical temperature ranges at four different life stages (eggs, juveniles, adults and during reproduction). Box plots diagrams show ranges of temperature tolerances of all fish species concerned. Finally interference with the temperature regime and possible effects on the fish fauna are discussed.
guild information	eurythermal + stenothermal
biotic variables	temperature, hydromporphology, anthropogenic influences, reproduction, growth
taxa studied	*Anguilla anguilla, Salmo salar, Salmo trutta fario, Salmo trutta lacustris, Oncorhynchus mykiss, Salvelinus fontinalis, Thymallus thymallus, Esox lucius, Cyprinus carpio, Abramis brama, Alburnoides bipunctatus, Alburnus alburnus, Barbus barbus, Carassius gibelio, Chondrostoma nasus, Gobio gobio, Leuciscus leuciscus, Leuciscus cephalus, Leuciscus souffia, Phoxinus phoxinus, Scardinius erythrophthalmus, Tinca tinca, Misgrunus fossilis, Barbatula barbatula, Ameiurus melas, Lota lota, Gasterosteus aculeatus, Perca fluviatilis, Lepomis gibbosus, Cottus gobio*
statistics	none
other modalities concerned	none

guild	temperature tolerance
paper	Ovidio et al. 2007
type of paper	monitoring study
summary	The adult brown trout and the European grayling were radio-tracked in three South Belgian rivers to assess their capabilities to bypass various obstacles. During their upstream migration individuals encountered different types of physical obstacles and successfully bypassed some under variable environmental conditions. The ability of the trout and the grayling to bypass different types of physical obstacles in natural river systems is discussed in the context of providing their free movement in rivers.
geographic location	Belgium – rivers Aisne, Néblon and Lhomme
type of water body	sub tributaries
spatial scale	103,9 km
temporal scale	8 years
study design	Trout and grayling were caught by electrofishing or caught in fish traps. Temperature and discharge conditions were continuously monitored. Obstacles were examined and described. The obstacles cleared by the fish were characterised based on a simple topographical description protocol and compared with tracking data.
guild information	stenothermal
biotic variables	migration, obstacles, fragmentation
taxa studied	*Salmo trutta, Thymallus thymallus*
statistics	none
other modalities concerned	intolerant to habitat degradation

guild	temperature tolerance
paper	**Zambrano et al. 2006**
type of paper	monitoring study
summary	In this paper the relationship between fish assemblage structure and other ecosystem characteristics in 28 shallow lakes, through the classification of fish species into feeding guilds according to the literature, was determined. Results showed that there was a striking lack of relationship between nutrients and other variables, indicating the importance of topdown rather than bottom-up processes as a structuring force in the generally eutrophic study lakes. The presence of submerged (and shoreline) vegetation was associated with a diverse assemblage of apparently coexisting piscivorous and zooplanktivorous species. The introduction of large benthivores to many study lakes could have precipitated a loss of submerged vegetation through direct uprooting during foraging, with the effect of simplifying the fish assemblage. This was most acute where littoral vegetation was limited by other anthropogenic factors. Promotion or restoration of submerged vegetation in these lakes is recommended and would best target species that use the benthic feeding habitat.
geographic location	eastern England
type of water body	lakes
spatial scale	~ 160 ha
temporal scale	unknown
study design	Both the limnetic and littoral zones were point-abundance sampled by electrofishing. Water chemistry, transparency, chlorophyll-a and zooplankton composition were determined. Fish were classified into 6 different feeding guilds. CCA was used to determine the relationships between the biomass of the fish guilds and selected environmental and trophic level variables.
guild information	stenothermal
biotic variables	trophic guilds, nutrient level, phytoplankton, zooplankton, benthic feeding habitat
taxa studied	*Anguilla anguilla, Gobio gobio, Rutilus rutilus, Scardinius erythrophthalmus, Gasterosteus aculeatus, Gymnocephalus cernuus, Esox lucius, Perca fluviatilis, Cyprinus carpio, Abramis brama, Tinca tinca*
statistics	Shannon-Wiener index, CCA, Cook’s distance test, QQ plots
other modalities concerned	benthic, insectivorous, omnivorous, piscivorous, planktivorous

guild	temperature tolerance
paper	**Lappalainen 2001**
type of paper	dissertation
summary	The effects of environmental factors on the population dynamics of the pikeperch were analysed in the coastal areas of the northern Baltic sea and in three lakes. Physical water parameters as well as fish traits were determined. Water temperature had positive effects on the annual abundance, growth, year-class strength and yields. The results further suggested that the size-dependent winter mortality was higher after cold than warm summers. Other environmental factors had little or no effects on the population dynamics. Pikeperch, as a warmwater species, seems to benefit from predicted climate warming based on the several positive effects of temperature on the population dynamics.
geographic location	Finnland, Estonia
type of water body	coastal waters, lakes
spatial scale	unknown
temporal scale	unknown
study design	The study analyzed abiotic factors were air and water temperature, water level and salinity, Secchi depth, wind velocity and distribution as well as duration of winter. The biotic factors studied were length, abundance, year-class strength, yields during subadult and adult stages. Effects of water temperature on length, growth and CPUE, size-dependent winter mortality and effects of seasonal and environmental factors were tested statistically.
guild information	stenothermal
biotic variables	climate change, season, temperature, growth, year-class strength, juveniles
taxa studied	*Sander lucioperca*
statistics	Spearman correlation, linear models, nonlinear regression, partial Spearman correlation, logistic regression, Mann-Whitney U-test, Kendall’s coefficient of concordance, cluster analysis
other modalities concerned	none

guild	habitat degradation tolerance
paper	Cucherousset et al. 2006
type of paper	study report
summary	The distribution and habitat selection of the invasive black bullhead *Ameiurus melas* in the ditches and surrounding temporary flooded habitats of an artificial wetland in western France was surveyd. Young-of-the-year (YOY) and adult individuals dominated the local fish assemblage but their appearance was highly variable among sites. Although evidence was found for some fine-scale habitat differences for YOY and adult individuals, the abundance of the black bullhead was positively and consistently related to the dominance of reed beds. Furthermore, *Ameiurus melas* preferentially used reed beds as opposed to marsh meadows during the flooding period. It is suggested that the invasion of *Ameiurus melas* has been facilitated by the expansion of reed beds associated with the diminution of agricultural pressure in recent decades. This study represents an unusual example of how human activities can have unexpected effects like facilitating an invasive fish species.
geographic location	western France
type of water body	wetlands
spatial scale	unknown
temporal scale	4 months
study design	A multiscale approach was used to quantify patterns of *Ameiurus melas* abundance in relation to physical habitat characteristics in the ditch network. Fish sampling was performed using the point abundance sampling (PAS) method. Ditch sizes were classified into two categories: those belonging to the primary network (main river or large ditches directly connected to the main river) and those belonging to the secondary network (ditches connected to the primary network level). Four fine-scale variables representing the microhabitat were measured additionally.
guild information	tolerant
biotic variables	invasive species, CPUE, wetlands, agriculture
taxa studied	*Ameiurus melas, Blicca bjoerkna, Abramis brama, Rutilus rutilus, Scardinius erythrophthalmus, Gambusia holbrooki, Lepomis gibbosus, Anguilla anguilla*
statistics	t-test, Mann-Whitney U-test
other modalities concerned	none

guild	habitat degradation tolerance
paper	Quintella 2006
type of paper	dissertation
summary	The research developed in this dissertation was directed to two sensitive periods of the life cycle of the sea lamprey: the larval phase and the time when individuals migrate to spawn. The duration of the larval stage in Portuguese rivers was calculated. The distribution of the ammocoetes along a river system, and the environmental factors responsible for the selection of habitat were also determined. The adult spawning migration was studied with telemetry techniques. The information gathered was used to define several management and conservation actions that might be useful to help increasing the sea lamprey numbers in Portugal and the available area to breed.
geographic location	Portugal
type of water body	rivers
spatial scale	unknown
temporal scale	unknown
study design	The characteristics of ammocoetes movement were studied with an innovative telemetry technique using passive integrated transponders detection system. Burrowing behaviour and performances of the ammocoetes in different substrate types were assessed in laboratory. Conventional radio telemetry was used to characterize the spawning migrations and physiological telemetry with electromyogram signal logging helped to determine the swimming behaviour and movement strategies of adult sea lampreys.
guild information	intermediately tolerant
biotic variables	migration, larval stage, spawning, endangerment
taxa studied	*Petromyzon marinus, Ichthyomyzon bdellium, Ichthyomyzon castaneus, Ichthyomyzon fossor, Ichthyomyzon gagei, Ichthyomyzon greeleyi, Ichthyomyzon unicuspis, Caspiomyzon wagneri, Tetrapleurodon geminis, Tetrapleurodon spadiceus, Entosphemus folletti, Entosphemus hubbsi, Entosphemus letophagus, Entosphemus macrostomum, Entosphemus minimus, Entosphemus similis, Entosphemus tridentatus, Eudontomyzon danfordi, Eudontomyzon hellenicus, Eudontomyzon mariae, Eudontomyzon moriii, Lampetra aepytera, Lampetra ayresi, Lampetra fluviatilis, Lampetra lanceolata, Lampetra pacifica, Lampetra planeri, Lampetra richardsoni, Lethenteron alaskense, Lethenteron appendix, Lethenteron japponicum, Lethenteron kessleri, Lethenteron reissneri, zanadreai, Geotria australis, Mordacia lapicida, Mordacia mordax, Mordacia praecox*
statistics	MDA, Press's Q statistic, Mantel test, ANOVA, SS-STP test, Tamhane's T2, ANCOVA, Kruskal-Wallis test, Mann-Whitney test
other modalities concerned	none

guild	habitat degradation tolerance
paper	Almeida et al.2002
type of paper	study
summary	The available spawning habitat for the anadromous sea lamprey population that enters the River Mondego has been drastically reduced in the last 20 years. The installation of a fish passage in the first impassable dam would enable sea lamprey to recolonise the 34.6 km river stretch between the Açude-Ponte and Raiva dams. The migratory paths of radio-tagged lampreys showed that they were unable to bypass intact weirs that had been built for recreational purposes. Sea lamprey movements were more frequent during dusk and night than other periods. Increased river discharge at night, resulting from the operation of a power station, stimulated the movement but reduced ground speed. After reaching a certain location some of the individuals maintained their position for several weeks, before moving again. Two of the main tributaries of this river stretch were used by some sea lamprey what indicates that they were able to find their historical spawning grounds.
geographic location	Portugal – river Montego
type of water body	river and its tributaries
spatial scale	34,6 km
temporal scale	4 months
study design	In order to assess the suitability of the upstream river stretches for migratory behaviour 10 radio-tagged sea lamprey were released upstream of the Açude-Ponte dam and tracked continously throughout their entire migratory path.
guild information	intermediately tolerant
biotic variables	migration, ground speed, obstacles
taxa studied	*Petromyzon marinus*
statistics	G-test of independence, Mann-Whitney U-test, Spearman's correlation coefficient
other modalities concerned	none

guild	habitat degradation tolerance
paper	Quintella et al. 2003
type of paper	study report
summary	The larval stage duration of the sea lamprey is estimated to last for four years. The number of annuli on statoliths provides reliable age estimates when compared with length-frequency distribution analysis. The growth rate of ammocoetes displays strong seasonal patterns and reaches its highest value during the first two years of the larval stage. About 69% of the length increment between hatching and metamorphosis is attained at the end of the second year. There is a longitudinal gradient associated with ammocoete distribution along the river. The relative abundance of ammocoetes decreases downstream from the Açude-Ponte dam, the first obstacle encountered by adults in their upstream spawning migration along the River Mondego.
geographic location	Portugal – river Montego
type of water body	estuarine freshwater stretch and river streches
spatial scale	1,36 km²
temporal scale	3 years
study design	Ammocoetes and metamorphosing sea lampreys were collected using electro-shocker and lengths were measured. Some staoliths were taken and age of individuals was equated to the number of annuli on the statoliths. Growth rates were calculated.
significant guild information	intermediately tolerant
biotic variables	metamorphoses, age, migration
taxa studied	*Petromyzon marinus*
statistics	Friedman's test, Kruskal-Wallis test
other modalities concerned	none

guild	habitat degradation tolerance
paper	Granado-Lorencio et al. 1985
type of paper	study report
summary	Growth parameters in three different populations of *Chondrostoma polylepis* are studied. They belong to the same hydrographic basin but as they are separated by reservoir constructions they have evolved according to the environmental characteristics of each reservoir. The differences found are related to environmental parameters like the mean depth, chlorophly-a concentration and the residence time of the water mass. The results are discussed with regard to the ecological processes that occur in aquatic ecosystems.
geographic location	western Spain – river Tagus
type of water body	reservoirs
spatial scale	9330 ha
temporal scale	3 years
study design	A comparative study in which the variables of Bertalanffy's growth equation were used; individuals were caught and taken to the laboratory where the growth parameters were determined.
guild information	intermediately tolerant
biotic variables	mean depth, chlorophyll-a, residence time, hydromorphology
taxa studied	*Chondrostoma polylepis*
statistics	PCA
other modalities concerned	none

guild	habitat degradation tolerance
paper	Santos et al. 2004
type of paper	study
summary	The microhabitat use of the Iberian nase *Chondrostoma polylepis* and the Iberian chub *Squalius carolitertii* is studied in three small streams. Both species move to shallow and slow flowing microhabitats in summer and autumn, what mainly reflects the seasonal variation in the microhabitat availability. Larger individuals of both species inhabit deeper areas and areas which are less covered. Significant ontogenetic differences are found for the behaviour towards water velocity. Different patterns of a nonrandom microhabitat use are displayed by both cyprinids. There is no evidence of interspecific competition for microhabitat.
geographic location	North West Portugal – Lima basin
type of water body	small warm-water streams
spatial scale	1500 m
temporal scale	12 months
study design	Measurements were made for 210 and 248 individuals distributed in two size classes based on fish ages. The procedures took place during winter, spring, summer and autumn 1998. Hypothesis were: Do species display seasonal or size-related (ontogenetic) differences in microhabitat use? Do species exhibit nonrandom microhabitat use? and Do species make af difference in microhabitat use and, if yest, is it indicative of resource partitioning?
guild information	intermediately tolerant
biotic variables	microhabitat use, habitat competition, water velocity, cover
taxa studied	*Chondrostoma polylepis, Squalius carolitertii, Salmo trutta, Anguilla anguilla*
statistics	DA, PCA, Mann Whitney U-test, Pearson's correlation, Tukey's pairwise comparison
other modalities concerned	intermediately tolerant to toxic contamination

guild	habitat degradation tolerance
paper	Santos et al. 2006
type of paper	study report
summary	The increased development of small hydropower projects makes issues related to fish passage very important. The effect of 18 small hydropower plants with different levels of fish-pass effectiveness was investigated. Fish assemblage and habitat structure were compared at 36 sites, above and below the power plants. As a result 8 of the surveyd passage facilities can be used by the targe species, other 10 fish passages are considered unsuitable. The species composition did not differ upstream and downstream from the small hydropower plants. Multivariate techniques identified cover, depth and coarse substrate as the main parameters causing a certain fish assemblage. Although populations of some species that occurred both upstream and downstream from the hydropower plants have developed differences in their size structures, fragmentation caused by obstacles like power plants may not necessarily result in genetic divergence among semi-isolated populations.
geographic location	central and northern Portugal – rivers Minho, Lima, Cávado, Douro, Vouga, Tagus
type of water body	medium-sized streams
spatial scale	7,2 km
temporal scale	2 years
study design	Selected characteristics including the hydraulic conditions within each fish pass, the attractivity of the fish entrance, the presence of downstream obstructions, the obstruction of orifices by debris loads and fine elements, the obstruction of notches by coarse elements, and the accessibility of the fish pass were recorded. Pool design data and design discharge were used to calculate hydraulic parameters. Finally, the effectiveness of each fish pass was globally evaluated using a set of selected characteristics and assigned to one of the following categories: “highly suitable”, “adequate”, “low” and “impassable”. Thirty-six sites were sampled in order to assess differences in fish assemblage composition and structure, upstream and downstream from the hydropower plants.
significant guild information	intermediately tolerant
biotic variables	fish passage, population composition, fish assemblage
taxa studied	*Barbus bocagei, Chondrostoma polylepis, Squalius carolitertii, Chondrostoma arcasii, Squalius alburnoides, Salmo trutta, Anguilla anguilla*
statistics	Sorensen’s Similarity Index, PCA, CCA, Kolmogorov-Smirnov test
other modalities concerned	none

guild	habitat degradation tolerance
paper	Torralva et al. 1999
type of paper	theoretical
summary	The first record of *Leuciscus pyrenaicus* in the basin of the river Segura dates back to the first half of the 19th century. Since the 1980s there has not been any record of *L. pyrenaicus* in this river anymore but recently individuals were found in tributaries where they live in assemblage with *Atherina boyeri, Aphanius iberius, Barbus sclateri, Gobio gobio and Chondrostoma polylepis.* The authors of the paper suggest that *L. pyrenaicus* has reached the new habitats by taking a deviation what had been already observed for other species.
geographic location	Spain – river Segura
type of water body	river and its tributaries
spatial scale	unknown
temporal scale	unknown
study design	Records of *Leuciscus pyrenaicus* in the Segura river basins are examined. The question is posed, wheter that fish species is still inhabting the above mentioned basin.
guild information	intermediately tolerant
biotic variables	assemblage, fish passage, extinction
taxa studied	*Leuciscus pyrenaicus, Atherina boyeri, Aphanius iberus, Barbus sclateri, Gobio gobio, Chondrostoma polylepis*
statistics	none
other modalities concerned	none

guild	habitat degradation tolerance
paper	Carmona et al. 1999
type of paper	study report
summary	The indigenous fishes analyzed in this study are distributed through the basin forming geographical assemblages (chorotypes), some of which are associated with environmental factors like river morphology, water quality or geographical location. Nevertheless, 40% of the variation in species occurrence remains unexplained by either environmental or geographical variables, suggesting that historical factors may influence the freshwater fish distribution patterns. Three main biogeographical areas, delimited by significant boundaries, were identified. Two of them are identified as the upper and the middle-lower basins of the Tagus River catchment; the third corresponds to the Alagón River.
geographic location	rivers Tagus and Alagón
type of water body	rivers
spatial scale	unknown
temporal scale	2 years
study design	Tests for the existence of distribution patterns shared by several indigenous freshwater fishes were conducted. Biogeographical boundaries and environmental factors that could explain distribution patterns were established. 120 fish sampling stations in the 54 tributaries of the SpanishTagus basin were selected, assigning more points to large tributaries where the environmental conditions are more variable. Presence-absence matrices were developed and species were classified according to their presence at sites.
guild information	intermediately tolerant + intolerant
biotic variables	hydromorphology, water quality, assemblages
taxa studied	*Barbus bocagei, Barbus comizo, Barbus microcephalus, Chondrostoma polylepis, Leuciscus pyrenaicus, Leuciscus carolitertii, Rutilus arcasii, Rutilus lemmingii, Tropidophoxinellus alburnoides, Cobitis paludica, Cobitis vettonica, Cobitis calderoni, Salmo trutta*
statistics	CCA
other modalities concerned	none

guild	habitat degradation tolerance
paper	Filipe et al. 2002
type of paper	modelling study
summary	This paper examines the use of multivariate statistics to model fish species distribution and habitat requirements for streams in semi-arid regions, many of which are coming under increasing pressure from water resource development schemes. The assessment was based on the geographical distribution of six endemic fish species. Their presence was related to 20 environmental variables linked to climate, geomorphology, riparian vegetation and location in the drainage basin. These variables were sampled or taken from topographical maps to evaluate habitat suitability and to predict the presence of the species according to the season. Multivariate logistic regression in a geographic information system environment was performed to identify regions with high probability of occurrence for each species. The variables that best explained the occurrence of the species were the sample location in the drainage basin, the geomorphology and the riparian vegetation. The models had a high predictive power and can be used in monitoring and predicting temporal changes caused by human activities. This modelling approach can be used to predict those areas that need to be conserved, protected or rehabilitated for endangered species.
geographic location	southern Portugal - river Guadiana
type of water body	semi-arid river system
spatial scale	1,2 km
temporal scale	8 months
study design	The topographical and environmental variables were collected at each site or from maps. For each site twenty macro-scale variables, likely to have predictive value in models of fish distribution, were considered and converted into classes. The similarity between the presence/absence of endangered species for different time intervals was compared. The species which exhibited seasonal variation in distribution were those with a Jaccard similarity index <0,6.
guild information	intermediately tolerant
biotic variables	endangerement, climate, geomorphology, riparian vegetation
taxa studied	*Leuciscus alburnoides, Barbus steindachneri, Anaecypris hispanica, Chondrostoma willkommii , Chondrostoma lemmingii, Leuciscus pyrenaicus, Barbus microcephalus, Barbus comizo, Barbus sclateri, Cobitis paludica, Salari fluviatilis, Esox lucius, Fundulus heteroclitus, Lepomis gibbosus, Micropterus salmoides, Gambusia holbrookii, Cichlasoma facetum, Cyprinus carpio, Carassius auratus*
statistics	Mantel–Haenszel test, Wald’s test, G-test
other modalities concerned	none

guild	habitat degradation tolerance
paper	Ovidio et al. 2007
type of paper	monitoring study
summary	The adult brown trout and the European grayling were radio-tracked in three southern Belgiam rivers to assess their capabilities to bypass various obstacles. During their upstream migrations individuals encountered different types of physical obstacles and successfully passed some under variable environmental conditions. The ability of trout and grayling to pass different typologies of physical obstacles in natural river systems is discussed in the context of enabling their free movement in rivers.
geographic location	Belgium – rivers Aisne, Néblon and Lhomme
type of water body	sub tributaries
spatial scale	103,9 km
temporal scale	8 years
study design	Trout and grayling were captured by electriofishing or caught in fish traps. Temperature and discharge conditions were continuously monitored. Obstacles were examined and described. The obstacles cleared by the fish were characterised based on a simple topographical description protocol and compared with tracking data.
guild information	intolerant
biotic variables	migration, obstacles, fragmentation
taxa studied	*Salmo trutta, Thymallus thymallus*
statistics	none
other modalities concerned	stenothermal

guild	habitat degradation tolerance
paper	Lamouroux & Cattanéo 2006
type of paper	study report
summary	Based on the published data, four guilds of European fish species with contrasting preferences for microhabitat hydraulics within stream reaches were defined. The study analyzed how fish guild proportions were related to reach hydraulics. The strongest correlations were observed between two fish guilds and the pool to riffle ratio and between one fish guild and the median discharge by unit width. The reach–scale relationship was consistent across six large French basins, and consistent with the analyses made at the microhabitat scale. Therefore, microhabitat preferences for hydraulics are strong enough to generate consistent reach-scale community responses to hydraulics across regions, despite the influence of other filters such as temperature, nutrient levels or history. The distribution of basic geomorphic features (pools, riffles) in streams and their modification (by dams, weirs and dikes) can modify the proportion of fish guilds by up to 80%, probably contributing to the longterm decline of riffle-dwelling species in Europe.
geographic location	France
type of water body	stream reaches
spatial scale	unknown
temporal scale	unknown
study design	Each stream reach was electrofished, ratio of pools to riffles as well as the median discharge was determined. Fish-hydraulics relationships were tested statistically.
guild information	intolerant
biotic variables	hydraulics, pool, riffle, discharge, microhabitat
taxa studied	*Anguilla Anguilla, Lepomis gibbosus, Barbatula barbatula, Abramis brama, Alburnoides bipunctatus, Alburnus alburnus, Barbus barbus, Abramis bjoerkna, Chondrostoma nasus, Gobio gobio, Leuciscus souffia, Leuciscus cephalus, Leuciscus leuciscus, Phoxinus phoxinus, Rodeus amarus, Rutilus rutilus, Scardinius erythrophthalmus, Tinca tinca, Esox lucius, Ameiurus melas, Cottus gobio, Perca fluviatilis, Salmo trutta*
statistics	F-test for homogeneity of slopes, divisive hierarchical cluster anlaysis, PCA
other modalities concerned	none

guild	tolerance to habitat degradation
paper	Welcomme et al. 2006
type of paper	theoretical
summary	Neglecting the fact that reliance on a single indicator species would be useful the paper proposes the use of environmental guilds based on common patterns of response by fish species to changes in river flow and geomorphology. A general framework consisting of two upland stream guilds, three lowland lentic guilds, four lowland lotic guilds, two generalist guilds and five estuarine guilds is proposed which aims at describing general trends in fish population and assemblage structure occurring during river development.
geographic location	Europe
type of water body	any
spatial scale	unlimited
temporal scale	unlimited
study design	According to predetermined criteria (location in river system, migration and movement, reproduction, resistence to anoxia) environmental guilds are created.
guild information	intolerant
biotic variables	hydrology, reproduction, migration, oxygen level tolerance, pool/riffle, river reaches
taxa studied	*Tinca tinca, Ameiurus melas, Misgurnus fossilis, Salmo salar, Onchorhynchus spp., Rutilus rutilus, Abramis brama, Esox lucius, Cyprinus carpio, Scardinius erythrophthalmus, Rhodeus sericeus, Carassius carassius*
statistics	none
other modalities concerned	tolerant + intermediately tolerant to habitat degradation, ostracophilic, resident, long anadromous

guild	tolerance to habitat degradation
paper	Schiemer & Waidbacher 1992
type of paper	theoretical
summary	In order to develop guidelines for improved ecological management and the evaluation of a National Park criteria for the structural quality of rivers had to be found. By comparing habitat guild data to habitat types and influences of impoundment five main types of habitat requirement were suggested.
geographic location	Europe
type of water body	stream
spatial scale	350 km
temporal scale	unlimited
study design	Fish catch data were compared to historical data. Habitat types were created. Effects of impoundments and lateral connections of the Danube on the fish fauna were evaluated by comparing habitat guild data.
guild information	intolerant
biotic variables	impoundments, lateral connectivity, degree of rheophily
taxa studied	*Tinca tinca, Salmo trutta, Hucho hucho, , Misgurnus fossilis, Salmo salar, Onchorhynchus mykiss, Rutilus rutilus, Abramis brama, Esox lucius, Cyprinus carpio, Scardinius erythrophthalmus, Rhodeus sericeus, Carassius carassius, Thymallus thymallus, Chondrostoma nasus, Barbus barbus, Rutilus pigus, Rutilus frisii, Leuciscus cephalus, Leuciscus leuciscus, Vimba vimba, Phoxinus phoxinus, Gobio kessleri, Gobio albipinatus, Gobio uranoscopus, Noemacheilus barbatulus, Alburnoides bipunctatus, Cottus gobio, Gymnocephalus baloni, Gymnocephylus schräetzer, Zingel zingel, Zingel streber, Leuciscus idus, Abramis sapa, Abramis ballerus, Pelecus cultratus, Aspius aspius, Cobitis taenia, Gobio gobio, Lota lota, Abramis bjoerkna, Carassius gibelio, Perca fluviatilis, Sander lucioperca, Proterorhinus marmoratus, Silurus glanis, Gymnocephylus cernua, Leucaspius delineatus, Carassius carassius, Gasterosteus aculeatus*
statistics	none
other modalities concerned	rheophilic, limnophilic, eurytopic, long anadromous

guild	tolerance habitat degradation
paper	Elvira 1996
type of paper	theoretical
summary	The endangerment of freshwater fish in Spain is discussed with regard to the Red Data List of 1986, the Red Data Book of 1992 and the National Catalogue of Threatened Species of 1990. The construction of dams, habitat destruction, pollution of waters, introduction of exotic fishes and overfishing are addressed.
geographic location	Spain
type of water body	all
spatial scale	any
temporal scale	any
study design	Categories of IUCN were used to indicate the state of conservation for freshwater fish. Species lists referring to the main detrimental factors were produced.
guild information	intolerant
biotic variables	invasive species, habitat, pollution, overfishing
taxa studied	*Lampetra fluviatilis, Lampetra planeri, Petromyzon marinus, Acipenser sturio, Alsoa alosa, Alosa fallax, Anguilla anguilla, Salmo salar, Salmo trutta, Anaecypris hispanica, Barbus comiza, Barbus guiraonis, Barbus haasi, Barbus meriodinalis, Barbus microcephalus, Chondrostoma arrigonis, Chondrostoma turiensis, Iberocypris palaciosi, Leuciscus carolitertii, Leuciscus cephalus, Rutilus lemmingii, Cobitis calderoni, Cobitis palucida, Aphanius iberus, Valencia hispanica, Gasterosteus aculeatus, Cottus gobio, Blennius fluviatilis*
statistics	none
other modalities concerned	none

5.3.2 Habitat

guild	habitat
paper	Blanck et al. 2007
type of paper	study report
summary	The report focuses on the “habitat template theory” and the hierachical “landscape filters concept”, the relationship between life-history traits of European freshwater fish and their habitat preferences helps to detect the strategies adopted by fish to cope with their current habitat. The study supports the idea that microhydraulics play a more important role than temperature regime and oxygen concentration. Relationships between hydraulics and traits are of a great importance.
geographic location	Europe
type of water body	fast flowing and shallow habitats
spatial scale	unknown
temporal scale	unknown
study design	The use of multivariate analyses to classify survival strategies and examine the relationship between those strategies and published data about habitat preferences
modality information	limnophilic + rheophilic
biotic variables	microhabitat hydraulics, oxygen level, temperature preferences
taxa studied	*Abramis brama, Alburnoides bipunctatus, Alburnus alburnus, Barbatula barbatula, Barbus barbus, Abramis bjoerkna, Carassius carassius, Chondrostoma nasus, Cottus gobio, Cyprinus carpio, Esox lucius, Gobio gobio, Gymnocephylus cernuss, Lepomis gibbosus, Leuciscus cephalus, Leuciscus leuciscus, Phoxinus phoxinus, Rhodeus sericeus, Rutilus rutilus, Salmo trutta, Sander lucioperca, Scardinius erythrophthalmus, Thymallus thymallus, Tinca tinca*
statistics	PCA, MCA, ANOVA
other modalities concerned	tolerant + intolerant to low oxygen concentration

guild	habitat
paper	**Aarts & Nienhuis 2003**
type of paper	theoretical
summary	The paper presents an ecological characerization of fish zones and fish communities in near-natural and in regulated large rivers using guild classifications of several life-history traits of fish and national Red Lists of threatened species. Flow preference and reproduction ecology of river fish are closely linked. The proportion of rehophilic species in the fish community decreases downstream, while the proportions of limnophillic and eurytopic species increase. Lithophilic and psamnophilic spawners are dominant in the upper zones. Whereas the lower zones are dominated by phytophilic and phytolithophilic spawners. The proportion of zoobenthivorous and periphytivorous species decreases downstream, while the proportions of zooplanktivorous and phytivorous species increase. Because of the subsequent over-abundance of the eurytopic species the original longitudinal fish zonations are hardly recognizable anymore in heavily stressed large rivers.
geographic location	France – river Doubs, Netherlands – rivers Rhine and Meuse
type of water body	near-natural and regulated large rivers
spatial scale	unknown
temporal scale	unknown
study design	Literature research of zonation concepts, ecological fish guilds, river fish data sets, and Red List was conducted. Taxonomic composition, composition of flow preference, reproductive and feeding guilds and Red list species were examined for all rivers.
modality information	rheophilic + eurytopic
biotic variables	endangered species, ecological guilds, natural-near rivers, regulated rivers
taxa studied	*Abramis brama, Alburnoides bipunctatus, Alburnus alburnus, Barbatula barbatula, Barbus barbus, Abramis bjoerkna, Chondrostoma nasus, Cottus gobio, Cyprinus carpio, Esox lucius, Gobio gobio, Gymnocephylus cernuus, Lepomis gibbosus, Leuciscus cephalus, Leuciscus leuciscus, Phoxinus phoxinus, Rhodeus sericeus, Rutilus rutilus, Salmo trutta, Sander lucioperca, Scardinius erythrophthalmus, Thymallus thymallus, Tinca tinca, Salvelinus fontinalis, Zingel asper, Chondrostoma toxostoma, Leuciscu souffia, Perca fluviatilis, Ameiurus melas, Micropterus salmoides*
statistics	none
other modalities concerned	resident, potamodromous

guild	habitat
paper	**Irz et al. 2007**
type of paper	theoretical
summary	The aim of the study was to assess whether eight traits of fish communities (species richness, three reproductive traits and four trophic traits) show a similarity in response to environmental gradients, and consequently display convergence between the lakes of France and north-eastern USA. The comparison of the regional pools of lacustrine fishes indicated that US lakes were about twice as species-rich as French ones. Warmer environments were consistently inhabited by a higher proportion of phytophilous and guarder species than were colder lakes. Hence there was convergence in community reproductive traits. The influence of temperature on the availability and quality of spawning substrates appears to be a major constraint on present-day lacustrine fish communities. In parallel, phylogenetic constraints, past events such as the diversification of the North American fish fauna, and selective extinctions during Pleistocene glaciations and subsequent recolonizations contribute to explaining the dissimilarities between the communities of the two regions and differences in connection to the environment.
geographic location	France, north-eastern USA
type of water body	lakes
spatial scale	unknown
temporal scale	28 years + 4 years
study design	The data encompass fish surveys, the assignment of species into reproductive and trophic guilds and environmental variables characterizing the lakes and their catchment areas. The methodology used relies upon partitioning the variance in community traits into a habitat component (common between regions), a regional component (differences between regional groups that persist regardless of habitat), with an added interaction component (habitat x region) as an indicator of between-region quantitative difference in responses to habitat conditions.
significant modality information	rheophilic + eurytopic + limnophilic
biotic variables	endangered species, ecological guilds, near-natural rivers, regulated rivers
taxa studied	*Carassius auratus, Cyprinus carpio, Esox lucius, Lepomis gibbosus, Lota lota, Micropterus salmoides, Oncorhynchus mykiss, Salmo trutta, Salvelinus umbla, Salvelinus namaycush, Scardinius erythrophthalmus*
statistics	general linerar models, pseudo R-square, ANOVA, hierarchical partitioning procedure
other guild modalities concerned	lithophilic, pelagophilic, phytophilic, phytolithophilic, psamnophilic

guild	habitat
paper	Waidbacher et al. 2003
type of paper	project report
summary	“Ecotones” in fish ecology are examined. Instream-ecotones that can be used by fish during different water level conditions are being altered by regulation and energy use of rivers. Fish samples from different habitat and microhabitat structure types result in the redefinition of 5 ecological groups. Macrophyte-fish interactions are also considered.
geographic location	Austria
type of water body	stream and its lateral structures
spatial scale	unknown
temporal scale	unknown
study design	Different habitat structures were examined and ecological groups were defined. Fish samples were taken during high water and at normal conditions.
modality information	rheophilic + eurytopic + limnophilic
biotic variables	endangered species, ecological guilds, near-natural rivers, regulated rivers
taxa studied	*Salmo trutta fario, Chondrostoma nasus, Barbus barbus, Leuciscus leuciscus, Rutilus pigus, Leuciscus cephalus, Vimba vimba, Gobio albipinatus, Gobio uranoscopus, Barbatula barbatula, Cottus gobio, Gymnocephalus baloni, Zingel streber, Zingel zingel, Gymnocephalus schraetzer, Leuciscus idus, Lot lota, Abramis sapa, Abramis ballerus, Aspius aspius, Gobio gobio, Esox lucius, Rutilus rutilus, Alburnus alburnus, Abramis bjoerkna, Abrmais brama, Carassius gibelio, Perca fluviatilis, Sander lucioperca, Neogobius kessleri, Proterorhinus marmoratus, Silurus glanis, Gymnocephalus cernuus, Cyprinius carpio, Scardinius erythrophthalmus, Rhodeus sericeus, Carassius carassius, Tinca tinca, Misgurnus fossilis, Sander volgensis, Gasterosteus aculeatus, Leucaspius delineatus, Umbra krameri, Lepomis gibbosus*
statistics	cluster analysis
other modalities concerned	none

guild	habitat
paper	Schiemer & Waidbacher 1992
type of paper	theoretical
summary	In order to develop guidelines for improved ecological management and the evaluation of a National Park criteria for the structural quality of rivers had to be found. By comparing habitat guild data to habitat types and influences of impoundment five main types of habitat requirement were suggested.
geographic location	Europe
type of water body	stream
spatial scale	350 km
temporal scale	unlimited
study design	Fish catch data were compared to historical data. Habitat types were created. Effects of impoundments and lateral connections of the Danube on the fish fauna were evaluated by comparing habitat guild data.
guild information	rheophilic + eurytopic + limnophilic
biotic variables	impoundments, lateral connectivity, degree of rheophily
taxa studied	*Tinca tinca, Salmo trutta, Hucho hucho, Misgurnus fossilis, Salmo salar, Onchorhynchus mykiss, Rutilus rutilus, Abramis brama, Esox lucius, Cyprinus carpio, Scardinius erythrophthalmus, Rhodeus sericeus, Carassius carassius, Thymallus thymallus, Chondrostoma nasus, Barbus barbus, Rutilus pigus, Rutilus frisii, Leuciscus cephalus, Leuciscus leuciscus, Vimba vimba, Phoxinus phoxinus, Gobio kessleri, Gobio albipinatus, Gobio uranoscopus, Noemacheilus barbatulus, Alburnoides bipunctatus, Cottus gobio, Gymnocephalus baloni, Gymnocephylus schräetzer, Zingel zingel, Zingel streber, Leuciscus idus, Abramis sapa, Abramis ballerus, Pelecus cultratus, Aspius aspius, Cobitis taenia, Gobio gobio, Lota lota, Abramis bjoerkna, Carassius gibelio, Perca fluviatilis, Sander lucioperca, Proterorhinus marmoratus, Silurus glanis, Gymnocephylus cernua, Leucaspius delineatus, Carassius carassius, Gasterosteus aculeatus*
statistics	none
other modalities concerned	intolerant to habitat degradation, long anadromous

guild	habitat
paper	Zauner & Eberstaller 1999
type of paper	theoretical
summary	In this paper attempts were made to present habitat structure, water velocity and spawning requirements of all Austrian riverine fish species. Based on these data, a new classification scheme is developed that categorizes species into groups with similar ecological requirements but at the same time allows consideration of the needs of individual species.
geographic location	Austria
type of water body	unknown
spatial scale	unknown
temporal scale	unlimited
study design	Information from literature research, collected data for habitat and habitat spawning preference guilds are compared. Prework for a classification scheme is done.
guild information	rheophilic + eurytopic + limnophilic
biotic variables	impoundments, lateral connectivity, degree of rheophily
taxa studied	*Zingel streber, Gobio uranoscopus, Chondrostoma nasus, Barbus barbus, Thymallus thymallus, Rutilus pigus, Neogobius kessleri, Hucho hucho, Leuciscus souffia, Huso huso, Acipenser stellatus, Acipenser güldenstaedti, Alburnoides bipunctatus, Gobio albipinatus, Barbus peloponnesius, Gobio gobio, Barbatula barbatula, Salmo trutta fario, Salvelinus fontinalis, Cottus gobio, Vimba vimba, Abramis sapa, Acipenser ruthenus, Acipenser nudiventris, Zingel zingel, Gymnocephalus schraetzer, Cobitis auratus, Cobitis taenia, Abramis ballerus, Aspius aspius, Ctenopharyngodon idella, Leuciscus leuciscus, Oncorhynchus mykiss, Alburnus alburnus, Abramis brama, Rutilus rutilus, Perca fluviatilis, Hypophtalmichtys molitrix, Hypophtalmichtys nobilis, Phoxinus phoxinus, Pseudroraspora parva, Abramis bjoerkna, Leuciscus idus, Sander lucioperca, Gymnocephalus cernuus, Sander volgensis, Leuciscus cephalus, Lota lota, Silurus glanis, Anguilla anguilla, Proterorhinus marmoratus, Neogobius kessleri, Gymnocephalus baloni, Pelecus cultratus, Cyrpinus carpio, Carassius gibelio, Esox lucius, Scardinius erythrophthalmus, Carassius carassius, Rhodeus sericeus, Leucaspius delineatus, Tinca tinca, Gasterosteus aculeatus, Pungitis pungitis, Umbra krameri, Misgrunus fossilis*
statistics	none
other modalities concerned	rheopar, limnopar, eurypar

guild	habitat
paper	Spindler 1997
type of paper	report
summary	The present fish study is the first Austrian-wide analysis of the state of the most endangered groups of species. Apart from listing of all Austria's fish species (native, exoctic and extinct), their distribution and ecological characteristics, the extent to which and why they are endangered as well as fishery and the laws related to fishing are discussed in detail. The major threats to the survival of the indigenous fish fauna are anthropogenic changes in their habitats. As fish are extremely sensitive to environmental impacts of various kinds, they are increasingly used as bioindicators.
geographic location	Austria
type of water body	any
spatial scale	unknown
temporal scale	unlimited
study design	Analysis of endangerment, life traits and commercial use of fish species based on literature and expert judgement is discussed.
guild information	eurytopic + limnophilic
biotic variables	pollution, habitat degradation, guilds, fishery
taxa studied	*Zingel streber, Gobio uranoscopus, Chondrostoma nasus, Barbus barbus, Thymallus thymallus, Rutilus pigus, Neogobius kessleri, Hucho hucho, Leuciscus souffia, Huso huso, Acipenser stellatus, Acipenser güldenstaedti, Alburnoides bipunctatus, Gobio albipinatus, Barbus peloponnesius, Gobio gobio, Barbatula barbatula, Salmo trutta fario, Salvelinus fontinalis, Cottus gobio, Vimba vimba, Abramis sapa, Acipenser ruthenus, Acipenser nudiventris, Zingel zingel, Gymnocephalus schraetzer, Cobitis auratus, Cobitis taenia, Abramis ballerus, Aspius aspius, Ctenopharyngodon idella, Leuciscus leuciscus, Oncorhynchus mykiss, Alburnus alburnus, Abramis brama, Rutilus rutilus, Perca fluviatilis, Hypophtalmichtys molitrix, Hypophtalmichtys nobilis, Phoxinus phoxinus, Pseudroraspora parva, Abramis bjoerkna, Leuciscus idus, Sander lucioperca, Gymnocephalus cernuus, Sander volgensis, Leuciscus cephalus, Lota lota, Silurus glanis, Anguilla anguilla, Proterorhinus marmoratus, Neogobius kessleri, Gymnocephalus baloni, Pelecus cultratus, Cyrpinus carpio, Carassius gibelio, Esox lucius, Scardinius erythrophthalmus, Carassius carassius, Rhodeus sericeus, Leucaspius delineatus, Tinca tinca, Gasterosteus aculeatus, Pungitis pungitis, Umbra krameri, Misgrunus fossilis, Barbus petenyi, Salvelinus umbla, Salvelinus namaycush, Lampetra planeri, Eudontomyzon mariae*
statistics	none
other modalities concerned	benthic, omnivorous, planktivorous, pelagophilic, psamnophilic

guild	habitat
paper	Godinho & Ferreira 1998
type of paper	theoretical
summary	The spatial variation in the native fish assemblage was related to biotic parametersThe best predictors were chosen and three species-size combinations were selected from the eight considered: *Micropterus salmoides, Lepomis gibbosus* and *Gambusia holbrooki*. The total variation in the native fish assemblage was partitioned into the following components: pure environmental, pure biotic, shared and unexplained. There was a significant influence of exotic fish on the native assemblage after taking in account the effects of environmental factors.
geographic location	Iberia – river Guadiana
type of water body	river and its tributaries
spatial scale	unknown
temporal scale	2 months
study design	The best predictors among the environmental and biotic variables were chosen and the total variation in native species abundances was portioned into that accounted for (1) only by selected environmental variables, (2) only by selected biotic variables, (3) by both environmental and biotic variables, and (4) unexplained. Of the 22 variables initially considered in the environmental CCA, only two dummy variables, substrate heterogeneity, and abundance of macrobenthos were selected as best predictors.
guild information	limnophilic
biotic variables	invasive species, substrate heterogeneity, makrophytes, makroinvertebrates
taxa studied	*Micropterus salmoides, Lepomis gibbosus, Gambusia holbrooki*
statistics	CCA, Monte Carlo simulation test
other modalities concerned	none

5.3.3 Feeding habitat

guild	feeding habitat
paper	Winkelmann et al. 2007
type of paper	study report
summary	The question posed is, wheter drift activity of invertebrates is reduced by benthivorous fish species. The presence of benthivorous fish reduces the nocturnal drift of the larvae of the mayfly *Baetis rhodani* while total invertebrate drift was not reduced. Although there was a similar benthic community composition at both reaches, drift composition differed significantly between reaches. As a conclusion, invertebrate drift is not always a mechanism of active escape from fish predators in natural streams, especially when benthos-feeding fish are present.
geographic location	Germany - Gauernitzbach
type of water body	second-order tributary
spatial scale	800 m
temporal scale	3 years
study design	An almost fishless reference reach was compared with a reach stocked with gudgeon and loach, and density and structure of the invertebrate communities in the benthos and in the drift were quantified in both reaches.
guild information	benthic
biotic variables	invertebrates, organism drift, top-down control
taxa studied	*Gobio gobio, Barbatula barbatula*
statistics	ANOVA, NMDS, ANOSIM, SIMPER ordination, exploratory data analysis
other modalities concerned	none

guild	feeding habitat
paper	Spindler 1997
type of paper	report
summary	The present fish study is the first Austrian-wide analysis of the state of the most endangered groups of species. Apart from listing of all Austria's fish species (native, exoctic and extinct), their distribution and ecological characteristics, the extent to which and why they are endangered as well as fishery and the laws related to fishing are discussed in detail. The major threats to the survival of the indigenous fish fauna are anthropogenic changes in their habitats. As fish are extremely sensitive to environmental impacts of various kinds, they are increasingly used as bioindicators. Apart from a comprehensive faunistic-ecological part of the study, great emphasis is laid on fishery in Austria.
geographic location	Austria
type of water body	any
spatial scale	unknown
temporal scale	unlimited
study design	Analysis of endangerment, life traits and commercial use of fish species based on literature and expert judgement is discussed.
guild information	benthic
biotic variables	pollution, habitat degradation, guilds, fishery
taxa studied	*Zingel streber, Gobio uranoscopus, Chondrostoma nasus, Barbus barbus, Thymallus thymallus, Rutilus pigus, Neogobius kessleri, Hucho hucho, Leuciscus souffia, Huso huso, Acipenser stellatus, Acipenser güldenstaedti, Alburnoides bipunctatus, Gobio albipinatus, Barbus peloponnesius, Gobio gobio, Barbatula barbatula, Salmo trutta fario, Salvelinus fontinalis, Cottus gobio, Vimba vimba, Abramis sapa, Acipenser ruthenus, Acipenser nudiventris, Zingel zingel, Gymnocephalus schraetzer, Cobitis auratus, Cobitis taenia, Abramis ballerus, Aspius aspius, Ctenopharyngodon idella, Leuciscus leuciscus, Oncorhynchus mykiss, Alburnus alburnus, Abramis brama, Rutilus rutilus, Perca fluviatilis, Hypophtalmichtys molitrix, Hypophtalmichtys nobilis, Phoxinus phoxinus, Pseudroraspora parva, Abramis bjoerkna, Leuciscus idus, Sander lucioperca, Gymnocephalus cernuus, Sander volgensis, Leuciscus cephalus, Lota lota, Silurus glanis, Anguilla anguilla, Proterorhinus marmoratus, Neogobius kessleri, Gymnocephalus baloni, Pelecus cultratus, Cyrpinus carpio, Carassius gibelio, Esox lucius, Scardinius erythrophthalmus, Carassius carassius, Rhodeus sericeus, Leucaspius delineatus, Tinca tinca, Gasterosteus aculeatus, Pungitis pungitis, Umbra krameri, Misgrunus fossilis, Barbus petenyi, Salvelinus umbla, Salvelinus namaycush, Lampetra planeri, Eudontomyzon mariae*
statistics	none
other modalities concerned	eurytopic, limnophilic, omnivorous, planktivorous, pelagophilic, psamnophilic

guild	feeding habitat
paper	Herzig et al. 1994
type of paper	report
summary	A detailed investigation of the fish ecology of the Neusiedler See aimed at defining a management plan for fisheries in compliance with the IUCN. Meeting the criteria for national parks, measures to ensure or even improve the water quality relevant for fish had to be taken. Managed fish as well as mass fish were studied. The trophic interactions and the habitat preference of ecosystem-relevant fishes were described and discussed. Finally a conclusion pinpoints the status quo of fisheries and the causes for changes within the past 25 years. It presents fundamental ideas for the management of fisheries management in accordance with the IUCN-criteria and their realization.
geographic location	Austria – Neusiedler See
type of water body	lake and wetlands
spatial scale	unknown
temporal scale	3 years
study design	Faunistic, semiquantitative (using gill nets) and quantitative data (using an echo sounder) were gathered. Information on abundance, distribution, population structure, reproduction, feeding habits, growth and parasitic infestation was elaborated on. Spawning, abundance, distribution, feeding and growth of juveniles were also studied.
guild information	benthic
biotic variables	guilds, fisheries, juvenile fish, parasitic infestation
taxa studied	*Anguilla anguilla, Sander lucioperca, Cyprinus carpio, Pelecus cultratus, Alburnus alburnus, Abramis bjoerkna, Abramis brama, Scardinius erythrophthalmus, Rutilus rutilus, Carassius auratus, Gymnocephalus cernuus, Esox lucius, Aspius aspius, Perca fluviatilis, Lepomis gibbosus, Ameiurus melas, Umbra krameri, Misgurnus fossilis, Rhodeus sericeus, Cobitis taenia, Abramis ballerus, Barbus barbus, Carassius gibelio, Ctenophyaryngodon idella, Gobio gobio, Hypophthalmichthys molitrix, Leucaspius delineatus, Leuciscus cephalus, Leuciscus idus, Tinca tinca, Barbatula barbatula, Silurus glanis, Protherorinus marmoratus, Gymnocephalus cernuus, Perca fluviatilis, Sander lucioperca*
statistics	regression
other modalities concerned	piscivorous, herbivorous, planktivorous

guild	feeding habitat

paper	Zambrano *et al*. 2006
type of paper	monitoring study
summary	In this paper the relationship between fish assemblage structure and other ecosystem characteristics in 28 shallow lakes, through the classification of fish species into feeding guilds according to the literature, was determined. Results showed that there was a striking lack of relationship between nutrients and other variables, indicating the importance of topdown rather than bottom-up processes as a structuring force in the generally eutrophic study lakes. The presence of submerged (and shoreline) vegetation was associated with a diverse assemblage of apparently coexisting piscivorous and zooplanktivorous species. The introduction of large benthivores to many study lakes could have precipitated a loss of submerged vegetation through direct uprooting during foraging, with the effect of simplifying the fish assemblage. This was most acute where littoral vegetation was limited by other anthropogenic factors. Promotion or restoration of submerged vegetation in these lakes is recommended and would best target species that use the benthic feeding habitat.
geographic location	eastern England
type of water body	lakes
spatial scale	~ 160 ha
temporal scale	unknown
study design	Both the limnetic and littoral zones were point-abundance sampled by electrofishing. Water chemistry, transparency, chlorophyll-a and zooplankton composition were determined. Fish were classified into 6 different feeding guilds. CCA was used to determine the relationships between the biomass of the fish guilds and selected environmental and trophic level variables.
guild information	benthic
biotic variables	trophic guilds, nutrient level, phytoplankton, zooplankton, benthic feeding habitat
taxa studied	*Anguilla anguilla, Gobio gobio, Rutilus rutilus, Scardinius erythrophthalmus, Gasterosteus aculeatus, Gymnocephalus cernuus, Esox lucius, Perca fluviatilis, Cyprinus carpio, Abramis brama, Tinca tinca*
statistics	Shannon-Wiener index, CCA, Cook's distance test, QQ plots
other modalities concerned	stenothermal, insectivorous, omnivorous, piscivorous, planktivorous

guild	feeding habitat
paper	Klemetsen et al. 2006
type of paper	experimental study
summary	The Arctic char shows resource polymorphism in postglacial lakes. In a subarctic lake two reproductively isolated morphs of the Arctic char are coexisting in distinct ecological niches. The littoral morph is more effective in feeding on live plankton, like Daphnia and littoral plankton and has a higher attack rate against pleuston compared to the profundal morph. The two morphs behave in accordance to the expectations with regard to their in situ niche utilisation and its connection to the three prey types. This indicates a case of incipient ecological specification where divergence in resource utilisation in contrasting niches has led to adaptations in feeding behaviour on the basis of natural selection.
geographic location	North Norway
type of water body	postglacial lake
spatial scale	unknown
temporal scale	unknown
study design	The offsprings of the two morphs were reared separately but under identical conditions. Their feeding behaviour was compared experimentally using different kinds of live prey.
significant guild information	benthic
biotic variables	zooplankton, feeding behaviour, littoral, benthos
taxa studied	*Anguilla anguilla, Gobio gobio, Rutilus rutilus, Scardinius erythrophthalmus, Gasterosteus aculeatus, Gymnocephalus cernuus, Esox lucius, Perca fluviatilis, Cyprinus carpio, Abramis brama, Tinca tinca*
statistics	chi-squared test
other guild modalities concerned	planktivorous

guild	feeding habitat
paper	Lafaille et al. 2002
type of paper	study report
summary	Juveniles and adults of *Liza ramada* colonize macrotidal salt marsh creeks of Mont Saint-Michel bay between March and November. This takes place during spring tide floods. They return to coastal waters during the ebb. This fish species actively feeds during its short stay in the creek (from 1 to 2 h). On average, each fish swallows sediment including living and inert organic matter, which makes up about 8% of its fresh body weight. Their diet is dominated by small benthic items (especially diatoms and salt marsh plant detritus) that correspond to the primary and detritic production of this macrotidal salt marsh creek. Despite very short submersion periods mullets filter and ingest large quantities of sediment. They concentrate and assimilate organic matter produced by the coastal wetlands, which therefore act as important feeding areas for *Liza ramada* and other species.
geographic location	France – Mont Saint-Michel bay
type of water body	marsh
spatial scale	~ 8 km²
temporal scale	12 months
study design	Individuals of *Liza ramada* were sampled during high spring tides. The digestive tract and gonads of each mullet were extracted and weighted. The percentage of organic matter was determined.
guild information	benthic
biotic variables	diet, benthivorous feeding, salt marshes
taxa studied	*Liza ramada*
statistics	ANCOVA, Tukey's multiple range test,
other modalities concerned	none

guild	feeding habitat
paper	Langston *et al*. 2002
type of paper	study report
summary	The purpose of the study was to examine the role of metallothioein in the detoxification and regulation of metals in the livers of eels by monitoring hepatic levels. Hepatic metallothioein concentrations were highly correlated with metal pollution notably reflecting Cu and Ag enrichment. Thus, despite causing induction of metallothioein , excess bioavailable Cu, Ag and Cd appear to be successfully detoxified in eels no matter how intense the environmental contamination is. Therefore, determination of hepatic MT (and associated metals) in eels could be useful for monitoring responses to metal exposure and environmental quality on a much broader basis.
geographic location	England
type of water body	estuary
spatial scale	100 km
temporal scale	6 months
study design	measurement and correlation of hepatic metallothioein levels and estuarine metal concentrations
guild information	benthic
biotic variables	bioavailability, pollution, adaption
taxa studied	*Anguilla anguilla*
statistics	ANOVA
other modalities concerned	planktivorous, tolerant + intermediately tolerant to toxic contamination

guild	feeding habitat
paper	Torras et al. 2000
type of paper	experimental study
summary	Flathead grey mullet were long considered to feed primarily on detritus. However, recent research has examined that they feed a lot on plankton and that they have a detrimental effect on pond zooplankton and large phytoplankton, whilst enhancing the distribution of small phytoplankton. It is suggested that flathead grey mullet may also increase the internal phosphorus loading of the ecosystem, which would also increase the phytoplankton density. In the presence of flathead grey mullets, the abundance of cladocerans, ostracods and chironomid larvae decreased compared to the control tanks, while there were more small phytoplankton and mud snails. The green algae *Cladophora* sp. did not occur at all. The presence of a mechanical filter also reduced cladoceran, ostracod and chironomid densities and increased phtyoplankton and mud snail density. The organic matter content of the sediment decreased throughout the experiment in the control and filter tanks, but remained stable in the fish tanks. Phosphorus and nitrogen concentrations were not affected by any treatment. These results showed that flathead grey mullet enhanced phytoplankton development due to the removal of large cladocerans and not as a consequence of nutrient release. Furthermore, the flathead grey mullet strongly modified the benthic community, probably due to direct predation.
geographic location	Spain - Barcelona
type of water body	pond
spatial scale	unknown
temporal scale	35 days
study design	Three treatments were compared: 1. fish absence, 2. presence of an air-lift connected to a mechanical filter with a mesh-size of 60 μm and 3. fish presence at a density of 243 g m^{-3}. After a 10-day incubation period, nine grey mullets were added to three randomly selected tanks, three in each. Three other randomly selected tanks served as control and the other three were supplied with the above mentioned mechanical filters. After 35 days algae and zooplankton as well as makroinvertebrates were examined and weighted.
guild information	benthic
biotic variables	macroinvertebrates, zooplankton, phytoplankton, phosporus
taxa studied	*Mugil cephalus*
statistics	ANOVA, Tukey's test
other modalities concerned	detritivorous

5.3.4 Adult trophic guilds

guild	adult trophic guild
paper	Almeida 2003
type of paper	study report
summary	The study examines the feeding activity of a *Liza ramada* population inhabiting the Mira estuary (Portugal) which is reduced during the winter and summer months. At the beginning of the spawning migration (i.e. November) an increase in the amount of food ingested was noticed. In the upper estuary, the feeding behaviour is independent of the tidal cycle, although there is some evidence of a daily rhythm in the food consumption rate, with a reduction during the night. No significant correlation was found between the quantity of particulate organic matter and the concentration of microalgae present in the stomach contents. It seems that the bulk of the organic matter ingested by the thin-lipped grey mullets comes from a different origin than plankton or benthic microalgae. The *Liza ramada* population selected sediment particles between 55 and 250 µm in diameter. In general, the diet composition of this species showed a low diversity of food items. A total of 52 food items were identified in the stomach contents with the Bacillariophyceae being the dominant group. The genera Melosira and Ciclotella were the most common and abundant food items, although the genera Navicula, Nitzschia and Surirella were also classified.
geographic location	Portugal – river Mira
type of water body	estuary
spatial scale	unknown
temporal scale	13 months
study design	Fish were sampled and the percentages of organic matter in the stomach contents were determined. The identification of the food items present in the stomach contents and the determination of the percentage of particulate organic matter, the fullness index, the vacuity index, the frequency of occurrence and the numerical frequency of each food item were done. To determine if the thin-lipped grey mullets selected a specific particle size, the granulometric composition of the intertidal sediment was also measured. The daily amount of sediment ingested by the mullets was determined using an adaptation of a mathematical consumption model.
guild information	detritivorous
biotic variables	algae, sediment, percentage of organic matter
taxa studied	*Liza ramada*
statistics	Spearman correlation, Shorygin similarity index, Kruskal Wallis test
other modalities concerned	none

guild	adult trophic guild
paper	Torras et al. 2000
type of paper	experimental study
summary	Flathead grey mullet were long considered to feed primarily on detritus. However, recent research has examined that they feed a lot on plankton. It is suggested that flathead grey mullet may also increase the internal phosphorus loading of the ecosystem, which would also increase the phytoplankton density. For testing fish-less tanks, tanks with a 60 μm mesh filter and tanks stocked at a fish density of 243 g m^{-3} were compared. In the presence of flathead grey mullets, the abundance of cladocerans, ostracods and chironomid larvae decreased compared to the control tanks, while there were more small phytoplankton and mud snails. The green algae *Cladophora* sp. did not occur at all. The presence of a mechanical filter also reduced cladoceran, ostracod and chironomid densities and increased phtyoplankton and mud snail density. Phosphorus and nitrogen concentrations were not affected by any treatment. These results showed that flathead grey mullet enhanced phytoplankton development due to the removal of large cladocerans and not as a consequence of nutrient release. Furthermore, the flathead grey mullet strongly modified the benthic community, probably due to direct predation.
geographic location	Spain - Barcelona
type of water body	pond
spatial scale	unknown
temporal scale	35 days
study design	Three treatments were compared: 1. fish absence, 2. presence of an air-lift connected to a mechanical filter with a mesh-size of 60 μm and 3. fish presence at a density of 243 g m^{-3}. After a 10-day incubation period, nine grey mullets were added to three randomly selected tanks, three in each. After 35 days algae and zooplankton as well as makroinvertebrates were examined and weighted.
guild information	detritivorous
biotic variables	macroinvertebrates, zooplankton, phytoplankton, phosporus
taxa studied	*Mugil cephalus*
statistics	ANOVA, Tukey's test
other modalities concerned	benthic

guild	adult trophic guild
paper	Herzig et al. 1994
type of paper	report
summary	A detailed investigation of the fish ecology of the Neusiedler See aimed at defining a management plan for fisheries in compliance with the IUCN. Meeting the criteria for national parks, measures to ensure or even improve the water quality relevant for fish had to be taken. The trophic interactions and the habitat preference of ecosystem-relevant fishes were described and discussed. Finally a conclusion pinpoints the status quo of fisheries and the causes for changes within the past 25 years. It presents fundamental ideas for the management of fisheries management in accordance with the IUCN-criteria and their realization.
geographic location	Austria
type of water body	lake and wetlands
spatial scale	unknown
temporal scale	3 years
study design	Faunistic, semiquantitative (using gill nets) and quantitative data (using an echo sounder) were gathered. Information on abundance, distribution, population structure, reproduction, feeding habits, growth and parasitic infestation was elaborated on. Spawning, abundance, distribution, feeding and growth of juveniles were also studied.
guild information	herbivorous, piscivorous, planktivorous
biotic variables	guilds, fisheries, juvenile fish, parasitic infestation
taxa studied	*Anguilla anguilla, Sander lucioperca, Cyprinus carpio, Pelecus cultratus, Alburnus alburnus, Abramis bjoerkna, Abramis brama, Scardinius erythrophthalmus, Rutilus rutilus, Carassius auratus, Gymnocephalus cernuus, Esox lucius, Aspius aspius, Perca fluviatilis, Lepomis gibbosus, Ameiurus melas, Umbra krameri, Misgurnus fossilis, Rhodeus sericeus, Cobitis taenia, Abramis ballerus, Barbus barbus, Carassius gibelio, Ctenophyaryngodon idella, Gobio gobio, Hypophthalmichthys molitrix, Leucaspius delineatus, Leuciscus cephalus, Leuciscus idus, Tinca tinca, Barbatula barbatula, Silurus glanis, Protherorinus marmoratus, Gymnocephalus cernuus, Perca fluviatilis, Sander lucioperca*
statistics	regression
other modalities concerned	benthic

guild	adult trophic guild
paper	Zambrano *et al*. 2006
type of paper	monitoring study
summary	In this paper the relationship between fish assemblage structure and other ecosystem characteristics in 28 shallow lakes, through the classification of fish species into feeding guilds according to the literature, was determined. Results showed that there was a striking lack of relationship between nutrients and other variables, indicating the importance of topdown rather than bottom-up processes as a structuring force in the generally eutrophic study lakes. The presence of submerged (and shoreline) vegetation was associated with a diverse assemblage of apparently coexisting piscivorous and zooplanktivorous species. The introduction of large benthivores to many study lakes could have precipitated a loss of submerged vegetation through direct uprooting during foraging, with the effect of simplifying the fish assemblage. This was most acute where littoral vegetation was limited by other anthropogenic factors. Promotion or restoration of submerged vegetation in these lakes is recommended and would best target species that use the benthic feeding habitat.
geographic location	eastern England
type of water body	lakes
spatial scale	~ 160 ha
temporal scale	unknown
study design	Both the limnetic and littoral zones were point-abundance sampled by electrofishing. Water chemistry, transparency, chlorophyll-a and zooplankton composition were determined. Fish were classified into 6 different feeding guilds. CCA was used to determine the relationships between the biomass of the fish guilds and selected environmental and trophic level variables.
guild information	insectivorous, omnivorous, piscivorous, planktivorous
biotic variables	trophic guilds, nutrient level, phytoplankton, zooplankton, benthic feeding habitat
taxa studied	*Anguilla anguilla, Gobio gobio, Rutilus rutilus, Scardinius erythrophthalmus, Gasterosteus aculeatus, Gymnocephalus cernuus, Esox lucius, Perca fluviatilis, Cyprinus carpio, Abramis brama, Tinca tinca*
statistics	Shannon-Wiener index, CCA, Cook's distance test, QQ plots
other modalities concerned	benthic, stenothermal

guild	adult trophic guild
paper	Spindler 1997
type of paper	report
summary	The present fish study is the first Austrian-wide analysis of the state of the most endangered groups of species. Apart from listing of all Austria's fish species (native, exoctic and extinct), their distribution and ecological characteristics, the extent to which and why they are endangered as well as fishery and the laws related to fishing are discussed in detail. 46 fishes, i.e. about 72 %, are already on the list of endangered species. 9 species are on the verge of extinction, 7 are strongly endangered, 11 vulnerable, 6 potentially endangered, 6 species not exactly definable and the survival of 2 further species is uncertain.The major threats to the survival of the indigenous fish fauna are anthropogenic changes in their habitats. As fish are extremely sensitive to environmental impacts of various kinds, they are increasingly used as bioindicators. Apart from a comprehensive faunistic-ecological part of the study, great emphasis is laid on fishery in Austria.
geographic location	Austria
type of water body	any
spatial scale	unknown
temporal scale	unlimited
study design	Analysis of endangerment, life traits and commercial use of fish species based on literature and expert judgement is discussed.
significant guild information	omnivorous, planktivorous
biotic variables	pollution, habitat degradation, guilds, fishery
taxa studied	*Zingel streber, Gobio uranoscopus, Chondrostoma nasus, Barbus barbus, Thymallus thymallus, Rutilus pigus, Neogobius kessleri, Hucho hucho, Leuciscus souffia, Huso huso, Acipenser stellatus, Acipenser güldenstaedti, Alburnoides bipunctatus, Gobio albipinatus, Barbus peloponnesius, Gobio gobio, Barbatula barbatula, Salmo trutta fario, Salvelinus fontinalis, Cottus gobio, Vimba vimba, Abramis sapa, Acipenser ruthenus, Acipenser nudiventris, Zingel zingel, Gymnocephalus schraetzer, Cobitis auratus, Cobitis taenia, Abramis ballerus, Aspius aspius, Ctenopharyngodon idella, Leuciscus leuciscus, Oncorhynchus mykiss, Alburnus alburnus, Abramis brama, Rutilus rutilus, Perca fluviatilis, Hypophtalmichtys molitrix, Hypophtalmichtys nobilis, Phoxinus phoxinus, Pseudroraspora parva, Abramis bjoerkna, Leuciscus idus, Sander lucioperca, Gymnocephalus cernuus, Sander volgensis, Leuciscus cephalus, Lota lota, Silurus glanis, Anguilla anguilla, Proterorhinus marmoratus, Neogobius kessleri, Gymnocephalus baloni, Pelecus cultratus, Cyrpinus carpio, Carassius gibelio, Esox lucius, Scardinius erythrophthalmus, Carassius carassius, Rhodeus sericeus, Leucaspius delineatus, Tinca tinca, Gasterosteus aculeatus, Pungitis pungitis, Umbra krameri, Misgrunus fossilis, Barbus petenyi, Salvelinus umbla, Salvelinus namaycush, Lampetra planeri, Eudontomyzon mariae*
statistics	none
other guild modalities concerned	benthic, pelagophilic, psamnophilic, eurytopic, limnophilic

guild	adult trophic guild
paper	Robalo et al. 2003
type of paper	experimental study
summary	In this paper it is for the first time described how and where agonistic behaviour of *Chondrostoma polylepis* occurs in captivity. In this species agonistic behaviour was present in adults of both sexes and juveniles, during spring and summer, as well as after the end of the breeding season. Qualitative observations revealed the presence of a similar pattern of agonistic behaviour in *Chondrostoma duriensis*. Despite intense observation, no signs of agonistic behaviour were detected in three other *Chondrostoma* species of the same geographical area, *C. macrolepidotus, C. lemmingii* and *C. lusitanicum*. The agonistic behaviour in *C. polylepis* and *C. duriensis* may be functionally linked to their feeding ecology.
geographic location	Portugal – river Tagus
type of water body	river
spatial scale	labratory
temporal scale	3 year
study design	A group of 30 juveniles of *C. polylepis*, bred in captivity, originated from a population of the Tagus basin, were kept in an aquarium. The 600 L tank was illuminated 8 h per day and was equipped with biological filters. The bottom of the tank was covered with a layer of sand and several large flat stones, and enriched with some aquatic plants. Fishes were fed with *Artemia* sp. and red chironomid larvae. The behaviour of the fishes towards each other was observed. A fish was classified as a " loser" of an encounter if at the end of the interaction it withdrew or fled from the opponent, or was threatened or attacked without retaliation. When both fishes withdrew without an apparent asymmetry, the outcome was classified as inconclusive.
guild information	omnivorous
biotic variables	agonistic behaviour, aggression, food defence, feeding ecology
taxa studied	*Chondrostoma duriensis, Chondrostoma macrolepidotus, Chondrostoma lemmingii, Chondrostoma lusitanicum, Chondrostoma polylepis*
statistics	none
other modalities concerned	none

guild	adult trophic guild
paper	Smith et al. 2006
type of paper	review
summary	Because the European bitterling uses a discrete spawning site (gills of freshwater mussels) that can be readily manipulated they represent an ideal model for linking reproductive decisions with population dynamics. In this paper male mating tactics, female mate and oviposition decisions and aggressive competition among juveniles are presented and may have significant impact on the bitterling population size and population genetics.
geographic location	unknown
type of water body	unknown
spatial scale	unknown
temporal scale	unknown
study design	Revision of the research on the behaviour of the European bitterling and its population dynamics using a combination of field, mesocosm, and aquarium experiments, in combination with population and genetic studies and modelling.
guild information	piscivorous
biotic variables	reproductive guild, selection, population dynamics
taxa studied	*Rodeus sericeus*
statistics	none
other modalities concerned	ostracophilic

guild	adult trophic guild
paper	Langston et al. 2002
type of paper	study report
summary	The purpose of the study was to examine the role of metallothioein in the detoxification and regulation of metals in the livers of eels by monitoring hepatic levels. Hepatic metallothioein concentrations were highly correlated with metal pollution notably reflecting Cu and Ag enrichment. Thus, despite causing induction of metallothioein , excess bioavailable Cu, Ag and Cd appear to be successfully detoxified in eels no matter how intense the environmental contamination is. Therefore, determination of hepatic MT (and associated metals) in eels could be useful for monitoring responses to metal exposure and environmental quality on a much broader basis.
geographic location	England
type of water body	estuary
spatial scale	100 km
temporal scale	6 months
study design	measurement and correlation of hepatic metallothioein levels and estuarine metal concentrations
guild information	planktivorous
biotic variables	bioavailability, pollution, adaption
taxa studied	*Anguilla anguilla*
statistics	ANOVA
other modalities concerned	tolerant + intermediately tolerant to toxic contaminatin, planktivorous, benthic

guild	adult trophic guild
paper	Alajärvi & Horppila 2004
type of paper	study report
summary	The variations in the vertical migration of zooplankton and food composition of fish in the shallow clay-turbid Mustionselkä basin of lake Hiidenvesi were studied. Daphnids showed signs of reverse migration, their density in the surface layer being highest during the day. The reverse migration was probably due to predation threat by the predatory cladoceran *Leptodora kindtii*. *Chydorus sphaericus*, which was consumed especially by the day active bleak (*Alburnus alburnus*), showed normal vertical migration. Copepods showed no clear vertical movements. *Leptodora kindtii* and the large herbivore *Limnosida frontosa* did not migrate vertically but their abundance increased considerably during the night, indicating horizontal movement towards the open water at night. Due to the shallowness of the water, vertical migration may not be a good predator-avoidance strategy for the largest cladoceran. They, instead, may perform horizontal migration.
geographic location	southwestern Finland - lake Hiidenvesi
type of water body	lake
spatial scale	unknown
temporal scale	4 days
study design	Zooplankton samples were collected with plankton net hauls from every 0.5 m layer down to 3 m depth. Thirty individuals from each taxon were measured. Water temperature, concentration of dissolved oxygen and light attenuation were measured. Fish for diet analysis were collected by trawling. To clarify the possible diurnal changes of the foraging behaviour of fish, the electivity index of smelt and bleak for different zooplankton taxa were calculated for both day and night samples.
guild information	planktivorous
biotic variables	migration, zooplankton, predation
taxa studied	*Osmerus eperlanus, Alburnus alburnus, Blicca bjoerkna, Abramis brama, Perca fluviatilis, Gymnocephalus cernuus*
statistics	t-test, Bonferroni t-test
other modalities concerned	none

guild	adult trophic guild
paper	Klemetsen et al. 2006
type of paper	experimental study
summary	The Arctic char shows resource polymorphism in postglacial lakes. In a subarctic lake two reproductively isolated morphs of the Arctic char are coexisting in distinct ecological niches. The littoral morph is more effective in feeding on live plankton, like Daphnia and littoral plankton and has a higher attack rate against pleuston compared to the profundal morph. The two morphs behav in accordance to the expectations with regard to their in situ niche utilisation and its connection to the three prey types. This indicates a case of incipient ecological specification where divergence in resource utilisation in contrasting niches has led to adaptions in feeding behaviour on the basis of natural selection.
geographic location	North Norway
type of water body	postglacial lake
spatial scale	unknown
temporal scale	unknown
study design	The offsprings of the two morphs were reared separately but under identical conditions. Their feeding behaviour was compared experimentally using different kinds of live prey.
guild information	planktivorous
biotic variables	zooplankton, feeding behaviour, littoral, benthos
taxa studied	*Anguilla anguilla, Gobio gobio, Rutilus rutilus, Scardinius erythrophthalmus, Gasterosteus aculeatus, Gymnocephalus cernuus, Esox lucius, Perca fluviatilis, Cyprinus carpio, Abramis brama, Tinca tinca*
statistics	chi-squared test
other modalities concerned	benthic

guild	adult trophic guild
paper	Vinyoles et al. 2007
type of paper	study report
summary	Since its first record in a tributary of the Ebro basin in 1992, the bleak *Alburnus alburnus* has spread to almost the whole Iberian peninsula. In this paper information is provided on the expansion of the bleak. The current distribution in the Ebro basin and the rivers of the eastern Pyrenees is detailed and its presence in three other major Iberian drainages reported. As the bleak is sympatric with 15 Iberian endemic species (58% of total Iberian endemic fish) possible threats to the Iberian ichthyofauna are discussed. The factors that promoted the extremely rapid expansion of this exotic cyprinid are examined, focusing on the role of reservoirs, which seem to favour its dispersal.
geographic location	Iberia
type of water body	rivers and drainages
spatial scale	unknown
temporal scale	5 years
study design	Based on electrofishing surveys in 598 localities, dispersal of the bleak was demonstrated. To test the hypothesis that reservoirs promote the dispersal of the bleak, the distance (≤ 50 km) between locations where the bleak was found and the nearest dam was recorded. The position of the dam (upstream or downstream of the bleak site) was also recorded. In three cases where bleak sites were located between two dams at distances smaller than 50 km, the distance to each dam was recorded separately. Five tests of distribution fitting were performed to determine distribution types.
guild information	planktivorous
biotic variables	exotic vs. endemic species, reservoirs
taxa studied	*Alburnus alburnus, Anaecypris hispanica, Lampetra planeri, Salmo trutta, Achondrostoma arcasii, Achondrostoma oligolepsis, Barbus bocagei, Barbus comizo, Barbus graellsii, Barbus guiraonis, Barbus haasi, Barbus meridionalis, Barbus microcephalus, Barbus scalteri, Barbus steindachneri, Gobio lozanoi, Iberochondrostoma lemmingii, Iberochondrostoma lusitanicum, Parachondrostoma arrigonis, Parachondrostoma miegii, Parachondrostoma turiense, Phoxinus phoxinus, Pseudochondrostoma duriense, Pseudochondrostoma polylepis, Pseudochondrostoma wilkommii, Squalis alburnoides, Squalis carolitertii, Squalis cephalus, Squalis palaciosi, Squalis pyrenaicus, Tinca tinca, Cobitis calderoni, Cobitis paludica, Barbatula barbatula, Gasterosteus gymnurus, Salaria fluviatilis*
statistics	Kolmogorov-Smirnov test, Mann-Whitney U-test
other modalities concerned	none

guild	adult trophic guild
paper	Vašek & Kubečka 2004
type of paper	study report
summary	The diel feeding patterns of subadult and adult cyprinids of three species (roach *Rutilus rutilus*, bream *Abramis brama* and bleak *Alburnus alburnus*), which foraged almost exclusively on microcrustacean plankton, were studied in a meso-eutrophic reservoir. All cyprinids showed a daytime feeding periodicity with a marked night-time decline in gut fullness. Diel variations in gut fullness were observed in roach and bream during may and in bleak, roach and bream during august. The results corroborate other studies in which light intensity was considered to be an important factor affecting cyprinid foraging on zooplankton.
geographic location	Czech Republic - Římov reservoir
type of water body	reservoir
spatial scale	unknown
temporal scale	4 months
study design	Cyprinids were collected in the open water area of three sites located along the longitudinal axis of the reservoir. A set of eleven monofilament gill nets with different mesh sizes was installed as surface nets throughout a 24-hour period. Water temperature in the open water area was recorded at 0.5 m intervals from surface to 4 m depth twice a day (morning, evening) on each sampling date to obtain mean values for each reservoir site. Epilimnetic zooplankton was sampled simultaneously with fish.
guild information	planktivorous
biotic variables	feeding periodicity, gut fullness, daily food ration, zooplankton
taxa studied	*Abramis brama, Rutilus rutilus, Alburnus alburnus*
statistics	none
other modalities concerned	none

guild	adult trophic guild
paper	Correia et al. 2001
type of paper	study report
summary	There are reported three landlocked populations of *Alosa alosa,* two of them in Portugal. In this paper data on the feeding habits and the state of endangerement of those two populations are presented. Individuals of both populations are zooplanktivorous. Cladocerans and cyclopoid copepods are the preferred prey for juveniles and adults of the Aguieira reservoir while in Castelo do Bode adults feed preferentially on calanoid copepods and cladocerans. Adults from the landlocked population appear to be in a worse constitution than migrating individuals.
geographic location	Portugal – rivers Tagus, Mondego, Zêzere
type of water body	reservoirs and rivers
spatial scale	unknown
temporal scale	1 year
study design	Fish were caught at different sampling sites and their stomach contents were analyzed.
guild information	planktivorous
biotic variables	feeding, migration, constitution, landlocked population
taxa studied	*Alosa alosa*
statistics	Friedman test, Kruskal-Wallis test, Mann-Whitney U test, G-test, Spearman rank-order correlation coefficient
other modalities concerned	none

guild	adult trophic guild
paper	Vinni et al. 2000
type of paper	study report
summary	The food, growth and abundance of five co-existing cyprinid fish species in the eutrophic Lake Hiidenvesi were studied. The diet used in shallow lake basins was compared with that in a deep basin, where littoral resources are less available. Roach, bleak and white bream inhabited both the shallow and the deep parts of the lake. Their growth rate was slow, probably due to the low availability of animal food, indicated by the increasing proportion of detritus and plant material in the diets towards the end of the summer. In the deep basin, roach and bleak, contrary to white bream, did not use the very abundant invertebrate *Chaoborus flavicans* as a food resource what can be explained by the migration behaviour of *C. flavicans*. Blue bream, unlike other cyprinids, utilized copepods and had a relatively fast growth rate but was mostly restricted to the shallow areas. The condition of the bream stock was weak both in terms of growth and abundance. The availability of zoobenthos was low and bream was not able to compete for zooplankton with the more specialized planktivores.
geographic location	unknown
type of water body	lake
spatial scale	south western Finland – lake Hiidenvesi
temporal scale	2 years
study design	The samples of fish for growth determinations were measured and weighted to the nearest gram. The age was determined by using both scales and cleithra. The yearly growth rates were back-calculated and diet analysis was done. All approaches aimed at comparing fish samples from a shallow basin to species inhabiting a deep basin.
guild information	planktivorous
biotic variables	diet composition, invertebrates, shallow and deep habitats in a lake
taxa studied	*Rutilus rutilus, Abramis brama, Abramis bjoerkna, Scardinius erythrophthalmus, Alburnus alburnus, Sander lucioperca*
statistics	Schoener's similarity index
other modalities concerned	none

5.3.5 Migration guild

guild	migration guild
paper	Aarts & Nienhuis 2003
type of paper	theoretical
summary	The paper presents an ecological characerization of fish zones and fish communities in near-natural and in regulated large rivers using guild classifications of several life-history traits of fish and national Red Lists of threatened species. Flow preference and reproduction ecology of river fish are closely linked. The proportion of rehophilic species in the fish community decreases downstream, while the proportions of limnophillic and eurytopic species increase. Lithophilic and psamnophilic spawners are dominant in the upper zones. Whereas the lower zones are dominated by phytophilic and phytolithophilic spawners. The proportion of zoobenthivorous and periphytivorous species decreases downstream, while the proportions of zooplanktivorous and phytivorous species increase. Because of the subsequent over-abundance of the eurytopic species the original longitudinal fish zonations are hardly recognizable anymore in heavily stressed large rivers.
geographic location	France – river Doubs, Netherlands – rivers Rhine and Meuse
type of water body	near-natural and regulated large rivers
spatial scale	unknown
temporal scale	unknown
study design	Literature research of zonation concepts, ecological fish guilds, river fish data sets, and Red List was conducted. Taxonomic composition, composition of flow preference, reproductive and feeding guilds and Red list species were examined for all coverd rivers.
modality information	resident, potamodromous
biotic variables	endangered species, ecological guilds, near-near rivers, regulated rivers
taxa studied	*Abramis brama, Alburnoides bipunctatus, Alburnus alburnus, Barbatula barbatula, Barbus barbus, Abramis bjoerkna, Chondrostoma nasus, Cottus gobio, Cyprinus carpio, Esox lucius, Gobio gobio, Gymnocephylus cernuus, Lepomis gibbosus, Leuciscus cephalus, Leuciscus leuciscus, Phoxinus phoxinus, Rhodeus sericeus, Rutilus rutilus, Salmo trutta, Sander lucioperca, Scardinius erythrophthalmus, Thymallus thymallus, Tinca tinca, Salvelinus fontinalis, Zingel asper, Chondrostoma toxostoma, Leuciscu souffia, Perca fluviatilis, Ameiurus melas, Micropterus salmoides*
statistics	none
other modalities concerned	rheophilic, eurytopic

guild	migration guild
paper	Welcomme et al. 2006
type of paper	theoretical
summary	Neglecting the fact that reliance on a single indicator species would be useful the paper proposes the use of environmental guilds based on common patterns of response by fish species to changes in river flow and geomorphology. A general framework consisting of two upland stream guilds, three lowland lentic guilds, four lowland lotic guilds, two generalist guilds and five estuarine guilds is proposed which aims at describing general trends in fish population and assemblage structure occurring during river development.
geographic location	Europe
type of water body	any
spatial scale	unlimited
temporal scale	unlimited
study design	According to criteria determined (location in river system, migration and movement, reproduction, resistence to anoxia) environmental guilds are created.
guild information	resident, long anadromous, potamodromous
biotic variables	hydrology, reproduction, migration, oxygen level tolerance, pool/riffle, river reaches
taxa studied	*Tinca tinca, Ameiurus melas, Misgurnus fossilis, Salmo salar, Onchorhynchus spp., Rutilus rutilus, Abramis brama, Esox lucius, Cyprinus carpio, Scardinius erythrophthalmus, Rhodeus sericeus, Carassius carassius*
statistics	none
other modalities concerned	ostracophilic, intolerant to habitat degradation, tolerant + intermediately tolerant to low oxygen concentration

guild	migration guild
paper	McDowell 2007
type of paper	theoretical
summary	Amphidromy is a distinctive form of diadromy that involves some fish, decapod crustaceans and gastropod molluscs. Characteristic elements in amphidromy are: reproduction in fresh water, passage to sea by newly hatched larvae, a period of feeding and growing at sea usually a few months long, the return of wellgrown juveniles to freshwater, a further period of feeding and growing in fresh water, followed by reproduction there. This life-history strategy is observed in numerous fish species, primarily of the tropic and subtropic islands and extends to temperate countries as far as Japan in the north and New Zealand in the south. There has been considerable confusion about the nature of amphidromy and its distinctiveness from anadromy, another category of diadromy. The return to freshwater of small juveniles of amphidromous fishes is functionally and strategically different from the return of large mature adults, as happens in anadromy.
geographic location	any
type of water body	any
spatial scale	unlimited
temporal scale	unlimited
study design	Theoretical report on amphidromy
guild information	long catadromous, long anadromous
biotic variables	migration, anadromy, diadromy, amphidromy
taxa studied	*Salmo salar, Acipenser* sp., *Eudontomyzon* sp., *Osmerus perlanus, Alosa alosa*
statistics	none
other modalities concerned	none

guild	migration guild
paper	Schiemer & Waidbacher 1992
type of paper	theoretical
summary	In order to develop guidelines for improved ecological management and the evaluation of a National Park criteria for the structural quality of rivers had to be found. By comparing habitat guild data to habitat types and influences of impoundment five main types of habitat requirement were suggested.
geographic location	Europe
type of water body	stream
spatial scale	350 km
temporal scale	unlimited
study design	Fish catch data were compared to historical data. Habitat types were created and rheophily guilds were divided by their habitat preferences. Effects of impoundments and lateral connections of the Danube on the fish fauna were evaluated by comparing habitat guild data.
guild information	long anadromous
biotic variables	impoundments, lateral connectivity, degree of rheophily
taxa studied	*Tinca tinca, Salmo trutta, Hucho hucho, , Misgurnus fossilis, Salmo salar, Onchorhynchus mykiss, Rutilus rutilus, Abramis brama, Esox lucius, Cyprinus carpio, Scardinius erythrophthalmus, Rhodeus sericeus, Carassius carassius, Thymallus thymallus, Chondrostoma nasus, Barbus barbus, Rutilus pigus, Rutilus frisii, Leuciscus cephalus, Leuciscus leuciscus, Vimba vimba, Phoxinus phoxinus, Gobio kessleri, Gobio albipinatus, Gobio uranoscopus, Noemacheilus barbatulus, Alburnoides bipunctatus, Cottus gobio, Gymnocephalus baloni, Gymnocephylus schräetzer, Zingel zingel, Zingel streber, Leuciscus idus, Abramis sapa, Abramis ballerus, Pelecus cultratus, Aspius aspius, Cobitis taenia, Gobio gobio, Lota lota, Abramis bjoerkna, Carassius gibelio, Perca fluviatilis, Sander lucioperca, Proterorhinus marmoratus, Silurus glanis, Gymnocephylus cernua, Leucaspius delineatus, Carassius carassius, Gasterosteus aculeatus*
statistics	none
other modalities concerned	rheophilic, limnophilic, eurytopic, intolerant to habitat degradation

guild	migration guild
paper	Costa et al. 2001
type of paper	theoretical
summary	The allis shad (*Alosa alosa*) and the twaite shad (*Alosa fallax*) are threatened in most of their geographic area of distribution. They are both anadromous migrating species. Overfishing, pollution, physical barriers and river-bed changes seem to be main reasons for the decline of the two Alosa species. In this report the current status of shade populations in Portugal is discussed and the distribution along the main Portugese watersheds and major threats are presented.
geographic location	Portugal – rivers Tagus, Lima, Douro
type of water body	rivers
spatial scale	unknown
temporal scale	unknwon
study design	The reduction of habitats due to constructin of dams and weirs was estimated and, together with historical data, compared with the fisheries statistics available.
guild information	long anadromous
biotic variables	migration, obstacles, endangerment
taxa studied	*Alosa alosa, Alosa fallax*
statistics	none
other modalities concerned	none

5.3.6 Reproductive guilds

guild	reproductive guild
paper	Balon 1975
type of paper	study
summary	An earlier concept of ecological groups was expanded to cover all living European freshwater fish and based on preferred spawning grounds and on features of reproductive behaviour. Within the adaptations reproduction and embryonic development two factors prevail concerning spawning behaviour and spawning grounds. A concept of 32 guilds that encompassed all 30.000 living fish taxa was developed and formed an ecological classification unrelated to the Linnean classification.
geographic location	any
type of water body	any
spatial scale	unlimited
temporal scale	unlimited
study design	Based on historical data and information about reproduction and spawning grounds a holistic classification system was developed.
guild information	lithopelagophilic, pelagophilic, lithophilic, ostracophilic, ariadnophilic, phytophilic, phytolithophilic, psamnophilic, polyphilic
biotic variables	reproduction, reproductive guilds
taxa studied	European freshwater fish
statistics	none
other modalities concerned	limnopar

guild	reproductive guild
paper	Irz et al. 2007
type of paper	theoretical
summary	The aim of the study was to assess whether eight traits of fish communities (species richness, three reproductive traits and four trophic traits) show a similarity in response to environmental gradients, and consequently display convergence between the lakes of France and north-eastern USA. The comparison of the regional pools of lacustrine fishes indicated that US lakes were about twice as species-rich as French ones, mostly due to higher species turnover across lakes although US lakes were consistently about 20% more rich in species than French lakes for a given surface area. Warmer environments were consistently inhabited by a higher proportion of phytophilous and guarder species than were colder lakes. Hence there was convergence in community reproductive traits. The influence of temperature on the availability and quality of spawning substrates appears to be a major constraint on present-day lacustrine fish communities. In parallel, phylogenetic constraints, past events such as the diversification of the North American fish fauna, and selective extinctions during Pleistocene glaciations and subsequent recolonizations contribute to explaining the dissimilarities between the communities of the two regions and differences in their relationship to the environment.
geographic location	France, nordeast USA
type of water body	lakes
spatial scale	unknown
temporal scale	28 years + 4 years
study design	The data encompass fish surveys, the assignment of species into reproductive and trophic guilds and environmental variables characterizing the lakes and their catchment areas. The methodology used relies upon partitioning the variance in community traits into a habitat component (common between regions), a regional component (differences between regional groups that persist regardless of habitat), with an added interaction component (habitat x region) as an indicator of between-region quantitative difference in responses to habitat conditions.
modality information	lithophilic, pelagophilic, phytophilic, phytolithophilic, psamnophilic
biotic variables	endangered species, ecological guilds, natural-near rivers, regulated rivers
taxa studied	*Carassius auratus, Cyprinus carpio, Esox lucius, Lepomis gibbosus, Lota lota, Micropterus salmoides, Oncorhynchus mykiss, Salmo trutta, Salvelinus umbla, Salvelinus namaycush, Scardinius erythrophthalmus*
statistics	general linerar models, pseudo R-square, ANOVA, hierarchical partitioning procedure
other modalities concerned	rheophilic, eurytopic, limnophilic

guild	reproductive guild
paper	Smith et al. 2006
type of paper	review
summary	Because the European bitterling uses a discrete spawning site (gills of freshwater mussels) that can be readily manipulated they represent an ideal model for linking reproductive decisions with population dynamics. In this paper male mating tactics, female mate and oviposition decisions and aggressive competition among juveniles are presented and may have significant impact on the bitterling population size and population genetics.
geographic location	unknown
type of water body	unknown
spatial scale	unknown
temporal scale	unknown
study design	Revision of the research on the behaviour of the European bitterling and its population dynamics using a combination of field, mesocosm, and aquarium experiments, in combination with population and genetic studies and modelling.
guild information	ostracophilic
biotic variables	reproductive guild, selection, population dynamics
taxa studied	*Rodeus sericeus*
statistics	none
other modalities concerned	piscivorous

guild	reproductive guild
paper	Spindler 1997
type of paper	report
summary	The present fish study is the first Austrian-wide analysis of the state of the most endangered groups of species. Apart from listing of all Austria's fish species (native, exoctic and extinct), their distribution and ecological characteristics, the extent to which and why they are endangered as well as fishery and the laws related to fishing are discussed in detail. 46 fishes, i.e. about 72 %, are already on the list of endangered species. 9 species are on the verge of extinction, 7 are strongly endangered, 11 vulnerable, 6 potentially endangered, 6 species not exactly definable and the survival of 2 further species is uncertain.The major threats to the survival of the indigenous fish fauna are anthropogenic changes in their habitats. As fish are extremely sensitive to environmental impacts of various kinds, they are increasingly used as bioindicators. Apart from a comprehensive faunistic-ecological part of the study, great emphasis is laid on fishery in Austria.
geographic location	Austria
type of water body	any
spatial scale	unknown
temporal scale	unlimited
study design	Analysis of endangerment, life traits and commercial use of fish species based on literature and expert judgement.
guild information	pelagophilic, psamnophilic
biotic variables	pollution, habitat degradation, guilds, fishery
taxa studied	*Zingel streber, Gobio uranoscopus, Chondrostoma nasus, Barbus barbus, Thymallus thymallus, Rutilus pigus, Neogobius kessleri, Hucho hucho, Leuciscus souffia, Huso huso, Acipenser stellatus, Acipenser güldenstaedti, Alburnoides bipunctatus, Gobio albipinatus, Barbus peloponnesius, Gobio gobio, Barbatula barbatula, Salmo trutta fario, Salvelinus fontinalis, Cottus gobio, Vimba vimba, Abramis sapa, Acipenser ruthenus, Acipenser nudiventris, Zingel zingel, Gymnocephalus schraetzer, Cobitis auratus, Cobitis taenia, Abramis ballerus, Aspius aspius, Ctenopharyngodon idella, Leuciscus leuciscus, Oncorhynchus mykiss, Alburnus alburnus, Abramis brama, Rutilus rutilus, Perca fluviatilis, Hypophtalmichtys molitrix, Hypophtalmichtys nobilis, Phoxinus phoxinus, Pseudroraspora parva, Abramis bjoerkna, Leuciscus idus, Sander lucioperca, Gymnocephalus cernuus, Sander volgensis, Leuciscus cephalus, Lota lota, Silurus glanis, Anguilla anguilla, Proterorhinus marmoratus, Neogobius kessleri, Gymnocephalus baloni, Pelecus cultratus, Cyrpinus carpio, Carassius gibelio, Esox lucius, Scardinius erythrophthalmus, Carassius carassius, Rhodeus sericeus, Leucaspius delineatus, Tinca tinca, Gasterosteus aculeatus, Pungitis pungitis, Umbra krameri, Misgrunus fossilis, Barbus petenyi, Salvelinus umbla, Salvelinus namaycush, Lampetra planeri, Eudontomyzon mariae*
statistics	none
other modalities concerned	benthic, omnivorous, planktivorous, eurytopic, limnophilic

guild	reproductive guild
paper	Bartulovic et al. 2006
type of paper	study report
summary	The characteristics of maturation and recruitment of the sand smelt, *Atherina boyeri*, from the Mala Neretva river estuary in the southeastern Adriatic are presented. The average gonadosomatic index (GSI) during a 12 month period was 1.59% for females and 2.1% for males. The highest value was in April, 5.4% for females and 4.7% for males. The smallest mature female was 5.2 cm total length. Fifty percent of the females were mature at 7.75 cm total length. New juveniles began to recruit in June and July and later appeared in fewer numbers. In general, the GSI was lower than in other sand smelt populations. The reasons are difficult to determine but might be partly explained by the high and unpredictable temperature and salinity variations in the researched area that have led to previously described disturbances of the sand smelt life cycle.
geographic location	Croatia – southeastern Adriatic
type of water body	estuary
spatial scale	unknwon
temporal scale	2 years
study design	Fish samples were collected monthly near a dam. Temperature and salinity were measured a with mercury thermometer and a laboratory inductive salinometer before sampling. Indiviudals were measured and gonads were examined to determine sex and reproductive stage, the gonadosomatic index was calculated.
guild information	phytophilic
biotic variables	salinity, reproduction, gonadosomatic index, age at maturity
taxa studied	*Atherina boyeri*
statistics	none
other modalities concerned	none

guild	reproductive guild
paper	Carbonero et al. 2006
type of paper	congress report
summary	At a congress on invasive species the “Spanish Convenio de Diversidad Biológica” elaborated some strategies for coping with neobiota. Especially the distribution of freshwater mussels which in Spain can be found in the river Ebro and other basins is difficult to survey. In this report steps are presented to get a picture of the situation and to create a basic working process in order to develop a nation wide strategy concept. Carbonero et al. discuss the reproductive behaviour of *Alburnus alburnus* in the river Tormes and its competitive advantages regarding the colonization of a new habitat by displacing autocton species. *Alburnus alburnus* was introduced in Spain in the middle of the 90ies for fishing purposes. It was detected in the river Tormes for the first time in 1999. While in literature one reproduction period is mentioned, an examination of the gonadosomatic index revealed two peaks of gonad development – one in summer and one in winter. A conclusion is that of *Alburnus alburnus has* two reproductive periods.
geographic location	Spain
type of water body	river
spatial scale	unknown
temporal scale	1 year
study design	During one year of research fish samples were taken every month and the individuals were weighted and measured. Sexes were determined and the development of the gonads was examined.
guild information	speleophilic
biotic variables	reproductive behaviour and timing, invasive species
taxa studied	*Alburnus alburnus*
statistics	unknown
other modalities concerned	none

guild	reproductive guild
paper	Vlaming & Vodicnik 1978
type of paper	experimental study
summary	The effects on gonadal activity of surgical removal of the pineal organ in the goldfish exposed to short or long periods of light were examined at different times of the year. From late winter to early summer pinealectomy had a clear effect on gonadal activity. It slowed down in fish maintained on long photoperiods but stimulated reproductive function in individuals exposed to short photoperiods. Pinealectomy had no obvious effects on the reproductive function from late summer to early winter.
geographic location	USA - Milwaukee
type of water body	any
spatial scale	any
temporal scale	1 year
study design	Individuals of goldfish were obtained from a commercial dealer at different times of the year and pinealectomyzed. They were exposed to 8 h light and 16 h dark photoperiod. The effect of pinealectomy on reproductive function was assessed by gravimetric and histological techniques. The gonadosomatic index was determined.
guild information	speleophilic
biotic variables	reproductive behaviour, photoperiods, gonadosomatic index
taxa studied	*Carassius auratus*
statistics	Mann-Whitney U-test
other modalities concerned	none

guild	reproductive guild
paper	Rinchard & Kestemond 1996
type of paper	study report
summary	To clarify the dynamics and regulation of oogenis in single and multiple-spawning cyprinid fish with group-synchronous oocyte development a multidisciplinary approach to their reproduction was undertaken. The gonadosomatic index and histomorphometric changes in the ovaries of *Rutilus rutilus, Alburnus alburnus* and *Blicca bjoerkna* are compared. The maximum gonadosomatic index was higher in roach than in bleak and white bream. The gonadosomatic index of multiple spawners decreades during the spawning season. In roach, a short gonadal period and an onset of vitellogenesis was recorded from late summer onwards, in bleak and white bream, exogenous vitellogenesis was not observed before winter. In bleak, the oocytes recruited arose from the stock of endogenous vitellogenesis. In white bream, the differentiation of vitellogenic oocytes from smaller oocytes was completed before the beginning of the spawning season. During the spawning period, the proportion of vitellogenic oocytes decreases whereas the percentage of oocytes in the final maturation stage remained approximately constant.
geographic location	Belgium – river Meuse
type of water body	river
spatial scale	unknown
temporal scale	1 year
study design	Female individuals were caught during and after spawning period. Ovaries and oocytes were examined.
guild information	speleophilic
biotic variables	gonadosomatic index, reproduction, spawning
taxa studied	*Rutilus rutilus, Alburnus alburnus, Blicca bjoerkna*
statistics	ANOVA, Scheffe F's test, Hartley test
other modalities concerned	fractional

guild	reproductive guild
paper	Villa-Gispert et al. 2002
type of paper	theoretical
summary	Multivariate analysis identified a two-dimensional continuum of life-history variation among 301 fish species from Europe, North America, South America and the Atlantic and Pacific coasts of North America. The first axis was associated with larger body size, higher fecundity, delayed maturation, fewer reproductive events, and shorter breeding season on one end and small size, low fecundity, early maturity, multiple reproductive events per year, and prolonged breeding season on the other. The second axis contrasted fishes having larger eggs and more parental care against fishes with the opposite suite of traits. Phylogenetic affiliations of species were apparent in the general patterns of ordination of species within orders, indicating evolutionary divergences in life-history patterns. In fact, partitioning the variance of life-history traits showed that taxonomic order and latitude were the most important factors and geographic region and habitat the least important factors. Species from South America show a skew toward the opportunistic endpoint, whereas North American marine species show a skew toward the periodic end-point of the trilateral continuum model. Most of the fish species from the South American data set came from fluctu-ating environments what results in opportunistic strategy of early maturation and continuous spawning. In contrast, most species in the North American and European data sets came from seasonal habitats that are nonetheless more hydrological stable. The periodic strategy of delaying maturation to attain large clutches enhances adult survi-vorship during suboptimal environmental conditions. Latitudinal affiliations were also observed: opportunistic strate-gists are more common in tropical latitudes and periodic strategists are more common in temperate and Arctic latitudes.
geographic location	global
type of water body	any
spatial scale	any
temporal scale	any
study design	The authors' own data for the following fish life-history traits were used in the analyses: (1) age at maturation; (2) maximum lenght; (3) egg size as the average diameter of the largest oocyte; (4) length of breeding season; (5) spawning mode; (6) fecundity as the average number of vitellogenic oocytes of mature females; (7) parental care. The effects on the variation of life history traits of three categorical factors (geographical distribution, habitat, and latitude) were anaylzed.
guild information	speleophilic
biotic variables	life history traits, geographical distribution, habitat, latitude
taxa studied	*Acipenser* spp, *Salmo* sp., *Oncorhynchus* sp., *Salvelinus* sp., *Astronotus ocellatus*, *Amblyopsis* spp., *Noturus* spp.
statistics	PCA, Kaiser-Meyer-Olkin's measure, CDF
other modalities concerned	fractional

5.3.7 Habitat spawning preference

guild	habitat spawning preference
paper	Zauner & Eberstaller 1999
type of paper	theoretical
summary	In this paper attempts were made to present habitat structure, water velocity and spawning requirements of all Austrian riverine fish species. Based on these data, a new classification scheme will be developed that categorizes species into groups with similar ecological requirements but at the same time allows consideration of the needs of individual species. This classification scheme will thus contribute to the value of the Austrian fish fauna as an indicator used to monitor or improve the habitat quality of running waters.
geographic location	Austria
type of water body	unknown
spatial scale	unknown
temporal scale	unlimited
study design	Information from literature research, collected data for habitat and habitat spawning preference guilds are compared. Prework for a classification scheme is done.
guild information	rheopar, limnopar, eurypar
biotic variables	impoundments, lateral connectivity, degree of rheophily
taxa studied	*Zingel streber, Gobio uranoscopus, Chondrostoma nasus, Barbus barbus, Thymallus thymallus, Rutilus pigus, Neogobius kessleri, Hucho hucho, Leuciscus souffia, Huso huso, Acipenser stellatus, Acipenser güldenstaedti, Alburnoides bipunctatus, Gobio albipinatus, Barbus peloponnesius, Gobio gobio, Barbatula barbatula, Salmo trutta fario, Salvelinus fontinalis, Cottus gobio, Vimba vimba, Abramis sapa, Acipenser ruthenus, Acipenser nudiventris, Zingel zingel, Gymnocephalus schraetzer, Cobitis auratus, Cobitis taenia, Abramis ballerus, Aspius aspius, Ctenopharyngodon idella, Leuciscus leuciscus, Oncorhynchus mykiss, Alburnus alburnus, Abramis brama, Rutilus rutilus, Perca fluviatilis, Hypophtalmichtys molitrix, Hypophtalmichtys nobilis, Phoxinus phoxinus, Pseudroraspora parva, Abramis bjoerkna, Leuciscus idus, Sander lucioperca, Gymnocephalus cernuus, Sander volgensis, Leuciscus cephalus, Lota lota, Silurus glanis, Anguilla anguilla, Proterorhinus marmoratus, Neogobius kessleri, Gymnocephalus baloni, Pelecus cultratus, Cyrpinus carpio, Carassius gibelio, Esox lucius, Scardinius erythrophthalmus, Carassius carassius, Rhodeus sericeus, Leucaspius delineatus, Tinca tinca, Gasterosteus aculeatus, Pungitis pungitis, Umbra krameri, Misgrunus fossilis*
statistics	none
other modalities concerned	rheophilic, eurytopic, limnophilic

guild	habitat spawning preference
paper	Collares-Pereira et al. 1999
type of paper	study report
summary	The status of the distribution and the abundance of the endangered stream fish *Anaecypris hispanica* in Portugal is presented. A highly discontinuous and fragmented population was observed, mainly because of water resource development schemes, habitat degradation and introduction of exotic fish species. This reinforces the urgent need for a targeted rehabilitation programme and the implementation of a specific code of practice to conserve and enhance the residual populations.
geographic location	Portugal – river Guadiana
type of water body	river
spatial scale	~5 km
temporal scale	7 months
study design	Fish were sampled at 124 different sites. The data on distribution and abundance were compared with information from previous studies to show how the importance of the species has changed over the past 20 years.
guild information	rheopar
biotic variables	endangerement, conservation, abundance
taxa studied	*Rutilus alburnoides, Barbus steindachneri, Anaecypris hispanica, Chondrostoma willkommii, Chondrostoma lemmingii, Leuciscus pyrenaicus, Barbus microcephalus, Barbus comiza, Barbus sclateri, Cobitis paludica, Esox lucius, Micropterus salmoides, Lepomis gibbosus, Gambusia holbrookii, Cichlasoma facetum, Cyprinus carpio, Carassius auratus, Procambarus clarkii*
statistics	none
other modalities concerned	none

guild	habitat spawning preference
paper	Balon 1975
type of paper	study
summary	An earlier concept of ecological groups was expanded to cover all living European freshwater fish and based on preferred spawning grounds and on features of reproductive behaviour. Within the adaptations reproduction and embryonic development two factors prevail concerning spawning behaviour and spawning grounds. A concept of 32 guilds that encompassed all 30.000 living fish taxa was developed and formed an ecological classification unrelated to the Linnean classification.
geographic location	any
type of water body	any
spatial scale	unlimited
temporal scale	unlimited
study design	Based on historical data and information about reproduction and spawning grounds a holistic classification system was developed.
guild information	limnopar
biotic variables	reproduction, reproductive guilds
taxa studied	all
statistics	none
other modalities concerned	lithopelagophilic, pelagophilic, lithophilic, ostracophilic, ariadnophilic, phytophilic, phytolithophilic, psamnophilic, polyphilic, parental care

guild	habitat spawning preference
paper	Gante & Santos 2002
type of paper	study report
summary	The North American catfish *Ameiurus melas* is recorded for the first time in Portugal. Its presence in the Tagus River Basin is probably due to natural spread of individuals from Spanish populations, while episodic translocation could explain its occurence in the previously non-invaded Guadiana and Sado River basins.
geographic location	Portugal – rivers Tagus, Guadiana, Sado
type of water body	rivers
spatial scale	unknown
temporal scale	1 year
study design	A total of 31 specimens were caught by angling with bait from a small reservoir in the Tagus River Basin, after reports of their presence by fishermen. The individuals caught were measured and archivated.
guild information	limnopar
biotic variables	abundance, invasive fish species
taxa studied	*Ameiurus melas*
statistics	none
other modalities concerned	none

5.3.8 Parental care

guild	parental care
paper	Balon 1975
type of paper	study
summary	An earlier concept of ecological groups was expanded to cover all living European freshwater fish and based on preferred spawning grounds and on features of reproductive behaviour. Within the adaptations reproduction and embryonic development two factors prevail concerning spawning behaviour and spawning grounds. A concept of 32 guilds that encompassed all 30.000 living fish taxa was developed and formed an ecological classification unrelated to the Linnean classification.
geographic location	any
type of water body	any
spatial scale	unlimited
temporal scale	unlimited
study design	Based on historical data and information about reproduction and spawning grounds a holistic classification system was developed.
guild information	non protecting, protection
biotic variables	reproduction, reproductive guilds
taxa studied	European freshwater fish
statistics	none
other modalities concerned	lithopelagophilic, pelagophilic, lithophilic, ostracophilic, ariadnophilic, phytophilic, phytolithophilic, psamnophilic, polyphilic, limnopar

5.3.9 Physiological and morphological parameters

parameters	longevity, fecundity, egg diameter
paper	Blanck et al. 2007
type of paper	study report
summary	The report focuses on the “habitat template theory” and the hierachical “landscape filters concept”, the relationship between life-history traits of European freshwater fish and their habitat preferences helps to detect the strategies adopted by fish to cope with their current habitat. The study supports the idea that microhydraulics play a more important role than temperature regime and oxygen concentration. Relationships between hydraulics and traits are of a great importance.
geographic location	Europe
type of water body	fast flowing and shallow habitats
spatial scale	unknown
temporal scale	unknown
study design	The use of multivariate analyses to classify survival strategies and examine the relationship between those strategies and published data about habitat preferences
biotic variables	microhabitat hydraulics, oxygen level, temperature preferences
taxa studied	*Abramis brama, Alburnoides bipunctatus, Alburnus alburnus, Barbatula barbatula, Barbus barbus, Abramis bjoerkna, Carassius carassius, Chondrostoma nasus, Cottus gobio, Cyprinus carpio, Esox lucius, Gobio gobio, Gymnocephylus cernuss, Lepomis gibbosus, Leuciscus cephalus, Leuciscus leuciscus, Phoxinus phoxinus, Rhodeus sericeus, Rutilus rutilus, Salmo trutta, Sander lucioperca, Scardinius erythrophthalmus, Thymallus thymallus, Tinca tinca*
statistics	PCA, MCA, ANOVA
other modalities concerned	tolerant + intolerant to low oxygen concentration, limnophilic, rheophilic

parameters	longevity, egg diameter
paper	Maitland 2000
type of paper	book
summary	Over 250 fish species representing 32 families are recorded. A guide for determining each species includes a detailed drawing, information on size, distinctive features, distribution, reproduction, food, commercial use and conservation status is presented. Furthermore anatomy, physiology, behaviour and reproduction are explained basically. Ecology, distribution, fishing and commercial use, conservation and threats are added.
geographic location	Britain and Europe
type of water body	freshwater bodies
spatial scale	Europe-wide
temporal scale	any
study design	Collection of information on European freshwater species and information on determination and scientific studies
biotic variables	conservation, reproduction, food, distribution, physiology
taxa studied	European freshwater fish
statistics	none
other modalites concerned	none

parameter	relative fecundity
paper	Bănărescu 1999
type of paper	book
summary	Numerous of European cyprinids including the geni Rhodeus, Gobio, Pseudorasbora, Tinca, Aulopyge and Capoeta are presented focusing on their habitat, migration, feeding habits, longevity, growth, reproduction and ontogentiv development.
geographic location	Europe
type of water body	any
spatial scale	Europe-wide
temporal scale	unknown
study design	Morphological features, distribution maps and drawings of single species are detailed. Plenty of references are added.
biotic variables	distribution, reproduction, feeding, habitat, migration, growth
taxa studied	*Rhodeus sericeus, Gobio albipinnatus, Gobio gobio, Gobio kessleri, Gobio uranoscopus, Pseudorasbora parva, Tinca tinca, Ctenopharyngodon idella, Mylopharyngodon piceus, Aulogyge huegeli, Capoeta capoeta, Capoeta sieboldi, Capoeta tinca*
statistics	none
other modalities concerned	none

parameter	egg diameter
paper	Bănărescu & Paepke 2001
type of paper	book
summary	Numerous of European cyprinids including the geni Carassius, Cyprinus, and Catla as well as gasterosteids including the geni Gasterosteus and Pungitis are presented focusing on their habitat, migration, feeding habits, longevity, growth, reproduction and ontogentiv development.
geographic location	Europe
type of water body	any
spatial scale	Europe-wide
temporal scale	unknown
study design	Morphological features, distribution maps and drawings of single species are detailed. Plenty of references are added.
biotic variables	distribution, reproduction, feeding, habitat, migration, growth
taxa studied	*Carassius auratus, Carassius carassius, Cyprinus carpio, Catla catla, Romanogobio pentatrichus, Gasterosteus aculeatus, Pungitis hellenicus, Pungitis platygaster, Pungitis pungitis*
statistics	none
other modalities concerned	none

5.4 Additional literature

Literature conncected to guilds but which could not be used in detail due to several reasons is listed in ANNEX I.

Kottelat (1997) has often been consulted for the EFI+ project with regard to taxonomy. Recently a book by Kottelat & Freyhof about all European fish species has been published in 2007. The "Handbook of European Freshwater Fishes" generally presents more facts at once than any literature collected. More than 500 species are listed by Kottelat & Freyhof. However, for the EFI+ list only 339 species were retained as some (endemic) species are not familiar to a broad community of scientists and therefore judgment at this point would end up to be controversial among experts and too uncertain to guarantee the right classifications. In the book all species of European inland waters are listed, including diadromous species. Introduced species are included if they have established self-sustaining populations or if they are stocked at the same localities regularly.

Families and Subfamilies are briefly introduced. For families with several genera in Europe identification keys to the genera are included. Keys to the species are provided for genera which are easily observed without dissections or sophisticated techniques. Every single species is described using a picture and information on the common name, morphological appearance, distribution, habitat, biology, conservation status and further reading suggestions. Those issues can be useful to determine feeding and reproductive guilds. Tolerance features for European freshwater species are not mentioned.

Taxonomic approaches of Kottelat & Freyhof follow the International Code of Zoological Nomenclature (state: 1 January 2000) and adopt in their book the latest nomenclature known to them as at 31 March 2007. The domination of species can be found in ANNEX III.

The species richness across Europe was generated by the superimposition of the distribution maps of 525 freshwater fishes. Analysis show that the highest species richness is found in the main channel and delta of the Danube, lower stretches and deltas of Dniestr, Dniepr and Don and in the Volga delta. Aquatic habitats of the Iberian penninsula, southern Italy and Greece and northern Europe are species-poor and often inhabitated by endemic species. 38% of European native freshwater fish are threatened and 2% are considered extinct (table 5.11).

Table 5.11 *Extinct freshwater fish species in Europe (adapted from Kottelat & Freyhof, 2007)*

family	species
Petromyzontidae	*Eudontomyzon* sp. migratory
Cyprinidae	*Romanogobio antipai*
	Alburnus danubicus
Coregonidae	*Coregonus bezola*
	Coregonus fera
	Coregonus hiemalis
	Coregonus restrictus
	Coregonus gutturosus
	Coregonus oxyrinchus
Salmonidae	*Salmo schiefermuelleri*
	Salvelinus neocomensis
	Salvelinus profundus
Gasterosteidae	*Gasterosteus crenobiontus*

As reasons for extinction construction of dams, water abstraction, over-exploitation, water pollution and introduction of exotic species are mentioned. The protection of single areas is not supposed to be useful since a stretch of river within a protected area is usually linked up and downstream to areas outside where deterations are taking place. Kottelat & Freyhof suggest a multi stakeholder, basin-wide management to fish species conservation.

6 Classification results and their discussion

6.1 Fish species and classifications

A list (see ANNEX II) displaying species and their families as well as classifications into guilds can be considered as a main result. The list is limited to the endemic species of the 12 cooperating countries and the common fish species (including that of the Balkans and Greece). 339 species that had been agreed on from 39 fish families were worked on. Individuals known only to family level (family sp.) and hybrids were not included. Information existed about 243 species other 93 species could not be classified. Therefore it would not make sense to take up every single endemic species or fish that are not even sure to be an independent species. For those cases classification is yet impossible and experts would have to guess about their guild belongings.

6.2 Fish families and with reference to guilds

To present the results of the classification process species were associated to their families. For the illustrations families with a high number of classified species or unusually classified species were chosen.

6.2.1 Fish family abundances

About 150 species of the guild-revision process belong to the family of cyprinids, 72% of them could be classified. The cyprinids were the most species-rich family in the classification procedure of guilds probably due to their state of being the largest family of fish in the world with about 2000 species.

In the EFI+ database where nearly 165.000 fish samples were collected across Europe abundances are similar. *Phoxinus phoxinus, Rutilus rutilus, Gobio gobio* and *Leuciscus cephalus* which are all Cyprinidae are the most abundant species (table 6.1). *Alburnus alburnus, Barbus barbus, Leuciscus leuciscus, Alburnoides bipunctatus, Leuciscus souffia, Rhodeus amarus* and *Abramis brama* may be less abundant but they all belong to the family of Cyprinidae which makes it a large family with in general abundant species. *Salmo trutta fario* as a salmonid, *Barbatula barbatula* belonging to the family of Nemacheilidae, Cottus *gobio* belonging to the family of Cottidae, *Perca fluviatilis* (Percidae) and *Anguilla anguilla* (Anguilidae) are also species who display abundances higher than 1%. It may be interesting that all species which are to be found in table 6.1 and have an abundance higher than 0,50% of species sampled in over 17.000 fishing occasions could be classified completely by literature and experts. It can be concluded that the 20 species mentioned are the most abundant species in Europe and that their ecological traits are well documented.

Table 6.1 *Abundances [%] of species in the EFI+ database calculated from 164.778 fish samples collected on 17.524 fishing occasions at 8.843 sampling sites (adapted from Melcher 2008; see also http://efi.boku.ac.at)*

Species	Abundance [%]
Phoxinus phoxinus	15,30

Salmo trutta fario	11,56
Rutilus rutilus	11,06
Gobio gobio	9,68
Barbatula barbatula	7,67
Leuciscus cephalus	6,43
Cottus gobio	6,35
Alburnus alburnus	4,94
Perca fluviatilis	2,69
Anguilla anguilla	1,85
Barbus barbus	1,80
Leuciscus leuciscus	1,51
Alburnoides biputactus	1,47
Leuciscus souffia	1,28
Rhodeus amarus	0,94
Thymallus thymallus	0,82
Gasterosteus aculeatus	0,78
Oncorhynchus mykiss	0,75
Abramis brama	0,72
Lampetra planeri	0,68

However, since in total 339 species were considered 96% of the species did not have higher abundances than 1% in the above mentioned sampling process. There are a lot of different fish species but only a few have high abundances. It seems that European inland waters are inhabited by other species rather than the classical species which are typical for the river regions like, for example, *Barbus barbus* (1,8%) and *Abramis brama* (0,72%).

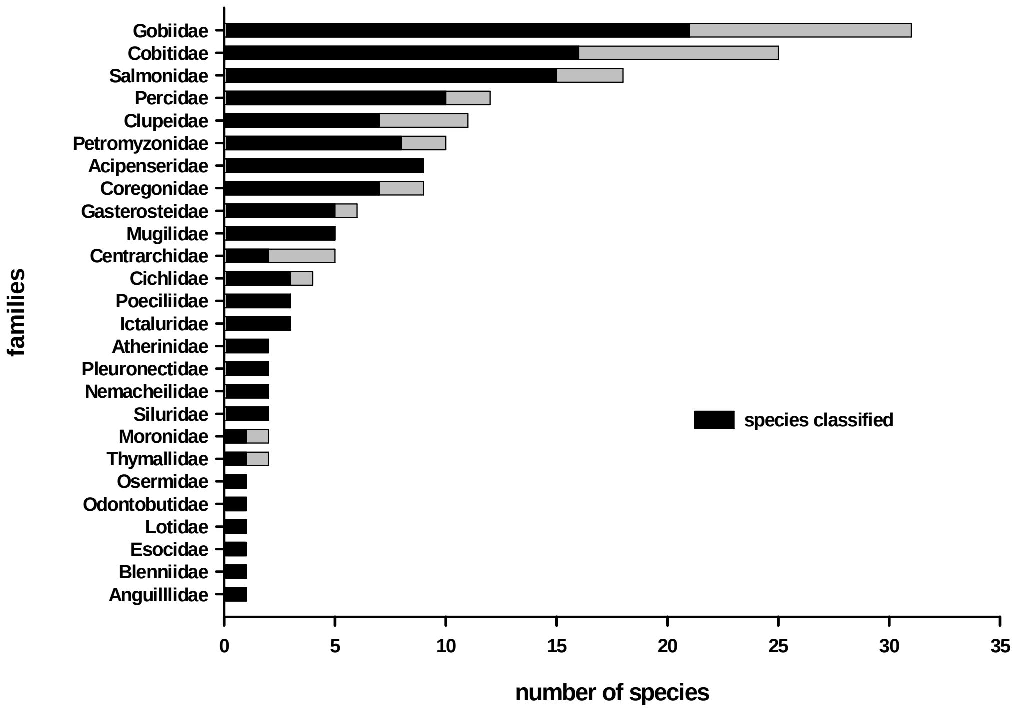


Figure 6.1 *Fish families and the absolute numbers of included species considered for classification; the absolute numbers of species which could be classified is illustrated by black barrs (Please note that Cyprinidae [n=147] are, for reasons of illustration, excluded from the figure)*

The Gobiidae include 31 species considered for classification. 68% of those species were successfully classified (figure 6.2). 25 species belonging to the family of Cobitidae were considered and 64% of them classified. Out of 18 species 15 salmonids were classified. 12 Percidae were present in the classification process and 10 ended up to be classified. All 9 Acipenseridae and all 5 Mugilidae could be classified. Other families which were completely or partially classified are the Poeciliidae with three species (*Gambusia affini, G. holbrooki* and *Poecilia reticulata*), the Ictaluridae with three species as well (*Ameiurus melas, A. punctatus and A. punctatus*). Other species like *Anguilla anguilla* (Anguillidae), *Esox lucius* (Esocidae), *Lota lota* (Lotidae) or *Osmerus eperlanus* (Osmeridae) are the only representatives for their families and they were all classified. In figure 6.2 their families are displayed. The only family including more than 5 species which could be classified was the family of Acipenseridae including the species *Acipenser baeri, A. gueldenstaedtii, A. naccarii, A. nudiventris, A. oxyrinchus, A. ruthenus, A. stellatus, A. sturio* and *Huso huso*. They are no abundant species but well documented probably because they are known and commercially used for thousands of years (Maitland, 2000). The Mugilidae considered in this paper were also completely classified. Worldwide there are about 100 species of Mugilidae but most of them are living in marine habitats and therefore only 5 species were retained for classification.

6.2.2 Frequency of fish families with regard to guild modalities

The most species-rich families or families displaying the clearest trends are analyzed with regard to their response to modalities of water quality guilds, habitat guilds, adult trophic guilds, migration, salinity and reproduction.

6.2.2.1 Water quality

Tolerance to water quality is described in general and by the modalities of oxygen concentration, toxic contamination, acidification, temperature regime and habitat degradation. Classification was possible into tolerant, intermediately tolerant and intolerant for five tolerance guilds and into stenothermal and eurythermal concerning temperature. All classifications of the species and their families can be found in ANNEX II.

<u>Tolerance to water degradation in general</u>

The guild provides information about the overall tolerance concerning water quality of species with regard to national water quality parameters. It is a general approach that is additionally explained by the five other water quality tolerance guilds. 127 species (out of 339) could be classified. 13% of the species were classified as intolerant to a general degradation of water quality like, for example, *Cottus gobio* and *Thymallus thymallus* as very abundant species (table 6.1). 30% of the species are supposed to be tolerant and 23% are intermediately tolerant.

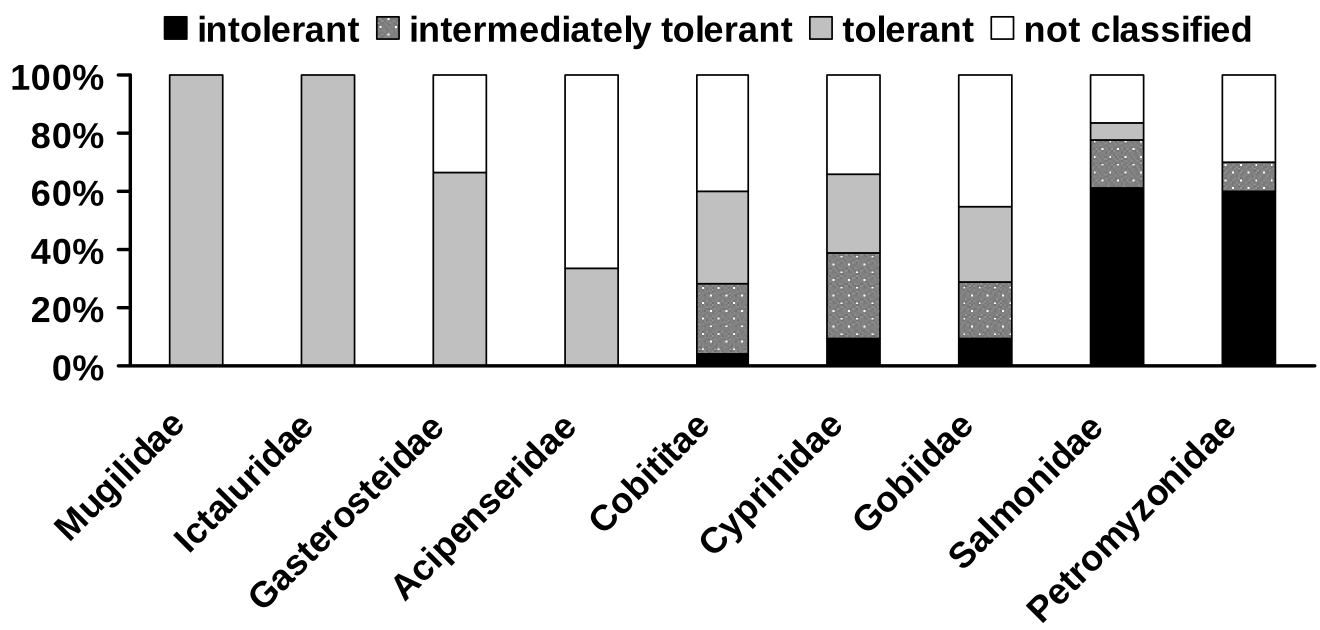


Figure 6.2 *Fish families and the percentage of species being tolerant, intermediately tolerant or intolerant. to degradation of water quality in general or were not classified (Mugilidae n=5; Ictaluridae n=3; Gasterosteidae n=6; Acipenseridae n=9; Cobitidae n=25; Cyprinidae n=147; Gobiidae n=31; Salmonidae n=18; Petromyzonidae n=1; white barrs: not classified; light grey barrs: tolerant; dotted barrs: intermediately tolerant; black barrs: intolerant)*

All five species of the Mugilidae and all three species of the Ictaluridae were classified as tolerant to degradation of water quality (figure 6.2).

Gasterosteus aculeatus, G. crenobiontus, G. gymnurus and *Pungitis pungitis* (all Gasterosteidae) were supposed to be tolerant. Two species of this family could not be classified.

Acipenser naccari, A. oxyrinchus and *A. sturio* are Acipenseridae which are intermediately tolerant to degradation of water quality. The other six Acipenseridae are tolerant. However, tolerance cannot be true in general for the Acipenseridae as they are extinct at least in Austria with only one exception (Spindler 1997).

Cobitis calderoni is the only representant of the Cobitidae which is classified as intolerant. Other eight Cobitidae are tolerant including *Cobitis elongata* and *Misgurnus fossilis*. The major part of the family (15 species) are intermediately tolerant or not classified.

13 of the 147 cyprinids are intolerant to water quality degradation encountering abundant species like *Alburnoides bipunctatus, Barbus barbus*, *Leuciscus souffia* and *Rhodeus amarus*. *Chondrostoma arrigonis, C. nasus, C. toxostoma, Barbus meriodinalis, B. caninus* and *B. haasi* are further examples for intolerant cyprinids. 27% of the Cyprinidae listed are tolerant including abundant species like *Abramis brama, Alburnus alburnus, Leuciscus cephalus* and *Rutilus rutilus.* Nearly 30% are intermediately tolerant. *Pelecus cultratus*, for example, which got more and more abundant within the last 30 years due to eutrophication of rivers and lakes (Herzig et al. 1994) is only intermediately tolerant.

Gobiidae which exhibit intolerance to water quality degradation are *Economidichthys pygmaeus, Knipowitschia punctatissima* and *K. thessala*. However, 26% of the Gobiidae are tolerant like, for example, *Knipowitschia caucasia, Neogobius fluviatilis* and *N. melanostomus.* Six of the 31 species are intermediately tolerant including *Knipowitschia panizzae* and *Proterorhinus marmoratus.* 45% of the species could not be classified.

61% of all salmonids species are intolerant to degradation of water quality including *Hucho hucho, Oncorhynchus gorbuscha, O. kisutsch, O. tschawytscha, Salmo salar, S. trutta fario, S. trutta lacustris, S. trutta trutta, Salvelinus alpinus, S. fontinalis* and *S. umbla*. The only species classified as tolerant is *Salvelinus namaycush*. *Oncorhynchus mykiss*, *Salmo marmoratus* and *Salmo trutta macrostigma* are supposed to be intermediately tolerant. The rest of the species (17%) could not be classified.

Lethenteron zanandreai is the only species belonging to the Petromyzonidae and being classified as intermediately tolerant to water quality degradation. For 30% of the Petromyzonidae classifications were lacking but six out of ten species are intolerant (*Eudontomyzon danfordi, E. mariae, E. vladykovi, Lampetra fluviatilis* and *Petromyzon marinus*). *Lampetra planeri*, an abundant species (table 6.1), is intolerant as well.

Since there is only one reference of literature with regard to water quality in general classifications that are mainly based on expert judgment can only rarely confirmed by citations. The parameter of water quality tolerance in general is repeatedly and more comprehensive explained by the five other parameters of tolerance.

Tolerance to a low concentration of oxygen

Classified species are supposed to be tolerant if they can cope with a oxygen concentration of $3 mgL^{-1}$ or even less. They are intolerant if their physical constitution requires a concentration of oxygen of more than $6 mgL^{-1}$. If oxygen concentrations are to be found somewhere between those ranges species are classified as intermediately tolerant.

63% of the species could be classified regarding their tolerance to a low oxygen concentration. 65 species of all 339 species (19%) were classified as intolerant. *Alosa alosa* and *A. fallax* (Clupeidae), for example, and three coregonid species (*Coregonus albula, C. lavaretus, C. maraena* and *C. oxyrinchus*) are intolerant. The Percidae encounter four species that are intolerant to a low oxygen concentration, *Romanichthys valsanicola, Zingel asper, Z. streber* and *Z. zingel. Polyodon spathula* as only representat of its family in the classification process is also supposed to be intolerant. *Thymallus thymallus* (Tymallidae) which is an abundant species (table 6.1) is intolerant, too. Fisher and Willis (2000) took fish samples in a wetland where the oxygen level was very low and the under water column became nearly anoxic. Nevertheless *Ameiurus melas* and *Cyprinus carpio* were present. They are classified as tolerant. In total 16% of the species were classified as tolerant and another 28% were classified as intermediately tolerant.

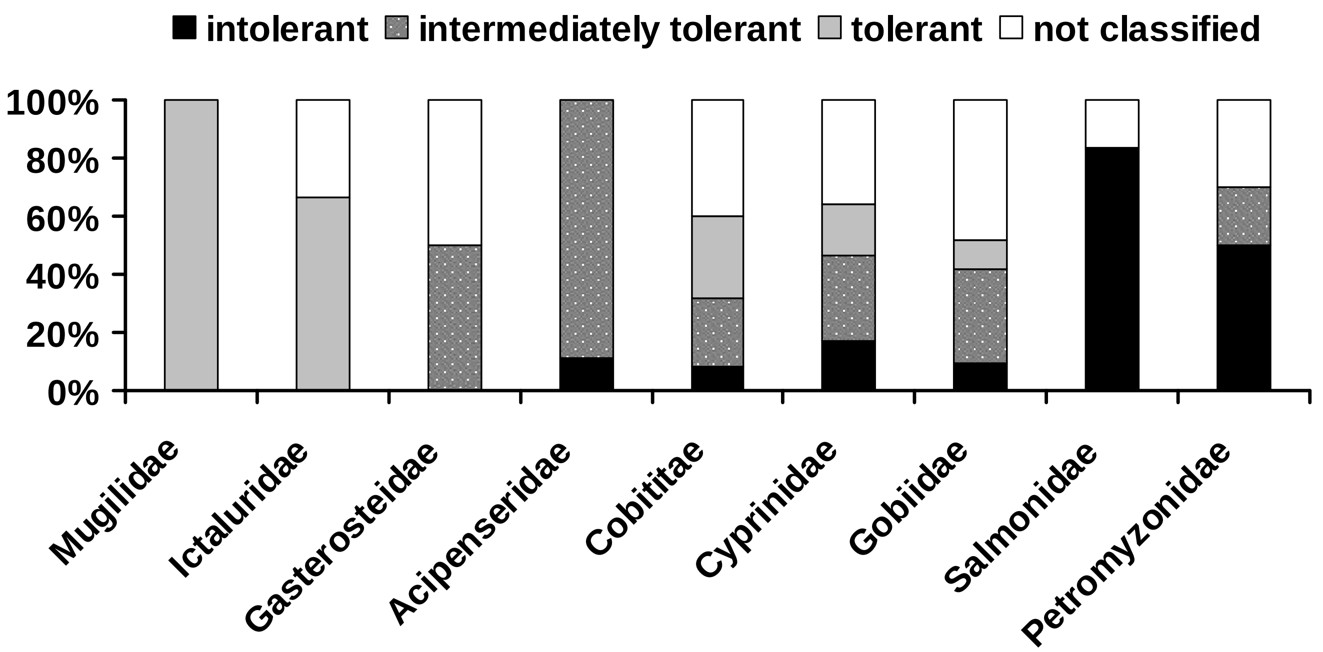


Figure 6.3*Fish families and the percentage of species being tolerant, intermediately tolerant or intolerant to low* *<u>concentration of oxygen</u> or were not classified (Mugilidae n=5; Ictaluridae n=3; Gasterosteidae n=6; Acipenseridae n=9; Cobitidae n=25; Cyprinidae n=147; Gobiidae n=31; Salmonidae n=18; Petromyzonidae n=10; white barrs: not classified; light grey barrs: tolerant; dotted barrs: intermediately tolerant; black barrs: intolerant)*

All five Mugilidae are tolerant to a low oxygen concentration as well as *Ameiurus melas* and *A. nebulosus* (Ictaluridae) while *A. punctatus* is intermediately tolerant (figure 6.3).

Four out of six species of the Gasterosteidae are intermediately tolerant with regard to a low oxygen concentration. *Pungitis hellenicus* and *Pungitis platygaster* could not be classified in any tolerance guild.

Huso huso is the only species belonging to the family Acipenseridae which is classified as intolerant to a low oxygen concentration. The other eight species are supposed to be intermediately tolerant.

Cobitis calderoni and *C. hellenica* are two Cobitidae which are intolerant to a low concentration of oxygen. Remarkably In total there were listed 25 species. 28% are tolerant including *Cobitis elongate, C. megaspila, C. vettonica, Misgurnus anguillicaudatis, M. fossilis, Sabanejewia bulgarica* and *Sabanejewia romanica* which are all tolerant to water quality degradation, too. The weatherfish (*Misgurnus fossilis*) can even tolerate complete anoxia (Welcomme *et al.*, 2006).40% of the species were not classified.

Cyprinidae which exhibit intolerance to a low concentration of oxygen are the abundant species *Alburnoides bipunctatus*, *Gobio gobio, Leuciscus souffia and Phoxinus phoxinus*. In total 17% of the cyprinid species are intolerant also including *Aspius aspius, Barbus cyclolepis, B. haasi, B. peloponnesius, B. petenyi, B. tyberinus, Chondrostoma nasus, C. turiense, Gobio albipinnatus, G. kesslerii, G. uranoscopus, Pseudophoxinus beoticus, P. stymphalicus, Romanogobio belingi, R. vladykovi, Pelecus cultratus, Rutilus frisii, R. pigus, Tropidophoxinellus hellenicus* and *T. spartiaticus.* According to their oxygen level preferences the spirlin (*Alburnoides bipucatatus),* the dace *(Leuciscus leuciscus),* the minnow *(Phoxinus phoxinus),* the bitterling *(Rhodeus amarus),* the chub *(Leuciscus cephalus)* and the nase *(Chondrostoma nasus)* are well adapted to a hig oxygen level and can only tolerate a decrease of oxygen concentration down to 2.5 mgL^{-1} (Blanck *et al*. 2007; Philippart & Vranken 1983). *Leuciscus cephalus* and *Rhodeus amarus* are classified as intermediately tolerant. *Tropidophoxinellus hellenicus* and *Pseudophoxinus stymphalicus* were classified as tolerant to water degradation in general. 18% are tolerant like, for example, *Tinca tinca, Scardinius erythrophtalmus, Rutilus rutilus, Cyprinus carpio, Carassius carassius, Blicca bjoerkna* and *Abramis brama*. *Carassius carassius, Cyprinus carpio*, and *Tinca tinca* are able to live in habitats where the oxygen level is continously <2.0 mgL^{-1}. *Abramis brama* also poses relatively low requirements to water purity and oxygen content (Žarski *et al*., 1995). Cyprinids display some form of tolerance-dimorphism: Phytophilic species (e.g. *Carassius carassius, Cyprinus carpio, Tinca tinca*) are generally adapted to survive in very low-oxygen concentration environments, whereas lithophilic species like *Chondrostoma nasus, Leuciscus cephalus* and *Phoxinus phoxinus* are adapted to well-oxygenated waters (Balon, 1975). *Cyprinus carpio* and *Scardinius erythrophthalmus* are usually tolerant of low dissolved oxygen (Welcomme *et al.* 2006). 36% of the species could not be classified.

The half of the Petromyzonidae is intolerant to a low oxygen concentration (*Eudontomyzon danfordi, E. mariae, E. vladykovi, Lampetra planeri* and *Lethenteron zanandreai*). *Lampetra planeri* and *Petromyzon marinus* are intermediatel tolerant and 30% of the species are not classified.

All salmonids are intolerant to a low oxygen concentration. Brown trout (*Salmo trutta*), for example, is well adapted to a high oxygen level and can only tolerate a decrease of oxygen concentration down to 2.5 mgL^{-1} (Blanck *et al*. 2007; Philippart & Vranken 1983). 17% of the species *(Salmo labrax, Salmo macedonius* and *Salmothymus obtusirostris)* could not be classified.

<u>Tolerance to toxic contamination</u>

There can be made a distinction between species which are generally tolerant against toxic contamination, species that are intermediately tolerant and species wich exhibit intolerance to toxic contamination.

189 of 339 species were classified with regard to their tolerance to toxicity and 12% of the classified species were intolerant like *Thymallus thymallus*, for example. *Syngnathus abaster* and *S. typhle* (Syngnathidae) and *Sparus aurata* (Sparidae) are intolerant, too. Other examples for intolerant species are *Platichthys flesus* (Pleuronectidae), *Zingel asper, Z. streber* and *Z. zingel* (Percidae), *Dicentrarchus labrax* (Moronidae) and *Alosa alosa* (Clupeidae). *Sander lucioperca* and *Silurus glanis* are classified as intermediately tolerant what cannot be confirmed by citations. In contrary Fent (2007) describes a rising fish mortality in Switzerland after wastewaters containing metalcyanid and other pesticides were introduced. He mentions that *Sander lucioperca* and *Silurus glanis* were particularly suffering from the toxic wastewaters. The situation is different for the eel (*Anguilla anguilla*) which is classified as tolerant. Eels can detoxify metals and are able to uptake relatively high concentrations (up to 11mg g^{-1}) of metals and metal burdens without any damages for their health (Langston *et al.* 2002).

12% of the species were classified as tolerant and 24% as intermediately tolerant.

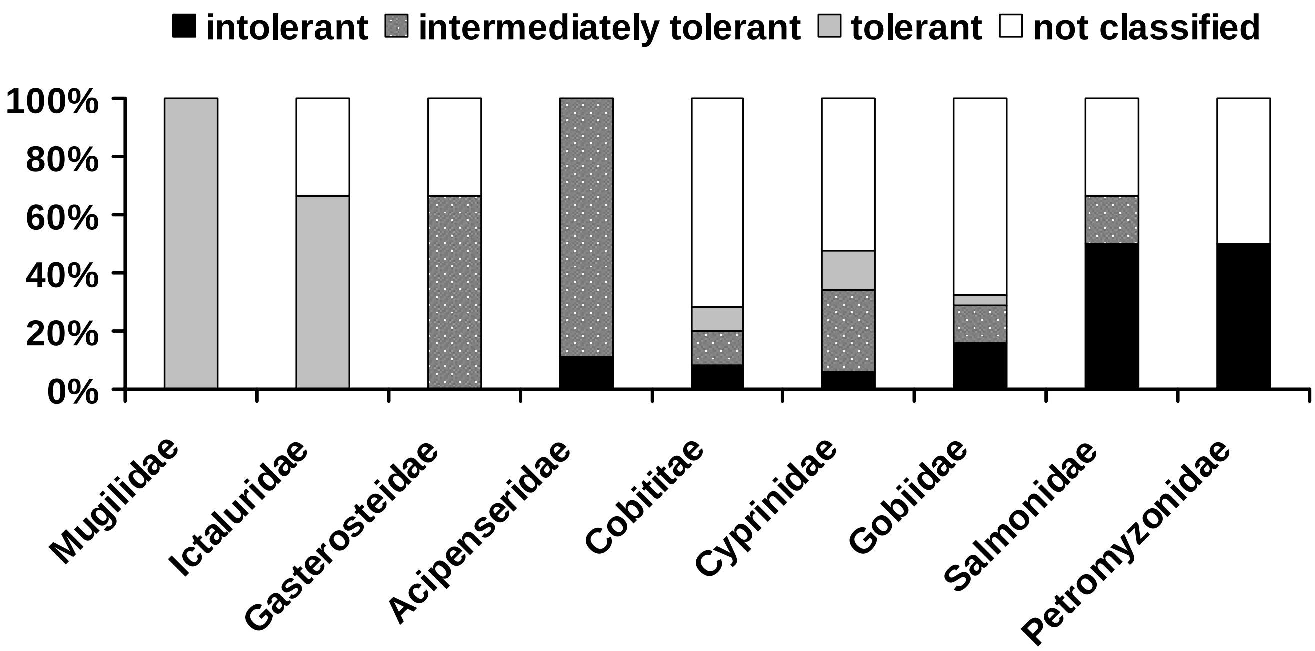


Figure 6.4 *Fish families and the percentage of species being tolerant, intermediately tolerant or intolerant to toxicity or were not classified (Mugilidae n=5; Ictaluridae n=3; Gasterosteidae n=6; Acipenseridae n=9; Cobitidae n=25; Cyprinidae n=147; Gobiidae n=31; Salmonidae n=18; Petromyzonidae n=10 white barrs: not classified; light grey barrs: tolerant; dotted barrs: intermediately tolerant; black barrs: intolerant)*

All five species belonging to the family of Mugilidae are tolerant to toxic contamination (figure 6.4).

The Ictaluridae *Ameiurus melas* and *A. nebulosus* are tolerant, too. *A. punctatus* could not be classified with regard to toxicity.

Gasterosteidae are intermediately tolerant. Two of the six species could not be classified regarding their tolerance to toxic contamination.

The genera Acipenser is supposed to be intermediately tolerant. From the family of Acipenseridae only Huso huso is classified as intolerant to toxicity.

Most of the Cobitidae (72%) could not be classified with regard to toxic contamination. *Cobitis calderoni* and *Sabanejewia larvata* are intolerant, *Cobitis vettonica* and *Misgurnus fossilis* are tolerant. *Cobitis paludica, Cobitis taenia* and *Sabanejewia aurata* are intermediately tolerant to toxicity.

9 species of the 147 cyprinids are intolerant to toxic contamination like, for example, *Aspius aspius, Barbus haasi, B. meriodinalis, Chondrostoma nasus* and *Rhodeus amarus.* 14% of the Cyprinidae are tolerant including *Tinca tinca, Rutilus rutilus, Cyprinus carpio, Carassius carassius, Blicca bjoerkna, Barbus microcephalus* and *Abramis brama,* just to mention a few. *Carassius auratus* is substantatially less sensitive to aqueos copper than other freshwater fish (Schjolden *et al.* 2007). It is also classified as tolerant. *Abramis brama* and *Rutilus rutilus* can also be used as indicator species for mercury pollution as they take up and

therefore tolerate relatively high concentrations (Dušek *et al.* 2004). 28% are intermediately tolerant (e.g. *Barbus barbus, Alburnus alburnus, Gobio gobio, Leuciscus leuciscus, Phoxinus phoxinus, Scardinius erythrophtalmus* and *Squalis alburnoides*). 52% of the Cyprinidae could not be classified.

Knipowitischa panizzae, K. punctatissima, Padogobius martensii, P. nigiricans and *Pomatoschistus minutus* are the five Gobiidae that were classified as intolerant to toxicity. Four species are intermediately tolerant, *Neogobius fluviatilis, N. gymnotrachelus, N. kessleri* and *Zostiserisessor ophocephalus. Neogobius melanostomus* is the only represtant of the Gobiidae which is classified as tolerant. 68% of the species could not be classified.

50% of the Salmonidae are intolerant to toxic contamination. *Oncorhynchus mykiss, Salmo trutta lacustris* and *Salvelinus fontinalis* are supposed to be only intermediately tolerant. Rainbow trout (*Oncorhynchus mykiss)* as a response to metallic pollutants synthesizes an intermediate amount of metallothionein to enhance detoxification (Langston *et*. *al* 2002). No salmonid is classified as tolerant to toxicity.

Five out of 10 species belonging to the Petromyzonidae are intolerant (*Eudontomyzon mariae, Lampetra fluviatlis, L. planeri, Lethenteron zanandraei* and *Petromyzon marinus*). The other half of the species could not be classified.

<u>Tolerance to acidification</u>

Species could be classified as tolerant, intermediately tolerant and intolerant to acidification. 54% of the species were classified. 31% of the species are intolerant including, for example, *Alsoa alosa, A. fallax, A. pontica*, and *Clupeonella cultriventris* (Clupediae), *Coregonus maraena* and *C. oxyrinchus* (Coregonidae), *Lota lota* (Lotidae), *Barbatula barbatula* (Nemacheilidae), *Percottus glenii* (Odonotbutidae), *Polydon spathula* (Polyodentidae), *Syngnathus abaster* (Syngnathidae) and *Thymallus thymallus* (Thymallidae).

Species that are tolerant to acidification are *Anguilla anguilla*, *Esox lucius, Umbra krameri* and *U. pygmaea* just to mention a few. In total only 7% of the species exhibit tolerance and 46% of the species could not be classified.

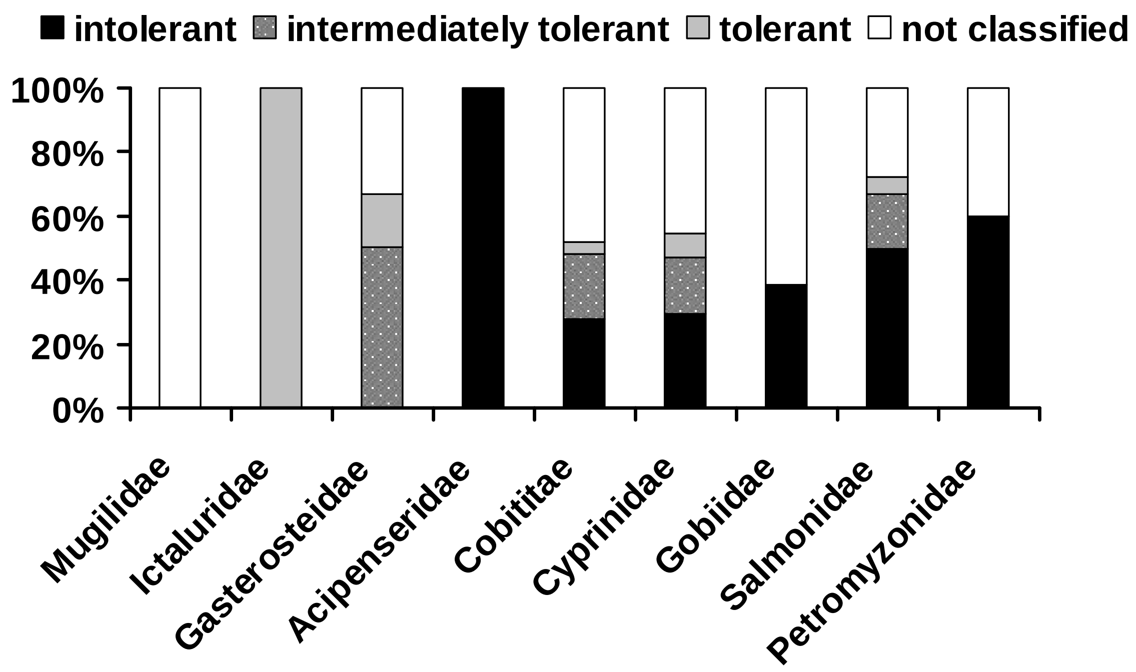


Figure 6.5 *Fish families and the percentage of species being tolerant, intermediately tolerant or intolerant to acidification or not classified (Mugilidae n=5; Ictaluridae n=3; Gasterosteidae n=6; Acipenseridae n=9; Cobitidae n=25; Cyprinidae n=147; Gobiidae n=31; Salmonidae n=18; Petromyzonidae n=10; white barrs: not classified; light grey barrs: tolerant; dotted barrs: intermediately tolerant; black barrs: intolerant)*

Although tolerance guild information for the Mugilidae is nearly completely provided they could not be classified with regard to acidification. In contrary all Ictaluridae could be classified and they all are supposed to be tolerant (figure 6.5).

Pungitis pungitis is tolerant. Three other Gasterosteidae are intermediately tolerant, *Gasterosteus aculeatus, G. crenobiontus* and *G. gymnurus.* Two of the six Gasterosteidae could not be classified.

All nine Acipenseridae are classified as intolerant.

28% of the species are intolerant to acidification with regard to the Cobitidae (e.g. *Cobitis elongata, C. megaspila, Sabanejewia bulgarica* and *S. romanica*). *Misgurnus fossilis* as only species out of 25 is tolerant whereas *Misgurnus anguillicaudatis* and four other species are intermediately tolerant. 48% of the species could not be classified.

30% of the cyprinid species are intolerant to acidification including even *Blicca bjoerkna* which is tolerant with regard to the other five tolerance parameters. Other examples for cyprinids which are usually tolerant intermediately tolerant but exhibit intolerance against acidification are *Abramis ballerus, A. brama, A. sapa, Aristichthys nobilis, Barbus graecus, Chalcalburnus chalcoides, Leuciscus cephalus, Pseudophoxinus stymphalicus, Pseudorasbora parva, Romanogobio banaticus* and *Scardinius racovitzai.* 18% are intermediately tolerant (e.g. *Carassius carassius, Carassius gibelio* and *Barbus microcephalus*). 11 of 147 species are tolerant including, for example, *Alburnus alburnus, Carassius auratus, Cyprinus carpio, Scardinius erythrophtalmus* and *Tinca tinca*.

All Gobiidae that could be classified (39%) are intolerant to acidification.

Again 50% of the salmonid species are intolerant with regard to acidification but there is even one species which is supposed to be tolerant (*Salvelinus fontinalis*) and 17% are intermediately tolerant like, for example, *Oncorhynchus kisutch*.

In contrary Petromyzonidae are intolerant (*Eudontomyzon danfordi, E. mariae, E. vladykovi, Lampetra fluviatilis, L. planeri* and *Petromyzon marinus*) or not classified (40%).

<u>Temperature tolerance</u>

Species which are sensitive to temperature changes and too hot or too cold temperatures were classified as stenothermal or intolerant. Species which are able to tolerate a wide range of temperatures were classified as eurythermal or tolerant.

36% of all species could be classified with regard to their temperature tolerance ranges and 24% of all species were classified as tolerant. Only 11% were classified as intolerant. No classifications could be made for over 64% of all species with regard to temperature. Stenothermal species are, for example, *Coregonus albula, C. lavaretus, C. maraena, C. oxyrinchus* (Coregonidae), *Lota lota* (Lotidae), *Barbatula bureschi* (Nemacheilidae), *Osmerus eperlanus* (Osmeridae), *Platichthys flesus* (Pleuronectidae) and *Thymallus thymallus* (Thymallidae).

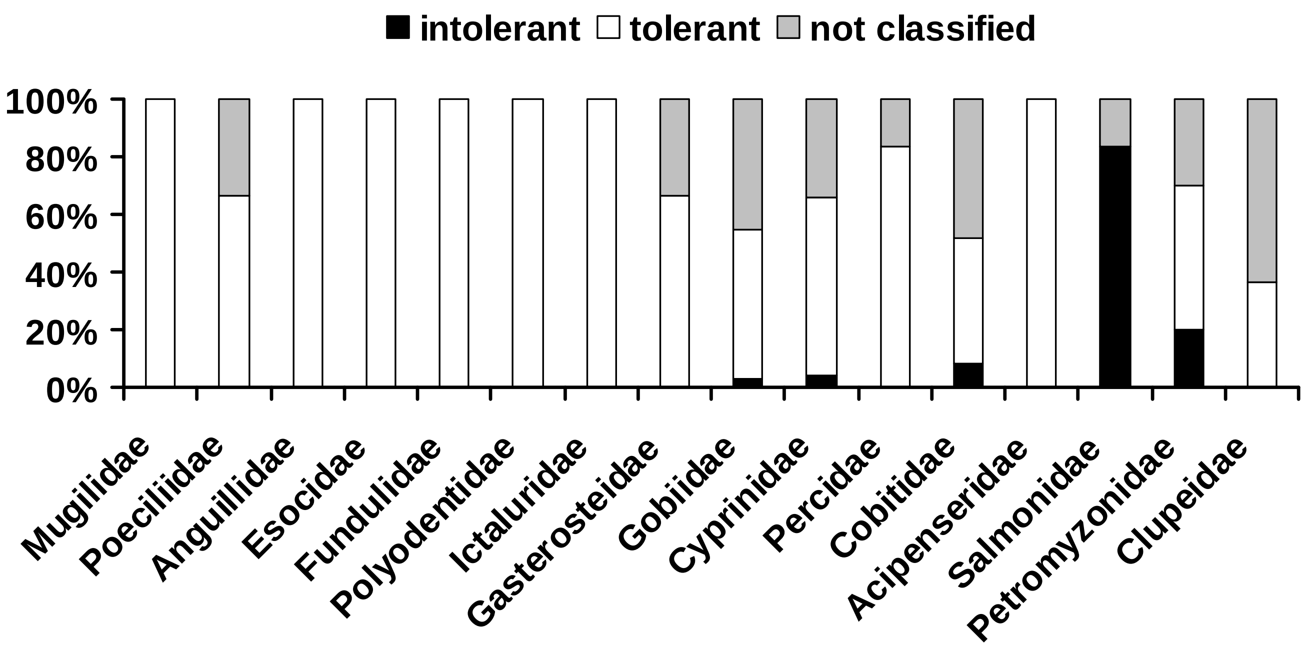


Figure 6.6 *Fish families and the percentage of species being tolerant (eurythermal) or intolerant (stenothermal) to unsuitable <u>temperatures</u> or are unclassified (Mugilidae n=5; Poeciliidae n=3; Anguillidae n=1; Esocidae n=1; Fundulidae n=1; Polyodontidae n=1; Ictaluridae n=3; Gasterosteidae n=6; Gobiidae n=31, Cyprinidae n=147; Percidae n=12; Cobitidae n=25; Acipenseridae n=9; Salmonidae n=18; Petromyzonidae n=10; Clupeidae n=11)*

All species of the families Mugilidae, Anguillidae, Esocidae, Fundulidae, Polyodontidae, Ictaluridae and Acipenseridae were classified with regard to temperature ranges (figure 6.6). They are all tolerant and can withstand a wide range of temperatures.

Gambusia affinis and *Gambusia holbrooki*, both Poeciliidae are tolerant, as well. One species of this family (*Poecilia reticulata*) could not be classified.

Four of the six Gasterosteidae are classified as eurythermal, two species were not classified.

Only the species *Knipowitschia punctatissima* is classified as stenothermal. 52% of the Gobiidae are tolerant and 45% could not be classified.

Alburnoides bipunctatus, Aristichthys nobilis, Barbus caninus, Leuciscus multicellus, Leuciscus souffia and *Phoxinus phoxinus* are cyprinids which are intolerant to unsuitable temperatures. 62% of the Cyprinidae are tolerant and 34% could not be classified.

All Percidae are classified as eurythermal except for *Percarina demidoffi* and Zingel *balcanicus.* Those two species could not be classified. *Sander lucioperca*, for example, will even benefit from expected climate warming (Lappalainen 2001).

Cobitis calderoni and *Sabanajewia larvata* can only cope with a narrow of temperatures. 11 species of the 25 Cobitidae are eurythermal and 48% of the family could not be classified.

All salmonids are clearly intolerant and do not tolerate temperature changes. Information on *Salmo labrax* and *Salmo macedonicus* is lacking. Increasing temperatures at summertime help cyprinids and percids dominate aquatic habitats in opposition to salmonids which are strongly adapted to low temperatures. Elevated temperatures can have either positive as well as negative effects depending on the species (Küttel et al., 2002). Low temperatures due to “coldwater pollution” (referable to overflow spillways) affect cyprinids and benefit salmonids (Kubecka & Vostradovsky 1995; Spence & Hynes 1971).

Lampetra planeri and *Lethenteron zanandreai* are intolerant. Five other species of the Petromyzonidae (*Eudontomyzon danfordi, E. mariae, E. vladykovi, Lampetra fluviatilis* and *Petromyzon marinus*) are tolerant. Three species could not be classified.

Alosa alosa, A. fallax, A. pontica and *Clupeonella cultriventris* are temperature tolerant. The rest of the species of the Clupeidae (27%) could not be classified.

Tolerance is mainly exhibited with regard to temperature. In no other tolerance guild there are so many tolerant species. In fact there are only three families which are clearly intolerant – the Salmonidae, the Coregonidae and the Cottidae. In experimental studies Beitinger et al. (2000) found out that Salmonidae along with Cottidae had the lowest tolerance of high temperatures and also the least variation in critical thermal maximum. Six salmonids surveyd had chronical lethal maxima between 25,9°C and 29,2°C. The individuals of Cottidae which Beitinger studied (n=44) displayed critical temperature maxima between 22,7 and 30,9°C.

Species which are stenothermal should also be intolerant to a low concentration of oxygen as the two parameters are closely linked. This hypothesis is confirmed for all Salmonidae, Coregonidae and Cottidae as well as for *Lota lota, Lenthenteron zanandraei, Thymallus thymallus, Leuciscus souffia, Cottus gobio, Alburnoides bipunctatus* and *Cobitis calderoni.* It is not true for *Sabanejewia larvata* and *Knipowitschia punctatissima.* They are classified as stenothermal but at the same time intermediately tolerant to a low concentration of oxygen what makes them more sensitive to temperature changes than to a low oxygen level.

Tolerance to habitat degradation

Species that do not react very sensitive to degradation of their habitat are classified as tolerant. Species can also show an intermediate tolerance to habitat degradation. Other species cannot compensate any degradation of their habitat – they are classified as intolerant. 65% of the species could be classified with regard to their ability to compensate habitat degradation. 22% are intolerant like, for example, *Coregonus albula, C. lavaretus* (Coregonidae), *Thymallus thymallus* (Thymallidae) and *Umbra krameri* (Umbridae).

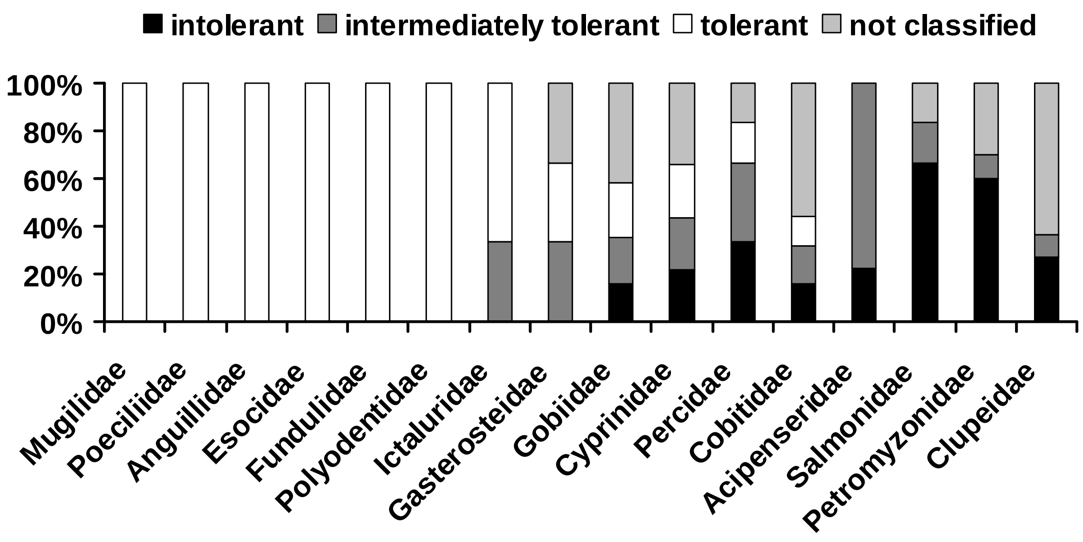


Figure 6.7 *Fish families and the percentage of species being tolerant, intermediately tolerant or intolerant to habitat degradation or unclassified (Mugilidae n=5; Poeciliidae n=3; Anguillidae n=1; Esocidae n=1; Fundulidae n=1; Polyodontidae n=1; Ictaluridae n=3; Gasterosteidae n=6; Gobiidae n=31, Cyprinidae n=147; Percidae n=12; Cobitidae n=25; Acipenseridae n=9; Salmonidae n=18; Petromyzonidae n=10; Clupeidae n=11)*

In contrary *Umbra pygmaea* (Umbridae) like 18% of all species is tolerant. Other species which exhibit tolerance are *Silurus glanis* (Siluridae), *Lepomis gibbosus* and *Micropterus salmoides* (Centrarchidae). 30% of the species could not be classified with regard to habitat degradation.

All Mugilidae, Poeciliidae, Anguillidae, Esocidae, Fundulidae and Polyodontidae were completely classified and are tolerant to habitat degradation (figure 6.7). Nevertheless *Esox lucius* declined during past decades due to a lack of submerse plants and flooded meadows as spawning habitat (Herzig et al. 1994).

Ameiurus melas and *A. nebulosus* are tolerant to habitat degradation, *A. punctatus* is intermediately tolerant. In a study about its distribution *Ameiurus melas* was highly variable among sites and was even facilitated by the expansion of reef beds (*Coucherousset et al. 2006*).

Gasterosteus aculeatus and *G. crenobiontus* are tolerant, *G. gymnurus* and *Pungitis pungitis* are intermediately tolerant. Two species of the Gasterosteidae could not be classified.

There are Gobiidae that are intolerant to habitat degradation, *Benthophiloides brauneri, B. stellatus, Knipowitschia punctatissima, Neogobius syman* and *Proterorhinus marmoratus.* 19% of the species of the Gobiidae are intermediately tolerant and 42% could not be classified. *Economidichthys pygmaeus, Knipowitschia caucasica, K. thessala, Neogobius fluviatilis, N. gymnotrachelus, N. kessleri* and *N. melanostomus* can tolerate degradation of their habitats.

22% of the cyprinid species are intolerant to habitat degradation including, for example, *Abramis ballerus, Barbus barbus, Chondrostoma nasus, Phoxinus phoxinus, Rhodeus amarus* and *Tinca tinca. Achondrostoma arcasii* is classified as intolerant, too. In a study about distribution of species within a river basin it was only found in intact habitats far from the main channel (Carmona *et* al. 1999*).* Another 22% are tolerant like, for example, *Abramis brama, Alburnus alburnus, Barbus graecus, Blicca bjoerkna, Gobio gobio* and *Rutilus rutilus*. 22% are intermediately tolerant and 34% could not be classified.

Romanichthys valsanicola, Zingel asper, Z. streber and *Z. zingel* are Percidae that are intolerant to habitat degradation. *Gymnocephalus baloni, G. schraetser, Sander lucioperca* and *Sander volgensis* are intermediately tolerant. *Gymnocephalus cernuus* and *Perca fluviatilis* are tolerant. Two species could not be classified.

Cobitis calderoni, Misgurnus fossilis, Sabanejewia balcanica and *S. larvata* are intolerant to a degradation of their habitat. *Cobitis elongatoides, C. hellenica* and *Misgurnus anugillicaudatis* are tolerant. 16% of the species were classified as intermediately tolerant and 56% could not be classified.

Acipenser oxyrinchus and *A. sturio* react sensitively to any degradation of their habitat. The other seven Acipenseridae are classified as intermediately tolerant.

67% of the salmonids are intolerant. The sea trout, for example, tends to disappear when a river gets dammed and are sensitive to structure of upstream habitats particulary presence or absence of woody debris (Welcomme *et al.* 2006). Only *Oncorhynchus mykiss, Salmo marmoratus* and *Salmo trutta macrostigma* are intermediately tolerant. No salmonid is tolerant. 17% could not be classified.

The Petromyzonidae only encounter species that are intolerant to habitat degradation with the exception of *Petromyzon marinus* which is intermediately tolerant. Another three out of ten species could not be classified.

Three Clupeidae are intolerant, *Alosa agone, A. alosa* and *A. pontica*. *A. fallax* was classified as intermediately tolerant and the seven other species could not be classified with regard to habiat degradation.

Salmonidae, Petromyzonidae and Clupeidae react sensitively to degradation of their habitats whereas there are six families which are completely tolerant with regard to their habitat. Lamouroux & Cattanéo (2006) unite *Phoxinus phoxinus, Gobio gobio, Leuciscus souffia, Alburnoides bipunctatus, Barbus barbus* (all cyprinids) and *Salmo trutta* (Salmonidae) in a „riffle-preferring guild“. They oppose the riffle-pool ratio of some sampled river stretches to the ratio of pool-preferring and riffle-preferring fish species. The results show that the abundance of species is strongly conncected to the percentage of pools. Increased percentage of pools enhances species belonging to the pool guild but species which need riffles get diminished by over 80%. Therefore species which prefer riffles as habitats are probably intolerant to habitat degradation, which also manifests as a decrease in riffles (for their study upstream reaches dominated by trout and other cold-water species were not considered). Their observations correlate with the classifications for *Samo trutta, Phoxinus phoxinus, Leuciscus souffia, Alburnoides bipuncatus* and *Barbus barbus.* However, *Gobio gobio* is supposed to be tolerant regarding the present classification whereas it is also intolerant as a member of the “riffle-preferring guild” defined.

6.2.2.2 Habitat

Species can be classified as rheophilic, eurytopic or limnophilic with regard to the habitat guild. 229 species out of 339 species could be classified. 32% of all species are rheophilic, 20% are eurytopic and 16% are limnophilic. The habitat guild is the one with the most classifications completed. Information on habitat is numerous and prevalent in most of the literature about fish and guilds. However, 32% of the species could not be classified with regard to habitat.

Firslty results for families which include only a few species are discussed. The three species of the family Catostomidae, for example, could not be classified. Only one species (*Atherina boyeri*) belonging to the family Atherinidae was classified, it is limnophilic. *Lepomis gibbosus* and *Micropterus salmoides* (Centrarchidae) are limnophilic. *Salaria fluviatilis* (Blenniidae) and two Cichlidae are also limnophilic – *Australoheros facetus* and *Oereochromis niloticus.* The two other Cichlidae concerned could not be classified. *Clarias gariepinus* as only representant in the classification process of the family Claridae is eurytopic. *Aphanius fasciatus* and *A. iberus* (Cyprinodontidae) are both limnophilic while *A. baeticus* could not be classified. *Lota lota* (Lotidae), *Dicentrarchus labrax* (Moronidae), *Osmerus eperlanus* (Osmeridae) and Sparus aurata (Sparidae) are eurytopic. The species of the families Pleuronectidae and Siluridae are not homogenous regarding their habitat preferences. *Plachtithys flesus* (Pleuronectidae) and *Silurus glanis* (Siluridae) are classified as eurytopic while *Pleuronectes platessa* (Pleuronectidae) and *Silurus aristotelis* (Siluridae) are limnophilic. Silurus glanis belongs to a group of species which are abundant in the main river as well as in different types of backwaters (Waidbacher *et al.* 2003). *Percottus glenii* (Odontobutidae), *Sygnathus abaster* and *S. typhe* (Sygnathidae), *Umbra krameri* and *U. pygmae* as well as *Valencia hispanica* and *V. lebourneuxi* (Valenciidae) are limnophilic, too. *Thymallus thymallus* (Thymallidae) and *Barbatula barbatula* (Nemacheilidae) are both considered to be rheophilic. Waidbacher et al. (2003) group *Barbatula barbatula* as a “rheophilic a”-type species which exlusively depend on litoral zones of the river itself and uses different structures there. In contrary *Umbra krameri* is a species which lives in strongly parched and often isolated oxbow lakes with an increased makrophyte density. Four out of five species belonging to the Cottidae are rheophilic. Only *Triglopsis quadricornis* is euryotpic. *Cottus gobio* is supposed to be rheophilic in small streams but eurytopic in large rivers, where it inhabits artificial stony habitats (Aarts & Nienhuis 2003).

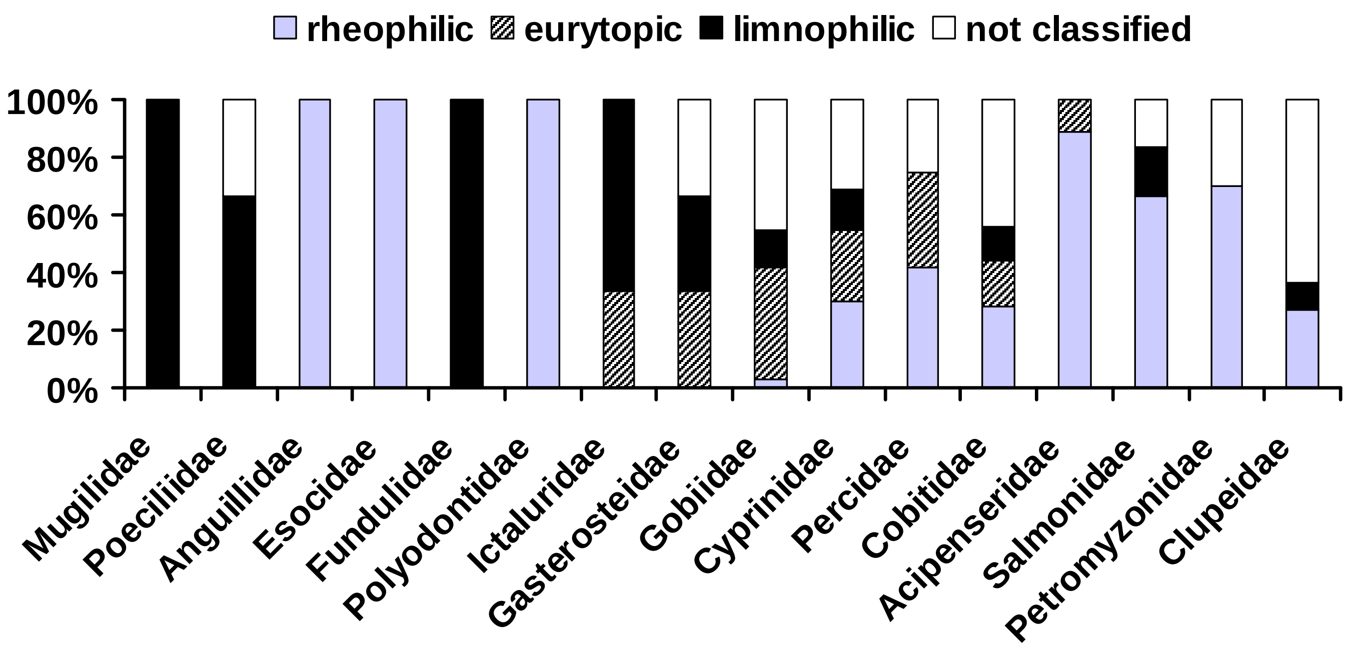


Figure 6.8 *Selected fish families and the percentage of species preferring rheophilic, eurytopic or limnophilic <u>habitats</u> or were not classified (Mugilidae n=5; Poeciliidae n=3; Anguillidae n=1; Esocidae n=1; Fundulidae n=1; Polyodontidae n=1; Ictaluridae n=3; Gasterosteidae n=6; Gobiidae n=31, Cyprinidae n=147; Percidae n=12; Cobitidae n=25; Acipenseridae n=9; Salmonidae n=18; Petromyzonidae n=10; Clupeidae n=11)*

All five species belonging to the Mugilidae are limnophilic.

Two Poeciliidae (*Gambusia affinis* and *G. holbrooki*) are also limnophilic, one species could not be classified.

Anguilla Anguilla, *Esox lucius* and *Polydon spathula* are rehophilic species. In contrary *Fundulus heteroclitus* is limnophilic. They are all the only representants of their families (figure 6.8).

Within the Ictaluridae there are two limnophilic species (*Ameiurus melas, A. nebulosus*) and one eurytopic species (*A. punctatus*).

Gasterosteus aculeatus and *G. gymnurus* are eurytopic whereas *Pungitis hellenicus* and *P. pungitis* are limnophilic. *Gasterosteus aculeatus* and *Osmerus eperlanus* (Osmeridae) have migratory populations which are rheophilic and non-migratory populations which are eurytopic (Aarts & Nienhuis 2003). Other two species belonging to the Gasterosteidae could not be classified.

39% of the Gobiidae which include in total 31 species are eurytopic. 45% of the species could not be classified. *Economidichthys trichonis, Knipowitschia caucasia, Pomatoschistus minutus* and *Zosterisessor ophiocephalus* are limnophilic. *Knipowitschia punctatissima* is the only species belonging to the family of Gobbidae which is classified as rheophilic.

29% of the cyprinid species are rheophilic like, for example, *Alburnoides bipunctatus, Aspius aspius, Barbus barbus, Chondrostoma nasus, Gobio gobio, Leuciscus cephalus* and *Phoxinus phoxinus*. 23% of the species are eurytopic including as an example *Rutilius rutilus*. Only 21 out of 147 species are supposed to be limnophilic. *Carassius auratus* and *C. carassius, Iberochondrostoma almacai, I. lemmingii* and *I. lusitanicum, Rhodeus amarus, Scardinius acarnaicus, S. erythrophtalmus, S. graecus* as well as *Tinca tinca* are all limnophilic, for example. 28% of the cyprinid species could not be classified with regard to their habitat preferences.

Percidae are either rheophilic or eurytopic. 42% of the species are rheophilic and 33% of the species are eurytopic. Two out of 12 species could not be classified. Familiar species in this family are *Perca fluviatilis* which is euryotpic and *Zingel streber* which is classified as rheophilic.

28% of the species belonging to the Cobitidae are rheophilic, 16% are eurytopic and 12% are limnophilic. 44% of the species could not be classified. To mention a few examples, *Cobitis taenia* is rheophilic and *Misgurnus anguillicaudatus* is eurytopic. *Misgurnus fossilis* is limnophlic and prefers to live in isolated oxbow lakes where it can adapt to extreme environmental conditions like a low oxygen level or even desiccation (Waidbacher et al. 2003).

All Acipenseridae are rheophilic with the exception of *Acipenser naccarii* which is supposed to be eurytopic.

67% of the species belonging to the Salmonidae are rheophilic, 17% could not be classified with regard to their habitat preferences. 3 out of 18 salmonid species are limnophilic (*Salvelinus alpinus, Salvelinus namaycush* and *Salvelinus umbla*). There are no eurytopic salmonids. Within the Salmonidae there can be made first estimations about the correlation between the degree of rheophily and the range of tolerance. Seven species belonging to the family Petromyzonidae which includes in total 10 species are rheophilic. The three other species could not be classified.

Three of the 11 species within the family of Clupeidae are rheophilic (*Alosa alosa, A. fallax* and *A. pontica*). *A. macedonica* is limnophilic. Other 7 species could not be classified.

Blanck et al. (2007) created four guilds of hydraulic preferences according to classifications proposed by Lamouroux & Cattanéo (2006). Two of them are made up of fish species that prefer fast flowing water – in shallow and in deep microhabitats – including *Abramis brama, Alburnoides bipunctatus, Alburnus alburnus, Barbatula barbatula, Barbus barbus, Chondrostoma nasus, Cottus gobio, Leuciscus cephalus, Phoxinus phoxinus, Salmo trutta* and *Thymallus thymallus*. Their observations correlate with the present classification except for *Abramis brama* and *Alburnus alburnus* which were rather classified as eurytopic.

6.2.2.3 Feeding

<u>Feeding habitat</u>

Species obtain food either from the ground or from the surface of a water body. The modality of benthic feeders also includes the trophic guild of benthivores which is used by several authors.

68% of the species could be classified with regard to their feeding habitat. 27% feed in the water column other 41% search for food in benthic surroundings. The family of Catostomidae could not be classified. *Atherina boyeri* and *A. presbyter* belonging to the family Atherinidae feed in the water column. *Salaria fluviatilis* (Blenniidae) and *Hemichromis fasciatus* (Cichlidae) are benthic feeders. The cichlid *Oerochromis niloticus* feeds from the water column. The two other Cichlidae concerned could not be classified. *Clarias gariepinus* as only representant in the classification process of the family Claridae is eurytopic. *Aphanius fasciatus* and *A. iberus* (Cyprinodontidae), *Lota lota* (Lotidae), *Dicentrarchus labrax* (Moronidae), *Osmerus eperlanus* (Osmeridae), *Sygnathus typhe* (Sygnathidae), *Valencia hispanica* and *V. letourneuxi* (Valenciidae) are all water column feeders. *Barbatula barbatula* (Nemacheilidae), *Percottus glenii* (Odontobutidae), *Plachtithys flesus* and *Pleuronectes platessa* (Pleuronectidae), Sparus aurata (Sparidae), *Sygnathus abaster* (Sygnathidae), *Umbra krameri* and *U. pygmae* (Umbridae) are all benthic feeders as well as all members of the family Cottidae.

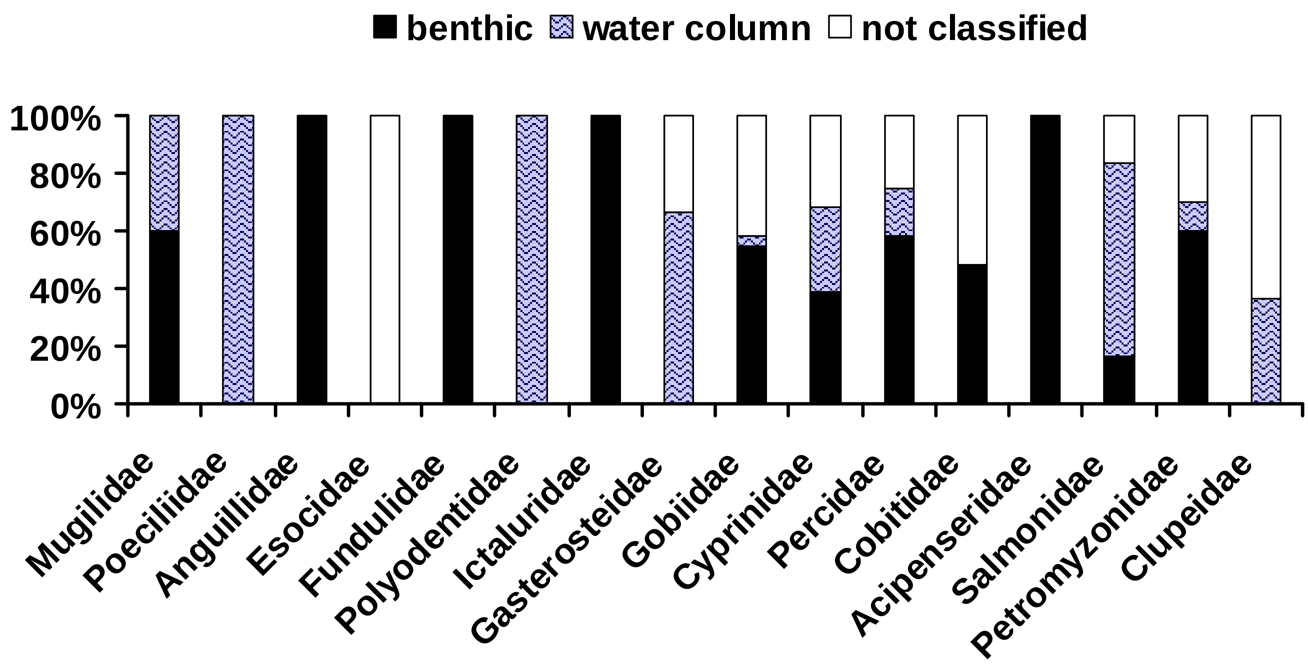


Figure 6.9 *The illustration displays abundant fish families and the percentage of species which feed benthic or from the water column or which are not classified (Mugilidae n=5; Poeciliidae n=3; Anguillidae n=1; Esocidae n=1; Fundulidae n=1; Polyodontidae n=1; Ictaluridae n=3; Gasterosteidae n=6; Gobiidae n=31, Cyprinidae n=147; Percidae n=12; Cobitidae n=25; Acipenseridae n=9; Salmonidae n=18; Petromyzonidae n=10; Clupeidae n=11)*

Although the five species of the Mugilidae are classified homogenously with regard to almost all guilds there are differences concerning feeding habitat, migration and salinity. *Chelon labrosus* and *Liza aurata* feed in the water column whereas *L. ramada, L. saliens* and *Mugil cephalus* are benthic feeders (figure 6.9).

All three species of the Poeciliidae are water column feeders.

Anguilla anguilla and *Fundulus heteroclitus* search for food in benthic surroundings whereas *Esox lucius* and *Polydon spathula* obtain food from the water column. *Anguilla Anguilla* feeds upon sediment and sediment-associated systems (Langston *et*. *al* 2002).

Ameiurus melas, A. nebulosus and *A. punctatus* (Ictaluridae) are classified as benthic feeders.

Four species belonging to the family of Gasterodeidea, including *Gasterosteus aculeatus*, feed in the water column, two more species could not be classified.

Economidichthys trichonis is a benthic feeder, 55% of the species feed in the water column. There is no information on the feeding habitat for 42% of the species of the Gobiidae.

39% of the cyprinids are benthic feeders among them *Abramis brama, Barbus barbus, Carassius carassius, Chondrostoma nasus, Gobio gobio, Tinca tinca* and *Vimba vimba*. Winkelmann *et al.* (2007) investigated lethal and sublethal predation effects of the gudgeon (*Gobio gobio*) on the grazing mayfly *Rhithrogena semicolorata* and the shredding amphipod *Gammarus pulex* in a largely detritus-based small stream. They defined *Gobio gobio* as a benthic feeder.

Other examples for benthivorous cyprinids are *Blicca bjoerkna, Carassius gibelio* and *Cyprinus carpio* whereas *Scardinius erythrophtamlus, Alburnus alburnus* and *Pelecus cultratus* obtain food from the water column (Herzig et al. 1994). 30% of the species feed in the water column like, for example, *Ctenopharyngodon idella, Leucaspius delineatus, Leuciscus leuciscus, Phoxinus phoxinus, Rutilus rutilus* and *Squalis alburnoides*. 30% of the species could not be classified with regard to their feeding habitat. Schiemer and Spindler (1989) rely on the facts that *Barbus barbus* is benthivorous from the onset of feeding and that in *Chondrostoma nasus* the surface orientated feeding during youth is replaced by a substrate oriented method.
Also for Dušek et al. (2004) *Blicca bjoerkna, Barbus barbus, Gobio gobio, Carassius auratus* and *Vimba vimba* (Cyprinidae) as well as *Ameiurus nebulosus* (Ictaulridae) are benthic feeders.

Seven out of 12 species belonging to the Percidae are benthic feeders. *Perca fluviatilis* and *Sander lucioperca* are the only Percidae that are supposed to be water column feeders. About three species there is no feeding habitat information.

48% of the species of the family Cobitidae are searching for food in benthic surroundings like, for example, *Cobitis taenia, Misgurnus fossilis* and *M. anguillicaudatus.* The other 52% could not be classified.

All Acipenseridae are benthic feeders.

67% of the salmonids feed in the water column. Only *Oncorhynchus gorbuscha, O. kisutsch* and *O. tschawytscha* obtain their food from the ground. 17% could not be classified.

Petromyzon marinus is a water column feeder. 60% of the species are benthic feeders and for 30% of the species there is no information on the feeding habitat.

Alosa alosa, A. fallax, A. macedonica and *Clupeonella cultriventris* feed in the water column. Another 64% of the species belonging to the family of Clupeidae could not be classified.

<u>Adult trophic guild</u>

The diet of a fish species changes according to time of the year, time of the day, water levels, habitat, length and age (Lelek & Köhler 1989). Nevertheless, there can be made clear differenciations. Adult fish could be classified into different trophic guilds according to the dominant food item in their diet. Species can be detritivorous, herbivorous, insectivorous, parasitic, planktivorous or a combination of feeding modes (for the definition of trophic guilds please refer to table 3.3). If the diet consists of more than 25% plant material and more than 25% animal material species are typical generalists and were classified as omnivorous.

58% of the species could be classified with regard to their feeding habits. Most of the species (27%) are insectivorous. Only 16% of the species were classified as omnivorous. 18 out of the 339 species are planktivorous. No species was classified as detritivorous, herbivorous or piscivorous alone. Instead of those definitions there were used combinations of food. 20 species are supposed to be piscivorous/parasitic and 14 species were classified as detritivorous/herbivorous. For 42% of the species information about their trophic guild was missing.

Anguilla anguilla is insectivorous.

Atherina presbyter (Atherinidae) and *Salaria fluviatilis* (Blenniidae) are insectivorous, too while *A. boyeri* is planktivorous (Atherinidae).

The species belonging to the Atherinopsidae and Catostomidae could not be classified with regard to their food sources as well as three species of the Centrarchidae. However, two other Centrarchidae, *Lepomis gibbosus* and *Micropterus salmoides*, are insectivorous and piscivorous/parasitic.

Australoheros facetus and *Hemichromis* fasciatus are both omnivores while two other Cichlidae could not be classified.

Clarias gariepinus (Clariidae) is an insectivorous species.

Three out of 11 Clupeidae are planktivorous (*Alosa alosa, A. fallax* and *Clupeonella cultiventris*). *A. pontica* is insectivorous. The other Clupeidae were not classified.

Coregonus albula, C. lavaretus and *C. peled* are planktivorous. *Coreguns* sp. are supposed to feed mainly or occasionally on large planktic crayfish (Spindler 1997).

C. maraena and *C. oxyrinchus* are insectivorous. For four other Coregonidae there was no information about their food sources.

Aphanius fasciatus and *A. iberus* (Cyprinodontidae) are both insectivorous. *Esox lucius* can feed parasitic or on other fish. *Fundulus heteroclitus* is insectivorous.

Gasterosteus acuelatus, *G. gymnurus* and *Pungitis pungitis* are omnivorous while *P. hellenicus* is supposed to be only insectivorous. Other two Gasterosteidae were not classified.

All three species of the Ictaluridae are omnivorous. *Lota lota* (Lotidae) and *Dicentrarchus labrax* (Moronidae) are piscivorous/parasitic.

Two Mugilidae are omnivorous (*Chelon labrosus, Liza aurata*) and other three of them are detritivorous and at the same time herbivorous (*Liza ramada, L. saliens, Mugil cephalus*).

Perccottus glenii (Odontobutidae) is omnivorous while *Osmerus eperlanus* (Osmeridae) was classified as planktivorous.

Platichthys flesus (Pleuronectidae), *Gambusia affinis* and *G. holbrooki* (Poeciliidae), *Syngnathus abaster* (Syngnathidae), *Thymallus thymallus* (Thymallidae), *Umbra krameri* and *U. pygmae* (Umbridae) as well as *Valencia hispanica* and *V. letourneux* (Valenciidae) are all insectivorous.

Polydon spathula (Polyodentidae) and *Syngnathus typhle* (Syngnathidae) are both planktivorous.

Silurus aristotelis and *S. glanis* (Siluridae) as well as *Sparus aurata* (Sparidae) can switch from a piscivorous to a parasitic feeding mode.

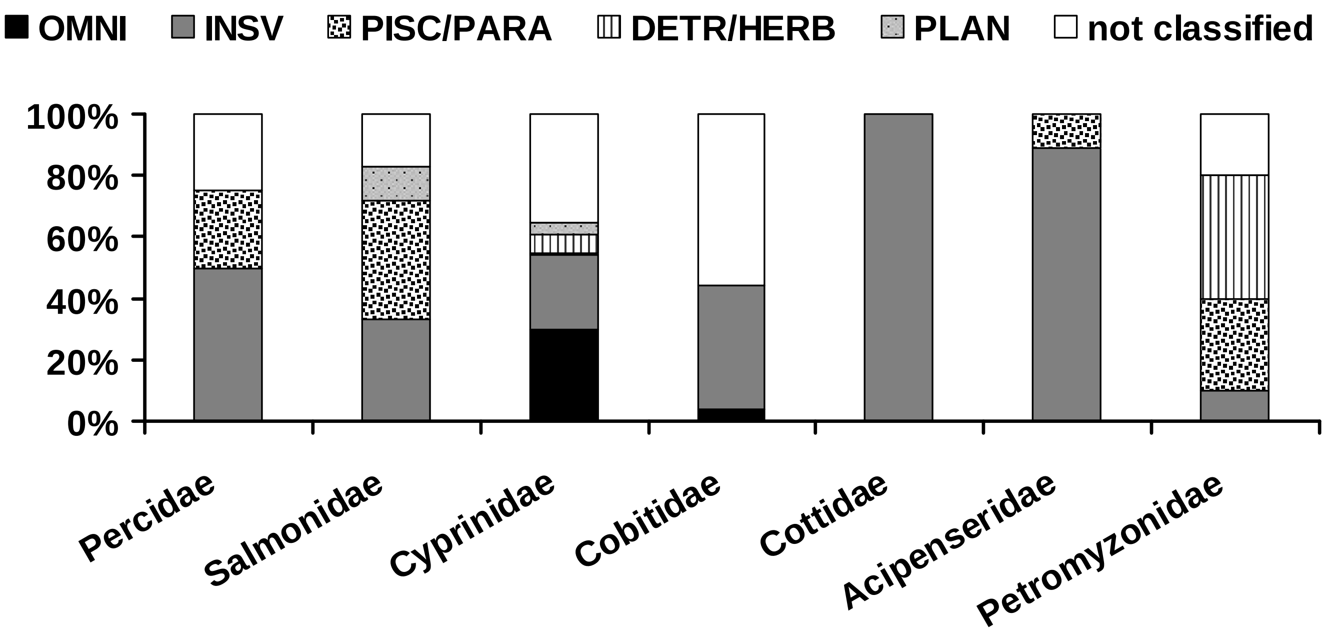


Figure 6.10 *Most common* <u>*food*</u> *sources of some fish families and the correspondent percentage of species (Percidae n=12, Salmonidae n=18, Cyprinidae n=147, Cobitidae n=25, Cottidae n=5, Acipenseridae n=9, Petromyzonidae n=10;* ***OMNI****=omnivorous,* ***INSV****=insectivorous,* ***PISC/PARA****=piscivorous/parasitic,* ***DETR/HERB****=detritivorous/herbivorous,* ***PLAN****=planktivorous)*

50% of the species belonging to the Percidae are insectivorous including, for example, *Gymnocephalus schraetser*, *Zingel zingel* or *Z. asper*. *Perca fluviatilis, Sander lucioperca* and *S. volgensis* instead are piscivorous/parasitic. Two species could not be classified (figure 6.10).

A major part of the salmonids (39%) are able to switch from being piscivores to a parasitic feeding mode (*Hucho hucho, Salmo salar,* and *Salmo trutta trutta*, for example). Another 28% are insectivorous (*Oncorhynchus mykiss, Salmo marmoratus, Salmo trutta fario, Salvelinus fontinalis* and *Salvelinus namaycush). Only two species (Salvelinus umbla* and *S. alpinus)* are planktivorous. 17% of the Salmonidae could not be classified.

4% of the species belonging to the Cyprinidae are planktivorous (*Abramis ballerus, Alburnus albidus, A. alburnus, Aristichthys nobilis, Hypophthalmichthys molitrix*, *Pelecus cultratus* and *Tropidophoxinellus hellenicus).* In an experiment the planktic *Chydorus sphaericus* was consumed especially by the day active bleak (*Alburnus alburnus*) (Alajarvi 2004). 24% are insectivorous including, for example, *Abramis sapa, Alburnoides bipunctatus, Barbus barbus, Gobio albipinnatus, Phoxinus phoxinus* and *Squalius alburnoides.* 30% of the cyprinid species are omnivorous. As examples *Abramis brama, Carassius carassius, Leucaspius delineatus, Leuciscus cephalus, Rhodeus amarus, Rutilus rutilus* and *Tinca tinca* are typical generalists. 6% are supposed to be detritivorous and herbivorous at the same time (*Chondrostoma nasus*, for example). *A. brama* finds food by paying attention to chemical stimuli whereas *A. ballerus* tends to filtrate zoo plankton (Spindler 1997). *Aspius apsius* is the only cyprinid that is classified as piscivorous/parasitic 35% of the species belonging to the Cyprinidae could not be classified with regard to their food sources.

Cobitis taenia and *Misgurnus fossilis* are typical Cobitidae since they are insectivorous like eight other species of this family (40%). Only *C. meriodinalis* is classified as omnivorous. 56% of the species could not be classified.

All Cottidae and eight out of nine species belonging to the Acipenseridae were classified as insectivorous. Only *Huso huso* is supposed to be piscivorous and parasitic.

40% of the species belonging to the Petromyzonidae choose between detritus or plant material as food sources (e.g. *Lampetra planeri*). Another 30% are piscivorous/parasitic (e.g. *Lampetra fluviatilis*). *Lethenteron camtschaticum* is an insectivorous species and 20% of the species were not classified.

The European fish fauna mainly consists of generalist feeders (Oberdorff & Hughes 1992). However, only 16% of the species considered in the classification process are omnivorous. That could mean that the European fish fauna is made up by plenty of individuals of only a few different species which mainly belong to the families Cyprinidae and Cobitidae that are to a great extend omnivores.

6.2.2.4 Migration and salinity

Migration

Differenciations can be made between species that only move within a particular river segment, species that migrate between river zones and long migrating species which includes both catadromous and anadromous species.

61% of all species considered were classified with regard to their migratory behaviour. The majority of the species (39%) is resident and does not move further than a river segment. 16% are potamodromous and migrate between river zones and not more than 10km. 8% are long migrating species.

Examples for long migrating species are *Anguilla anguilla* which breeds in the sea and migrates as the larval stage to estuaries and rivers (Langston et al. 2002), *Mugil cephalus* (Mugilidae) and *Platichthys flesus* (Pleuronectidae). *Esox lucius, Osmerus eperlanus*, *Polydon spathula* and *Thymallus thymallus* are some of the potamodromous species. Non-migrating species are, for example, *Atherina boyeri, Salaria fluviatilis, Lepomis gibbosus, Micropterus salmoides, Australoheros facetus, Hemichromis fasciatus, Aphanius fasciatus, Fundulus heteroclitus, Barbatulua barbatula, Gambusia affinis, G. holbrooki, Poecilia reticulata, Syngnathus abaster, S. typhle, Umbra krameri, U. pygmae* and *Valencia letourneuxi.*

All Gobiidae which could be classified (52% of the species) are resident. *Knipowitschia caucasica, Neogobius fluviatilis, N. kessleri, N. melanostomus* and *Proterorhinus marmoratus*, for example, do not migrate at all.

Salinity

Species were classified according to their envrionment's ideal level of salinity. There are species that exclusively live in freshwater habitats, species that spend life periods in freshwater and brackish habitats (abbreviated FRESAL in further analysis), brackish and marine species and andadromous or catadromous species that spend life periods in freshwater, brackish and marine habitats (abbreviated ANCA in further analysis).

51% of the species present in the classification process live exclusively in freshwater habitats. 2% live in freshwater and brackish habitats. 3,5% are brackish and 1,5% marine species and 6% spend live periods in each of the three environments. 65% of the species could not be classified with regard to their salinity preferences.

Pure freshwater species are, for example, *Salaria fluviatilis, Lepomis gibbosus, Micropterus salmoides, Australoheros facetus, Esox lucius, Fundulus heteroclitus, Ameiurus melas, A. punctatus, A. nebulosus, Barba-*

tulua barbatula, Perccottus glenii, Gambusia affinis, G. holbrooki, Silurus glanis, S. typhle, Umbra krameri and *U. pygmae.*

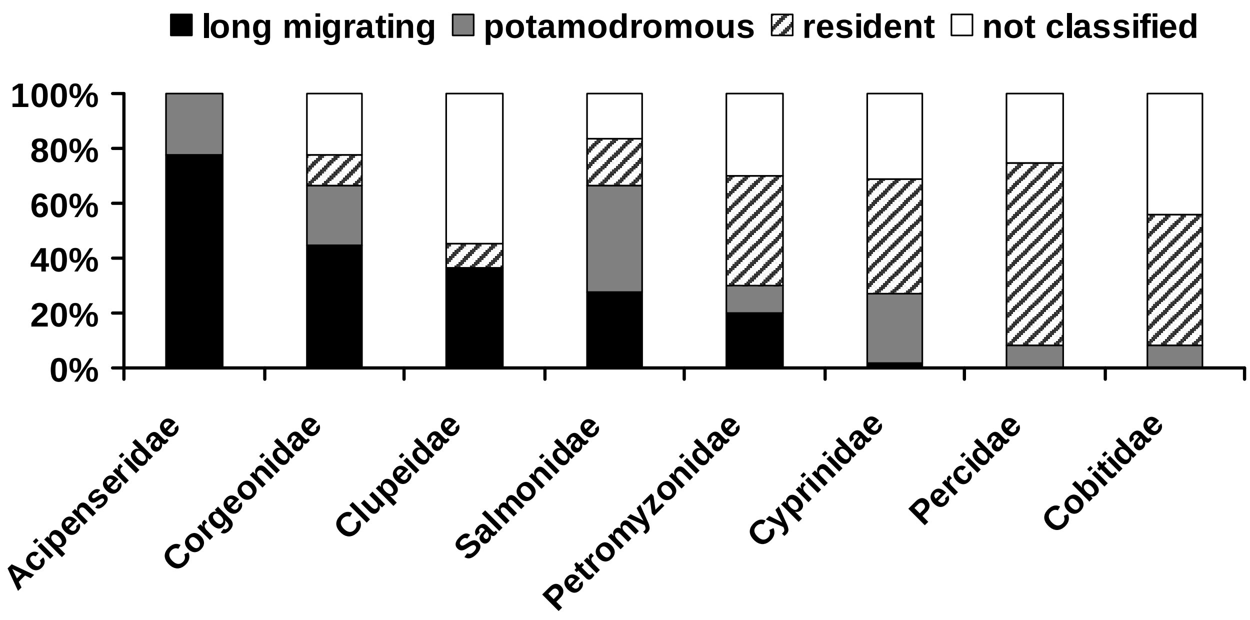
Osmerus eperlanus and *Syngnathus abaster* spend live periods in both freshwater and brackish habitats while *Syngnathus typhle* exlusively lives in marine habitats.

Examples for species typical for estuatries are *Atherina boyeri, Atherina presbyter, Aphanius fasciatus* and *Sparus aurata.*

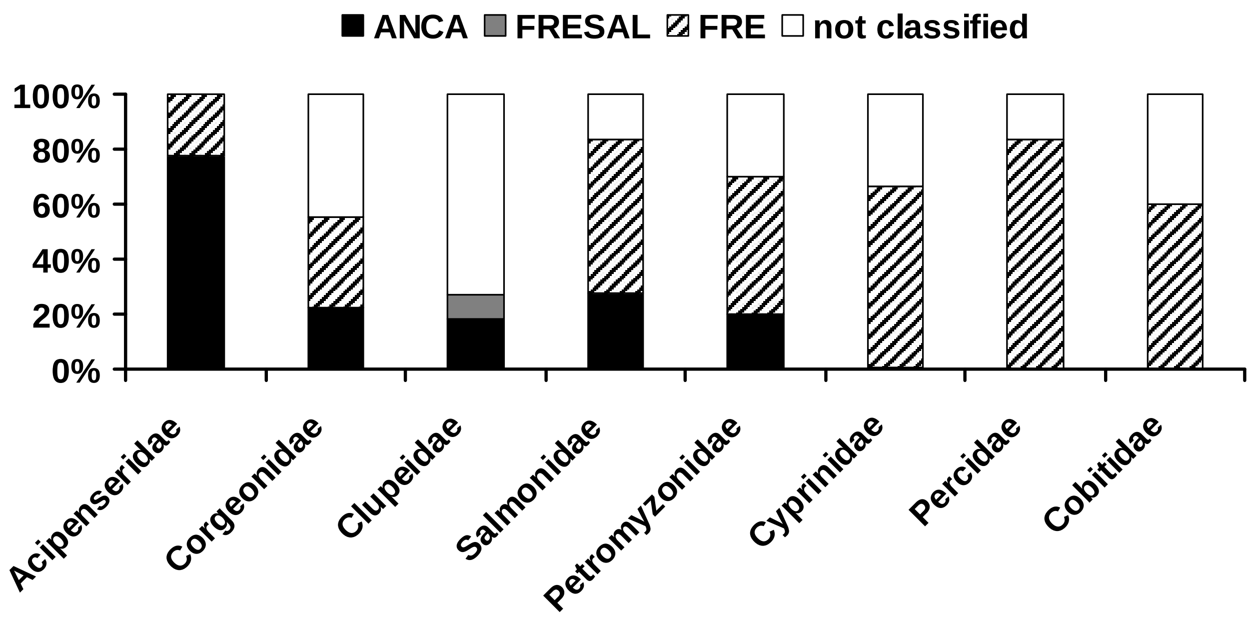
Platichthys flesus and *Anguilla anguilla* are species that spends life periods in freshwater, estuarine and marine habitats since they are also a long migrating species (see the results for migration above).

The Gobiidae are mostly either pure freshwater (32% of the species) or pure estuarine (10% of the species) living fish (48% of the species could not be classified with regard to their salinity level). However, for *Neogobius fluviatilis* and *N. melanostomus* there are contradictionary classifications. They are both classified as resident species but what concerncs the salinity level of their habitats they are supposed to spend life periods in both freshwater and brackish habitats.

The families which are analyzed in the following two figures (Acipenseridae, Coregonidae, Clupeidae, Salmonidae, Petromyzonidae, Cyprinidae, Percidae and Cobitidae) do not encounter any pure marine or estuarine species. Those families are made up by freshwater species and species that either spend life periods in freshwater and marine habitats or in freshwater, marine and brackish habitats. They are therefore ideal families to represent the European fish fauna of running waters.



(a)



(b)

Figure 6.11 *Fish families and the percentage of species connected with* ***(a)*** *migration and* ***(b)*** *salinity level (Acipenseridae n=9, Corgenoidae n=9, Clupeidae n=11, Salmonidae n=18, Petromyzonidae n=10, Cyprinidae n=147, Percidae n=12, Cobitidae n=25;* ***ANCA****=anadromous/catadromous,* ***FRESAL****=freshwater and marine,* ***FRE****=freshwater)*

Acipenser baeri and *A. ruthenus* are the two out of nine Acipenseridae that are potamodromous. The seven other species considered in the classification process are long migrating species. The results correspond well with their salinity preferences. *A. baeri* and *A. ruthenus* are freshwater species while the other seven species are classified as ANCA (figure 6.11).

Coregonus albula is a resident and freshwater species. *C. lavaretus* and *C. peled* only migrate between river zones and are freshwater species, too. *C. autumnalis, C. maraena*, *C. oxyrinchus* and *C. pidschian* are long migrating species but only C. maraena and C. oxyrinchus are studied well enough to classify them as anadromous/catadromous referring to salinity. 22% of the Coregonidae could not be classified with regard to migration and 44% of them could not be classified with regard to salinity.

Alosa macedonica is the only species belonging to the family of Clupeidae which was classified as resident. *A. alosa, A. fallax, A. pontica* and *Cluponella cultriventris* are long migrating species. *Alosa fallax*, for example, is anadromous (Aarts & Nienhuis, 2003), as well as *Alosa alosa.* Both species are euryhaline and migrate only over an intermediate spatial scale but they are still anadromous (Noble et al., 2007). 54% of the species could not be classified with regard to migration but 72% with regard to salinity. *A. pontica* was classified as a species which spends life periods in freshwater and brackish habitats.

Salevlinus alpinus, *S. fontinalis* and *S. umbla are the only* Salmonidae that were classified as resident. *Hucho hucho, Oncorhynchus mykiss, Salmo marmoratus, S. trutta fario, S. trutta lacustris, S. trutta macrostigma*, and *Salvelinus namaycush* are all potamodromous. All salmonids mentioned were also classified as pure freshwater species. Long migrating salmonids that were also classified as ANCA are *Oncorhynchus gorbuscha, O. kisutsch, O. tschawytscha, Salmo salar* and *S. trutta trutta. Salmo salar*, for example, is a typical anadromous species migrating between a downstream feeding site and an upstream breeding one (Welcomme et al. 2006). 17% of the species were not classified.

Lampetra fluviatilis and *Petromyzon marinus* are both long migrating and anadromous/catdromous species. *Eudontomyzon mariae, E. vladykovi, Lampetra planeri* and *Lethenteron zanandreai* are resident and pure freshwater species. *E. danfordi* is classified as a potamodromous and freshwater species. 30% of the species belonging to the Petromyzonidae could not be classified with regard to migration and salinity.

Aristichthys nobilis, Ctenopharyngodon idella and *Hypophthalmichthys molitrix* are classified as long migrating species but at the same time as pure freshwater fish.

24% of the species belonging to the Cyprinidae were classified as potamdromous species exclusively living in freshwater habitats (e.g. *Abramis brama, A. sapa, Barbus barbus, Chondrostoma nasus, Leuciscus cephalus, L. idus, Pelecus cultratus, Rutilus rutilus*). *Rutilus rutilus* and *Abramis brama* exhibit short distance but non-obligate migratory behaviour (Welcomme et al. 2006). *Vimba vimba* is potamodromous, too but it is supposed to spend life periods in freshwater and brackish habitats. *Barbus prespensis* is also classified as potamodromous but there is no information on its salinity preferences. *Abramis ballerus, Alburnoides bipunctatus, Alburnus alburnus, Carassius carassius, Gobio gobio, G. kessleri, Leuciscus souffia, Phoxinus phoxinus, Scardinius erythrophtalmus* and *Tinca tinca* are some species of the 40% belonging to the cyprinids which are resident and freshwater fish. *Barbus euboicus, B. petenyi, Chalcalburnus chalcoides* and *Scardinius acarnanicus* are also resident species but they were not classified with regard to salinity. 31% of the species could not be classified.

67% of the species belonging to the Percidae are resident species exclusively living in freshwater habitats. *Sander lucioperca* is a potamodromous and freshwater species. 25% of the species could not be classified.

Cobitis meriodinalis is residend like 48% of the species belonging to the Cobitidae but it is not classified with regard to salinity compared to the other resident Cobitidae which are, for example, *Cobitis calderoni, C. hel-*

lenica, C. paludica, C. taenia, C. vettonica, Missgurnus anguillicaudatis and *M. fossilis*. For Welcomme et al. (2006) the weatherfish is usually a non-migratory species.

Sabanejewia bulgarica and *S. romanica* are potamdromous and freshwater species. About 40% of the species were not classified.

Information on migration and salinity often correspondend well although there were a few more species classified with regard to their migratory behaviour than to their salinity level preferences.

6.2.2.5 Reproduction

Reproduction modalities include information on substrata used for reproduction, preferences for a certain spawning habitat, reproductive timing and parental care.

Reproductive guilds

Species could be classified in 11 different groups according to their preferred substrata for reproduction. Some combinations of substrata or reproductive modes were also possible (like, for example, ostracophilic combined to viviparous). Species can be rock and gravel spawners with pelagic free embryos (lithopelagophilic) or stone spawners (lithophilic). They may deposit their eggs in shells of molluscs (ostracophilic), into the pelagic zone (pelagophilic), on submerged plants (phytophilic) or on submerged plants and other submerged items (phytolithophilic). They can also be non-specialised spawners (polyphilic) or spawn on roots or grass above sandy bottom (psamnophilic). Spawning in interstitial spaces means that the corresponding species are speleophilic spawners. Live bearers are defined as viviparous. Ariadnophilic species build nests and may exhibit some form of parental care (for further definitions of reproductive guilds please refer to table 3.5).

A relatively high percentage of the species (28%) concerned for classification are lithophilic. 13% of the species were classified as phytophilic. 4% are pelagophilic and another 4% speleophilic. 2% of the species are supposed to be psamnophilic. 6% of the species are lithopelagophilic, ariadnophilic, ostracophilic/viviparous and polyphilic (1,5% of the species corresponding to each of the four modalities). Only 6% of the species could not be classified with regard to their reproductive guild. Reproduction is probably the most studied issue in connection with fish ecology. Balon published his definitions of reproductive guilds already in 1975 and created a foundation for a comprehensive classification of species.

Lota lota (Lotidae), *Barbatula barbatula* (Nemacheilidae), *Osmerus eperlanus* (Osmeridae), Ameiurus melas (Ictaluridae), *Polyodon spathula* (Polyodontidae) and *Thymallus thymallus* (Thymallidae) are litophilic, for example. *Anguilla Anguilla* (Anguillidae), *Platichthys flesus* (Pleuronectidae) and *Dicentrarchus labrax* (Moronidae) are pelagophilic. *Salaria fluviatilis* (Bleniidae) and *Ameiurus nebulosus* (Ictaluridae) are speleophilic. *Atherina boyeri* (Atherinopsidae*), Esox lucius* (Esocidae), *Clarias gariepinus* (Clariidae) and *Ameiurus punctatus* (Ictaluridae) are phytophilic. *Umbra krameri, U. pygmae* (Umbridae) and the two Valenciidae *(Valencia hispanica* and *V. letourneuxi*) are phytophilic, too. *Atherina presbyter* (Atherinopsidae) and *Percottus glenii* (Odontobutidae) are phytolithophilic. *Lepomis gibbosus* and *Micropterus salmoides* (Centrarchidae) are polyphilic as well as *Syngnathus abaster* (Syngnathidae). *Hemichromis fasciatus* (Cichlidae) is ariadnophilic. *Fundulus heteroclitus* (Fundulidae) is ostracophilic/viviparous like all three species of Poeciliidae.

32% of the Gobiidae are speleophilic (e.g. *Economidichthys pygmaeus, Knipowitschia punctatissima* or *Neogobius syrman*) 12% are phytophilic (*Economidichthys trichonis, Knipowitschia caucasica* and *Zosteris-*

essor ophiocephalus). *Knipowitschia panizzae, Pomatoschistus microps* and *P. minutus* are ariadnophilic. *Neogobius melanostomus* and *N. kesslerii* are two lithophilic Gobiidae while *N. trachelus* and *Padogobius bonelli* are phytolithophilic. *Knipowitschia cameliae* is classified as ostracophilic/viviparous.

All five species of the Mugilidae are pelagophilic and all Cottidae are speleophilic.

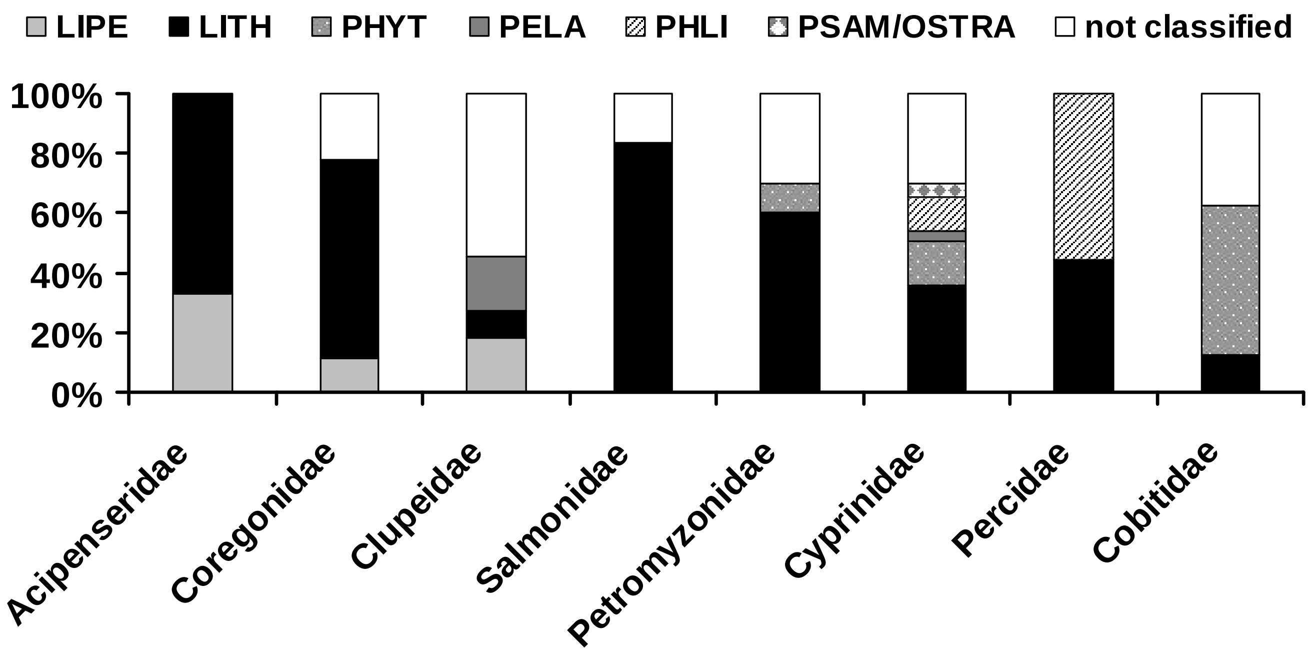


Figure 6.12 *Fish families and the percentage of species connected with the substrata preferred for reproduction (Acipenseridae n=9, Coregonidae n=9, Clupeidae n=11, Salmonidae n=18, Petromyzonidae n=10, Cyprinidae n=147, Percidae n=12, Cobitidae n=25, n=11; light grey barrs:* ***LIPE****=lithopelagophilic, black barrs:* ***LITH****=lithophilic, grey dotted barrs:* ***PHYT****=phytophilic, dark grey barrs:* ***PELA****=pelagophilic, barrs with stripes:* ***PHLI****=phytolithophilic, barrs with check:* ***PSAM/OSTRA****=psamnophlic and ostracophilic)*

Seven out of nine species belonging to the Acipenseridae are lithophilic. *A. gueldenstaedtti, A. nudiventris* and *A. stellatus* are lithopelagohphilic (figure 6.12).

67% of the Coregonidae could be classified and nearly all of them are lithophilic except for *C. pidschian* which is lithopelagophilic.

Alosa alosa and *A. fallax* are lithopelagophilic, *A. macedonica* was classified as lithophilic and *Cluponella cultiventris* as pelagophilic. 55% of the species belonging to the Clupeidae could not be classified.

Information is lacking for three species but the rest of the salmonids is lithophilic.

Eudontomyzon mariae, E. vladykovi, Lampetra fluviatilis, L. planeri, Lethenteron zanandreai and *Petromyzon marinus* are lithophilic while *Eudontomyzon danfordi* is supposed to be phytophilic. Three species of the Petromyzonidae could not be classified.

37% of the species belonging to the Cyprinidae are lithophilic like, for example, *Abramis ballerus, Aspius aspius, Barbus barbus, Chondrostoma nasus, Leuciscus cephalus* or *Vimba vimba.* 12% are classified as phytophilic (e.g. *Achondrostoma arcasii, Carassius carassius, Leuapsius delineatus, Rutilus pigus, Scardin-*

ius erythrophtalmus and *Tinca tinca*). *Cyprinus carpio* is strictly phytophilic and is adapted to spawn only on freshly flooded plants (Balon, 1975). *Alburnus alburnus, Leuciscus idus* and *Pseudorasbora parva* are examples for phytolithophilic cyprinids which are in total 7% of the species. There are also five out of 147 species that are psamnophilic (*Gobio albipinnatus, G. kessleri, G. lozanoi, Romanogobio belingi* and *R. valdykovi*). *Aristichthys nobilis* is pelagophilic and *Rhodeus amarus* ostracophilic.

Five species belonging to the Percidae are phytolithophilic (*Gymnocephalus baloni, G. cernuus, Perca fluviatilis, Sander lucioperca* and *S. volgensis*). Four species are lithophilic (*Gymnocepahlus schraetser, Zingel asper, Z. streber* and *Z. zingel*).

52% of the species belonging to the Cobitidae are phytophilic, among them *Cobitis taenia* and *Misgurnus fossilis*. 16% are lithophilic (e.g. Cobitis calderoni). *Cobitis paludica* is a polyphilic species. 36% could not be classified. Cobitidae are mainly phytophilic like, for example, *Cobitis taenia, Cobitis calderoni, Cobitis elongata, Sabanejewia* sp. and *Misgurnus fossilis* (Balon, 1975).

Spawning habitat preference

The guild describes wheter species prefer to spawn in fast flowing (rehopar) or stagnant (limnopar) surroundings. It is also possible that species have no clear preference concerning their spawning habitat (eurypar).

31% of the species are rheopar and 15% prefer to spawn in stagnant waters. 16% do not discriminate between habitats with different flow conditions with regard to the spawning event. 38% of the species could not be classified.

Thymallus thymallus (Thymallidae) and *Dicentrarchus labrax* (Moronidae) prefer fast flowing waters for spawning.

Ictiobus bubalus (Catostomidae), *Gasterosteus gymnurus* (Gasterosteidae), *Dicentrarchus labrax* (Moronidae), *Barbatula barbatula* (Nemacheilidae), *Platichthys flesus* (Pleuronectidae), *Silurus glanis* and *Silurus aristotelis* (Siluridae), *Sparus aurata* (Sparidae), *Syngnathus typhle* and *S. abaster* (Syngnathidae), *Salaria fluvitatilis* (Blenniidae), *Lota lota* (Lotidae) and *Osmerus eperlanus* (Osmeridae) are all eurypar.

Anguilla Anguilla (Anguillidae), *Atherina boyeri* (Atherinopsidae), *Aphanius fasciatus* (Cyprinodontidae) *Lepomis gibbosus* and *Micropterus salmoides* (Centrarchidae), *Hemichromis fasciatus* and *Australoheros facetus* (Cichlidae), all three Icatluridae and all Umbridae, *Esox lucius* (Esocidae), *Gasterosteus acuelatus* and *Pungitis pungitis* (Gasterosteidae), *Gambusia holbrooki* and *G. affinis* (Poeciliidae) are all preferring stagnant waters as spawning habitats.

Three species of the Cottidae are rheopar, *Cottus gobio*, *C. petiti* and *C. poecilopus*.

11% of the Gobiidae are rheopar (e.g. *Knipowitschia punctatissima, Padogobius martensii*). 28% are eurypar (e.g. *Neogobius kessleri, N. melanostomus*). 18% are limnopar (e.g. *Pomatoschistus minutus*).

All species of the Mugilidae are indifferent to flow conditions in their spawning habitats.

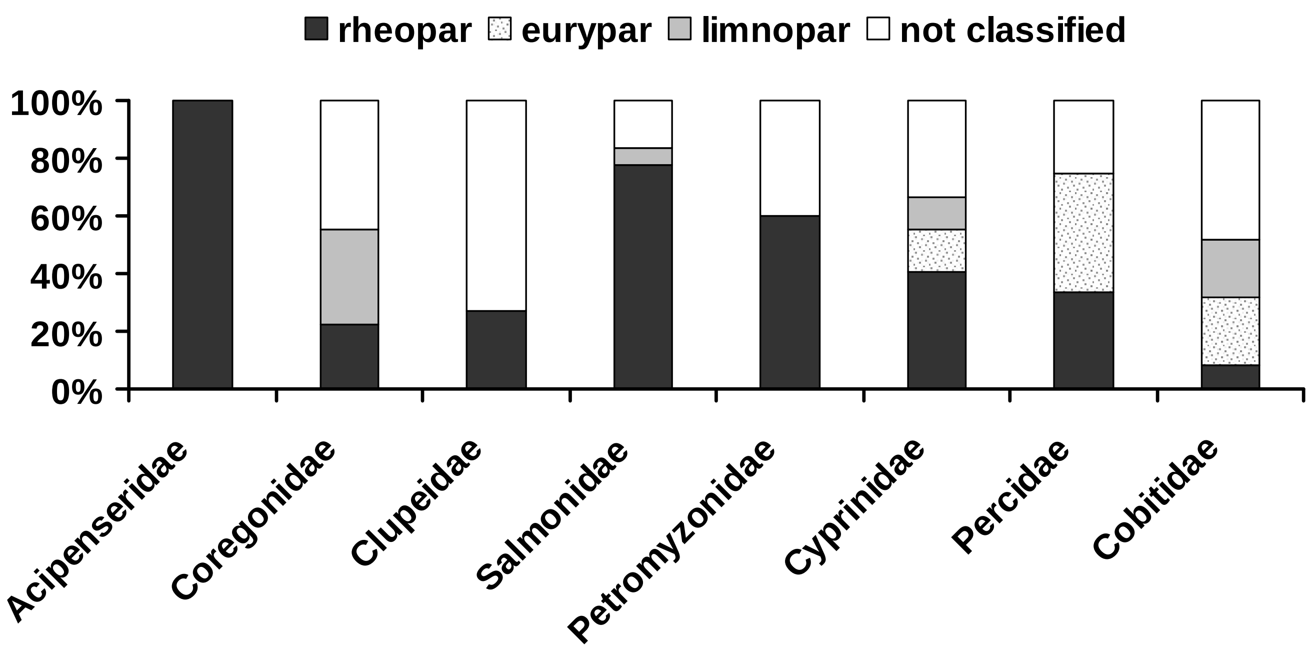


Figure 6.13 *Fish families and the percentage of species connected to* <u>*spawning habitat*</u> *(Acipenseridae n=9, Coregonidae n=9, Clupeidae n=11, Salmonidae n=18, Petromyzonidae n=10, Cyprinidae n=147, Percidae n=12, Cobitidae n=25)*

Acipenseridae clearly prefer fast flowing waters as spawning habitats (figure 6.13).

Coregonidae show heterogenous spawning habitat preferences. *C. albula, C. lavaretus* and *C. peled* are limnopar whereas *C. maraena* and *C. oxyrinchus* are rheopar. The other Coregonidae could not be classified as there spawning habits may differ. *C. lavaretus* deposits eggs on a rock, rubble or gravel bottom and the embryos develop there. These sites can be in streams and rivers as well as in lakes (Balon, 1975).

Alosa alosa, A. fallax and *A. pontica* are rheopar. All other species of the Clupeidae could not be classified with regard to their spawning habitat preferences.

The salmonids are to a high percentage rheopar (78%). Only *Salvelinus namaycush* is supposed to be limnopar.

All Petromyzonidae that could be classified are rheopar. About 40% of them there is no information on their spawning habitat flow preferences.

40% of the species belonging to the Cyprinidae are rheopar like, for example, *Alburnoides bipunctatus, Chondrostoma nasus, Leuciscus leuciscus* or *Rutilus rubilio*. 14% of the cyprinids are eurypar (e.g. *Abramis brama, Alburnus alburnus, Leuciscus idus* and *Pseudorasbora parva*). 11% are limnopar (e.g. *Carassius carassius* and *Gobio lozanoi*).

Zingel asper, Z. zingel and *Z. streber* are rheopar. Another six species out of 11 are eurypar. The rest of the Percidae could not be classified.

Sabanejewia balcanica and *Cobitis calderoni* are rheopar. 24% of the species belonging to the Cobitidae are eurypar. *Misgurnus fossilis* and three other species are limnopar. 52% of the species could not be classified.

Flow preference and reproduction ecology of river fish are closely linked (Aarts & Nienhuis, 2003). A comparison between reproductive guilds and spawning habitats reveals slight correlations of lithophilic species and fast flowing waters as spawning habitats and phytophilic species and stagnant waters used for spawning. 14% of all species are both lithophilic and rheopar (e.g. *Alburnoides bipunctatus, Leuciscus leuciscus* and 12 out of 18 salmonids). 4% of the species are both phytophilic and limnopar (e.g. *Misgurnus fossilis, Umbra pygmaea*) On the contrary only 3% of the species are both phytophilic and rheopar and another 3% are both lithophilic and limnopar.

Reproductive behaviour

Another issue concerning reproduction summarizes the saisonality of spawning events. When they occur only once in the potential season the reproductive behaviour is defined as "single". Fractional spawners have repeated spawning events within a season or different groups of the population spawn at different times. When spawning takes place over a long period during the potential season it was called "protracted" during the classification process. 38% of all species concerned spawn only at a single event during the season. 14% are fractional spawners and only 4% of the species protract their spawning times. A quite high percentage (47%) of the species could not be classified.

Anguilla anguilla (Anguillidae), Esox lucius (Esocidae), all Ictaluridae, *Lota lota* (Lotidae)*, Dicentrarchus labrax* (Mornonidae), all Mugilidae, all Siluridae, all Umbridae, *Barbatula barbatula* (Nemacheilidae), Osmerus eperlanus (Osmeridae), Platichthys flesus (Pleuronectidae), *Polydon spathula* (Polyodentidae), *Sparus aurata* (Sparidae), *Syngnathus typhle* and *S. abaster* (Syngnathidae) and *Thymallus thymallus* (Thymallidae) have single spawning events.

Salaria fluviatilis (Bleniidae), *Micropterus salmoides* and *Lepomis gibbosus* (Centrarchidae) are fractional spawners.

Atherina boyeri (Atherinopsidae) and *Aphainus fasciatus* (Cyprinodontidae) are classified as protracted spawners.

Classification results connected with the reproductive behaviour of the Cichlidae reveals also differences. *Oreochromis niloticus* is a "protracted" spawner and *Australoheros facetus* spawns at one single time only.

Four Cottidae use single spawning events (*Cottus gobio, C. koshewniko, C. poecilopus* and *Triglopsis quadricornis*) whereas *C. petiti* is a fractional spawner.

The Gasterosteidae *Gasterosteus acuelatus* and *Pungitis hellenicus* have protracted spawning events. *G. gymnurus* is a fractional spawner.

The Gobiidae encounter species for each reproductive behaviour. *Economidichthys pygmaeus, E. trichonis, Knipowitschia caucasia, K. thessala* and *Padogobius bonelli* are fractional spawners. *Knipowitschia panizzae, K. punctatissima, Padogobius martensii, P. nigricans, Pomatoschistus minutus*, *Proterorhinus marmoratus* and *Zosterisessor ophiocephalus* have only single spawning events. *Neogobius fluviatilis, N. gymnotrachelus, N. kessleri* and *N. melanostomus* protract their spawning events.

Gambusia affinis and *G. holbrooki* (Poeciliidae) have protracted spawning events.

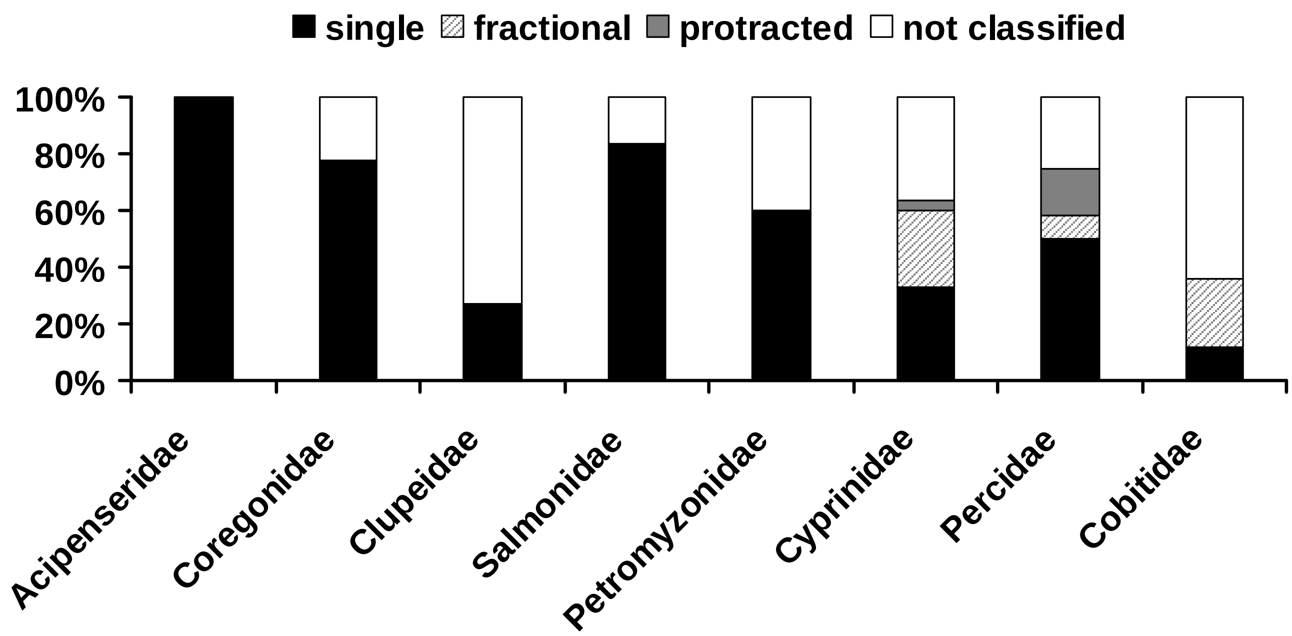


Figure 6.14 *Fish families and the percentage of species with regard to their* <u>*reproductive behaviour*</u> *(Acipenseridae n=9, Coregonidae n=9, Clupeidae n=11, Salmonidae n=18, Petromyzonidae n=10, Cyprinidae n=147, Percidae n=12, Cobitidae n=25)*

All Acipenseridae and all Coregonidae spawn at single events during the potential season except for *Coregonus muscun* and *C. tryborni* which could not be classified.

Alosa alosa, *A. fallax* and *A. macedonica* use single events, too. The other Clupeidae were not classified.

Salmonids have also single spawning events. Three of them could not be classified.

Four Petromyzonidae were not classified but the rest of them spawn at one single event only.

33% of the species belonging to the Cyprinidae use single events only like, for example, *Abramis brama, Aspius aspius, Chondrostoma nasus, Leuciscus leuciscus* and *Rutilus rutilus*. 26% of the species are fractional spawners (e.g. *Tinca tinca, Scardinius erythrophtalmus, Rhodeus amarus* and *Leuciscus cephalus*). Carbonero et al. (2006) studied individuals of *Alburnus alburnus* over a year and found out that the development of their gonads showed two peaks, one in summer time and one in winter time, together with the presence of alevines in the following months. *Alburnus alburnus* is a fractional spawner. Only 4% are protracted spawners like, for example, *Blicca bjoerkna*. 37% of the cyprindis could not be classified with regard to their reproductive behaviour.

Perca fluviatilis, Sander lucioperca, S. volgensis, Zingel asper, *Z. streber* and *Z. zingel* have single spawning events. *Gymnocephalus cernuus* is a fractional spawner. *G. baloni* and *G. schraetser* exhibit protracted spawning. 25% of the Percidae could not be classified.

Misgurnus anguillicaudatus, M. fossilis and *Sabanejewia larvata* have single spawning events. *Cobitis calderoni*, *C. elongatoides, C. hellenica*, *C. taenia, Sabanajewia aurata* and *S. balcanica* are fractional spawners.

Parental care

Species either exhibit no form of parental care or protect their eggs and/or larve what also includes hiding of the nests or the eggs in any manner.

48% of the species do not exhibit any form of parental care and 38% of the species do. About 38% there is no information on their parental care.

Anguilla Anguilla (Anguillidae), *Atherina boyeri* and *A. presbyter* (Atherinidae), *Australoheros facetus* (Cichlidae), *Aphanius fasciatus* and *A. iberus* (Cyprinodontidae), *Esox lucius* (Esocidae), *Fundulus heteroclitus* (Fundulidae), *Lota lota* (Lotidae), *Dicentrarchus labrax* (Moronidae), *Barbatula barbatula* (Nemacheilidae), *Osmerus eperlanus* (Osmeridae), *Platichthys flesus* (Pleuronectidae), *Polydon spathula* (Polyodontidae), *Sparus aurata* (Sparidae) and *Valencia hispanica* (Valenciidae) do not exhibit parental care.

Salaria fluviatilis (Bleniidae), all Cottidae, all Ictaluridae, all Siluridae, all Umbridae, *Gambusia affinis* and *G. holbrooki* (Poeciliidae), *Percottus glenii* (Odontobutidae), *Syngnathus abaster* and *S. typhle* (Syngnathidae) and *Thymallus thymallus* (Thymallidae) protect their eggs and/or larvae and may build nests.

Gasterosteus aculeatus, G. gymnurus and *Pungitis pungitis* (Gasterosteidae) also exhibit some form of parental care as well as 48% of the Gobiidae. The latter include three non protecting species (*Benthophiloides brauneri, B. stellatus* and *Knipowitschia caucasica*).

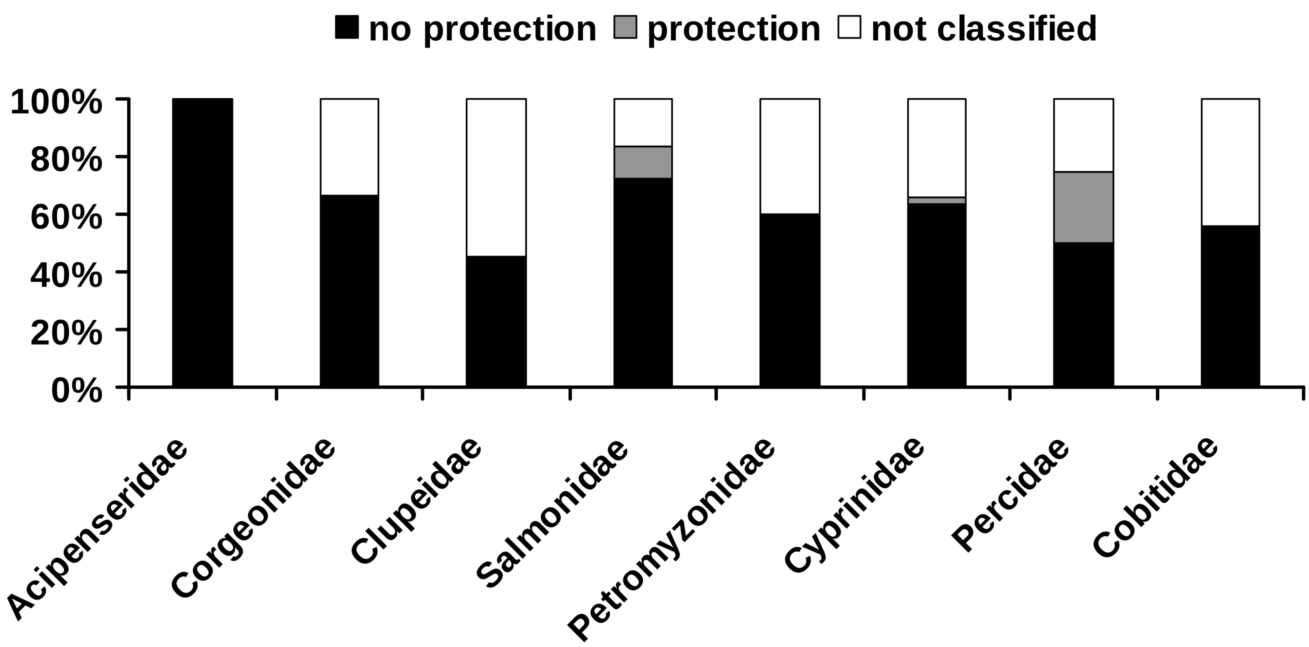


Figure 6.15 *Fish families and the percentage of species which exhibit or do not exhibit* <u>*parental care*</u> *(Acipenseridae n=9, Coregonidae n=9, Clupeidae n=11, Salmonidae n=18, Petromyzonidae n=10, Cyprinidae n=147, Percidae n=12, Cobitidae n=25)*

All Acipenseridae, 67% of the Coregonidae, 45% of the Clupeidae, 60% of the Petromyzonidae and 56% of the Cobitidae exhibit no form of parental care as well as 72% of the Salmonidae but they include two species which exhibit parental care (*Salmo salar* and *Salmo trutta macrostigma*).

Abramis brama, Alburnus alburnus, Barbus barbus, Carassius carassius, Chondrostoma nasus, Rutilus rutilus, Phoxinus phoxinus and *Tinca tinca* are examples for the 63% of the species belonging to the Cyprinidae that do not exhibit parental care. *Leucaspius delineatus, Pimephales promelas, Pseudorasbora parva* and *Rhodeus amarus* protect their offsprings. 34% of the cyprinids could not be classified.

50% of the Percidae do not exhibit parental care, *Sander lucioperca, S. volgensis* and *Zingel asper* do. *Sander lucioperca*, for example, is a guarding and nest spawning fish species. Its protective behaviour enables it to become independent of the fluvial environment since the spawning grounds can be expanded into less well oxygenated waters with silted or sandy bottoms (Balon et al. 1977). 25% of the species were not classified.

There are no signs for the correlation of spawning habitat preference, spawning event frequency and parental care.

6.2.2.6 Physiological and morphological parameters

Additionally to guild classification information on physiological and morphological parameters of the single species referring to maximum length, length relation a and b as well as body shapes for biomass calculations, the shape factor, the swimming factor, maximum longevity, fecundity, relative fecundity, egg diameter, age at maturity, incubation time of the eggs and catch occurrence was collected. Tolerance analysis has been done for those parameters. However, in the result table (ANNEX II) only maximum length, body shape, length relation a and b and catch occurrence were retained.

Maximum length

The maximum length is defined excluding exceptional cases. For 60% of the species figure values existed about their maximum lengths. *Huso huso* (Acipenseridae) is the largest species measuring 8000mm. *Acipenser sturio* (Acipenseridae) and *Silurus glanis* (Siluridae) are the second largest fish. For both existed figure values of 5000mm. The smallest fish – among those which could be defined – belong to the family of Gobiidae. *Knipowitschia thessala* measures 45mm, *K. panizzae* 40mm and *K. cameliae* 30mm.

Apart from *Huso huso* and *Acipenser sturio* the Acipenseridae have rather average maximum lengths (from 1250 to 2000mm).

Within the family of Clupeidae there are some differences. While *Alosa alosa* and *A. fallax* are rather large fish (830 and 600mm) *A. pontica* and *Clupeonella cultriventris* are somewhat smaller species (390 and 120mm).

Misgurnus anguillcaudatis and *M. fossilis* both measure 300mm. Other Cobitidae have value figures of around 150mm. *Cobitis vettonica, Sabanajewia aurata, S. larvata* and *S. romanica* are each 100mm long.

The largest coregonid is *Coregonus maraena* (1300mm) the smallest is *C. albula* (450mm). *C. lavaretus* is 790 and *C. oxyrinchus* 500mm long.

While *Cottus gob*io is 180mm long *C. petiti* only measures 65mm.

Cyprinids that measure more than 1000mm are *Ctenopharyngodon idella* (1500mm), *Barbus barbus* (1400mm), *Cyprinus carpio* (1300mm), *Aristichthys nobilis* (1120mm), *Aspius aspius* (1120mm), *Barbus bocagei* (1070mm), *Barbus comizo* (1050mm) and *Hypopthalmichthys molitri*x (1050mm). On the contrary *Achondrostoma occidentale* (93mm), Ladigesocypris gighii (90mm), Romanogobio antipai (90mm), R. banaticus (80mm), *Anaecypris hispanica* (75mm) and *Iberocypris palaciosi* (50mm) are small cyprnids which measure less than 100mm. *Phoxinus phoxinus* (140mm), *Gobio gobio* (224), *Alburnus alburnus* (310mm) and *Abramis ballerus* (350mm) have average lengths. About 38% of the Cyprinidae there is no homogenous information on their maximum lengths.

Apart from the three species belonging to the Gobiidae which are the smallest ones present in the whole classification process *Neogobius cephalargoides* and *N. melanostomus* both measure 250mm. *N. fluviatilis* and *N. kessleri* (both 220mm) are not much smaller.

Although *Sander lucioperca* is 1300mm long *S. volgensis* measures only 500mm. The other Percidae measure from 110mm (*Romanichthys valsanicola)* to 640mm (*Perca fluviatlis*).

Petromzyon marinus (1200mm), *Lampetra planeri* (600mm) and *L. fluviatilis* (500mm) are rather large Petromyzoidae while *Lethenteron zanandreai* is only 150mm long.

The salmonids include large species. For 83% of them there existed information on their maximum lengths and the average maximum length of these 15 species is 1072mm. *Oncorhynchus tschwytscha* measures 1600mm and *Salvelinus umbla* 600mm.

Length relations a and b

A and b are variables that help calculating the weigth of a fish in terms of its length (length/weight correlation). Together with the value figures for body shapes it is possible to determine biomasses. For 31% of the species value figures for the length relations a and b were found and defined.

Catch occurrence

This parameter informs about the fact wheter a species has already been present in the EFI database (created from 164.778 fish samples collected on 17.524 fishing occasions at 8.843 sampling sites).

31% of the species have already been sampled for EFI and are present in the database among them *Accipenser naccari* (Acipenseridae), *Anguilla anguilla* (Anguillidae), *Alosa alosa* (Clupeidae), *Cottus gobio* (Cottidae), *Alburnus alburnus, Blicca bjoerkna*, *Chondrostoma nasus* and *Phoxinus phoxinus* (Cyprinidae), *Knipowitschia panizzae* (Gobiidae), *Lampetra fluviatlis* (Petromzyonidae), *Salvelinus alpinus* (Salmonidae), *Thymallus thymallus* (Thymallidae), *Umbra krameri* (Umbridae) and many more.

Body shape

Species can be spindle shaped like *Salmo trutta*, they can be high backed like *Abramis brama*, very slender and bottom living like *Zingel zingel* and they can also be eel-shaped. Definitions of body shapes for single species were exclusively taken from Kottelat & Freyhof (2007) as the parameter had to be defined after the classification process had already been finished and also for reasons of homogeneity and simplicity.

I found body shape descriptions for 315 of the 339 species. 52% of the species are spindle shaped like, for example, all Acipenseridae, all Clupeidae, all Coregonidae, a major part of the Cyprinidae, *Esox lucius* (Esocidae), all Percidae, all Thymallidae and all Umbridae. Fewer species (11,5%) are high backed, including, *Lepomis gibbosus* (Centrarchidae), *Abramis brama, Blicca bjoerkna, Carassius carassius, Leuciscus idus, Rutilus rutilus, Scardinius erythrophtamlus* and *Tinca tinca* (Cyprindidae), *Perca fluviatilis* (Percidae) and others. As very slender and bottom living 26% of the species were defined. Slender and bottom living species are of course species that belong to the Gobiidae, Cobititdae and Blenniidae. Others are part of the Cyprinidae (e.g. *Barbus* spp., *Gobio* spp. and *Romanogobio* spp.), Lotidae (*Lota lota*), Nemacheilidae (*Barbatula barbatula* and *B. bureschi*) and Percidae (*Romanichthys valsanicola*).

18 out of 339 species are supposed to be eel-shaped, among them, *Anguilla Anguilla* (Anguillidae), *Misgurnus anguillicaudatis* (Cobitidae), *Clarias gariepinus* (Clariidae), all Petromyzonidae, *Silurus glanis* and *S. aristotelis* (Siluridae) as well as all Syngnathidae. The cyprinids are the only family that include species with three different body shapes (spindle shaped, high backed and very slender).

6.2.2.7 Unclassified species

There are 79 species from 16 different families which could only be classified with regard to their body shapes. I only found information on them in Kottelat & Freyhof (2007) but guilds could not be defined.

Table 6.2 *Species which could not be classified with regard to guilds and listed with their families*

Cyprinidae
Gobio banarescui
Gobio benacensis
Gobio elimeius
Leuciscus illyricus
Leuciscus microlepis
Leuciscus polylepis
Leuciscus turskyi
Leuciscus ukliva
Leuciscus zrmanjae
Phoxinellus croaticus
Phoxinellus epiroticus
Phoxinellus fontinalis
Phoxinellus metohiensis
Phoxinellus prespensis
Phoxinellus pstrossii
Pseudophoxinus minutus
Cichlidae
Tilapia zillii
Clupeidae
Alosa caspia
Alosa killarnensis
Alosa maeotica
Alosa tanaica
Alosa vistonica
Cobitidae
Cobitis arachthosensis
Cobitis bilineata
Cobitis meridionalis
Cobitis peschevi
Cobitis punctilineata
Cobitis rhodopensis
Cobitis stephanidisi
Cobitis strumicae
Cobitidae
Cobitis trichonica
Cobitis vardarensis
Coregonidae
Coregonus muscun
Coregonus trybomi
Cyprinidae
Aulopyge huegelii
Barbus balcanicus
Barbus macedonicus
Barbus steindachneri
Barbus tauricus
Chalcalburnus belvica
Chondrostoma knerii
Chondrostoma phoxinus
Chondrostoma prespense
Chondrostoma vardarense
Leuciscus burdigalensis
Leuciscus montenigrinus
Pachychilon macedonicum
Parabramis pekinensis
Phoxinellus adspersus
Phoxinellus alepidotus
Rutilus basak
Rutilus heckelii
Rutilus karamani
Rutilus meidingeri
Rutilus ohridanus
Rutilus prespensis
Scardinius scardafa
Squalius valentinus
Vimba melanops
Cyprinodontidae
Aphanius baeticus
Gasterosteidae
Pungitius platygaster
Gobiidae
Caspiosoma caspium
Gobius cobitis
Gobius niger
Knipowitschia goerneri
Knipowitschia longecaudata
Knipowitschia milleri
Mesogobius batrachocephalus
Neogobius eurycephalus
Moronidae
Morone saxatilis
Percidae
Percarina demidoffi
Zingel balcanicus
Petromyzonidae
Eudontomyzon hellenicus
Eudontomyzon stankokaramani
Lethenteron camtschaticum
Pleuronectidae
Pleuronectes platessa
Salmonidae
Salmo labrax
Salmo macedonicus
Salmothymus obtusirostris
Syngnathidae
Nerophis ophidion
Thymallidae
Thymallus baicalensis

Another 17 species belonging to three different families could not be classified at all. Information on their ecology and physiology is widely lacking.

Table 6.3 *Species which could not be classified at all and listed with their families*

Atherinopsidae
Odonthestes bonariensis
Cyprinidae
Gobio banarescui
Gobio benacensis
Gobio elimeius
Leuciscus microlepis
Leuciscus polylepis
Leuciscus turskyi
Leuciscus ukliva
Leuciscus zrmanjae
Cyprinidae
Phoxinellus croaticus
Phoxinellus epiroticus
Phoxinellus fontinalis
Phoxinellus metohiensis
Phoxinellus prespensis
Phoxinellus pstrossii
Pseudophoxinus minutus
Gobiidae
Neogonius ratan

The majority of them is probably endemic and their ecology may unknown or only be familiar to a few experts only. It is also possible that morphs of species were declared own species based on genetically analyses but cannot be differenciated from the original species. Morphs could also be denominated as different species although they are both the same species. Taxonomy is almost daily changing and new species are created while others are neglected.

6.2.3 Guilds and tolerance ranges

For analyzing the correspondence of tolerances to fish families and their guilds the four tolerance parameters of water quality in general, oxygen concentration, temperature, habitat degradation and the habitat itself were statistically tested together with the species classified for the mentioned guilds.

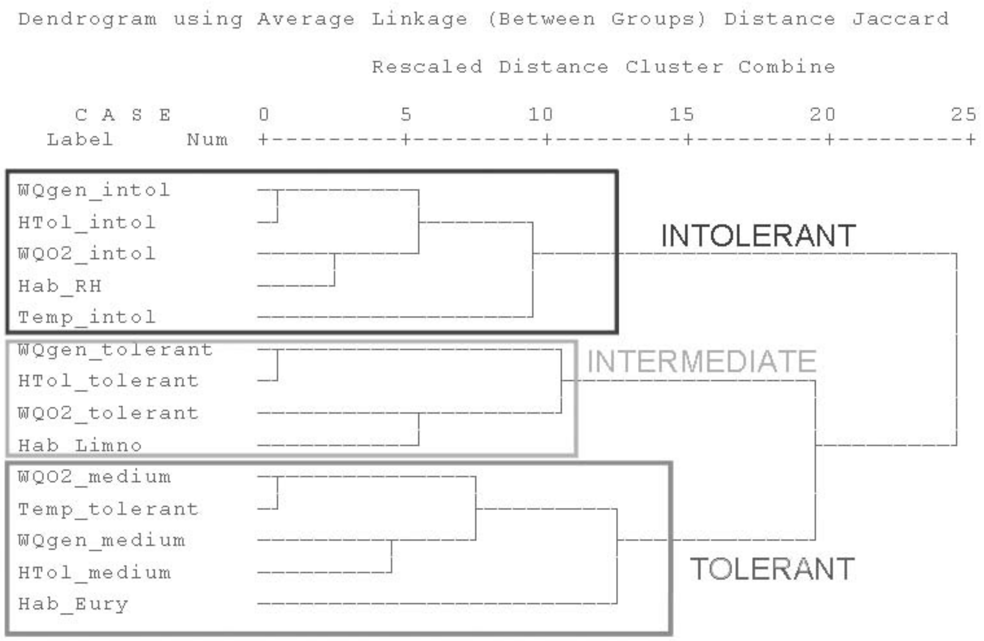


Figure 6.16 *Resulting dendrogram of hierarchical cluster analysis using average linkage distance by means of Jaccard between the following groups: water quality in general (**WQgen**), oxygen concentration (**WQO2**), temperature tolerance (**Temp**), tolerance to habitat degradation (**HTol**) and habitat (**Hab**). Three tolerance groups were formed (adapted from Melcher A. 2008)*

First hierarchical cluster analysis revealed simlarities between intolerance to water quality in general, intolerance to habitat degradation, intolerance to low oxygen concentration, the habitat for rheophilic species and intolerance to wide temperature ranges forming a group of indicators of intolerance. Tolerance to water quality in general, habitat degradation, low oxygen concentration and the habitat of limnophilic species are also similar parmameters for explaining an intermediate tolerance (figure 6.16).

An intermediate tolerance of low oxygen concentration, temperature tolerance, eurytopic habitats and intermediate tolerance of water quality in general and habitat degradation are indicators for tolerance. The three habitat types can be directly connected to the three modalities of tolerance. Rheophilic species seem to be intolerant, limonphilic species are intermediately tolerant and eurytopic species can cope best with unstable environmental conditions.Schiemer & Waidbacher (1992) who concluded that although there are practically no records on the population structure prior to river regulation it is evident from habitat changes that rheophilic species must have declined in favour of eurytopic and limnophilic species. Above all rheophilic species are most negatively affected by a low dissolved oxygen concentration (Kruk 2007).

The results from the first cluster analysis for each species were refined by another hierarchical cluster analysis what explained the tolerance range for each species more detailed. Species can be “tolerant1” (very tolerant), “tolerant2” (tolerant), “intermediate” (intermediately tolerant), “intolerant2” (intolerant) and “intolerant1” (very intolerant). The results were summarized for families and the percentages of the species again.

Whittier et al. (2007) calculated their “assemblage tolerance index” (ATI) in a similar way. They used fish and amphibian species data in connection with chemical, physical and landscape indicators of human disturbance. They used principal component analysis to create synthetic disturbance values then they calculated species’ tolerance values for the four synthetic disturbance values (for water nutrients, site-scale physical habitat, catchment-scale land use and overall human disturbance).

<u>Tolerance ranges and families</u>

As the results showed *Anguilla anguilla* (Anguillidae), *Micropterus salmoides* (Centrarchidae), *Australoheros facetus* (Cichlidae), *Alosa pontica* (Clupeidae), *Triglopsis quadricornis* (Cottidae), *Aphanius fasciatus* (Cyprinodontidae), *Esox lucius* (Esocidae), *Percottus glenii* (Odontobutidae), *Osmerus eperlanus* (Osmeridae), *Platichthys flesus* (Pelruonectidae), *Polydon spathula* (Polyodentidae), *Silurus glanis* (Siluridae) and *Umbra krameri* (Umbridae) are tolerant species.

The Gasterosteidae *Gasterosteus aculeatus, G. gymnurus* and *Pungitis pungitis* are also tolerant.

The Ictaluridae are in general tolerant and *Ameiurus melas* and *A. nebulosus* are even very tolerant.

Atherina boyeri (Atherinidae), *Salaria fluviatilis* (Blenniidae), *Dicentrarchus labrax* (Moronidae), *Barbatula barbatula* (Nemacheilidae), *Sparus aurata* (Sparidae), *Syngnathus abaster* and *S. typhle* (Syngnathidae) are intermediately tolerant.

Lepomis gibbosus (Centrarchidae), *Gambuisa affinis* and *G. holbrooki* (Poeciliidae) and *Umbra pygmae* (Umbridae) are very tolerant species.

Cottus gobio and *C. poecilopus* (Cottidae) are very intolerant as well as *Thymallus thymallus* (Thymallidae).

Alosa alosa and *A. fallax* (Clupeidae) are intolerant species.

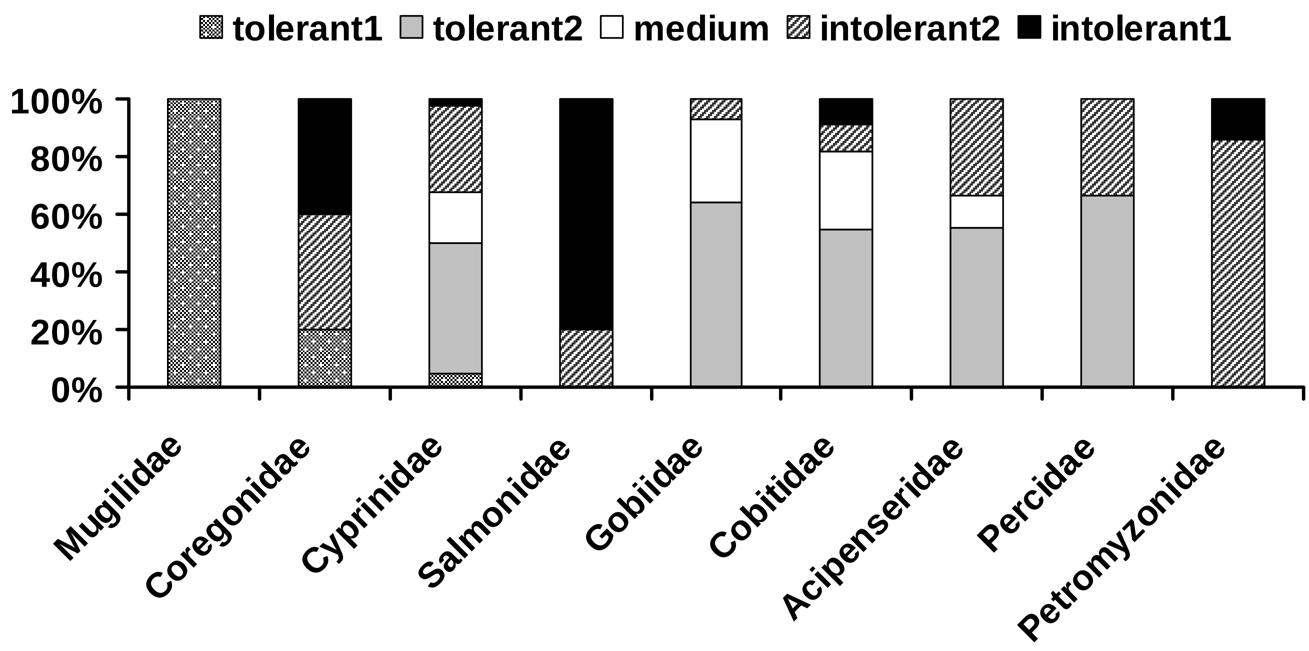


Figure 6.17 *The percentage of species of the abundant fish families corresponding to the five tolerance clusters (Mugilidae n=5, Coregonidae n=5, Cyprinidae n=90, Salmonidae n=15, Gobiidae n=14, Cobitidae n=11, Acipenseridae n=9, Percidae n=9, Petromyzonidae n=7)*

All Mugilidae are very tolerant (figure 6.17).

Coregonus peled is also very tolerant whereas *C. maraena* and *C. oxyrhinchus* are intolerant. *C. albula* and *C. lavaretus* are even very intolerant.

Carassius auratus, C. carassius, Pimephales promelas and *Scardinius graecus* are very tolerant cyprinids. *Blicca bjoerkna, Cyrpinus carpio, Pelecus cultratus, Rutilus rutilus, Scardinius erythrophtalmus* and *Tinca tinca* are some of the 28% of the cyprinids which are tolerant. 11% of the cyprinids are intermediately tolerant (e.g. *Barbus plebejus, Leuciscus idus, L. leuciscus*). 18% of the Cyprinidae are intolerant like, for example, *Barbus barbus, Chondrostoma nasus, Gobio gobio, Rhodeus amarus* and *Vimba vimba*. *Leuciscus souffia* is the only cyprinid which is very intolerant.

Oncorhynchus mykiss, Salmo marmoratus and *Salmo trutta macrostigma* are intolerant. The other salmonids are very intolerant like, for example, *Hucho hucho, Salmo trutta trutta* and *Salvelinus alpinus*.

29% of the Gobiidae are tolerant (e.g. *Knipowitschia caucasia, Neogobius fluviatilis, N. kessleri* and *Proterorhinus marmoratus*). *Knipowitschia panizzae, Padogobius martensii, P. nigricans* and *Pomatoschistus minutus* are intermediately tolerant.

Cobitis elongatoides, C. hellenica, C. vettonica, Misgurnus anguillicaudatis, M. fossilis and *Sabanajewia larvata* are tolerant. *Cobitis paludica, C. taenia* and *Sabanejewia aurata* are intermediately tolerant. *Sabanajewia balcanica* is intolerant and *Cobitis calderoni* even very intolerant.

Acipenser baeri, A. gueldenstaedtii, A. nudiventris, A. ruthenus and *A. stellatus* are tolerant. *A. naccari* is intermediately tolerant. *A. oxyrinchus, A. sturio* and *Huso huso* are intolerant.

Gymnocephalus baloni, G. cernuus, G. schraetser, Perca fluviatilis, Sander lucioperca and *S. volgensis* are tolerant species. Perch and pike are often reported in degraded waters (Kruk 2007). *Zingel asper, Z. streber* and *Zingel zingel* are intolerant. Verneaux (1981) calculated a resistance index “Ir” for each species in the River Doubs, whereas a low Ir meant high sensitivity or intolerance to perturbation, a high Ir labeld tolerant fish species. The generalistic eurytopic species had a mean Ir of 6.72. *Zingel asper* as an endangered species had an Ir of 3.5.

All Petromyzonidae which could be classified are intolerant, *Lampetra planeri* is even very intolerant.

Only 5% of all species are very tolerant. 25% of the species are tolerant. 9% of the species are intermediately tolerant. 11% of all species are intolerant and 6% very intolerant.

The family of Acipenseridae seems to be rather tolerant although most of the acipenserids are endangered. Tolerance to several parameters may obvisiouly not protect from over exploitation. The cobitits are a tolerant family as well as the pericds, the gobiids and the cyprinids. However, the Cyprinidae at the same time include several species that are intolerant.

The petromyzonids are an absolute intolerant family as well as the salmonids.

<u>Tolerance ranges of abundant fish species</u>

From a neutral point of view one could conclude that intolerant species cannot be abundant. Analysing the tolerances of the most abundant fish species in European freshwaters (see table 6.1) this is not true. *Phoxinus phoxinus* is in the results of the classification and statistical analyses an intolerant species although it is supposed to be the most abundant species. *Salmo trutta fario* is even very intolerant but the second most abundant species. Other abundant species are *Rutilus rutilus* which is tolerant and *Barbatula barbatula* which is intermediately tolerant.

Reasons for those contradictionary results could be an uncorrect classification. It could mean that those species are tolerant. Another conclusion is possible. Probably these results also may stress the fact that the tolerance guilds alone cannot properly describe strategies of fish to establish stable populations. Schmutz et al. (2000) indicate that a disadvantage of fish as bioindicators may be the fact that fishery-caused alterations such as species transfer, stocking and overfishing mask other human alterations affecting water quality and morphology of hydrologic habitats. Phoxinus phoxinus and Salmo trutta as examples for intolerant species may be that high in numbers because their typical habitas (upper regions of rivers) may still be intact while the lower regions of rivers due to channelisation, pollution and power plants are strongly being affected and habitats for the typical species (e.g. *Abramis brama* and *Barbus barbus*) of those regions are disappearing (Melcher et al. 2007).

<u>Tolerance ranges with regard to physiological and morphological parameters</u>

Conducting the cluster analysis with the Ward Euclidean distance and apposing it to physiological parameters some more conclusions on tolerance ranges can be made.

First the mean of the egg diameter, the mean of incubation time, the mean of age at maturity and the mean of longevity was connected with the five new toleranc groups obtained by the hierarchical cluster analysis: “tolerant1” (very tolerant), “tolerant2” (tolerant), “intermediate” (intermediately tolerant), “intolerant2” (intolerant) and “intolerant1” (very intolerant). As a distance Ward Euclidean was used. Reproduction strategies and tolerance ranges are displayed.

For analyses of morphological adaptions and tolerance ranges the mean of maximum length and the mean of the swimming factor are illustrated together with the five tolerance groups mentioned above (the Ward Euclidean distance was used).

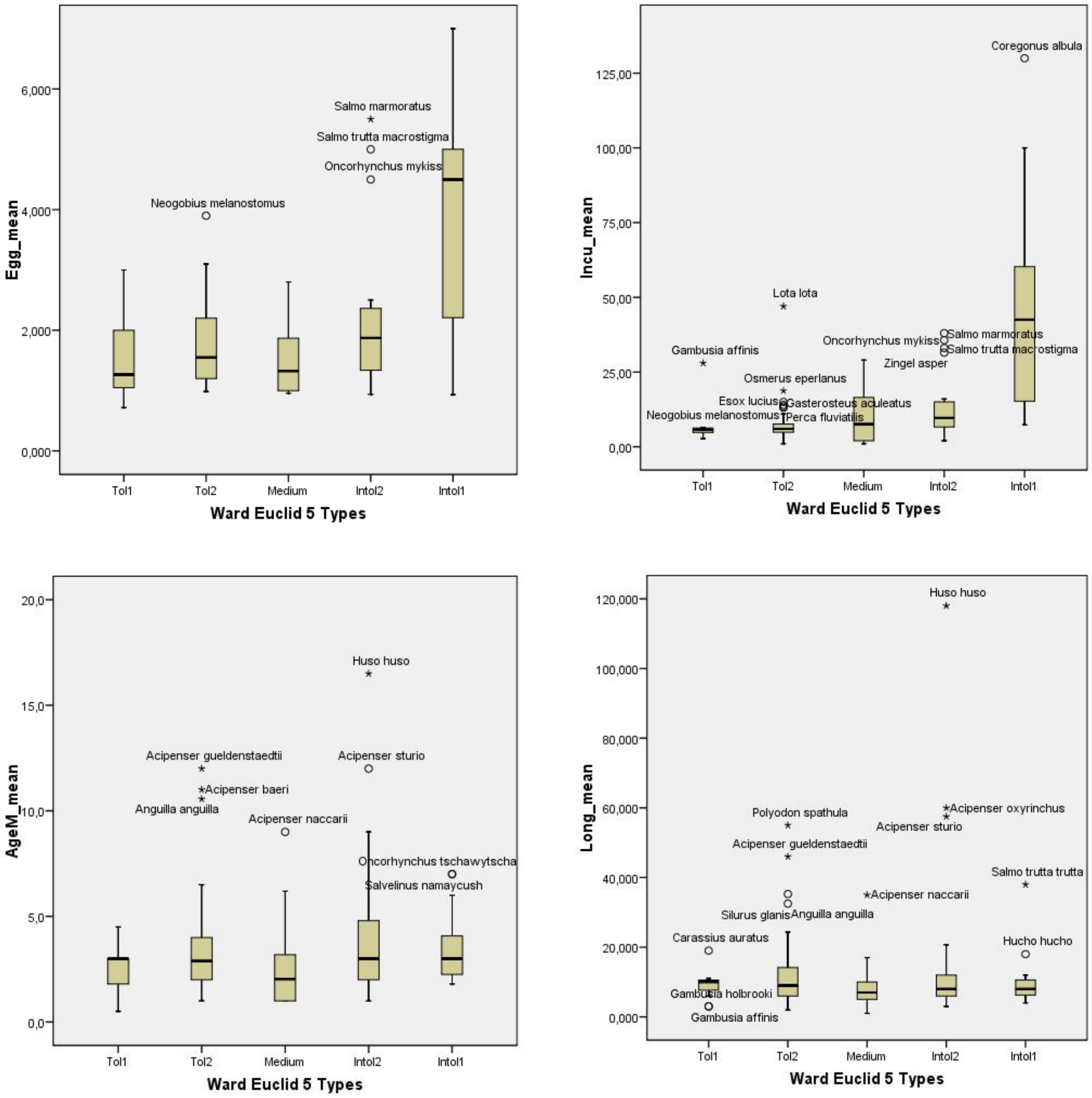


Figure 6.18 *The five tolerance groups and their correlation to the mean of egg diameter, the mean incubation time, the the mean of age at maturity and the mean of longevity of abundant fish species* ***Egg_mean****=mean of egg diameter,* ***Incu_mean****=mean of incubation time,* ***AgeM_mean****=mean of age at maturity,* ***Long_mean****=mean of longevity; adapted from Melcher A., 2008)*

Species with large egg diameters (with a mean value of 4,5mm) are very intolerant and mean egg diameters of 1,8mm still indicate intolerant species. The salmonids *Salmo marmoratus, Salmo trutta macrostigma* and *Oncorhynchus mykiss* have egg diameters up to 5,5mm and are intolerant but are not included in the group of very intolerant species (figure 6.18).

Furthermore it seems that intermediately tolerant species have smaller egg diameters (mean value of 1,5mm) than tolerant species (mean egg diameter of 1,7mm). Species with the smallest egg diameters (mean value of 1,3mm) are very tolerant. There is the exception of *Negogobius melanostomus* (Gobiidae) which has relatively large egg diameters of 4mm but is still tolerant.

Similar to the egg diameters tolerances decrease with high values for the incubation time. Species that produce eggs with need a long incubation time (mean value of 35 days) are very intolerant. The value of incubation time of eggs from *Coregonus albula* (130 days) supports this result since it is a very intolerant species. Again three salmonids and one member of the Percidae do not follow exactly the trend. *Salmo marmoratus*, *Salmo trutta macrostigma, Oncorhynchus mykiss* and *Zingel asper* have incubation times of up to 40 days but are only intolerant whereas other species are also intolerant but have mean values of only 10 days. Analyses show that in general species that incubation times have mean values below 9 days are tolerant or even very tolerant. *Neogobius melanostomus* (Gobiidae), *Perca fluviatilis* (Percidae), *Gasterosteus aculeatus* (Gasterosteidae), *Esox lucius* (Esocidae), *Osmerus eperlanus* (Osermidae), *Gambusia affinis* (Poeciliidae) and *Lota lota* (Lotidae) are more tolerant than other species. They have incubation times from 15 up to 48 days and are still supposed to be tolerant.

The age at maturity does not tell a lot about tolerances. Species with a mean value of 6,5 years are very intolerant and species with a mean value of 6 years are very tolerant. Also the outliers indicate that with this parameter there cannot be made any conclusions about tolerances. The salmonids *Oncorhynchus tschawytscha* and *Salvelinus namaycush* mature at the age of 7 years and are very intolerant, *Acipenser sturio* and *Huso huso* (Acipenseridae) have ages of maturity of 12 and 17 years but are only intolerant. *Anguilla anguilla* (Anguillidae), *Acipenser baeri* and *A. gueldenstaedtii* (Acipenseridae) mature between ages of 11 and 12 but are even tolerant.

Mean values of longevity show a slight trend for species that live longer (mean value of 10 years) to be a lot more tolerant than species which have a mean value of 8 years. However, the outliers present a distinct picture. The salmonids *Hucho hucho* (longevity of 19 years) and *Salmo trutta trutta* (40 years) are clearly very intolerant. The Acipenseridae *Acipenser sturi*o (longevity of 58 years), *A. oxyrinchus* (59 years) and *Huso huso* (118 years) are intolerant. *Silurus glanis* (Siluridae), *Anguilla Anguilla* (Anguillidae), *A. gueldenstaedtii* (Acipenseridae) and *Polyodon spathula* (Polyodontidae) have longevities between 35 and 59 years and are supposed to be tolerant. One result that could be concluded is that very tolerant species have maximum ages of 20 years and not higher (like the outlier *Carassius auratus* which is a cyprinid) and that species that can get really old are likely to never be very tolerant.

It seems that the typical k-strategists which invest a lot of energy in reproduction (large egg diameters and long time of incubation) are as adults more intolerant than other species which have smaller egg diameters and shorter incubation times. This result is not true for the age of maturity and the general longevity. No clear trends corresponding to different tolerance ranges can be observated with regard to the two parameters. The fact that there is a slight tolerance of species with high longevity can probably explained by the fact that once a larger fish with late maturity and large egg diameter is fully grown and established in its environment it surely can get very old and exhibits somewhat more tolerance than in younger years.

The analyses of lengths and swimming factors give an overview of the morphological paramters and their correspondence to tolerance ranges.

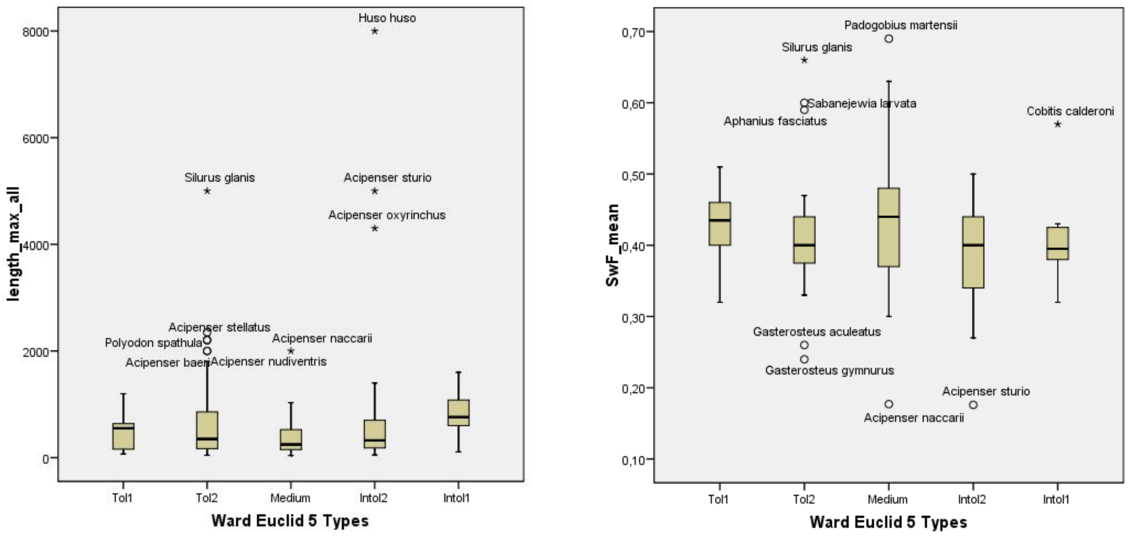


Figure 6.19 *The five tolerance groups and their correlation to the mean of maximum lengths and the mean of the swimming factor of abundant fish species (**length_max_all**=mean of total maximum lengths, **SwF_mean**=mean of the swimming factor; adapted from Melcher A., 2008)*

Within the range of mean values of maximum lengths between 50 and 1000mm there can only be slightly drawn conclusions on tolerances. Larger species (mean value 1000mm) are very intolerant. Species wich are a lot smaller (mean value of 100mm) are still intolerant but can also be tolerant. There are also species with mean values of maximum lengths of 600mm but they are supposed to be very tolerant. Some outliers make the situation clearer. Correspondences between tolerance ranges and maximum lengths can only be found for single species (not even within families). *Acipenser oxyrinchus, A. sturio* and *Huso huso* are between 4300 and 8000mm long and they are three Acipenseridae which are intolerant. *Acipenser naccari* (2000mm) is intermediately tolerant and *A. baeri*, *A. nudiventris* and *A. stellatus* have also lengths around 2000mm and are tolerant. Within the family of Acipenseridae it can be concluded that large species are more intolerant than smaller species. For *Silurus glanis* (Siluridae) this is not true. It has a maximum length of 5000mm and nevertheless is tolerant.

The swimming factor is defined as the ratio of the minimum depth of the caudal penducle to the maximum caudal fin depth. Species with a small value for the swimming factor (what means a small ratio) are capable of strong swimming. In the analysis those species (with a mean value for the swimming factor of 40) can be very intolerant, intolerant or tolerant. A clearer conclusion can be made for species which have a mean value for the swimming factor of 43. They are very tolerant. *Acipenser sturio* and *A. naccari* (both with a swimming factor of 18 and therefore strong swimmers), for example, are intolerant and intermediately tolerant. On the other hand *Cobitis calderoni* (Cobitidae) has a high swimming factor (58) but is even very intolerant. *Gasterosteus aculeatus* and *G. gymnurus* (Gasterosteidae) are strong swimmers (swimming factors of 26 and 24) and at the sime time tolerant. *Aphanius fasciatus* (Cyprinodontidae), *Sabanajewia larvata* (Cobitidae) and *Silurus glanis* (Siluridae) are also tolerant and have high swimming factors (from 59 up to 67).

There is some evidence for the fact that species with an elevated mean maximum length and an increased mean value for the swimming factor are more intolerant than smaller species whith a high swimming factor.

In general there cannot be made any clear distinctions between the tolerances of e.g. small or large species or the tolerances connected to other morphological or physiological parameters. The parameters of reproduction show only slightly trends for k- (e.g. large egg diamters and long time of incubation) or r- strategists.

6.3 Classification results corresponding to the literature search

The classification results do not always correspond to the guild classifications found during literature search but sometime the classifications suggested by experts and the classifications found in literature correspond.

Water quality – Tolerance to a low concentration of oxygen

For Dušek et al. (2004) *Abramis brama* is intolerant to a low oxygen concentration in the classification results it is tolerant. Žarski et al. 1995 define it as tolerant, too.

Abramis brama is tolerant for Blanck et al. 2007 like *Blicca bjoerkna*, *Alburnus alburnus*. *Barbatula barbatula, Carassius carassius, Chondrostoma nasus, Cyprinus carpio, Esox lucius, Gobio gobio, Gymnocephalus cernuus, Lepomis gibbosus, Leuciscus cephalus, L. leuciscus, Phoxinus phoxinus, Rhodeus amarus, Rutilus rutilus, Salmo trutta trutta, Sander lucioperca* and *Tinca tinca*. As a result of the classification process *Alburnus alburnus*, *Barbatula barbatula, Esox lucius, Gymnocephalus cernuus, Leuciscus cepahlus, L. leuciscus*, *Rhodeus amarus* and *Sander lucioperca* are intermediately tolerant to a low concentration of oxygen. *Blicca bjoerkna, Carassius carassius, Cyrpinus carpio, Lepomis gibbosus*, *Rutilus rutilus* and *Tinca tinca* are tolerant. *Chondrostoma nasus, Gobio gobio, Salmo trutta trutta* and *Phoxinus phoxinus* areclassified as intolerant.

Ameiurus melas and *A. nebulosus* as well as *Tymallus thymallus* are defined as intolerant by Blanck et al. and *Thymallus thymallus* is classified so but the two ictalurids are classified as tolerant. *Ameiurus melas* is defined as intermediately tolerant by Welcomme et al. (2006). Furthermore Welcomme et al. suppose *Cyprinus carpio* and *Misgurnus fossilis* as tolerant to a low concentration of oxygen and they are also classified so.

Water quality – Tolerance to toxic contamination

Anguilla anguilla and *Salmo salar* are defined as tolerant to toxic contamination by Langston et al. (2002). Whereas *Anguilla anguilla* is classified as tolerant *Salmo salar* is classified as intolerant. For Fent (2007) *Anguilla anguilla* is intolerant. *Oncorhynchus mykiss* is classified as intermediately tolerant as it has also suggested Langston et al. For Dušek et al. (2004) *Abramis brama* is tolerant to toxicity while *Perca fluviatilis* is intolerant. In the classification results *Abramis* brama is tolerant but *Perca fluviatilis* is intermediately tolerant.

Temperature tolerance

Lappalainen (2001) studied *Sander lucioperca* and finds it to be stenothermal while in the classification process it is classified as eurythermal.

Abramis brama, Ameiurus punctatus, Anguilla anguilla, Barbatula barbatula, Carassius carassius, Cottus gobio, Cyprinus carpio, Esox lucius, Gasterosteus aculeatus, Lepomis gibbosus, Leuciscus cephalus, Perca fluviatlis, Rutilus rutilus, Scardinius erythrophtalmus and *Thymallus thymallus* are supposed to be eurythermal by Küttel et al. (2002). All species are classified as eurythermal. Only *Cottus gobio* and *Thymallus thymallus* are classified as stenothermal.

Alburnoides bipunctatus, Lota lota, Oncorhynchus mykiss, Salmo salar, Salmo trutta lacutris, Salvelinus fontinalis and *Tinca tinca* are stenothermal for Küttel et al. All were classified so except for *Tinca tinca* which is classified as eurythermal.

Ovidio et al. 2007 finds *Salmo trutta lacustris* and *Thymallus thymallus* to be stenothermal and they aree also classified so. Zambrano (2006) supposed *Perca fluviatilis* to be stenothermal but it is classified as eurythermal.

<u>Tolerance to degradation of habitat</u>

Zingel asper is intolerant to the degradation of its habitat for both Verneaux (1981) and the classification experts. *Thymallus thymallus* is also intolerant for Ovidio et al. (2007) and is also classified so.

Chondrostoma nasus, Cyprinus carpio, Leuciscus cephalus, Leuciscus leuciscus, Lota lota, Silurus glanis and *Tinca tinca* are all intolerant to the degradation of their habitat for Schiemer & Waidbacher (1992). *Chondrostoma nasus* are classified as intolerant. *Cyprinus carpio, Silurus glanis* and *Leuciscus cepahlus* are classified as tolerant. *Leuciscus leuciscus* and *Lota lota* are classified as intermediately tolerant. Only

Welcomme et al. 2006 define *Salmo trutta trutta* as an intolerant species and it is classified as one. *Ameiurus melas, Barbatula barbatula, Gobio gobio* and *Phoxinus phoxinus* are all intolerant for Lamouroux (2005). In the classification results *Gobio gobio* and *Ameiurus melas* are tolerant, *Barbatula barbatula* is intermediately tolerant. Only *Phoxinus phoxinus* is classified as tolerant.

<u>Habitat</u>

Zauner & Eberstaller (1999) mention habitat guilds of several species. In some cases the classifications differ from that of the overall results. *Abramis ballerus, Aspius aspius, Leuciscus cephalus, L. leuciscus* and *Oncorhynchus mykiss* are eurytopic species for Zauner & Eberstaller while they are classified as rheophilic. *Carassius auratus* is only eurytopic for them but it is classified as limnophilic. *Gasterosteus aculeatus* is seen as a limnophilic species by Zauner & Eberstaller. The classification results define it as eurytopic species.

Leuciscus cephalus is also for Spindler (1997) a eurytopic species and Gasterosteus *aculeatus* limnophilic. For Aarts & Nienhuis (2003) *Gasterosteus aculeatus* is either rheophilic or eurytopic. For them *Osmerus eperlanus* is eurytopic and it is also classified so.

Waidbacher et al. (2003) define *Gasterosteus aculeatus* as limnophilic, too. *Lota lota* is supposed to be rheophilic by them whereas it is classified as eurytopic. *Sander volgensis* is classified as eurytopic, too. Waidbacher et al. find it to be limnophilic. For the rest of the species their definitions correlate with the classification results.

Carassius auratus is eurytopic for Schiemer & Waidbacher (1992). It is classified as limnophilic. *Gasterosteus aculeatus* is defined as limnophilic again. *Lota lota* is supposed to be rheophilic by them whereas it is classified as eurytopic. *Sander volgensis* is classified as eurytopic, too. Schiemer & Waidbacher suppose it to be limnophilic. For the rest of the species their definitions correlate with the classification results.

Blicca bjoerkna, Cyprinus carpio, Esox lucius, Gymnocephalus cernuus, Rutilus rutilus and *Sander lucioperca* are defined as limnophilic by Blanck et al. (2007). They are classified as eurytopic. *Abramis brama, Alburnoides bipunctatus, Barbatula barbatula, Barbus barbus, Leuciscus cephalus, Phoxinus phox-*

inus, Thymallus thymallus and *Salmo trutta trutta* were rheophilic for Blanck et al. and are also classified so. *Lepomis gibbous*, *Rhodeus amarus, Scardinius erythrophtalmus* and *Tinca tinca* are classified as limnophilic by both the classification process and Blanck et al. *Alburnus alburnus* is supposed to be rheophilic by Black et al. while it is classified as eurytopic.

Irz et al. define *Aspius aspius* and *Cobitis elongatoides* as rheophilic and it is classified so. *Atherina boyeri* and *Carassius auratus* are eurytopic for them but they are classified as limnophilic. *Ctenopharyngodon idella, Hypophthalmichthys molitrix* and *Lota lota* are rehophilic for Irz et al. but classified as eurytopic. *Leuciscus borysthenicus* and *Umbra krameri* are even supposed to be rheophilic by Irz et al. but classified as limnophilic. *Neogobius gymnotrachelus, N. kessleri* and *Pseudorasbora parva* are classified as eurytopic by both the classification process and Irz et al. *Syngnathus abster* is limnophilic for both, too.

Adult trophic guild and feeding habitat

Klemetsen et al. (2005) define *Salvelinus umbla* as a benthic planktivorous species. In the classification results it is planktivorous but feeds from the water column. Winkelmann et al. (2007) conclude from their studies that *Gobio gobio* would be a benthic and insectivorous species which is retained in the classification results. *Abramis ballerus, Alburnus alburnus, Chalcalburnus chalcoides, Coregonus maraena* and *Vimba vimba* are planktivorous species in the extensive definitions of Spindler (1997). In the classification process only *Abramis ballerus* and *Alburnus alburnus* are classified as planktivorous. *Rutilus rutilus* is omnivorous and *Abramis brama* and *Blicca bjoerkna* are benthic feeders like Spindler suggested in his publication.

For Smith (2006) *Perca fluviatilis* is piscivorous. Experts classify it as piscivorous/parasitic. *Blicca bjoerkna, Ameiurus nebulosus, Barbus barbus, Carassius auratus, Gobio gobio* and *Vimba vimba* are supposed to be benthic feeders (Dušek et al. 2004) and they are also classified so. *Silurus glanis*, *Sander lucioperca*, *Esox lucius* and *Anguilla anguilla* are defined as piscivorous species by Dušek et al. (2004). In the classification results *Anguilla anguilla* is insectivorous, *Esox lucius, Silurus glanis* and *Sander lucioperca* are piscivorous/parasitic. *Alburnoides bipunctatus, Alburnus alburnus, Leuciscus cephalus* and *Scardinius erythropthalmus* are omnivorous for Dušek et al. (2004). *Alburnoides bipunctatus* is insectivorous, *Alburnus alburnus* is planktivorous but *Leuciscus cephalus* and *Scardinius erythrophtalmus* are omnivorous for the experts of the classification process, too.

Herzig et al. (1993) define *Blicca bjoerkna, Abramis brama, Anguilla anguilla, Carassius gibelio* and *Gymnocephalus baloni* as benthivorous and *Alburnus alburnus* as well as *Pelecus cultratus* as planktivorous and the experts fully agreed. *Rutilus rutilus* and *Scardinus erythrophtalmus* are supposed to be herbivorous and are classified as omnivorous. Herzig et al. 1993 suppose *Sander lucioperca*, *Esox lucius* and *Anguilla anguilla* to be piscivorous. They are classified as piscivirous/parasitic or even insectivorous (*Anguilla anguilla*). The eel is also for Langston et al. (2002) a benthic feeder as it is classified. *Abramis brama, Cyprinus carpio, Gobio gobio, Gymnocephalus baloni* and *Tinca tinca* are benthic feeders, too (Zambrano et al. 2006). They are also classified so. Zambrano et al. define *Gasterosteus aculeatus, Gobio gobio* and *Gymnocephalus cernuus* as planktivoros but in the classification results *Gasterosteus aculeatus* is omnivorous and *Gobio gobio* and *Gymnocephalus cernuus* are insectivorous. *Abramis brama*, *Rutilus rutilus*, *Tinca tinca* and *Cyprinus carpio* are supposed to be omnivorous and also classified so. Zambrano et al. (2006) declare *Anguilla anguilla* insectivorous and *Esox lucius* and *Perca fluviatilis* to be piscivorous species. The eel is classified as insectivorous. *Esox lucius* and *Perca fluviatilis* are piscivorous/parasitic in the classification results.

Alajärvi & Horppila (2004) define *Alburnus alburnus* as a planktivorous species and it is also classified so.

Migration

Schiemer & Waidbacher (1992) suppose *Acipenser gueldenstaedtii, A. nudiventris, A. stellatus* and *Huso huso* to be long migrating species and they are also classified so.

Anguilla anguilla is not only for McDowell (2007) a long migrating species.

Abramis brama, Cyprinus carpio, Esox lucius, Misgurnus fossilis and *Rutilus rutilus* are defined as resident species by Welcomme et al. (2006). *Salmo trutta trutta* is defined as long migrating species and also classified as one. However, *Abramis brama, Esox lucius* and *Rutilus rutilus* are classified as potamodromous species. *Cyprinus carpio* and *Misgurnus fossilis* are classified as resident.

Aarts & Nienhuis (2003) suppose *Gasterosteus aculeatus* and *Osmerus eperlanus* resident or potamodromous species. The latter is classified as potamodromous and *Gasterosteus aculeatus* is classified as resident.

Reproduction

Smith (2006) writes about the spawning behaviour of *Rhodeus amarus* and therefore define it as ostracophilic. It is classified ostracophilic/viviparous.

In Spindler's publication (1997) information on reproduction of *Anguilla anguilla* which is supposed to be pelagophilic and *Barbatula barbatula* (psamnophilic) can be found. *Anguilla anguilla* is classified as pelagophilic but *Barbatula barbatula* as lithophilic.

Balon (1975) classifies a lot of species with regard to their reproductive guilds and parental care. There are some cases where his definitions do not correlate with the results of the classification process. *Blicca bjoerkna* and *Sander lucioperca* are classified as phytolithophilic (Balon's definition was phytophilic), *Acipenser naccari* and *A. sturio* are classified as lithophilic while Balon found them to be lithopelagophilic. *Alosa alsoa* and *A. fallax* are supposed to be lithopelagophilic while Balon saw them as pelagophilic species. *Atherina presbyter* is phytolithophilic, for Balon it was phytophilic only. *Cobitis calderoni* is classified as lithophilic while Balon suppose it to be phytophilic. *Coregonus albula*, C. *oxyrinchus, C. peled, Osmerus eperlanus* and *Lota lota* are defined as lithopelagophilic by Balon while in the classification process they are lithophilic. *Gasterosteus aculeatus* is classified as phytophilic, Balon supposed it to be ariadnophilic. *Gobio uranoscopus* is defined as psamnophilic, in the classification results it is lithophilic. *Gymnocephalus schraetser, Leuciscus borysthenicus, L. leuciscus* and *L. souffia* are classified as lithophilic while Balon defined them as phytolithophilic. *Mugil cephalus* is classified as pelagohphilic whereas Balon suppose it to be psamnophilic.

For parental care there are no differences between Balon's definitions and the classification results.

Irz et al. (2007) define *Cobitis elongatoides* as phytophilic*, Ctenopharyngodon idella* and *Hypophthalmichthys molitrix* as pelagophilic, *Neogobius gymnotrachelus*, *N. kessleri* and *N. melanostomus* as lithophilic, *Pseudorasbora* parva as phytolithophilic and *Umbra krameri* as lithophilic/pelagophilic. The results of the classification process are the same with the exception of *Neogobius gymnotrachelus* which is classified as phytolithophilic and *Umbra krameri* which is classified as phytophilic.

Zauner & Eberstaller (1999) define habitat spawning preferences for a lot of species. In some cases they do not match the classification results like, for example for *Abramis ballerus* and *Barbatula barbatula* which are supposed to be rheopar but are classified as eurypar. *Anguilla anguilla* is classified as limnopar but was supposed to be eurypar by Zauner & Eberstaller whereas *Gymnocephalus baloni* is supposed to be limnopar but is classified as eurypar. Zauner & Eberstaller finds *Hypophthalmichthys molitrix* to be eurypar while it is classified rheopar.

There are several aberrances of the classification results from the guild classifications found in literature. But the results of the literature search are not homogenous and therefore the method of collecting literature and expert judgments may be the right way to find one acceptable classification for each species. Difficulties to provide a homogenous classification probably arose because species may have been observed in different habitats with different environmental conditions (e.g. lakes or streams, acute contamination, intact water body) or different primary literature was cited.

7 Conclusion

In this thesis 339 European freshwater fish species are included. 243 were partially classified and 133 species could be classified completely with regard to their guilds according to the opinion of the majority (from a pool of experts) and literature proofs (results of the literature search). 72% of the species which could be classified successfully belong to the family of cyprinids, which is the most species-rich family in European inland waters. They are well described together with the gobiids which are the second largest family considered in this thesis.

Denomination of species was not always easy as there is no broad consens on taxonomy of European freshwater fish among experts. Nevertheless it was very important to create a unified species list as guild classification and assessment of water quality depend on it. Due to numerous discussions *Blicca bjoerkna,* for example, was named *Abramis bjoerkna* for several times before it finally retained its original name. *Salvelinus alpinus* was renamed *Salvelinus umbla* before experts insisted on the existence of a separate morph living in northern European waters (pers. corresp. Degermann 2008). In contrary to the common *Salvelinus umbla* it is now called *Salvelinus alpinus*. Taxonomic differences are hard to follow as experts often stick to their own definitions for different species.

Concerning common fish species guild classification was possible. Endemic species and newly described species could hardly be classified due to a lack of literature and expert knowledge. There is little or no information about the ecological traits of 96 freshwater fish species present in European waters. Guild classifications provided by the experts were sometimes contradictionary as they often had completely opposite opinions with regard to each other and to the literature proofs about several species also including well described species. Observation of tolerance ranges, feeding or reproductive behaviour is rare in publications and often limited to a few species which are known to be abundant. From my point of view there has to be done a lot more work on taxonomy and guild classification of European freshwater fish in the future. Better cooperation of scientists by discussing ecological traits of fish is necessary. A homogenous taxanomy without any limitation for describing new fish species would make cooperation easier.

Comparing guilds and the frequency of species within the families percentages of intolerant species are mostly somewhat higher than percentages of tolerant species. Tolerance to a low concentration of oxygen is exhibited by 16% of the species while 19% were classified as intolerant (many salmonids and petromyzonids). A clear picture presents the tolerance to toxic contamination. Only 7% of the species are tolerant and 31% are intolerant. Again those species are mainly salmonids or petromyzonids but other families like gobiids, cyprinids and acipenserids include intolerant species, too. The trend continues for all other tolerance guilds except for the tolerance to a general degradation of water quality. Here 30% were classified as tolerant to a general degradation of water quality 13% were classified as intolerant (mainly salmonids and petromyzonids).

A third of the species prefer fast flowing habitats, 30% prefer slow flowing habitats and 30% can cope with both. Clearly more species feed benthic (41%) than in the water column (27%).

Most of the species (27%) are insectivorous. The majority of the species (39%) is resident and does not move further than a river segment. 16% are potamodromous and migrate between river zones and not more than 10km. 8% are long migrating species. A relatively high percentage of the species (28%) concerned for classification are lithophilic. 13% of the species were classified as phytophilic. 4% are pelagophilic and another 4% speleophilic. 2% of the species are supposed to be psamnophilic. 6% of the species are lithopelagophilic, ariadnophilic, ostracophilic/viviparous and polyphilic (1,5% of the species corresponding to each of the four modalities).

When examinating tolerance in general, rheophilic species seem to be intolerant, limonphilic species are intermediately tolerant and eurytopic species are tolerant. Abundant species are not necessarily tolerant.In some cases they are even very intolerant. This could originate to the fact that fish data are mainly available from the upper parts of European running waters. Due to hydromorphological alterations the number of typical fish regions belonging to the epipotamal and metapotamal are decreasing in favour of upper regions inhabitated by *Salmo trutta, Cottus gobio* and *Phoxinus phoxinus* (Melcher et al. 2007). Probably these results also may stress the fact that the tolerance guilds alone cannot properly describe strategies of fish to establish stable populations and that the work on guilds needs continuation.

Species with large egg diameters are slightly more intolerant than species with smaller egg diameters. A few species with a high longevity are tolerant. However, in general physiological parameters do not allow conclusions on tolerance.

This thesis is not only a contribution to the EFI+ project but should be a basic for further investigation on guilds and tolerance ranges of fish. The help table for calculating the metrics for the fish index can also be used as an extensive list of guild information to either classify fish or get information about their lifestyle. With the literature suggested and the summaries provide further classification processes can be initiated.

REFERENCES

AARTS B. & NIENHUIS P., 2003. Fish zonations and guilds as the basis for assessment of ecological integrity of large rivers. Hydrobiologia 500: 157-178. Kluwer Academic Publishers

ALAJÄRVI E. & HORPPILA J., 2004. Diel variations in the vertical distribution of crustacean zooplankton and food selection by planktivorous fish in a shallow turbid lake. International Review of Hydrobiology 89(3): 238-249

ALMEIDA P.R., QUINTELLA B.R., DIAS N.M., 2002. Movement of radio-tagged anadromous sea lamprey during the spawning migration in the River Mondego (Portugal). Hydrobiologia 483: 1–8

ALMEIDA P.R., 2003. Feeding ecology of *Liza ramada* (Risso, 1810) (Pisces, Mugilidae) in a south-western estuary of Portugal. Estuarine, Coastal and Shelf Science 57: 313–323

ANDRADE N.O., QUINTELLA B.R., FERREIRA J., PINELA S., PÓVOVA I., PEDRO S., ALMEIDA P.R., 2007. Sea lamprey (*Petromyzon marinus* L.) spawning migration in the Vouga river basin (Portugal): poaching impact, preferential resting sites and spawning grounds. Hydrobiologia 582(1): 121-132

ANGERMEIER P.L. & KARR J. R.; 1986. Applying an Index of Biotic Integrity Based on Stream-Fish Communities: Considerations in Sampling and Interpretations. North American Journal of Fisheries Management 6: 418-429

BALON E. K., 1975. Reproductive Guilds of Fishes: A Proposal and Definition. Journal of the Fisheries Research Board of Canada 32: 821-864

BALON E.K., MOMOT W.T., REGIER H.A., 1977. Reproductive guilds of percids: results of the paleogeographical history and ecological succession. Journal of the Fisheries Research Board of Canada 34

BALON E.K., 1981a. Reproductive guilds and the ultimate structure of fish taxocenes: amended contribution to the discussion presented at the mini-symposium. Environmental Biology of Fishes 3: 149-152

BALON E.K., 1981b. Additions and amendments to the classification of reproductive styles in fishes. Environmental Biology of Fishes 6: 377-389

BĂNĂRESCU P.M., (ed) 1999. The Freshwater Fishes of Europe. Vol 5/1 Cyprinidae. Aula Verlag. 426pp

BĂNĂRESCU P.M. & PAEPKE H.J., (eds) 2001. The Freshwater Fishes of Europe. Vol 5/3 Cyprinidae 2. - Carassius to Cyprinus. Gasterosteidae. Aula Verlag. 305pp

BARTULOVIĆ V., GLAMUZINA B., CONIDES A., GAVRILOVIĆ A., DULČIĆ J., 2006. Maturation, reproduction and recruitment of the sand smelt, *Atherina boyeri* Risso, 1810 (Pisces: Atherinidae) in the estuary of Mala Neretva River (southeastern Adriatic, Croatia). Acta Adriat. 47(1): 5-11

BEIER U., DEGERMAN E., MELCHER A., ROGERS C., WIRLÖF H., 2007. Processes of collating a European fisheries database to meet the objectives of the European Framework Water Directive. Fisheries Management and Ecology 14:407-416

BEITINGER T.L., BENNETT W.A., McCAULEY R.W., 2000. Temperature tolerances of North American freshwater fishes exposed to dynamic changes in temperature. Enironmental Biology of Fishes 58: 273-275

BELLIDO M., HERNANDO J.A., FÉRNANDEZ-DELGADO C., HERRERA M., 1989. Alimentación de la boga del Guadiana (*Chondrostoma polylepis willkommii*, Stein. 1866) en la interfase río-embalse de Sierra Boyera (Córdoba. España). Doñana, Acta Vertebrata, 16: 189-201

BERKMAN H.E. & RABENI C.F., 1987. Effect of siltation on stream fish communities. Environmental Biology of Fishes 18: 285-294

BLANCK A., TEDESCO P.A., LAMOUROUX N., 2007. Relationships between life-history strategies of European freshwater fish species and their habitat preferences. Freshwater Biology 52: 843-859. Blackwell Publishing

BLANCK A. & LAMOUROUX N., 2006. Large-scale intraspecific variation in life-history traits of European freshwater fish. Journal of Biogeography 34: 862-875. Blackwell Publishing

BLOCKSOM K. A., 2003. A performance comparison of metric scoring methods for a multimetric Index for Mid-Atlantic highlands streams. Environmental Management 31(5): 670-682

BOET P., CHESSEL D., HUGUENY B., OBERDORFF T., PONT D., PORCHER J.P., 1999. Rapport final de la Phase II du programme national (Indice Poisson). Conseil Superieur de la Pêche, Direction Generale, 134, Avenue de Malakoff, 75116 Paris, France. 60pp

BOUGHIDA L., 1992. Ecological aspects of the roach (*Rutilus rutilus* L.). Growth, reproduction and development of two populations in the river Seine at upstream and downstream of Paris. Travaux Universitaires - Thèse nouveau doctorat. Université de Paris. 176pp

BRUTON M.N. & MERRON G.S., 1990. The proportion of different eco-ethological sections of reproductive guilds of fishes in some African inland waters. Environmental Biology of Fishes 28: 179-187

CARBONERO J., COLINO V. J., VELASCO J. C., LIZANA M., 2006. Biología reproductiva del alburno (*Alburnus alburnus*) en el río Tormes. Ventaja competitiva de las mútiples puestas en la colonización de un nuevo hábitat y desplazamiento de especies autóctonas. in : Actas 2º Congreso Nacional sobre Especies Exóticas Invasoras, León: 88

CARMONA J.A., DOADRIO I., MÁRQUEZ A.L., REAL R., HUGUENY B., VARGAS J.M., 1999. Distribution patterns of indigenous freshwater fishes in the Tagus River basin, Spain. Environmental Biology of Fishes, 54: 371-387

CHADWICK E.M.P., 1976. Ecological fish production in a small Precambrian shield lake. Environmental Biology of Fishes 1: 13-60

CHANGEUX T. & PONT D., 1995. Current status of the riverine fishes of the French Mediterranean basin. Biological conservation 72: 137-158

COELHO M.M., 1987. Estudo sistemático de populações de Chondrostoma Agassiz, 1835 (Pisces, Cyprinidae). A especiação de *Ch. polylepis* Stein., 1865 e *Ch. Willkommii* Stein., 1866. Thesis, University of Lisboa. 457 pp

COLLARES-PEREIRA M.J., COWX I.G., RODRIGUES J.A., ROGADO L., DA COSTA L.M., 1999. The status of *Anaecypris hispanica* in Portugal: problems of conserving a highly endangered species. Biological Conservation 88: 207-212

CORREIA M.J., COSTA J.L., TEIXEIRA C., ALMEIDA P.R., DOMINGOS I., COSTA M.J., 2001. Feeding habits and condition of allis shad (*Alosa alosa*) in Portugal. Bulletin francais de la pêche et de la pisciculture 362/363: 823-835

COSTA M.J., ALMEIDA P.R., DOMINGOS I.M., COSTA J.L., CORREIA M.J., CHAVES M.L., TEIXEIRA C.M., 2001. Present status of the main shad populations in Portugal. First international conference on European shads, Bordeaux, 22-25 May 2000. GRISAM. Ministere de l' Amenagement du territoire et de l'environnement 362-363 : 1109-1116. Bulletin francais de la pêche et de la pisciculture

COWX I., 2001. Factors influencing coarse fish populations in rivers: A literature review. Environment Agency, Rio House, Waterside Drive, Bristol BS32 4UD, UK. R&D Publication 18, 146pp

CUCHEROUSSET J., PAILLISSON J.-M., CARPENTIER A., EYBERT M.-C., OLDEN J.D., 2006. Habitat use of an artificial wetland by the invasive catfish *Ameiurus melas*. Ecology of Freshwater Fish 15: 589–596

DUŠEK L., SVOBODOVÁ Z., JANOUŠKOVÁ D., VYKUSOVÁ B., JARKOVSKÝ J., ŠMÍD R., PAVLIŠ P., 2004. Bioaccumulation of mercury in muscle tissues of fish in the Elbe River (Czech Republic): multispecies monitoring study 1991-1996. Ecotoxicology and Environmental Safety. Elsevier

ELLIOT M., WHITFIELD A.K., POTTER I.C., BLABER S.J.M., CYRUS D.P., NORDLIE F.G., HARRISON T.D., 2007. The guild approach to categorize estuarine fish assemblages: a global review. Fish and Fisheries, 8: 241-268

ELVIRA B., 1996. Endagered freshwater fish of Spain. in: Conservation of Endangered Freshwater Fish in Europe. eds. Kirchhofer & Hefti. Birkhäuser. 341pp

ENCYCLOPEDIA BRITANNICA; 25-05-2008. Incubation (of eggs). URL: http://www.britannica.com/eb/topic-284938/incubation

ENVIRONMENTAL PROTECTION AGENCY OF THE U.S.; 03-03-2008. About Biological Indicators. URL: http://www.epa.gov/bioindicators/html/about.html

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

FAME consortium; 03-03-2008. Overview. URL: http://fame.boku.ac.at/overview.htm

FILIPE A.F., COWX I.G., COLLARES-PERREIRA M.J., 2002. Spatial modelling of freshwater fish in semi-arid river systems: a tool for conservation. River Research & Application 18: 123-136

FENT K., 2007. Ökotoxikologie. 3: 338pp. Georg Thieme Verlag

FERNÁNDEZ-DELGADO C. & HERRERA M., 1994. Population structure, growth and reproduction of *Tropidophoxinellus alburnoides* (Steindachner, 1866) in an intermittent stream of the Guadalquivir river basin (southern Spain). Arch. Hydrobiol. 130: 359–369

FILIPE A. F., COWX I. G., COLLARES-PEREIRA M. J., 2002. Spatial modelling of freshwater fish in semi-arid river systems: a tool for conservation. River Research and Applications 18: 123-136

FISHER S.J. & WILLIS D.W., 2000. Seasonal dynamics of aquatic fauna and habitat parameters in a perched upper Missouri river wetland. Wetlands 470-478

FOX M.G. & CRIVELLI A.J., 1998. Body size and reproductive allocation in a multiple spawning centrarchid. Canadian Journal of Fisheries and Aquatic Sciences 55(3): 737–748

GANTE H. F & SANTOS C. D., 2002. First records of the North American catfish *Ameiurus melas* in Portugal. Journal of Fish Biology 61: 1643-1646

GODHINO F.N. & FERREIRA M.T., 1998. The relative influences of exotic species and environmental factors. Environmental Biology of Fishes 51(1):41-51

GRANADO-LORENCIO C., HORTAL E.G., GUTIERREZ M.C., 1985. The influence of some environmental factors on growth of Iberian nase *Chondrostoma polylepis* (Steindachner, 1865) in three reservoirs of western Spain. Cybium 9: 225-232

GRANDMOTTET J.P., 1983. Principales exigences de téléostéens dulcicoles vis-à-vis de l'habitat aquatique. Annls. scient. Univ. Besançon 4: 3-32

GROSSMAN G.D. & SOSTOA A., 1994. Microhabitat use by fish in the upper Rio Matarrana, Spain, 1984-1987. Ecology of Freshwater Fish 3(4): 141-152

HERZIG A., MIKSCHI E., AUER B., HAIN A., WAIS A., WOLFRAM G., 1994. Fischbiologische Untersuchung des Neusiedler Sees. Biologische Station Neusiedler See. BFB Bericht 81

IRZ P., MICHONNEAU F., OBERDORFF T., WHITTIER T.R., LAMOUROUX N., MOUILLOT D., ARGILLIER C., 2007. Fish community comparisons along environmental gradients in lakes of France and north-east USA. Global Ecology and Biogeography 16: 350-366. Blackwell Publishing

JOBLING M., 1994. Fish Bioenergetics. Chapman and Hall, London

KARR J. R. & DUDLEY D. R.; 1981. Ecological perspectives on water quality goals. Environmental Management 5: 55-68

KEITH P. & ALLARDI J. ,2001. Atlas des poissons d'eau douce de France. Muséum national d'Histoire naturelle

KLAAR M., COPP C.H., HORSFIELD R., 2004. Autumnal habitat use of non-native pumpkinseed *Leposmis gibbosus* and associations with native fish species in English streams. Foolia Zoologica 53(2): 189-202

KLEE O., 1991. Angewandte Hydrobiologie. Trinkwasser – Abwasser – Gewässerschutz. 2: 271pp. Georg Thieme Verlag Stuttgart

KLEMESTEN A., 2006. Divergent, genetically based feeding behaviour of two sympatric Arctic charr, *Salvelinus alpinus* (L.), morphs. Ecology of Freshwater Fish 15: 350-355. Blackwell Publishing

KOTTELAT M., 1997. European Freshwater Fishes. Biologia 52(5): 1-271

KOTTELAT M. & FREYHOF J., 2007. Handbook of European Freshwater Fishes. Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany. 1: 646pp

KÜTTEL S., PETER A., WÜEST A., 2002. Temperaturpräferenzen und –limiten von Fischarten Schweizerischer Fliessgewässer. Publikation Nummer 1. Rhône Revitalisierung

KUBECKA J. & VOSTRADOVSKY J., 1995. Effects of dams, regulation and pollution on fish stocks in the Vltava River in Prague. Regulated Rivers Research and Management 10:93-98

KRUK A., 2007. Role of habitat degradation in determining fish distribution and abundance along the lowland Warta River, Poland. Journal of Applied Ichthyology 23: 9-18.

LAFAILLE P., FEUNTEUN E., LEFEBVRE C., RADUREAU A., SAGAN G., LEFEUVRE J.C., 2002. Can thin-lipped mullet exploit the primary and detritic production of European macrotidal salt marshes? Estuarine, Costal and Shelf Science 54: 729-736

LAMOUROUX N. & CATTNÉO F., 2005. Fish assemblages and stream hydraulics: consistent relations across spatial scales and regions. River Research and Applications 22: 727–737. John Wiley & Sons

LANGSTON W.J., CHESMAN B.S., BURT G.R., POPE N.D., McEVOY J., 2002. Metallothionein in liver of eels *Anguilla anguilla* from the Thames Estuary: an indicator of environmental quality? Marine Environmental Research 53: 263-293. Elsevier Science

LAPPALAINEN J., 2001. Effects of environmental factors, especially temperature, on the population dynamics of pike-perch (*Stizostedion lucioperca* (L.)). Academic dissertation in Fisheries Science. Helsinki 2001

LELEK A. & KÖHLER C., 1989. Zustandanalyse der Fischartengemeinschaften im Rhein (1987–1988). Fischökologie 1: 47-64

LINDHOLM T., ÖHMAN P., KURKI-HELASMO K., KINCAID B., MERILUOTO J., 1999. Toxic algae and fish mortality in a brackish-water lake in Åland, SW Finland. Hydrobiologia 397: 109-120

LOBON-CERVÍA J. & ELVIRA B. 1981. Edad, crecimiento y reproducción de la boga de rıó (Chondrostoma polylepis polylepis Stein, 1865) en el embalse de Pinilla (rió Lozoya). Boletin del Instituto Español de Oceanografía 6: 200–213

LOBÓN-CERVIÁ J., RINCÓN P.A., 1994. Trophic ecology of red roach (*Rutilus arcasii*) in a seasonal stream; an example of detritivory as a feeding tactic. Freshwater Biology 32(1): 123–132

MAHON R., 1984. Divergent structure in fish taxocenes of North Temperate streams. Canadian Journal of Fisheries and Aquatic Sciences 41: 330-350

MARSCHALL E.A., QUINN T.P.,ROFF D.A., HUTCHINGS J.A., METCALFE N.B., BAKKE T.A., SAUNDERS R.L., POFF L., 1998. A framework for understanding Atlantic salmon (*Salmo salar*) life history. Canadian Journal of Fisheries and Aquatic sciences 55(S1): 48-58

MELCHER A., SCHMUTZ S., HAIDVOGL G., MODER K., 2007. Spatially based methods to assess the ecological status of European fish assemblage types. Fisheries Management and Ecology 14:453-463

MC DOWALL R. M., 2007. On amphidromy, a distinct form of diadromy in aquatic organism. Fish and Fisheries 8: 1-13. Blackwell Publishing

MORMAN R.H., CUDDY D.W., RUGEN P.C., 1980. Factors Influencing the Distribution of Sea Lamprey (*Petromyzon marinus*) in the Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences 37: 1811-1826

NOBLE R.A.A. & COWX I.G., 2002. Development of a river-type classification system (D1). Compilation and harmonisation of fish species classification (D2). Final Report. Development, Evaluation & Implementation of a Standardised Fish-based Assessment Method for the Ecological Status of European Rivers – A Contribution to the Water Framework Directive. (FAME) http://fame.boku.ac.at

NOBLE R.A.A., COWX I.G., GOFFAUX D., KESTEMONT P., 2007. Assessing the health of European rivers using functional ecological guilds of fish communities: standardising species classification and approaches to metric selection. Fisheries Management and Ecology 14 (6): 381-392

OBERDORFF T. & HUGHES R.M., 1992. Modification of an index of biotic integrity based on fish assemblages to characterize rivers of the Seine Basin, France. Hydrobiologia 228: 117-130

OBERDORFF T., PONT D., HUGUENY B., PORCHER J.-P., 2002. Development and validation of a fish-based index for the assessment of 'river health' in France. Freshwater Biology 47(9): 1720–1734

OVIDIO M. & PHILIPPART J.C., 2005. Long range seasonal movements of northern pike (*Esox lucius* L.) in the barbel zone of the River Ourthe (River Meuse basin, Belgium). Aquatic telemetry: advances and applications. Proceedings of the Fifth Conference on Fish Telemetry held in Europe. Ustica, Italy, 9-13 June 2003. Rome, FAO/COISPA. 295pp

OVIDIO M., CAPRA H., PHILIPPART J.C., 2007. Field protocol for assessing small obstacles to migration of brown trout *Salmo trutta*, and European grayling *Thymallus thymallus*: a contribution to the management of free movement in rivers. Fisheries Management and Ecology 14: 41–50. Blackwell Publishing

PEDROLI B., ZAUGG B., KIRCHHOFER A., 1991. Atlas de distribution des poissons et cyclostomes de suisse. 45

PHILIPPART J.C. & VRANKEN M., 1983. Atlas des Poissions de Wallonie, distribution, écologie, éthologie, pêche, conservation. Cahiers d'Ethologie Appliquée 3: 395pp

POFF N.L. & ALLAN J.D., 1995. Functional organization of stream fish assemblages in realtion to hydrological variability. Ecology 76(2): 606-227

CHANGEUX T. & PONT D., 1995. Current status of the riverine fishes of the French Mediterranean basin. Biological conservation 72: 137-158

PUSCH M. & HOFFMANN, 2000. Conservation concept for a river ecosystem(River Spree, Germany) impacted by flow abstraction in a large post-mining area. Urban planning and landscape 51: 165-176

QUINTELLA B.S.R., 2006. Biology and conservation of the Sea Lamprey (*Petromyzon marinus* L.) in Portugal. Dissertation. Universidade de Lisboa. 299pp

QUINTELLA B.S.R., ANDRADE N.O., ALMEIDA P.R., 2003. Distribution, larval stage duration and growth of the sea lamprey ammocoetes, *Petromyzon marinus* L., in a highly modified river basin. Ecology of Freshwater Fish 12: 286-293

RIBEIRO F.V., COWX I.G., COLLARES-PEREIRA M.J., 2000. Life history traits of the endangered Iberian cyprinid *Anaecypris hispanica* and their implications for conservation. Arch. Hydrobiol. 149: 569 –586

RIBEIRO F.V., ELVIRA B., COLLARES-PEREIRA M.J., MOYLE P.B., 2008. Life-history traits of non-native fishes in Iberian watersheds across several invasion stages: a first-approach. Biological Invasions 10: 89-102

RINCHARD J. & KESTEMONT P., 1996. Comparative study of reproductive biology in single- and multiple-spawner cyprinid fish. I. Morphological and histological features. Journal of Fish Biology 49(5): 883–894

ROBALO J.I., ALMADA V.C., FARIA C., 2003. First description of agonistic behaviour in *Chondrostoma polylepis* (Pisces: Cyprinidae) with notes on the behaviour of other *Chondrostoma* species. Etologia 11: 9-13

RODRIGUEZ J., JIMÉNEZ F., BEGOÑA B., RODRIGUEZ V., 1987. Planktonic biomass spectra dynamics during a winter production pulse in Mediterranean coastal waters. Journal of Plankton Research 9(6): 1183-1194

ROSECCHI E., THOMAS F., CRIVELLI A.J., 2001. Can life-history traits predict the fate of introduced species? A case study on two cyprinid fish in southern France. Freshwater Biology 46(6): 845–853

ROOT R.B., 1976. The niche explotation pattern of the blue gray gnatchater. Ecological Monographs 37: 317-350

SANTOS J.M., FERREIRA M.T., GODINHO F.N., BOCHECHAS J., 2002. Performance of fish lift recently built at the Touvedo dam on the Lima River, Portugal. Journal of Applied Ichthyology 18: 118-123

SANTOS J.M., GODINHO F., FERREIRA M.T., CORTES R., 2004. The organisation of fish assemblages in the regulated Lima basin, Northern Portugal. Limnologica 34, 224-235.

SANTOS J.M., FERREIRA M.T., PINHEIRO A.N., BOCHECHAS J., 2006. Effects of small hydropower plants on fish assemblages in medium-sized streams in Central and Northern Portugal. Aquatic Conservation: Marine and Freshwater Ecosystems 16: 373-388

SCARNECCHIA D.L., 1988. The importance of streamlining in influencing fish community structure in channelized and unchannelized reaches of a prairie stream. Regulated Rivers 2: 155-166

SCHIEMER F. & SPINDLER T., 1989. Endangered fish species of the Danube river in Austria. Regulated Rivers: Research and Management 4: 397-407. John Wiley & Sons

SCHIEMER F. & WAIDBACHER H., 1992. Strategies for Conservation of a Danubian Fish Fauna. River Conservation and Management 23: 364-381. John Wiley & Sons

SCHJOLDEN J., SORENSEN J., NILSSON G.E., POLÉO A.B.S., 2007. The toxicity of copper to crucian carp (*Carassius carassius*) in soft water. Science of the Total Environment 384(1-3): 239-251

SCHMUTZ S., HAIDVOGL G., NOBLE R.A.A., SCHINEGGER R., 03-03-2008. Improvement and Spatial extension of the European Fish Index (EFI+). Project Description. URL: http://efi-plus.boku.ac.at/summary.htm

SCHMUTZ S., KAUFMANN M., VOGEL B., JUNGWIRTH M., MUHAR S., 2000. A multi-level concept for fish-based, river-type-specific assessment of ecological integrity. Hydrobiologia 422/423: 279-289

SCOTT W.B. & CROSSMAN E.J., 1973. Freshwater fishes of Canada. Bulletin of Fisheries Research Board Canada 184: 1-966

SIMON T.P., 1999a. Assessing the sustainability and biological integrity of water resources using fish communities. CRC Press, Boca Raton, FL

SMITH C., 2006. Population consequences of behaviour in the European bitterling (*Rhodeus sericeus* Cyprinidae). Ecology of Freshwater Fish 15: 139-145. Blackwell Munksgaard

SPENCE J.A. & HYNES H.B.N., 1971. Differences in fish populations upstream and downstream of a mainstream impoundment. Journal of the Fisheries Research Board of Canada 28: 45-46

SPILLMAN J.C., 1961. Poissons d'eau douce. Faune de France 65: 302pp

SPINDLER T., 1997. Fischfauna in Österreich. Ökologie – Gefährdung – Bioindikation - Fischerei – Gesetzgebung. Monographien Band 87. Bundesministerium für Umwelt, Jugend und Familie

TORRALVA M.M., UBERO-PASCAL N.A., OLIVA-PATERNA F.J., MALO J., 1999. *Leuciscus pyrenaicus* Günther, 1868 (Pisces, Cyprinidae) en la cuenca del río Segura (S. E. de España). Zoologica baetica 10: 203-205

TORRAS X., CARDONA L., GISBERT E., 2000. Cascading effects of the flathead grey mullet *Mugil cephalus* in freshwater eutrophic microcosmos. Hydrobiologia 429(1-3): 49-57

VAŠEK M. & KUBEČKA J., 2004. In situ diel patterns of zooplankton consuption by subadult/adult roach *Rutilus rutilus*, bream *Abramis brama*, and bleak *Alburnus alburnus*. Folia Zoologica 53: 203-214

VERNEAUX J., 1981. Les poissons et la qualité des cours d'eau. Ann. Sci. Univ. Fr. Comté, Besançon. Biology 4(2): 33-41

VILA-GISPERT A., 1996. Estratègies reproductives de les espècies íctiques de les famílies Centrarchidae i Ciprinidae a L'Estany de Banyoles. Ph.D. Thesis, University of Girona. 289 pp

VILA-GISPERT A., MORENO-AMICH R., GARCIA-BERTHOU E., 2002. Gradients of life-history variation: an intercontinental comparison of fishes. Reviews in Fish Biology and Fisheries 12: 417–427

VINNI M., HORPPILA J., OLIN M., RUUHIJÄRVI J., NYBERG K., 2000. The food, growth and abundance of five coexisting cyprinids in lake basins of different morphometry and water quality. Aquatic Ecology 34(4): 421-431

VINYOLES D., ROBALO J.I., SOSTOA A. de, ALMODOVÁR A., ELVIRA B., 2007. Spread of the alien bleak *Alburnus Alburnus* (Linnaeus, 1758) (Actinopterygii, Cyprinidae) in the Iberian penninsula: the role of reservoirs. Graellsia 63(1): 101-110

VLAMING V. & VODICNIK M.J., 1978. Seasonal effects of pinealectomy on gonadal activity in the goldfish, *Carassius auratus*. Biology of Reproduction 19: 57-63

WAIDBACHER H., SPOLWIND R., STRAIF M., 2003. In-shore Ökotone, Fischhabitate und Makrophyten-Fisch Interaktionen. Ökotone Donau-March 2003: 53

WELCOMME R. L., WINEMILLER K.O., COWX I.G., 2006. Fish environmental guilds as a tool for assessment of ecological condition of rivers. River Research and Applications 22: 377-396. John Wiley & Sons

WIKIPEDIA; 05-09-2008. Delphi-Methode. URL: http://de.wikipedia.org/wiki/Delphi-Methode

WINEMILLER K.O., 1989. Patterns of variation in life-history among South American fishes in periodic environments. Oecologia 81: 225-241

WINEMILLER K.O. & ROSE K.A., 1992. Patterns of life-history diversification in North American fishes: implications for population regulation. Canadian Journal of Fisheries and Aquatic Sciences 49: 2196-2218

WINKELMANN C., PETZOLDT T., KOOP J.H.E., MATTHAEI C.D., BENNDORF J., 2007. Benthivorous fish reduce stream invertebrate drift in a large-scale field experiment. Aquatic Ecology. Springer

WINKELMANN C., WORISCHKA S., KOOP J.H.E., BENNDORF J., 2006. Predation effects of benthivorous fish on grazing and shredding macroinvertebrates in a detritus-based stream food web. Limnologica 37: 121-128. Elsevier

WOOTTON R.J. (ed), 1998. Ecology of Teleost Fishes. Fish and Fisheries Series 24(2): 386pp. Kluwer Academic Publishers.

ZAMBRANO L., PERROW M.R., SAYER C.D., TOMLINSON M.L., DAVIDSON T.A., 2006. Relationships between fish feeding guild and trophic structure in English lowland shallow lakes subject to anthropogenic influence: implications for lake restoration. Aquatic Ecology 40(3): 391-405

ŽARSKI T.P., DEBSKI B., BESEDA I., VAL'KA J., 1995. Mercury pollution of bream (*Abramis brama* L.) caught in the middle course of the Vistula River in 1990 and 1993. Ekologia (Bratislava)/Ecology (Bratislava) 14(3): 317-321

ZAUNER G. & EBERSTALLER J., 1999. Klassifizierungsschema der österreichischen Flußfischfauna in bezug auf deren Lebensraumansprüche. Österreichs Fischerei 52: 198-205

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Additional Literature

ANWAND K., 1965. Die Schleie. A. Ziemsen Verlag, Wittenberg Lutherstadt, Die Neue Brehm-Bücherei.

ANWAND K., 1989. Blei, Plötze und Barsch als Wirtschaftsobjekte - eine Übersicht. Zeitschrift für Binnenfischerei 36: 53-65.

ARLINGHAUS R. & WOLTER C., 2003. Amplitude of ecological potential: chub *Leuciscus cephalus* (L.) spawning in an artificial lowland canal. Journal of Applied Ichthyology 19: 52-54

BACKIEL T. & ZAWISZA J., 1968. Synopsis of biological data on the bream *Abramis brama* (L.). FAO Fisheries Synopsis 36

BĂNĂRESCU P.M., 1964. Fauna republici populare Romine Pisces – Osteichthyes. (The fauna of People's Republic of Romania) Editura academiei republici populare Romine Bucarest.

BĂNĂ RESCU P.M.,Ă 1995. Biogeographie der oberen Donau am Beispiel der Fische. Fischökologie 8: 13-22.

BANGEL T., 1993. Untersuchungen zur Reproduktion von Flußneunaugen (*Lampetra fluviatilis*) im Oder-Neiße-Stromsystem. Naturschutz und Landschaftspflege in Brandenburg 2: 28-30

BARAS E. & NINDABA J., 1999. Diel dynamics of habitat use by riverine young-of-the-year *Barbus barbus* and *Chondrostoma nasus* (Cyprinidae). Archiv für Hydrobiologie 146: 431-448.

BARAS E., NINDABA J., PHILIPPART J.C., 1995. Microhabitat used in a 0+ rheophilous cyprinid assemblage: quantitative assessment of community structure and fish density. Bulletin francais de la pêche et de la pisciculture 337-339: 241-247

BARTL G. & TROSCHEL H.J., 1997. Historische Verbreitung, Bestandsentwicklung und aktuelle Situation von *Alosa alosa* und *Alosa fallax* im Rheingebiet. Zeitschrift für Fischkunde 4: 119-162

BEAMISH F.W.H., 1964. Respiration of fishes with special emphasis on standard oxygen consumption. II. Influence of weight and temperature on respiration of several species. Canadian Journal of Zoology 42: 177-187

BEERS M.C., 2005. Kennisdocument riviergrondel, *Gobio gobio* (L.). Organisatie ter Verbetering van de Binnenvisserij (OVB), Nieuwegein. The Netherlands.

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

BLESS R., 1992. Einsichten in die Ökologie der Elritze. Schriftenreihe für Landschaftspflege und Naturschutz 35: 7-57

BLESS R., 2001. Spawning and niche shift of some threatened riverine fishes of Europe. Archiv für Hydrobiologie. Suppl. 135: 293-305

BOHL E., 1982. Food supply and prey selection in planktivorous Cyprinidae. Oecologia 53: 134-138

BOHL E., 1993. Rundmäuler und Fische im Sediment. Ökologische Untersuchungen an Bachneunauge (*Lampetra planeri*), Schlammpeitzger (*Misgurnus fossilis*) und Steinbeisser (*Cobitis taenia*) in Bayern. Berichte der Bayerischen Landesanstalt für Wasserforschung 22: 1-129

BOHLEN, J. 2003. Temperature and oxygen requirements of early life stages of the endangered spined loach, *Cobitis taenia* L. (Teleostei, Cobitidae) with implications for the management of natural populations. Archiv für Hydrobiologie 157: 195-212

BOHLEN J., 2003. Spawning habitat in the spined loach, *Cobitis taenia* L. (Cypriniformes, Cobitidae). Ichthyological Research 50: 98-101

BRABRAND A., 1985. Food of roach (*Rutilus rutilus*) and ide (*Leuciscus idus*): significance of diet shift for interspecific competition in omnivorous fish. Oecologia 44: 461-467

BREDER C.M. & ROSEN D.E., 1966. Modes of reproduction in Fishes. New Jersey: TFH publications

BREITINGER T.L., BENNETT W.A., McCAULEY R.W., 2000. Temperature tolerance of North American freshwater fish species exposed to dynamic changes in temperature. Environmental Biology of Fishes 58: 237-275

BRUNKEN H., 1988. Ausbreitungsdynamik von *Noemacheilus barbatulus* (Linnaeus, 1758). TU Braunschweig, Dissertation

BURROUGH R.J., 1978. The biology and management of roach (*Rutilus rutilus* L.) and rudd (*Scardinius erythrophthalmus* L.) in Slapton Ley, Devon. Ph.D. Thesis, University of Exeter, England

BURROUGH R.J., BREGAZZI P.R., KENNEDY C.R., 1979. Interspecific dominance amongst three species of coarse fish in Slapton Ley, Devon. Journal of Fish Biology 15: 535-544

CASSELMAN J.M. & LEWIS C.A. 1996. Habitat requirements of northern pike (*Esox lucius*). Canadian Journal of Fisheries and Aquatic Sciences 53 (1): 161-17

CHARLEBOIS P.M., MARSDEN J.E., GOETTEL R.G., WOLFE R.K., JUDE D.J., RUDNIKA S., 1997. The Round Goby, *Neogobius melanostomus* (Pallas). A Review of European and North American Literature, Illinois Natural History Survey and Illinois-Indiana Sea Grant Program

COPP G.H., 1989. The habitat diversity and fish reproductive function of floodplain ecosystems. Environmental Biology of Fishes 26: 1-27

COWX I.G., 1980. Population ecology and management of coarse fish in the River Exe and River Culm. PhD Thesis, University of Exeter, U.K.

COWX I.G., 1983. The biology of bream, *Abramis brama* (L.) and its natural hybrid with roach, *Rutilus rutilus* (L.) in the River Exe. Journal of Fish Biology 22: 631-646

COWX I.G., 1988. Distribution and variation in the growth parameters of roach, *Rutilus rutilus* (L.), and dace, *Leuciscus leuciscus* (L.), in a river catchment in the south-west of England. Journal of Fish Biology 33: 59-72

COWX I.G., 1989. Interaction between roach (*Rutilus rutilus*) and dace (*Leuciscus leuciscus*) populations in a river catchment in the south-west of England. Journal of Fish Biology 35(Supplement A): 279-284

COWX, I.G. (1990b). Growth and reproduction tactics of roach, *Rutilus rutilus* (L.), and dace, *Leuciscus leuciscus* (L.), populations in the Rives Exe and Culm, England. Polskie Archiwum Hydrobiologii 37(1/2): 195-210

COWX I.G., PITTS C.S., SMITH K.L., HAYWARD P.J., VAN BREUKELEN S.W.F., 1995a. Coarse fish populations in rivers: Literature Review. R&D Note 459 National River Authority, Bristol 129 pp

COWX I.G., PITTS C.S., SMITH K.L., HAYWARD P.J., VAN BREUKELEN S.W.F., 1995b. Factors influencing coarse fish populations in rivers R&D Note 460 National River Authority, Bristol 125 pp

COWX I.G. & WELCOMME R.L. (eds), 1998. Rehabilitation of Rivers for Fish. FAO, Rom

CRAIG, J.F., 1987. The biology of perch and related fish. London: Croom Helm 333p

DAVIES A.W., 1977. What water quality is necessary to maintain a satisfactory coarse fishery? Proc. 8th Brit. Coarse Fish Conf. Univ. of Liverpool, pp 169-176

DIAMOND M., 1985a. Some observations of spawning by roach, *Rutilus rutilus* L., and bream, *Abramis brama* L., and their implication for management. Aquacult. Fish. Mgmt 16: 359-367

DOUDOROFF P. & SHUMWAY D.L., 1970. Dissolved oxygen requirements of freshwater fishes. FAO, Rome. FAO Fisheries Technical Paper 86

EKLÖV P., 1997. Effects of habitat complexity and prey abundance on the spatial and temporal distributions of perch (*Perca fluviatilis*) and pike (*Esox lucius*). Canadian Journal of Fisheries and Aquatic Sciences 54: 1520-1531

EKLÖV P. & HAMRIN S.F. (1989). Predatory efficiency and prey selection: interactions between pike, *Esox lucius*, perch *Perca fluviatilis* and rudd *Scardinius erythrophthalmus.* Oikos 56: 149-156

EMMERIK W.A.M. van, 2003. Indeling van de vissoorten van de Nederlandse binnenwateren in ecologische gilden en in hoofdgroepen. Organisatie ter Verbetering van de Binnenvisserij (OVB), Nieuwegein. The Netherlands

EMMERIK W.A.M. van, 2003. Indeling van de vissoorten van de Nederlandse binnenwateren in ecologische gilden en in hoofdgroepen. Organisatie ter Verbetering van de Binnenvisserij (OVB), Nieuwegein. The Netherlands

ERÖS T. & GROSSMAN G.D., 2005. Effects of within-patch habitat structure and variation on fish assemblage characteristics in the Bernecei stream, Hungary. Ecology of Freshwater Fish 14: 256-266

ERÖS T. & GROSSMAN G.D., 2005. Fish biodiversity in two Hungarian streams: a landscape-based approach. Archiv für Hydrobiologie 162: 53-61

FICKLING N.J. & LEE R.L.G., 1983. A review of the ecological impact of the introduction of the zander (*Stizostedion lucioperca*) into waters of the Eurasian mainland. Fisheries Management 14: 151-155

FREDRICH F., OHMANN S., CURIO B., KIRSCHBAUM F., 2003. Spawning migrations of the chub in the River Spree, Germany. Journal of Fish Biology 63: 710-723

FREYHOF J., 1998. Strukturierende Faktoren für die Fischartengemeinschaft der Sieg. Cuvillier Verlag, Göttingen

FREYHOF J. & SCHRÖTER C., 2005. The houting *Coregonus oxyrinchus* (L.) (Salmoniformes: Coregonidae), a globally extinct species from the North Sea basin. Journal of Fish Biology 67: 713-729

FRIES G., 1965. Längen-, Gewichts- und Eiverhältnisse beim Dreistacheligen Stichling (Gasterosteus aculeatus L.). Zeitschrift für Fischerei NF 13: 171-180

FROST W.E., 1946. On the food relationships of fish in Windermere. Biologisches Jahrbuch 13: 216-231

FROST W.E. (1954). The food of pike (*Esox lucius* L.) in Windermere. Journal of Animal Ecolocy 23(2): 339-360.

FROST W.E. & KIPLING C., 1967. A study of reproduction, early life, weight-length relationship and growth of pike, *Esox lucius* L., in Windermere. Journal of Animal Ecolocy 36 (3): 651-693

GARNER P. & CLOUGH S., 1996. Habitat use by adult dace, *Leuciscus leuciscus* (L.), in a side cahnnel of the River Frome, England. Fisheries Management and Ecology 3: 349-352

GERSTMEIER R. & ROMIG T., 2000. Zoetwatervissen van Europa. Tirion Uitgevers BV, Baarn. The Netherlands

GILES N., STREET M., WRIGHT R. M., 1990. Diet composition and prey preference of tench, *Tinca tinca* (L.), common bream, *Abramis brama* (L.), perch, *Perca fluviatilis* (L.) and roach, *Rutilus rutilus* (L.), in two contrasting gravel pit lakes: potential trophic overlap with wildfowl. Journal of Fish Biology 37: 945-957

GILLET C. & DUBOIS J.P., 1995. A survey of the spawning of perch (*Perca fluviatilis*), pike (*Esox lucius*) and roach (*Rutilus rutilus*) using artifical spawning substrates in lakes. Hydrobiologia 301: 409-415

GRIFT R., 2001. How fish benefit from floodplain restoration along the lower River Rhine. Ponsen & Looijen, Wageningen

GUNN J.M., QADRI S.U., MORTIMER D.C., 1977. Filamentous algae as a food source for the brown bullhead (*Ictalurus nebulosus*). Journal of the Fisheries Research Board of Canada 34: 396-401

HABERLEHNER E., 1988. Comparative analysis of feeding and schooling behaviour of the Cyprinidae *Alburnus alburnus* (L. 1758), *Rutilus rutilus* (L 1758), and *Scardinius erythrophtalmus* (L 1758) in a backwater of the Danube near Vienna. Internationale Revue der gesamten Hydrobiologie 73: 537-546

HALASI-KOVÁCS B. & TÓTHMÉRÉSZ B., 2007. Fish assemblage - based ecological classification of hungarian running waters in conformity with the Water Framework Directive. In: SOMLYÓDY L. & SIMONFFY Z. (eds) 2008. Scientific development of the suistanable water management for fulfilment of the Water Framework Directive in Hungary. in print

HARSANYI A. & ASCHENBRENNER P., 1995. Die Nase – *Chondrostoma nasus* (Linnaeus, 1758). Biologie und Aufzucht. Fischer & Teichwirt 46: 150-154

HARTLEY P.H.T, 1940. The food of coarse fish. Freshwater Biological Association Scientific Publication 3 32pp

HARTLEY P.H.T, 1947a. The natural history of some British freshwater fishes. Proc. zool. soc. Lond. 117: 129-206.

HARTLEY P.H.T, 1947b. The coarse fishes of Britain. Freshwater Biological Association Scientific Publication 12, 40pp

HAWKES H.A., 1975. River zonation and classification. in: B.A. Whitton (ed.) River Ecology. University of California Press, Berkeley, 374pp

HEESE T., 1988. Some aspects of the biology of the whitefish, *Coregonus lavaretus* (L.), from the Pomeranian Bay. Finnish Fisheries Research 9: 165-174

HEGEMANN M., 1964. Der Hecht. A. Ziemsen Verlag, Wittenberg Lutherstadt, Die Neue Brehm-Bücherei

HELLAWELL J.M., 1971a. The autecology of the chub, *Squalis cephalus* (L.), at the River Lugg and Afon Llynfi. Freshwater Biology 1: 29-60, 1: 135-148, 1: 269-387

HELLAWELL J.M., 1972. The growth, reproduction and food of the roach *Rutilus rutilus* (L.), of the River Lugg, Herefordshire. Journal of Fish Biology 4: 469-486

HELLAWELL J.M., 1974b. The ecology of populations of dace, *Leuciscus leuciscus* (L.), from two tributaries of the River Wye, Herefordshire, England. Freshwater Biology 4: 577-604

HEUSCHMANN O., 1962. Die Weißfische (Cyprinidae). in: DEMOLL R. & MAIER H.N. (eds) Handbuch der Binnenfischerei Mitteleuropas, III b, 23-200 E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart

HICKS M., 2002. Evaluating Standards for Protecting Aquatic Life in Washington's Surface Water Quality Standards. Temperature Criteria. Washington State Department of Ecology. Water Quality Program

HINRICHS D., 1996. Habitatansprüche und Ortsbewegungen des Schlammpeitzgers *Misgurnus fossilis* (Linnaeus, 1758), (Cobitidae) im Unteren Havelgebiet/Sachsen-Anhalt. Technische Universität Braunschweig, Zoologisches Institut, Diplomarbeit

HODGSON B.P., 1993. The ecology and management of the coarse fish populations of the Lower Welsh Dee. PhD. Thesis. Univ. of Liverpool

HOESTLANDT H. (ed.), 1991. The Freshwater Fishes of Europe Volume 2: Clupeidae, Angullidae. AULA-Verlag, Wiesbaden

HOFMANN N. & FISCHER P., 2002. Temperature preferences and critical thermal limits of burbot: Implications of habitat selection and ontogenetic habitat shift. Transactions of the American Fisheries Society 131: 1164-1172

HOLCIK J. & HRUSKA V., 1966. On the spawning substrate of the roach- *Rutilus rutilus* (Linnaeus, 1758) and bream- *Abramis brama* (Linnaeus,1758) and notes on the ecological characteristics of some European fishes. Vest. Cesk. Spol. Zool. 30: 22-29

HOLCIK J., (ed.) 1986. The Freshwater Fishes of Europe V Volume 1/I (Petromyzontiformes). AULA-Verlag, Wiesbaden

HOLCIK J., 1989. The Freshwater Fishes of Europe Volume 1/II: General Introduction to Fishes; Acipenseriformes. AULA-Verlag, Wiesbaden

HÖLKER F. & THIEL R., 1998. Biology of ruffe (*Gymnocephalus cernuus* (L.)) - A review of selected aspects from European literature. Journal of Great Lakes Research 24: 186-204

HOLMES J.A. & LIN P., 1994. Thermal niche of larval sea lamprey, *Petromyzon marinus*. Canadian Journal of Fisheries and Aquatic Sciences 51: 253-262

HUNT P.C. & JONES J.W., 1974. A population study of *Barbus barbus* (L.) in the River Severn, England. Journal of Fish Biology 6: 255-267, 6: 269-278, 7:361-376

HUTCHINGS J.A., 1996. Adaptive phenotypic plasticity in brook trout, *Salvelinus fontinalis*, life histories. Ecoscience 3: 25-32

JUNGWIRTH M., SCHMUTZ S., WEISS S.(eds), 1998. Fish migration and fish bypasses. Fishing News Books, Blackwell science, Oxford

KAMMERAD B., ELLERMANN S., MENCKE J., WÜSTEMANN O. & ZUPPKE U., 1997. Die Fischfauna von Sachsen-Anhalt. Verbreitungsatlas. Ministerium für Raumordnung, Landwirtschaft und Umwelt des Landes Sachsen-Anhalt, Magdeburg

KARABANOWICZ J. & KOMPOWSKI A., 1994. On biology of reproduction of blue bream, *Abramis ballerus* (L., 1758), in the lower part of River Odra, Lake Dabie and Szczecin Lagoon. Acta Ichthyologica et Piscatoria 24: 77-92

KENNEDY M., 1969. Spawning and early development of the dace, *Leuciscus leuciscus* (L.). Journal of Fish Biology 1: 249-259

KENNEDY M. & FITZMAURICE P., 1968. The biology of the bream (*Abramis brama* L.) in Irish waters. Proc. Ir. Acad. 5: 95-157

KENNEDY M. & FITZMAURICE P., 1969. Factors affecting the growth of coarse fish. Proc. 4th Brit. Coarse Fish Conf., Univ. of Liverpool 42-49

KENNEDY M. & FITZMAURICE P., 1970. The biology of the tench, *Tinca tinca*(L.), in Irish waters. Proc. R. Ir. Acad. 69(B): 31-84

KENNEDY M. & FITZMAURICE P., 1972. Some aspects of the gudgeon, *Gobio gobio* (L.) in Irish waters. Journal of Fish Biology 4: 425-440

KENNEDY M. & FITZMAURICE P., 1974. Biology of the rudd, *Scardinius erythrophthalmus* (L.) in Irish waters. Proc. R. Ir. Acad. 74(B(3)): 245-303

KESTEMONT P., 1989. Study on the reproductive cycle of the gudgeon (*Gobio gobio* L) Journal of Applied Ichthyology Zeitschrift für angewandte Ichthyologie 5: 111-121

KESTEMONT P., DIDIER J., DEPIEREUX E., MICHA J.C., 2000. Selecting ichthyological metrics to assess river basin ecological quality. Archiv für Hydrobiologie Suppl. 121: 321-348

KIME D.E., 1995. The effects of pollution on reproduction in fish. Reviews in Fish Biology and Fisheries 5: 52-96

KLARBERG D.P. & BENSON A., 1975. Food habits of *Ictalurus nebulosus* in acid polluted water of Northern West Virginia. Transactions of the American Fisheries Society 104: 541-547

KLEIN BRETELER J.G.P. & LAAK G.A.J. de, 2003. Lengte-gewicht relaties Nederlandse vissoorten. Organisatie ter Verbetering van de Binnenvisserij (OVB), Nieuwegein. The Netherlands

KLINE J.L. & WOOD B.M., 1996. Food habits and diet selectivity of the brown bullhead. Journal of Freshwater Ecology 11: 145-151

KÖHLER C. & LELEK A., 1992. Die Fischfauna des Rheins: Analyse der Artengemeinschaften sowie Daten zur Morphometrie und Meristik der vorkommenden Arten. Courier Forschungsinstitut Senckenberg 148: 53-153

KOMPOWSKI A., 1997. Reproduction and fecundity of blue bream *Abramis ballerus* L., 1758 in Miedzyodrze. Acta Ichthyologica et Piscatoria 27: 57-77

KORTE E.J., 1999. Bestandsentwicklung der Fischarten in der Hessischen Rheinaue. PhD Thesis, Philipps-University, Marburg

KRYKHTIN M.L. & GORBACH E.I., 1981. Reproductive ecology of the grass carp, *Ctenopharyngodon idella*, and the silver carp, *Hypophthalmichthys molitrix*, in the Amur Basin: Journal of Ichthology 21: 109-123

KUGEL G., 1942. Untersuchungen über den Ukelei. Zeitschrift für Fischerei 40: 227-261

LAMMENS E.H.R.R. & HOOGENBOEZEM W., 1991. Diets and feeding behaviour. in: I.J. Winfield & J.S. Nelson (eds.) Cyprinid fishes, systematics, biology and exploitation. London: Chapman and Hall.
572-588, 353-377

LAMOUROUX N., OLIVIER J.-M., PERSAT H., POUILLY M., SOUCHON Y., STATZNER B., 1999. Predicting community characteristics from habitat conditions: fluvial fish and hydraulics. Freshwater Biology 42: 275-299

LELEK A. & BUHSE G., 1992. Fische des Rheins – früher und heute. Springer Verlag, Heidelberg

LEMCKE R., 1999. Untersuchungen zur Populationsökologie des Bachneunauges, *Lampetra planeri* Bloch 1784, und des Flußneunauges, *Lampetra fluviatilis* Linnaeus 1758. Shaker Verlag, Aachen

LESKO L.T., SMITH S.B., BLOUIN M.A., 1996. The effect of contaminated sediments on fecundity of the brown bullhead in three Lake Erie tributaries. Journal of Great Lakes Research 22: 830-837

LUCAS M.C. & BATLEY E., 1996. Seasonal movements and behaviour of adult barbel (*Barbus barbus*), a riverine cyprinid fish: implications for river management. Journal of Applied Biology 33: 1345-1358

LUCAS M.C. & FREAR P.A., 1997. Effects of a flow-gauging weir on the migratory behaviour of adult barbel, a riverine, cyprinid. Journal of Fish Biology 50: 382-396

McDOWALL R.M., 1988. Diadromy in Fishes. Croom Helm, London

MACKAY I. & MANN K.H., 1969. Fecundity of two cyprinid fishes in the River Thames at Reading, England. Journal of the Fisheries Research Board Canada 26: 2795-2805

MANN R.H.K., 1973, 1974, 1976. Observations on the age, growth, reproduction and food of the roach *Rutilus rutilus* (L.) in two rivers in southern England. Journal of Fish Biology 5: 707-736, 6: 237-253, 8: 265-288, 8: 179-197, 8: 229-239

MANN R.H.K., 1980a. The growth and reproductive strategy of the gudgeon, *Gobio gobio* (L.), in two hardwater rivers in southern England. Journal of Fish Biology 17: 163-176

MANN R.H.K. & MILLS C.A., 1985. Variations in the sizes of gonads, eggs and larvae of the dace, *Leuciscus leuciscus* (L.). Envionmental Biology of Fishes 13: 277-287

MANN R.H.K., MILLS C.A., CRISP D.T., 1984. Geographical variation in the life-history tactics of some species of freshwater fish. In: G.W. Petts & R.J. Wootton (eds.) Fish Reproduction: Strategies and Tactics 171-186

MANN R.H.K., 1996. Environmental requirements of European non salmonid fish in rivers. Hydrobiologia 323: 223 235

MEYER L. & HINRICHS D., 2000. Microhabitat preferences and movements of the weatherfish, *Misgurnus fossilis*, in a drainage channel. Environmental Biology of Fishes 58: 297-306

MICHEL P. & OBERDORFF T., 1995. Feeding habits of fourteen European freshwater fish species. Cybium 19: 5-46

MIHALIK J., 1995. Der Wels. Westarp-Wissenschaften, Magdeburg

MILLER P.J., (ed.) 2003. The Freshwater Fishes of Europe. Volume 8, Part I: Mugilidae, Atherinidae, Atherinopsidae, Blenniidae, Odonotbutdae, Gobiidae 1. AULA-Verlag, Wiesbaden

MILLER P.J., (ed.) 2003. The Freshwater Fishes of Europe. Volume 8, Part II: Gobiidae II. AULA-Verlag, Wiesbaden

MILLS C.A., 1980. Spawning and rearing the eggs of the dace, *Leuciscus leuciscus* (L.). Fish. Mgmt 11: 67-72

MILLS C.A., 1981a. Egg population dynamics of naturally spawning dace, *Leuciscus leuciscus* (L.). Environmental Biology of Fishes 6: 151-158.

MILLS C.A., 1981b. The attachment of dace, *Leuciscus leuciscus* (L.), eggs to the spawning substratum and the influence of changes in water current on their survival. Journal of Fish Biology 19: 129-134

MILLS C.A., 1981c. The spawning of roach *Rutilus rutilus* (L.) in a chalk stream. Fish. Mgmt 12: 49-53

MILLS C.A., 1991. Reproduction and life history. in: WINFIELD I.J. & NELSON J.S. (eds.) Cyprinid fishes, systematics, biology and exploitation. 483-504 London: Chapman and Hall

MOLLS F., 1997. Populationsbiologie der Fischarten einer niederrheinischen Auenlandschaft. PhD Thesis, University of Cologne, Cologne

MÜLLER W., 1960. Beiträge zur Biologie der Quappe (*Lota lota* L.) nach Untersuchungen in den Gewässern zwischen Elbe und Oder. Zeitschrift für Fischerei NF 9: 1-72

MÜLLER W., 1961. Neuere Untersuchungen über die Quappe (*Lota lota* L.). Deutsche Fischerei-Zeitung 8: 43-47

NORTHCOTE T.G., 1978. Migratory strategies and production in freshwater fishes. in: GERKING S.D. (ed.) Ecology of Freshwater Fish Production. 326-359 Blackwell Scientific Publications: Oxford

NORTHCOTE T.G., 1984. Mechanisms of fish migration in rivers. in: McCLEAVE J.D., DODSON J.J., NEILL W.H. (eds) Mechanisms of migration of fishes. 317-355 Plenuem: New York

NUNN A.D., COWX I.G., HARVEY J.P., 2003. Note on the ecology of spined loach in the lower River Trent, England. Fisheries Management and Ecology 10: 117-121

O'HARA K., 1976. An ecological study of fishes, with particular reference to freshwater species, in the Welsh Dee at Chester. PhD Thesis, University of Liverpool

OLIVEIRA J.M., FERREIRA M.T., PINHEIRO A.N., BOCHECHAS J.H., 2004. A simple method for assessing minimum flows in regulated rivers: the case of sea lamprey reproduction. Aquatic Conservation: Marine and Freshwater Ecosystems 14: 481-489

PERSAT H., OLIVIER J.-M., PONT D., 1994. Theoretical habitat templets, species traits, and species richness: fish in the upper Rhône River and its floodplain. Freshwater Biology 31: 439-454

PINDER L.C.V., MANN R.H.K., LADLE M., COWX I.G., O'HARA K., COPP G.H., GARNER P., BARK A.W., 1996. Factors affecting coarse fish recruitment. Bristol: Environment Agency R&D Technical Report W75, 18pp

PONT D., HUGUENY B., OBERDORFF T., 2005. Modelling habitat requirement of European fishes: do species have similar responses to local and regional environmental constraints? Canadian Journal of Fisheries and Aquatic Sciences 62: 163-173

PRZYBYLSKI M. & ZIEBA G., 2000. Microhabitat preference of European bitterling, *Rhodeus sericeus* in the Drzewiczka River (Pilica basin). Polish Archive Hydrobiology 47: 99-114

RAAT A.J.P., 1988. Synopsis of biological data on the northern pike, *Esox lucius* Linnaeus, 1758. FAO Fish. Syn. 30(2): 178pp

RITTERBUSCH D., 1998. Zur Autökologie des Steinbeißers (*Cobitis taenia*, L. 1758) im Müggelsee. Freie Universität Berlin, Diplomarbeit

RITTERBUSCH D. & BOHLEN J., 2000. On the ecology of spined loach in Lake Müggelsee. Folia Zoologica 49: 187-192

ROBOTHAM P.W.J., 1981. Age, growth and reproduction of a population of spined loach, *Cobitis taenia* (L.). Hydrobiologia 85: 129-136

SCHIEMER F., JUNGWIRTH M., IMHOF G., 1994. Ökologische Bewertung der Umgestaltung der Donau. Verlag Ulrich Moser, Graz

SCHMUTZ S., KAUFMANN M., VOGEL B., JUNGWIRTH M., 2000. Methodische Grundlagen und Beispiele zur Bewertung der fischökologischen Funktionsfähigkeit österreichischer Fließgewässer. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien

SCHOLTEN M., WIRTZ C., FLADUNG E., THIEL R., 2003. The modular habit model (MHM) for the ide, *Leuciscus idus* (L.) - a new method to predict the suitability of inshore habitats for fish. Journal of Applied Ichthyology 19: 315-329

SHIREMAN J.V. & SMITH C.R., 1983. Synopsis of biological data on the grass carp *Ctenopharyngodon idella* (Cuvier and Valenciennes, 1844). FAO Fisheries Synopsis No. 135. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy

SINDILARIU P.-D., FREYHOF J., WOLTER C., 2006. Habitat use of juvenile fish in the lower Danube and the Danube Delta: implications for ecotone connectivity. Hydrobiologia 571: 51-61

SILLAH A.B.S., 1981. The feeding ecology of cyprinids with particular reference to the dace, *Leuciscus leuciscus* (L.). PhD Thesis, University of Liverpool

SMITH R.P., 1989. Distribution and habitat requirements of chub, *Leuciscus cephalus* (L.), in several lowland rivers in eastern England. PhD Thesis, University of East Anglia

SMITH C., REICHARD M., JURAJDA P., PRZYBYLSKI M., 2004. The reproductiv ecology of the European bitterling (*Rhodeus sericeus*). Journal of Zoology (London) 262: 107-124

SMOLIAN K., 1920. Merkbuch der Binnenfischerei. I. Band, Börsenbuchdruckerei Denter & Nicolas, Berlin

SPOTILA J.R., TERPIN K.M., KOONS R.R., BONANTI R.L., 1979. Temperature requirements of fishes from eastern Lake Erie and the upper Niagara River: a review of the literature. Environmental Biology of Fishes 4: 281-307

THIEL R., SEPÚLVEDA A., KAFEMANN R., NELLEN W., 1995. Environmental factors as forces structuring the fish community of the Elbe Estuary. Journal of Fish Biology 46: 47-69

TOWNSEND C.R., 1989. Population cycles in freshwater fish. Journal of Fish Biology 35(A): 125-131

TOWNSEND C.R. & PERROW M.R., 1989. Eutrophication may produce population cycles in roach (*Rutilus rutilus* (L)) by two contrasting mechanisms. Journal of Fish Biology 34: 161-164

TOWNSEND C.R., SUTHERLAND W.J., PERROW M.R., 1990. A modeling investigation of populations cycles in the fish *Rutilus rutilus*. Journal of Animal Ecology 59: 469-485

TOWNSEND C.R., WINFIELD I.J., PEIRSON G., CRYER M., 1986. The response of young roach *Rutilus rutilus* to seasonal changes in abundance of microcrustacean prey: a field demonstration of switching. Oikos 46: 372-378

VARLEY M.E., 1967. British Freshwater Fishes. Fishing News Books, London. 148pp

WHEELER A., 1969. Fishes of the British Isles and North-West Europe. London: Macmillan 613pp

WHITTIER T.R., HUGHES R.M., LOMNICKY G.A., PECK D.V., 2007. Fish and Amphibian Tolerance Values and an Assemblage Tolerance Index for Streams and Rivers in the Western USA. Transactions of the American Fisheries Society 136: 254-271

WINFIELD I.J. & TOWNSEND C.R., 1988 Factors affecting prey selection by young bream *Abramis brama* and roach *Rutilus rutilus*: insights provided by parallel studies in the laboratory and field. Environmental Biology of Fishes 21(4): 279-292

WILKINSON D.R. & JONES J.W., 1977. The fecundity of dace, *Leuciscus leuciscus* (L.) in Emral Brook, Clwyd, North Wales. Freshwater Biology 7: 135-145.

WOLTER C. & VILCINSKAS A., 1997. Perch (*Perca fluviatilis*) as an indicator species for structural degradation in regulated rivers and canals in the lowlands of Germany. Ecology of Freshwater Fish 6: 174-181

WOLTER C., ARLINGHAUS R., GROSCH U.A., VILCINSKAS A., 2003. Fische & Fischerei in Berlin. Verlag Natur & Wissenschaft, Solingen

WOOTTON R.J., 1984. A functional biology of sticklebacks. Beckenham: Croom Helm

ZALEWSKI M., FRANKIEWICZ, P., PRZYBYLSKI M., BANBURA J., NOVAK M., 1990. Structure and dynamics of fish communities in temperate rivers in relation to the abiotic-biotic reguatory continuum concept. Pol. Arch. Hydrobiol. 37: 151-176.

ZALEWSKI M. & NAIMAN R.J., 1985. The regulation of riverine fish communities by a continuum of abiotic -biotic factors. in: ALABASTER J.S. (ed.) Habitat modification and freshwater fisheries. 3-9 London: Butterworths

ZOETEMEYER R.B., 2006. Veldgids De Nederlandse zoetwatervissen. Vereniging Sportvisserij Nederland, Bilthoven. The Netherlands

ZWEIMÜLLER I., 1995. Microhabitat use by 2 small benthic stream fish in a 2nd order stream. Hydrobiologia 303: 125-137

ANNEX II

Table A.1 *Final list containing all classifications into guilds with regard to* <u>*tolerance and habitat*</u> *(**TOL**=tolerant, **IM**=intermediately tolerant, **INTOL**=intolerant, **O2TOL**=tolerant to a low concentration of oxygen, **O2IM** intermediately tolerant to a low concentration of oxygen, **O2INTOL**=intolerant to a low concentration of oxygen, **TOXTOL**=tolerant to toxicity, **TOXIM**=intermediately tolerant to toxicity, **TOXINTOL**=intolerant to toxicity, **ATOL**=tolerant to acidification, **AIM**=intermediately tolerant to acidification, **AINTOL**=intolerant to acidification, **EUTHER**=eurythermal, **STTHER**=stenothermal, **HTOL**=tolerant to habitat degradation, **HIM**=intermediately tolerant to habitat degradation, **HINTOL**=intolerant to habitat degradation, **RH**=rheophilic, **EURY**=eurytopic, **LIMNO**=limnophilic, **B**=benthic, **WC**=water column; for further explanation of guild modalities please refer to tables 4.1, 4.2 and 4.3)*

species	water quality in general	water quality O_2	water quality toxicity	water quality acidification	temperature tolerance	habitat degradation	habitat	feeding habitat
Acipenseridae								
Acipenser baeri	TOL	O2IM	TOXIM	AINTOL	EUTHER	HIM	RH	B
Acipenser gueldenstaedtii	TOL	O2IM	TOXIM	AINTOL	EUTHER	HIM	RH	B
Acipenser naccarii	IM	O2IM	TOXIM	AINTOL	EUTHER	HIM	EURY	B
Acipenser nudiventris	TOL	O2IM	TOXIM	AINTOL	EUTHER	HIM	RH	B
Acipenser oxyrinchus	IM	O2IM	TOXIM	AINTOL	EUTHER	HINTOL	RH	B
Acipenser ruthenus	TOL	O2IM	TOXIM	AINTOL	EUTHER	HIM	RH	B
Acipenser stellatus	TOL	O2IM	TOXIM	AINTOL	EUTHER	HIM	RH	B
Acipenser sturio	IM	O2IM	TOXIM	AINTOL	EUTHER	HINTOL	RH	B
Huso huso	TOL	O2INTOL	TOXINTOL	AINTOL	EUTHER	HIM	RH	B
Anguillidae								
Anguilla anguilla	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HTOL	EURY	B
Atherinidae								
Atherina boyeri	IM	O2IM	TOXIM	AIM	EUTHER	HIM	LIMNO	WC
Atherina presbyter								WC
Atherinopsidae								
Odonthestes bonariensis								
Blenniidae								
Salaria fluviatilis	IM	O2IM	TOXIM	AIM	EUTHER	HIM	LIMNO	B
Catostomidae								
Ictiobus bubalus								
Ictiobus cyprinellus								
Ictiobus niger								
Centrarchidae								
Ambloplites rupestris								
Lepomis auritus								
Lepomis cyanellus								
Lepomis gibbosus	TOL	O2TOL	TOXIM	AIM	EUTHER	HTOL	LIMNO	WC
Micropterus salmoides	TOL	O2IM	TOXIM	AIM	EUTHER	HTOL	LIMNO	WC
Cichlidae								
Australoheros facetus	TOL	O2TOL	TOXTOL	AIM	EUTHER	HIM	LIMNO	
Hemichromis fasciatus					EUTHER			B
Oreochromis niloticus							LIMNO	WC

Table A.1 *(continued)*

Tilapia zillii								
Clariidae								
Clarias gariepinus						HIM	EURY	
Clupeidae								
Alosa agone						HINTOL		
Alosa alosa	INTOL	O2INTOL	TOXINTOL	AINTOL	EUTHER	HINTOL	RH	WC
Alosa caspia								
Alosa fallax	INTOL	O2INTOL	TOXIM	AINTOL	EUTHER	HIM	RH	WC
Alosa killarnensis								
Alosa macedonica							LIMNO	WC
Alosa maeotica								
Alosa pontica	TOL	O2TOL		AINTOL	EUTHER	HINTOL	RH	
Alosa tanaica								
Alosa vistonica								
Clupeonella cultriventris	TOL	O2TOL		AINTOL	EUTHER			WC
Cobitidae								
Cobitis arachthosensis								
Cobitis bilineata								
Cobitis calderoni	INTOL	O2INTOL	TOXINTOL	AIM	STTHER	HINTOL	RH	B
Cobitis elongata	TOL	O2TOL		AINTOL	EUTHER			
Cobitis elongatoides	IM	O2IM		AINTOL	EUTHER	HTOL	RH	B
Cobitis hellenica	TOL	O2INTOL		AINTOL	EUTHER	HTOL	EURY	B
Cobitis megaspila	TOL	O2TOL		AINTOL	EUTHER			
Cobitis meridionalis							LIMNO	B
Cobitis paludica	IM	O2IM	TOXIM	AIM	EUTHER	HIM	LIMNO	B
Cobitis peschevi								
Cobitis punctilineata								
Cobitis rhodopensis								
Cobitis stephanidisi								
Cobitis strumicae								
Cobitis taenia	IM	O2IM	TOXIM	AINTOL	EUTHER	HIM	RH	B
Cobitis trichonica								
Cobitis vardarensis								
Cobitis vettonica	TOL	O2TOL	TOXTOL		EUTHER	HIM	EURY	B
Misgurnus anguillicaudatus	TOL	O2TOL		AIM	EUTHER	HTOL	EURY	B
Misgurnus fossilis	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HINTOL	LIMNO	B
Sabanejewia aurata	IM	O2IM	TOXIM	AIM	EUTHER	HIM	RH	B
Sabanejewia balcanica	IM	O2IM		AIM	EUTHER	HINTOL	RH	B
Sabanejewia bulgarica	TOL	O2TOL		AINTOL			RH	
Sabanejewia larvata	IM	O2IM	TOXINTOL		STTHER	HINTOL	EURY	B
Sabanejewia romanica	TOL	O2TOL		AINTOL			RH	
Coregonidae								
Coregonus albula	INTOL	O2INTOL	TOXIM	AIM	STTHER	HINTOL	LIMNO	WC
Coregonus autumnalis							EURY	
Coregonus lavaretus	INTOL	O2INTOL	TOXIM	AIM	STTHER	HINTOL	LIMNO	WC
Coregonus maraena	IM	O2INTOL		AINTOL	STTHER	HTOL	RH	B

***Table A.1** (continued)*

Coregonus muscun								
Coregonus oxyrinchus	IM	O2INTOL		AINTOL	STTHER	HTOL	RH	B
Coregonus peled	TOL	O2TOL	TOXIM	ATOL	EUTHER	HTOL	LIMNO	WC
Coregonus pidschian						HIM	LIMNO	
Coregonus trybomi								
Cottidae								
Cottus gobio	INTOL	O2INTOL	TOXINTOL	AIM	STTHER	HINTOL	RH	B
Cottus koshewniko	IM			AIM		HIM	RH	B
Cottus petiti	INTOL				STTHER	HINTOL	RH	B
Cottus poecilopus	INTOL	O2INTOL	TOXIM	AIM	STTHER	HINTOL	RH	B
Triglopsis quadricornis	TOL	O2IM		AINTOL	EUTHER	HTOL	EURY	B
Cyprinidae								
Abramis ballerus	TOL	O2IM	TOXIM	AINTOL	EUTHER	HINTOL	RH	WC
Abramis brama	TOL	O2TOL	TOXTOL	AINTOL	EUTHER	HTOL	EURY	B
Abramis sapa	TOL	O2TOL	TOXTOL	AINTOL	EUTHER	HTOL	RH	B
Achondrostoma arcasii	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HINTOL	RH	WC
Achondrostoma occidentale	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HIM	LIMNO	WC
Achondrostoma oligolepis	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HIM	LIMNO	WC
Alburnoides bipunctatus	INTOL	O2INTOL	TOXIM	AINTOL	STTHER	HINTOL	RH	WC
Alburnus albidus	IM	O2IM	TOXIM		EUTHER	HTOL	LIMNO	WC
Alburnus alburnus	TOL	O2IM	TOXIM	ATOL	EUTHER	HTOL	EURY	WC
Alburnus alburnus alborella	TOL				EUTHER	HTOL	EURY	WC
Anaecypris hispanica	IM	O2TOL	TOXTOL	AIM	EUTHER	HIM	EURY	WC
Aristichthys nobilis	TOL	O2IM	TOXIM	AINTOL	STTHER	HTOL	EURY	WC
Aspius aspius	IM	O2INTOL	TOXINTOL	AINTOL	EUTHER	HTOL	RH	WC
Aulopyge huegelii								
Barbaus carpaticus					EUTHER			
Barbus albanicus	TOL	O2IM		AINTOL	EUTHER	HTOL	EURY	B
Barbus balcanicus								
Barbus barbus	INTOL	O2IM	TOXIM	AINTOL	EUTHER	HINTOL	RH	B
Barbus bocagei	TOL	O2IM	TOXTOL	AIM	EUTHER	HIM	EURY	B
Barbus caninus	INTOL				STTHER	HINTOL	RH	B
Barbus comizo	TOL	O2IM	TOXTOL	AIM	EUTHER	HIM	EURY	WC
Barbus cyclolepis	IM	O2INTOL	TOXIM	AINTOL	EUTHER	HINTOL	RH	B
Barbus euboicus							RH	B
Barbus graecus	TOL	O2IM		AINTOL	EUTHER	HTOL	EURY	B
Barbus graellsii	IM	O2IM	TOXIM		EUTHER	HIM	EURY	B
Barbus guiraonis	IM	O2IM	TOXIM		EUTHER	HIM	EURY	B
Barbus haasi	INTOL	O2INTOL	TOXINTOL		EUTHER	HINTOL	RH	B
Barbus macedonicus								
Barbus meridionalis	INTOL	O2IM	TOXINTOL	AINTOL	EUTHER	HINTOL	RH	B
Barbus microcephalus	IM	O2IM	TOXTOL	AIM	EUTHER	HIM	EURY	B
Barbus peloponnesius	IM	O2INTOL	TOXIM	AINTOL	EUTHER	HINTOL	RH	B
Barbus petenyi		O2INTOL			EUTHER	HINTOL	RH	B
Barbus plebejus	IM	O2IM	TOXIM		EUTHER	HIM	RH	B
Barbus prespensis							LIMNO	B

Table A.1 *(continued)*

Barbus sclateri	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HIM	EURY	B
Barbus steindachneri								
Barbus tauricus								
Barbus tyberinus	IM	O2INTOL	TOXINTOL		EUTHER	HINTOL	RH	B
Blicca bjoerkna	TOL	O2TOL	TOXTOL	AINTOL	EUTHER	HTOL	EURY	B
Carassius auratus	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HTOL	LIMNO	B
Carassius carassius	TOL	O2TOL	TOXTOL	AIM	EUTHER	HTOL	LIMNO	B
Carassius gibelio	TOL	O2TOL	TOXTOL	AIM	EUTHER	HTOL	EURY	B
Chalcalburnus belvica								
Chalcalburnus chalcoides	TOL	O2IM		AINTOL	EUTHER	HINTOL	EURY	WC
Chondrostoma arrigonis	INTOL	O2IM	TOXIM		EUTHER	HINTOL	RH	B
Chondrostoma genei	INTOL	O2IM	TOXIM		EUTHER	HINTOL	RH	B
Chondrostoma knerii								
Chondrostoma miegii	IM	O2IM	TOXIM		EUTHER	HINTOL	RH	B
Chondrostoma nasus	INTOL	O2INTOL	TOXINTOL	AINTOL	EUTHER	HINTOL	RH	B
Chondrostoma phoxinus								
Chondrostoma prespense								
Chondrostoma soetta	IM	O2IM	TOXIM		EUTHER	HINTOL	RH	B
Chondrostoma toxostoma	INTOL				EUTHER	HINTOL	RH	B
Chondrostoma turiense	IM	O2INTOL		AINTOL	EUTHER	HINTOL	RH	B
Chondrostoma vardarense								
Ctenopharyngodon idella	TOL	O2IM	TOXTOL	AIM	EUTHER	HTOL	EURY	WC
Cyprinus carpio	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HTOL	EURY	B
Eupallasella perenurus	TOL	O2TOL	TOXIM	ATOL	EUTHER	HINTOL	LIMNO	WC
Gobio albipinnatus	IM	O2INTOL	TOXIM	AINTOL	EUTHER	HIM	RH	B
Gobio banarescui								
Gobio benacensis								
Gobio elimeius								
Gobio gobio	IM	O2INTOL	TOXIM	AINTOL	EUTHER	HTOL	RH	B
Gobio kesslerii	IM	O2INTOL	TOXIM	AINTOL	EUTHER	HINTOL	RH	B
Gobio lozanoi	IM	O2IM	TOXIM	AIM	EUTHER	HIM	EURY	B
Gobio uranoscopus	IM	O2INTOL		AINTOL	EUTHER	HINTOL	RH	B
Hypophthalmichthys molitrix	TOL	O2IM	TOXIM	AIM	EUTHER	HTOL	EURY	WC
Iberochondrostoma almacai	INTOL	O2IM	TOXINTOL	AINTOL	EUTHER	HINTOL	LIMNO	WC
Iberochondrostoma lemmingii	IM	O2IM	TOXIM	AIM	EUTHER	HIM	LIMNO	B
Iberochondrostoma lusitanicum	IM	O2TOL	TOXIM	AIM	EUTHER	HIM	LIMNO	WC
Iberocypris palaciosi	IM	O2IM	TOXIM		EUTHER	HINTOL	RH	WC
Ladigesocypris ghigii	TOL	O2TOL		AIM	EUTHER	HTOL	EURY	B
Leucaspius delineatus	TOL	O2IM	TOXIM	AIM	EUTHER	HIM	LIMNO	WC
Leuciscus borysthenicus				AINTOL			LIMNO	WC
Leuciscus burdigalensis								
Leuciscus cephalus	TOL	O2IM	TOXIM	AINTOL	EUTHER	HTOL	RH	WC
Leuciscus idus	IM	O2IM	TOXIM	AINTOL	EUTHER	HIM	RH	WC
Leuciscus illyricus								
Leuciscus keadicus	IM	O2IM		AINTOL	EUTHER	HTOL	RH	B
Leuciscus leuciscus	IM	O2IM	TOXIM	AINTOL	EUTHER	HIM	RH	WC

Table A.1 *(continued)*

Leuciscus lucumonis	TOL	O2IM	TOXIM		EUTHER	HTOL	EURY	WC
Leuciscus microlepis								
Leuciscus montenigrinus								
Leuciscus muticellus	INTOL				STTHER	HINTOL	RH	B
Leuciscus pleurobipunctatus							RH	WC
Leuciscus polylepis								
Leuciscus souffia	INTOL	O2INTOL	TOXIM	AINTOL	STTHER	HINTOL	RH	B
Leuciscus svallize	IM	O2IM		AINTOL	EUTHER	HTOL	EURY	B
Leuciscus turskyi								
Leuciscus ukliva								
Leuciscus zrmanjae								
Mylopharyngodon piceus						HIM	EURY	
Pachychilon macedonicum								
Pachychilon pictum	TOL	O2TOL		AIM	EUTHER	HTOL	EURY	B
Parabramis pekinensis								
Pelecus cultratus	IM	O2INTOL		AINTOL	EUTHER	HIM	EURY	WC
Phoxinellus adspersus								
Phoxinellus alepidotus								
Phoxinellus croaticus								
Phoxinellus epiroticus								
Phoxinellus fontinalis								
Phoxinellus metohiensis								
Phoxinellus prespensis								
Phoxinellus pstrossii								
Phoxinus phoxinus	IM	O2INTOL	TOXIM	AINTOL	STTHER	HINTOL	RH	WC
Pimephales promelas	TOL	O2TOL		ATOL	EUTHER	HTOL	LIMNO	B
Pseudochondrostoma duriense	IM	O2IM	TOXIM	AIM	EUTHER	HIM	RH	B
Pseudochondrostoma polylepis	IM	O2IM	TOXIM	AIM	EUTHER	HIM	RH	B
Pseudochondrostoma willkommii	IM	O2IM	TOXIM	AIM	EUTHER	HIM	RH	B
Pseudophoxinus beoticus	INTOL	O2INTOL		AINTOL	EUTHER	HINTOL	RH	B
Pseudophoxinus minutus								
Pseudophoxinus stymphalicus	TOL	O2INTOL		AINTOL	EUTHER	HTOL	LIMNO	B
Pseudorasbora parva	TOL	O2TOL	TOXTOL	AINTOL	EUTHER	HTOL	EURY	WC
Rhodeus amarus	INTOL	O2IM	TOXINTOL	AIM	EUTHER	HINTOL	LIMNO	WC
Romanogobio antipai	TOL	O2TOL		AINTOL				
Romanogobio banaticus	TOL	O2TOL		AINTOL				
Romanogobio belingi	IM	O2INTOL		AINTOL	EUTHER	HTOL	RH	B
Romanogobio vladykovi	IM	O2INTOL		AINTOL	EUTHER	HIM	RH	B
Rutilus aula	IM	O2TOL	TOXINTOL		EUTHER	HIM	LIMNO	WC
Rutilus basak								
Rutilus frisii	IM	O2INTOL	TOXIM	AINTOL	EUTHER	HIM	EURY	B
Rutilus heckelii								
Rutilus karamani								
Rutilus meidingeri								
Rutilus ohridanus								
Rutilus pigus	IM	O2INTOL	TOXTOL	AINTOL	EUTHER	HIM	RH	B

Table A.1 *(continued)*

Rutilus prespensis								
Rutilus rubilio	IM	O2IM	TOXINTOL		EUTHER	HIM	EURY	WC
Rutilus rutilus	TOL	O2TOL	TOXTOL	AIM	EUTHER	HTOL	EURY	WC
Rutilus ylikiensis	TOL	O2IM		AIM	EUTHER	HTOL	LIMNO	WC
Scardinius acarnanicus							LIMNO	WC
Scardinius erythrophthalmus	TOL	O2TOL	TOXIM	ATOL	EUTHER	HIM	LIMNO	WC
Scardinius graecus	TOL	O2TOL		AIM	EUTHER	HTOL	LIMNO	
Scardinius racovitzai	TOL	O2TOL		AINTOL	EUTHER	HINTOL		WC
Scardinius scardafa								
Squalius alburnoides	IM	O2IM	TOXIM	AIM	EUTHER	HTOL	EURY	WC
Squalius aradensis	IM	O2IM	TOXIM	AIM	EUTHER	HIM	EURY	WC
Squalius carolitertii	IM	O2IM	TOXIM	AIM	EUTHER	HIM	EURY	WC
Squalius malacitanus								
Squalius pyrenaicus	IM	O2IM	TOXIM	AIM	EUTHER	HIM	EURY	WC
Squalius torgalensis	IM	O2IM	TOXIM	AIM	EUTHER	HIM	EURY	WC
Squalius valentinus								
Tinca tinca	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HINTOL	LIMNO	B
Tropidophoxinellus hellenicus	TOL	O2INTOL		AINTOL	EUTHER	HTOL	EURY	WC
Tropidophoxinellus spartiaticus	IM	O2INTOL		AINTOL	EUTHER	HTOL	RH	B
Vimba melanops								
Vimba vimba	IM	O2IM	TOXIM	AINTOL	EUTHER	HINTOL	RH	B
Cyprinodontidae								
Aphanius baeticus								
Aphanius fasciatus	IM	O2TOL	TOXIM		EUTHER	HIM	LIMNO	WC
Aphanius iberus					EUTHER		LIMNO	WC
Esocidae								
Esox lucius	IM	O2IM	TOXIM	ATOL	EUTHER	HTOL	EURY	WC
Fundulidae								
Fundulus heteroclitus	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HTOL	LIMNO	B
Gasterosteidae								
Gasterosteus aculeatus	TOL	O2IM	TOXIM	AIM	EUTHER	HTOL	EURY	WC
Gasterosteus crenobiontus	TOL	O2IM		AIM	EUTHER	HTOL		
Gasterosteus gymnurus	TOL	O2IM	TOXTOL	AIM	EUTHER	HIM	EURY	WC
Pungitius hellenicus							LIMNO	WC
Pungitius platygaster								
Pungitius pungitius	TOL	O2IM	TOXIM	ATOL	EUTHER	HIM	LIMNO	WC
Gobiidae								
Benthophiloides brauneri	TOL	O2TOL		AINTOL	EUTHER	HINTOL		
Benthophilus stellatus	TOL	O2TOL		AINTOL	EUTHER	HINTOL		
Caspiosoma caspium								
Economidichthys pygmaeus	INTOL	O2INTOL		AINTOL	EUTHER	HTOL	EURY	B
Economidichthys trichonis							LIMNO	WC
Gobius cobitis								
Gobius niger								
Knipowitschia cameliae				AINTOL				
Knipowitschia caucasica	TOL	O2IM		AINTOL	EUTHER	HTOL	LIMNO	B

Table A.1 *(continued)*

Knipowitschia goerneri								
Knipowitschia longecaudata								
Knipowitschia milleri								
Knipowitschia panizzae	IM	O2IM	TOXINTOL		EUTHER	HIM	EURY	B
Knipowitschia punctatissima	INTOL	O2IM	TOXINTOL		STTHER	HINTOL	RH	B
Knipowitschia thessala	INTOL	O2INTOL		AINTOL	EUTHER	HTOL	EURY	B
Mesogobius batrachocephalus								
Neogobius cephalargoides								
Neogobius eurycephalus								
Neogobius fluviatilis	TOL	O2IM	TOXIM	AINTOL	EUTHER	HTOL	EURY	B
Neogobius gymnotrachelus	TOL	O2IM	TOXIM	AINTOL	EUTHER	HTOL	EURY	B
Neogobius kessleri	TOL	O2IM	TOXIM	AINTOL	EUTHER	HTOL	EURY	B
Neogobius melanostomus	TOL	O2IM	TOXTOL	AINTOL	EUTHER	HTOL	EURY	B
Neogobius syrman	IM					HINTOL	EURY	B
Neogonius ratan								
Padogobius bonelli					EUTHER	HIM	EURY	B
Padogobius martensii	IM	O2IM	TOXINTOL		EUTHER	HIM	EURY	B
Padogobius nigricans	IM	O2IM	TOXINTOL		EUTHER	HIM	EURY	B
Pomatoschistus microps								B
Pomatoschistus minutus	IM	O2IM	TOXINTOL		EUTHER	HIM	LIMNO	B
Proterorhinus marmoratus	IM	O2INTOL		AINTOL	EUTHER	HINTOL	EURY	B
Zosterisessor ophiocephalus	TOL	O2TOL	TOXIM	AINTOL	EUTHER	HIM	LIMNO	B
Ictaluridae								
Ameiurus melas	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HTOL	LIMNO	B
Ameiurus nebulosus	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HTOL	LIMNO	B
Ameiurus punctatus	TOL	O2IM		ATOL	EUTHER	HIM	EURY	B
Lotidae								
Lota lota	IM	O2INTOL	TOXIM	AINTOL	STTHER	HIM	EURY	B
Moronidae								
Dicentrarchus labrax	IM	O2IM	TOXINTOL		EUTHER	HIM	EURY	WC
Morone saxatilis								
Mugilidae								
Chelon labrosus	TOL	O2TOL	TOXTOL		EUTHER	HTOL	LIMNO	WC
Liza aurata	TOL	O2TOL	TOXTOL		EUTHER	HTOL	LIMNO	WC
Liza ramada	TOL	O2TOL	TOXTOL		EUTHER	HTOL	LIMNO	B
Liza saliens	TOL	O2TOL	TOXTOL		EUTHER	HTOL	LIMNO	B
Mugil cephalus	TOL	O2TOL	TOXTOL		EUTHER	HTOL	LIMNO	B
Nemacheilidae								
Barbatula barbatula	IM	O2IM	TOXIM	AINTOL	EUTHER	HIM	RH	B
Barbatula bureschi					STTHER			
Odontobutidae								
Perccottus glenii	TOL	O2TOL		AINTOL	EUTHER	HIM	LIMNO	B
Osmeridae								
Osmerus eperlanus	IM	O2IM	TOXIM	AIM	STTHER	HIM	EURY	WC
Percidae								
Gymnocephalus baloni	TOL	O2IM	TOXTOL	AINTOL	EUTHER	HIM	RH	B

Table A.1 *(continued)*

Gymnocephalus cernuus	TOL	O2IM	TOXIM	AIM	EUTHER	HTOL	EURY	B
Gymnocephalus schraetser	TOL	O2IM	TOXTOL	AINTOL	EUTHER	HIM	RH	B
Perca fluviatilis	TOL	O2IM	TOXIM	ATOL	EUTHER	HTOL	EURY	WC
Percarina demidoffi								
Romanichthys valsanicola	INTOL	O2INTOL		AINTOL	EUTHER	HINTOL		
Sander lucioperca	TOL	O2IM	TOXIM	AIM	EUTHER	HIM	EURY	WC
Sander volgensis	TOL	O2IM	TOXIM	AINTOL	EUTHER	HIM	EURY	B
Zingel asper	INTOL	O2INTOL	TOXINTOL		EUTHER	HINTOL	RH	B
Zingel balcanicus								
Zingel streber	IM	O2INTOL	TOXINTOL	AINTOL	EUTHER	HINTOL	RH	B
Zingel zingel	IM	O2INTOL	TOXINTOL	AINTOL	EUTHER	HINTOL	RH	B
Petromyzonidae								
Eudontomyzon danfordi	INTOL	O2INTOL		AINTOL	EUTHER	HINTOL	RH	B
Eudontomyzon hellenicus								
Eudontomyzon mariae	INTOL	O2INTOL	TOXINTOL	AINTOL	EUTHER	HINTOL	RH	B
Eudontomyzon stankokaramani								
Eudontomyzon vladykovi	INTOL	O2INTOL		AINTOL	EUTHER	HINTOL	RH	B
Lampetra fluviatilis	INTOL	O2IM	TOXINTOL	AINTOL	EUTHER	HINTOL	RH	B
Lampetra planeri	INTOL	O2INTOL	TOXINTOL	AINTOL	STTHER	HINTOL	RH	B
Lethenteron camtschaticum								
Lethenteron zanandreai	IM	O2INTOL	TOXINTOL		STTHER	HINTOL	RH	B
Petromyzon marinus	INTOL	O2IM	TOXINTOL	AINTOL	EUTHER	HIM	RH	WC
Pleuronectidae								
Platichthys flesus	IM	O2IM	TOXINTOL	AIM	STTHER	HIM	EURY	B
Pleuronectes platessa							LIMNO	B
Poeciliidae								
Gambusia affinis	TOL	O2TOL	TOXTOL		EUTHER	HTOL	LIMNO	WC
Gambusia holbrooki	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HTOL	LIMNO	WC
Poecilia reticulata						HTOL		WC
Polyodentidae								
Polyodon spathula	TOL	O2INTOL		AINTOL	EUTHER	HTOL	RH	WC
Salmonidae								
Hucho hucho	INTOL	O2INTOL	TOXINTOL	AINTOL	STTHER	HINTOL	RH	WC
Oncorhynchus gorbuscha	INTOL	O2INTOL		AIM	STTHER	HINTOL	RH	B
Oncorhynchus kisutch	INTOL	O2INTOL		AIM	STTHER	HINTOL	RH	B
Oncorhynchus mykiss	IM	O2INTOL	TOXIM	AINTOL	STTHER	HIM	RH	WC
Oncorhynchus tschawytscha	INTOL	O2INTOL		AIM	STTHER	HINTOL	RH	B
Salmo labrax								
Salmo macedonicus								
Salmo marmoratus	IM	O2INTOL	TOXINTOL	AINTOL	STTHER	HIM	RH	WC
Salmo salar	INTOL	O2INTOL	TOXINTOL	AINTOL	STTHER	HINTOL	RH	WC
Salmo trutta fario	INTOL	O2INTOL	TOXINTOL	AINTOL	STTHER	HINTOL	RH	WC
Salmo trutta lacustris	INTOL	O2INTOL	TOXIM	AINTOL	STTHER	HINTOL	RH	WC
Salmo trutta macrostigma	IM	O2INTOL	TOXINTOL		STTHER	HIM	RH	WC
Salmo trutta trutta	INTOL	O2INTOL	TOXINTOL	AINTOL	STTHER	HINTOL	RH	WC
Salmothymus obtusirostris								

Table A.1 *(continued)*

Salvelinus alpinus	INTOL	O2INTOL	TOXINTOL	AINTOL	STTHER	HINTOL	LIMNO	WC
Salvelinus fontinalis	INTOL	O2INTOL	TOXIM	ATOL	STTHER	HINTOL	RH	WC
Salvelinus namaycush	TOL	O2INTOL	TOXINTOL	AINTOL	STTHER	HINTOL	LIMNO	WC
Salvelinus umbla	INTOL	O2INTOL	TOXINTOL	AINTOL	STTHER	HINTOL	LIMNO	WC
Siluridae								
Silurus aristotelis							LIMNO	B
Silurus glanis	TOL	O2IM	TOXIM	AIM	EUTHER	HTOL	EURY	B
Sparidae								
Sparus aurata	IM	O2IM	TOXINTOL		EUTHER	HIM	EURY	B
Syngnathidae								
Nerophis ophidion								
Syngnathus abaster	IM	O2IM	TOXINTOL	AINTOL	EUTHER	HIM	LIMNO	B
Syngnathus typhle	IM	O2IM	TOXINTOL		EUTHER	HIM	LIMNO	WC
Thymallidae								
Thymallus baicalensis								
Thymallus thymallus	INTOL	O2INTOL	TOXINTOL	AINTOL	STTHER	HINTOL	RH	WC
Umbridae								
Umbra krameri	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HINTOL	LIMNO	B
Umbra pygmaea	TOL	O2TOL	TOXTOL	ATOL	EUTHER	HTOL	LIMNO	B
Valenciidae								
Valencia hispanica					EUTHER		LIMNO	WC
Valencia letourneuxi							LIMNO	WC

Table A.2 *Final list containing all classifications into guilds with regard to* <u>*feeding, migration and reproduction*</u> *(**INSV**=insectivorous, **PISC-PARA**=piscivorous-parasitic, **PLAN**=planktivorous, **OMNI**=omnivorous, **DETR-HERB**=detritivorous/herbivorous, **POTAD**=potamodromous, **LONG**=long migrating, **RESI**D=resident, **FRE**=freshwater, **ANCA**=anadromous/catadromous, **ESTU**=estuarine, **FRESAL**=freshwater/marine, **MAR**=marine, **LITH**=lithophilic, **LIPE**=lithopelagophilic, **PELA**=pelagophilic, **PHYT**=phytophilic, **PHLI**=phytolithophilic, **SPEL**=speleophilic, **POLY**=polyphilic, ARIAD=ariadnophilic, PSAM=psamnophilic, **OSTRA-VIVI**=ostracophilic/viviparous, **RHPAR**=rheopar, **LIPAR**=limnopar, **EUPAR**=eurypar, **SI**N=single, **PRO**=protracted, **FR**=fractional, **NOP**=no protection, **PROT**=protection; for further explanation of the guild modalities please refer to tables 4.4, 4.5 and 4.6)*

species	trophic guild	migration	salinity	reproduction	spawning habitat	reproductive behaviour	parental care
Acipenseridae							
Acipenser baeri	INSV	POTAD	FRE	LITH	RHPAR	SIN	NOP
Acipenser gueldenstaedtii	INSV	LONG	ANCA	LIPE	RHPAR	SIN	NOP
Acipenser naccarii	INSV	LONG	ANCA	LITH	RHPAR	SIN	NOP
Acipenser nudiventris	INSV	LONG	ANCA	LIPE	RHPAR	SIN	NOP
Acipenser oxyrinchus	INSV	LONG	ANCA	LITH	RHPAR	SIN	NOP
Acipenser ruthenus	INSV	POTAD	FRE	LITH	RHPAR	SIN	NOP
Acipenser stellatus	INSV	LONG	ANCA	LIPE	RHPAR	SIN	NOP
Acipenser sturio	INSV	LONG	ANCA	LITH	RHPAR	SIN	NOP
Huso huso	PISC-PARA	LONG	ANCA	LITH	RHPAR	SIN	NOP
Anguillidae							
Anguillidae	INSV	LONG	ANCA	PELA	LIPAR	SIN	NOP
Atherinidae							
Atherina boyeri	PLAN	RESID	ESTU	PHYT	LIPAR	PRO	NOP
Atherina presbyter	INSV		ESTU	PHLI			NOP
Atherinopsidae							
Odonthestes bonariensis							
Blenniidae							
Salaria fluviatilis	INSV	RESID	FRE	SPEL	EUPAR	FR	PROT
Catostomidae							
Ictiobus bubalus							
Ictiobus cyprinellus							
Ictiobus niger							
Centrarchidae							
Ambloplites rupestris							
Lepomis auritus							
Lepomis cyanellus							
Lepomis gibbosus	INSV	RESID	FRE	POLY	LIPAR	FR	PROT
Micropterus salmoides	PISC-PARA	RESID	FRE	POLY	LIPAR	FR	PROT
Cichlidae							
Australoheros facetus	OMNI	RESID	FRE	POLY	LIPAR	SIN	NOP
Hemichromis fasciatus	OMNI	RESID		ARIAD			
Oreochromis niloticus						PRO	
Tilapia zillii							
Clariidae							
Clarias gariepinus	INSV			PHYT			
Clupeidae							
Alosa agone							

Table A.2 *(continued)*

Alosa alosa	PLAN	LONG	ANCA	LIPE	RHPAR	SIN	NOP
Alosa caspia							
Alosa fallax	PLAN	LONG	ANCA	LIPE	RHPAR	SIN	NOP
Alosa killarnensis							
Alosa macedonica		RESID		LITH		SIN	
Alosa maeotica							
Alosa pontica	INSV	LONG	FRESAL	PELA	RHPAR		NOP
Alosa tanaica							NOP
Alosa vistonica							
Clupeonella cultriventris	PLAN	LONG		PELA			NOP
Cobitidae							
Cobitis arachthosensis							
Cobitis bilineata							
Cobitis calderoni	INSV	RESID	FRE	LITH	RHPAR	FR	NOP
Cobitis elongata			FRE	PHYT	EUPAR		NOP
Cobitis elongatoides	INSV	RESID	FRE	PHYT	EUPAR	FR	NOP
Cobitis hellenica		RESID	FRE	PHYT		FR	
Cobitis megaspila			FRE	PHYT			NOP
Cobitis meridionalis	OMNI	RESID		LITH			
Cobitis paludica	INSV	RESID	FRE	POLY	EUPAR		NOP
Cobitis peschevi							
Cobitis punctilineata							
Cobitis rhodopensis							
Cobitis stephanidisi							
Cobitis strumicae							
Cobitis taenia	INSV	RESID	FRE	PHYT	EUPAR	FR	NOP
Cobitis trichonica							
Cobitis vardarensis							
Cobitis vettonica	INSV	RESID	FRE	LITH	EUPAR		NOP
Misgurnus anguillicaudatus	INSV	RESID	FRE	PHYT	LIPAR	SIN	NOP
Misgurnus fossilis	INSV	RESID	FRE	PHYT	LIPAR	SIN	NOP
Sabanejewia aurata	INSV	RESID	FRE	PHYT	EUPAR	FR	NOP
Sabanejewia balcanica	INSV	RESID	FRE	PHYT	RHPAR	FR	NOP
Sabanejewia bulgarica		POTAD	FRE	PHYT	LIPAR		NOP
Sabanejewia larvata	INSV	RESID	FRE	PHYT	LIPAR	SIN	NOP
Sabanejewia romanica		POTAD	FRE	PHYT	LIPAR		NOP
Coregonidae							
Coregonus albula	PLAN	RESID	FRE	LITH	LIPAR	SIN	NOP
Coregonus autumnalis		LONG		LITH		SIN	
Coregonus lavaretus	PLAN	POTAD	FRE	LITH	LIPAR	SIN	NOP
Coregonus maraena	INSV	LONG	ANCA	LITH	RHPAR	SIN	NOP
Coregonus muscun							
Coregonus oxyrinchus	INSV	LONG	ANCA	LITH	RHPAR	SIN	NOP
Coregonus peled	PLAN	POTAD	FRE	LITH	LIPAR	SIN	NOP
Coregonus pidschian		LONG		LIPE		SIN	NOP
Coregonus trybomi							

***Table A.2** (continued)*

Cottidae							
Cottus gobio	INSV	RESID	FRE	SPEL	RHPAR	SIN	PROT
Cottus koshewniko	INSV	RESID		SPEL		SIN	PROT
Cottus petiti	INSV	RESID	FRE	SPEL	RHPAR	FR	PROT
Cottus poecilopus	INSV	RESID	FRE	SPEL	RHPAR	SIN	PROT
Triglopsis quadricornis	INSV	RESID	ESTU	SPEL		SIN	PROT
Cyprinidae							
Abramis ballerus	PLAN	RESID	FRE	LITH	EUPAR	PRO	NOP
Abramis brama	OMNI	POTAD	FRE	PHLI	EUPAR	SIN	NOP
Abramis sapa	INSV	POTAD	FRE	LITH	RHPAR	SIN	NOP
Achondrostoma arcasii	DETR-HERB	RESID	FRE	PHYT	RHPAR	SIN	NOP
Achondrostoma occidentale	OMNI	RESID	FRE	PHYT	RHPAR	FR	NOP
Achondrostoma oligolepis	OMNI	RESID	FRE	PHYT	RHPAR	FR	NOP
Alburnoides bipunctatus	INSV	RESID	FRE	LITH	RHPAR	FR	NOP
Alburnus albidus	PLAN	RESID	FRE	PHLI	EUPAR	PRO	NOP
Alburnus alburnus	PLAN	RESID	FRE	PHLI	EUPAR	FR	NOP
Alburnus alburnus alborella	INSV	RESID	FRE	PHLI	EUPAR		NOP
Anaecypris hispanica	OMNI	RESID	FRE	PHLI	RHPAR	FR	NOP
Aristichthys nobilis	PLAN	LONG	FRE	PELA	RHPAR	PRO	NOP
Aspius aspius	PISC-PARA	POTAD	FRE	LITH	RHPAR	SIN	NOP
Aulopyge huegelii							
Barbaus carpaticus							
Barbus albanicus	OMNI	RESID	FRE	LITH	EUPAR	FR	NOP
Barbus balcanicus							
Barbus barbus	INSV	POTAD	FRE	LITH	RHPAR	FR	NOP
Barbus bocagei	OMNI	POTAD	FRE	LITH	RHPAR	SIN	NOP
Barbus caninus	INSV	POTAD	FRE	LITH	RHPAR		NOP
Barbus comizo	OMNI	POTAD	FRE	LITH	RHPAR	SIN	NOP
Barbus cyclolepis	INSV	POTAD	FRE	LITH	RHPAR	FR	NOP
Barbus euboicus		RESID		LITH	RHPAR	SIN	NOP
Barbus graecus	OMNI	RESID	FRE	LITH	EUPAR	FR	NOP
Barbus graellsii	OMNI	POTAD	FRE	LITH	RHPAR	SIN	NOP
Barbus guiraonis	OMNI	POTAD	FRE	LITH	RHPAR	SIN	NOP
Barbus haasi	OMNI	POTAD	FRE	LITH	RHPAR	SIN	NOP
Barbus macedonicus							
Barbus meridionalis	INSV	POTAD	FRE	LITH	RHPAR	SIN	NOP
Barbus microcephalus	OMNI	POTAD	FRE	LITH	RHPAR	SIN	NOP
Barbus peloponnesius	INSV	POTAD	FRE	LITH	RHPAR	FR	NOP
Barbus petenyi	INSV	RESID		LITH	RHPAR	SIN	NOP
Barbus plebejus	INSV	POTAD	FRE	LITH	RHPAR	SIN	NOP
Barbus prespensis		POTAD		LITH	RHPAR	SIN	NOP
Barbus sclateri	OMNI	POTAD	FRE	LITH	RHPAR	SIN	NOP
Barbus steindachneri							
Barbus tauricus							
Barbus tyberinus	INSV	POTAD	FRE	LITH	RHPAR	SIN	NOP
Blicca bjoerkna	OMNI	RESID	FRE	PHLI	EUPAR	PRO	NOP

Table A.2 *(continued)*

Carassius auratus	OMNI	RESID	FRE	PHYT	LIPAR	FR	NOP
Carassius carassius	OMNI	RESID	FRE	PHYT	LIPAR	FR	NOP
Carassius gibelio	OMNI	RESID	FRE	PHYT	LIPAR	FR	NOP
Chalcalburnus belvica							
Chalcalburnus chalcoides	OMNI	RESID		LITH	LIPAR	SIN	NOP
Chondrostoma arrigonis	DETR-HERB	POTAD	FRE	LITH	RHPAR	SIN	NOP
Chondrostoma genei	INSV	POTAD	FRE	LITH	RHPAR	SIN	NOP
Chondrostoma knerii							
Chondrostoma miegii	DETR-HERB	POTAD	FRE	LITH	RHPAR	SIN	NOP
Chondrostoma nasus	DETR-HERB	POTAD	FRE	LITH	RHPAR	SIN	NOP
Chondrostoma phoxinus							
Chondrostoma prespense							
Chondrostoma soetta	INSV	POTAD	FRE	LITH	RHPAR	SIN	NOP
Chondrostoma toxostoma	OMNI	POTAD	FRE	LITH	RHPAR	SIN	NOP
Chondrostoma turiense	DETR-HERB	POTAD	FRE	LITH	RHPAR	SIN	NOP
Chondrostoma vardarense							
Ctenopharyngodon idella	DETR-HERB	LONG	FRE	PELA	RHPAR	SIN	NOP
Cyprinus carpio	OMNI	RESID	FRE	PHYT	LIPAR	SIN	NOP
Eupallasella perenurus	OMNI	RESID	FRE	PHYT	LIPAR	FR	NOP
Gobio albipinnatus	INSV	RESID	FRE	PSAM	RHPAR	FR	NOP
Gobio banarescui							
Gobio benacensis							
Gobio elimeius							
Gobio gobio	INSV	RESID	FRE	PSAM	RHPAR	FR	NOP
Gobio kesslerii	INSV	RESID	FRE	PSAM	RHPAR	FR	NOP
Gobio lozanoi		RESID	FRE	PSAM	LIPAR	FR	NOP
Gobio uranoscopus	INSV	RESID	FRE	LITH	RHPAR	FR	NOP
Hypophthalmichthys molitrix	PLAN	LONG	FRE	PELA	RHPAR	FR	NOP
Iberochondrostoma almacai	OMNI	RESID	FRE	PHLI	RHPAR	FR	NOP
Iberochondrostoma lemmingii	OMNI	POTAD	FRE	PHLI	RHPAR	FR	NOP
Iberochondrostoma lusitanicum	OMNI	RESID	FRE	PHLI	RHPAR	FR	NOP
Iberocypris palaciosi	INSV	RESID	FRE	LITH	EUPAR	SIN	NOP
Ladigesocypris ghigii	OMNI	RESID	FRE	PHYT	EUPAR	FR	NOP
Leucaspius delineatus	OMNI	RESID	FRE	PHYT	LIPAR	FR	PROT
Leuciscus borysthenicus	OMNI	FRE			LITH		
Leuciscus burdigalensis							
Leuciscus cephalus	OMNI	POTAD	FRE	LITH	RHPAR	FR	NOP
Leuciscus idus	OMNI	POTAD	FRE	PHLI	EUPAR	SIN	NOP
Leuciscus illyricus							
Leuciscus keadicus	INSV	RESID	FRE	LITH	RHPAR		NOP
Leuciscus leuciscus	OMNI	RESID	FRE	LITH	RHPAR	SIN	NOP
Leuciscus lucumonis	OMNI	POTAD	FRE	LITH	RHPAR	SIN	NOP
Leuciscus microlepis							
Leuciscus montenigrinus							
Leuciscus muticellus	INSV	RESID	FRE	LITH	RHPAR	SIN	NOP
Leuciscus pleurobipunctatus	OMNI	RESID	FRE	LITH	RHPAR	FR	NOP

Table A.2 *(continued)*

Leuciscus polylepis							
Leuciscus souffia	INSV	RESID	FRE	LITH	RHPAR	SIN	NOP
Leuciscus svallize		RESID	FRE	LITH	RHPAR		NOP
Leuciscus turskyi							
Leuciscus ukliva							
Leuciscus zrmanjae							
Mylopharyngodon piceus	OMNI				PELA		
Pachychilon macedonicum							
Pachychilon pictum	INSV	RESID	FRE	PHLI	EUPAR		NOP
Parabramis pekinensis							
Pelecus cultratus	PLAN	POTAD	FRE	PELA	LIPAR	SIN	NOP
Phoxinellus adspersus							
Phoxinellus alepidotus							
Phoxinellus croaticus							
Phoxinellus epiroticus							
Phoxinellus fontinalis							
Phoxinellus metohiensis							
Phoxinellus prespensis							
Phoxinellus pstrossii							
Phoxinus phoxinus	INSV	RESID	FRE	LITH	EUPAR	FR	NOP
Pimephales promelas	OMNI	RESID	FRE	PHLI	LIPAR	FR	PROT
Pseudochondrostoma duriense	DETR-HERB	POTAD	FRE	LITH	RHPAR	SIN	NOP
Pseudochondrostoma polylepis	DETR-HERB	POTAD	FRE	LITH	RHPAR	SIN	NOP
Pseudochondrostoma willkommii	DETR-HERB	POTAD	FRE	LITH	RHPAR	SIN	NOP
Pseudophoxinus beoticus		RESID	FRE	LITH	RHPAR		
Pseudophoxinus minutus							
Pseudophoxinus stymphalicus	INSV	RESID	FRE	PHYT	LIPAR	PRO	NOP
Pseudorasbora parva	OMNI	RESID	FRE	PHLI	EUPAR	FR	PROT
Rhodeus amarus	OMNI	RESID	FRE	OSTRA-VIVI	LIPAR	FR	PROT
Romanogobio antipai	OMNI	POTAD	FRE				
Romanogobio banaticus	OMNI	POTAD	FRE				
Romanogobio belingi	INSV	RESID	FRE	PSAM	RHPAR	FR	NOP
Romanogobio vladykovi	INSV	RESID	FRE	PSAM	RHPAR	FR	NOP
Rutilus aula	INSV	RESID	FRE	PHYT	LIPAR	SIN	NOP
Rutilus basak							
Rutilus frisii	INSV	RESID	FRE	PHLI	RHPAR	SIN	NOP
Rutilus heckelii				PHYT			
Rutilus karamani							
Rutilus meidingeri							
Rutilus ohridanus							
Rutilus pigus	INSV	RESID	FRE	PHYT	RHPAR	SIN	NOP
Rutilus prespensis							
Rutilus rubilio	INSV	RESID	FRE	PHLI	RHPAR	SIN	NOP
Rutilus rutilus	OMNI	POTAD	FRE	PHLI	EUPAR	SIN	NOP
Rutilus ylikiensis	OMNI	RESID	FRE	PHLI		SIN	

Table A.2 *(continued)*

Scardinius acarnanicus	OMNI	RESID		PHYT		FR	
Scardinius erythrophthalmus	OMNI	RESID	FRE	PHYT	LIPAR	FR	NOP
Scardinius graecus		RESID	FRE	PHYT	LIPAR	FR	NOP
Scardinius racovitzai	OMNI		FRE	PHYT	LIPAR		
Scardinius scardafa							
Squalius alburnoides	INSV	RESID	FRE	LITH	EUPAR	SIN	NOP
Squalius aradensis	INSV	RESID	FRE	LITH	EUPAR	SIN	NOP
Squalius carolitertii	INSV	RESID	FRE	LITH	EUPAR	SIN	NOP
Squalius malacitanus							
Squalius pyrenaicus	INSV	RESID	FRE	LITH	EUPAR	SIN	NOP
Squalius torgalensis	INSV	RESID	FRE	LITH	EUPAR	SIN	NOP
Squalius valentinus							
Tinca tinca	OMNI	RESID	FRE	PHYT	LIPAR	FR	NOP
Tropidophoxinellus hellenicus	PLAN	RESID	FRE	PHYT	EUPAR	FR	NOP
Tropidophoxinellus spartiaticus	INSV	RESID	FRE	PHYT	RHPAR	FR	NOP
Vimba melanops							
Vimba vimba	INSV	POTAD	FRESAL	LITH	RHPAR	FR	NOP
Cyprinodontidae							
Aphanius baeticus							
Aphanius fasciatus	INSV	RESID	ESTU	PHYT	LIPAR	PRO	NOP
Aphanius iberus	INSV			PHYT			NOP
Esocidae							
Esox lucius	PISC-PARA	POTAD	FRE	PHYT	LIPAR	SIN	NOP
Fundulidae							
Fundulus heteroclitus	INSV	RESID	FRE		OSTRA-VIVI		NOP
Gasterosteidae							
Gasterosteus aculeatus	OMNI	RESID	FRESAL	PHYT	LIPAR	PRO	PROT
Gasterosteus crenobiontus							
Gasterosteus gymnurus	OMNI	RESID	FRE	ARIAD	EUPAR	FR	PROT
Pungitius hellenicus	INSV	RESID		PHYT		PRO	
Pungitius platygaster							
Pungitius pungitius	OMNI	RESID	FRE	ARIAD	LIPAR	FR	PROT
Gobiidae							
Benthophiloides brauneri					PSAM	LIPAR	
Benthophilus stellatus					PSAM	LIPAR	
Caspiosoma caspium							
Economidichthys pygmaeus	INSV	RESID	FRE	SPEL	EUPAR	FR	PROT
Economidichthys trichonis					PHYT		FR
Gobius cobitis							
Gobius niger							
Knipowitschia cameliae					OSTRA-VIVI	LIPAR	
Knipowitschia caucasica	INSV	RESID	FRE	PHYT	LIPAR	FR	NOP
Knipowitschia goerneri							
Knipowitschia longecaudata							
Knipowitschia milleri							
Knipowitschia panizzae	INSV	RESID	FRE	ARIAD	LIPAR	SIN	PROT

Table A.2 *(continued)*

Knipowitschia punctatissima	INSV	RESID	FRE	SPEL	RHPAR	SIN	PROT
Knipowitschia thessala	INSV	RESID	FRE	SPEL	EUPAR	FR	PROT
Mesogobius batrachocephalus							
Neogobius cephalargoides							
Neogobius eurycephalus							
Neogobius fluviatilis	INSV	RESID	FRESAL	SPEL	EUPAR	PRO	PROT
Neogobius gymnotrachelus	INSV	RESID	FRE	PHLI	EUPAR	PRO	PROT
Neogobius kessleri	INSV	RESID	FRE	LITH	EUPAR	PRO	PROT
Neogobius melanostomus	INSV	RESID	FRESAL	LITH	EUPAR	PRO	PROT
Neogobius syrman	INSV			SPEL			
Neogonius ratan							
Padogobius bonelli	INSV	RESID	FRE	PHLI	EUPAR	FR	PROT
Padogobius martensii	INSV	RESID	FRE	SPEL	RHPAR	SIN	PROT
Padogobius nigricans	INSV	RESID	FRE	SPEL	RHPAR	SIN	PROT
Pomatoschistus microps	INSV	ESTU		ARIAD			
Pomatoschistus minutus	INSV	RESID	ESTU	ARIAD	LIPAR	SIN	PROT
Proterorhinus marmoratus	INSV	RESID	ESTU	SPEL	EUPAR	SIN	PROT
Zosterisessor ophiocephalus	OMNI	RESID	MAR	PHYT	LIPAR	SIN	PROT
Ictaluridae							
Ameiurus melas	OMNI	RESID	FRE	LITH	LIPAR	SIN	PROT
Ameiurus nebulosus	OMNI	RESID	FRE	SPEL	LIPAR	SIN	PROT
Ameiurus punctatus	OMNI	RESID	FRE	PHLI	LIPAR	SIN	PROT
Lotidae							
Lota lota	PISC-PARA	POTAD	FRESAL	LITH	EUPAR	SIN	NOP
Moronidae							
Dicentrarchus labrax	PISC-PARA		MAR	PELA	RHPAR	SIN	NOP
Morone saxatilis							
Mugilidae							
Chelon labrosus	OMNI		MAR	PELA	EUPAR	SIN	NOP
Liza aurata	OMNI	POTAD	ESTU	PELA	EUPAR	SIN	NOP
Liza ramada	DETR-HERB	POTAD	ESTU	PELA	EUPAR	SIN	NOP
Liza saliens	DETR-HERB		ESTU	PELA	EUPAR	SIN	NOP
Mugil cephalus	DETR-HERB	LONG	ESTU	PELA	EUPAR	SIN	NOP
Nemacheilidae							
Barbatula barbatula	INSV	RESID	FRE	LITH	EUPAR	FR	NOP
Barbatula bureschi							
Odontobutidae							
Perccottus glenii	OMNI	RESID	FRE	PHLI	LIPAR	SIN	PROT
Osmeridae							
Osmerus eperlanus	PLAN	POTAD	FRESAL	LITH	EUPAR	SIN	NOP
Percidae							
Gymnocephalus baloni	INSV	RESID	FRE	PHLI	EUPAR	PRO	NOP
Gymnocephalus cernuus	INSV	RESID	FRE	PHLI	EUPAR	FR	NOP
Gymnocephalus schraetser	INSV	RESID	FRE	LITH	RHPAR	PRO	NOP
Perca fluviatilis	PISC-PARA	RESID	FRE	PHLI	EUPAR	SIN	NOP
Percarina demidoffi							

Table A.2 *(continued)*

Romanichthys valsanicola		FRE		FRE			
Sander lucioperca	PISC-PARA	POTAD	FRE	PHLI	EUPAR	SIN	PROT
Sander volgensis	PISC-PARA	RESID	FRE	PHLI	EUPAR	SIN	PROT
Zingel asper	INSV	RESID	FRE	LITH	RHPAR	SIN	PROT
Zingel balcanicus							
Zingel streber	INSV	RESID	FRE	LITH	RHPAR	SIN	NOP
Zingel zingel	INSV	RESID	FRE	LITH	RHPAR	SIN	NOP
Petromyzonidae							
Eudontomyzon danfordi	PISC-PARA	POTAD	FRE	PHYT			
Eudontomyzon hellenicus							
Eudontomyzon mariae	DETR-HERB	RESID	FRE	LITH	RHPAR	SIN	NOP
Eudontomyzon stankokaramani							
Eudontomyzon vladykovi	DETR-HERB	RESID	FRE	LITH	RHPAR	SIN	NOP
Lampetra fluviatilis	PISC-PARA	LONG	ANCA	LITH	RHPAR	SIN	NOP
Lampetra planeri	DETR-HERB	RESID	FRE	LITH	RHPAR	SIN	NOP
Lethenteron camtschaticum	INSV						
Lethenteron zanandreai	DETR-HERB	RESID	FRE	LITH	RHPAR	SIN	NOP
Petromyzon marinus	PISC-PARA	LONG	ANCA	LITH	RHPAR	SIN	NOP
Pleuronectidae							
Platichthys flesus	INSV	LONG	ANCA	PELA	EUPAR	SIN	NOP
Pleuronectes platessa		LONG	MAR				
Poeciliidae							
Gambusia affinis	INSV	RESID	FRE	OSTRA-VIVI	LIPAR	PRO	PROT
Gambusia holbrooki	INSV	RESID	FRE	OSTRA-VIVI	LIPAR	PRO	PROT
Poecilia reticulata		RESID			OSTRA-VIVI		
Polyodentidae							
Polyodon spathula	PLAN	POTAD	FRE	LITH	RHPAR	SIN	NOP
Salmonidae							
Hucho hucho	PISC-PARA	POTAD	FRE	LITH	RHPAR	SIN	NOP
Oncorhynchus gorbuscha	PISC-PARA	LONG	ANCA	LITH	RHPAR	SIN	NOP
Oncorhynchus kisutch	PISC-PARA	LONG	ANCA	LITH	RHPAR	SIN	NOP
Oncorhynchus mykiss	INSV	POTAD	FRE	LITH	RHPAR	SIN	NOP
Oncorhynchus tschawytscha	PISC-PARA	LONG	ANCA	LITH	RHPAR	SIN	NOP
Salmo labrax							
Salmo macedonicus							
Salmo marmoratus	INSV	POTAD	FRE	LITH	RHPAR	SIN	NOP
Salmo salar	PISC-PARA	LONG	ANCA	LITH	RHPAR	SIN	PROT
Salmo trutta fario	INSV	POTAD	FRE	LITH	RHPAR	SIN	NOP
Salmo trutta lacustris	PISC-PARA	POTAD	FRE	LITH	RHPAR	SIN	NOP
Salmo trutta macrostigma	INSV	POTAD	FRE	LITH	RHPAR	SIN	PROT
Salmo trutta trutta	PISC-PARA	LONG	ANCA	LITH	RHPAR	SIN	NOP
Salmothymus obtusirostris							
Salvelinus alpinus	PLAN	RESID	FRE	LITH	RHPAR	SIN	NOP
Salvelinus fontinalis	INSV	RESID	FRE	LITH	RHPAR	SIN	NOP
Salvelinus namaycush	INSV	POTAD	FRE	LITH	LIPAR	SIN	NOP
Salvelinus umbla	PLAN	RESID	FRE	LITH	RHPAR	SIN	NOP

Table A.2 *(continued)*

Siluridae							
Silurus aristotelis	PISC-PARA	RESID		PHYT	EUPAR	SIN	PROT
Silurus glanis	PISC-PARA	RESID	FRE	PHYT	EUPAR	SIN	PROT
Sparidae							
Sparus aurata	PISC-PARA		ESTU	PELA	EUPAR	SIN	NOP
Syngnathidae							
Nerophis ophidion							
Syngnathus abaster	INSV	RESID	FRESAL	POLY	EUPAR	SIN	PROT
Syngnathus typhle	PLAN	RESID	MAR		EUPAR	SIN	PROT
Thymallidae							
Thymallus baicalensis							
Thymallus thymallus	INSV	POTAD	FRE	LITH	RHPAR	SIN	PROT
Umbridae							
Umbra krameri	INSV	RESID	FRE	PHYT	LIPAR	SIN	PROT
Umbra pygmaea	INSV	RESID	FRE	PHYT	LIPAR	SIN	PROT
Valenciidae							
Valencia hispanica	INSV			PHYT			NOP
Valencia letourneuxi	INSV	RESID		PHYT		FR	

Table A.3 *Final list containing classifications of physiological and morphological parameters as well as the results of the hierarchical cluster analysis (**intermediate**=intermediately tolerant, **Tol2**=tolerant, **Medium**=intermediately tolerant, **Intol2**=intolerant, **Tol1**=very tolerant, **Intol1**=very intolerant; body shape **1**=spindle shaped, **2**=high backed, **3**=very slender, **4**=eel shaped; for further descriptions please refer to table 4.3)*

species	maximum length [mm]	cluster analysis I	cluster analysis II	length relation a	length relation b	catch occurence	body shape
Acipenseridae							
Acipenser baeri	2000	Intermediate	Tol2	0,002	3,26		1
Acipenser gueldenstaedtii	2350	Intermediate	Tol2	0,009	2,99		1
Acipenser naccarii	2000	Intermediate	Medium			1	1
Acipenser nudiventris	2000	Intermediate	Tol2	0,044	2,60		1
Acipenser oxyrinchus	4300	Intermediate	Intol2	0,011	3,18		1
Acipenser ruthenus	1250	Intermediate	Tol2	0,001	3,61	1	1
Acipenser stellatus	2200	Intermediate	Tol2	0,019	2,28		1
Acipenser sturio	5000	Intermediate	Intol2	0,016	2,82		1
Huso huso	8000	Intermediate	Intol2	0,004	3,16		1
Anguillidae							
Anguillidae	1500	Tolerant	Tol2	0,001	3,12	1	4
Atherinidae							
Atherina boyeri	246	Intermediate	Medium	0,006	3,26	1	1
Atherina presbyter	200					1	1
Atherinopsidae							
Odonthestes bonariensis							
Blenniidae							
Salaria fluviatilis	150	Intermediate	Medium	0,012	2,99	1	3
Catostomidae							
Ictiobus bubalus							2
Ictiobus cyprinellus							1
Ictiobus niger							2
Centrarchidae							
Ambloplites rupestris							2
Lepomis auritus							2
Lepomis cyanellus							2
Lepomis gibbosus	400	Tolerant	Tol1	0,011	3,17	1	2
Micropterus salmoides	970	Tolerant	Tol2	0,040	2,88	1	1
Cichlidae							
Australoheros facetus	193	Tolerant	Tol2			1	2
Hemichromis fasciatus							1
Oreochromis niloticus							2
Tilapia zillii							2
Clariidae							
Clarias gariepinus							4
Clupeidae							
Alosa agone							1
Alosa alosa	830	Intolerant	Intol2	0,005	2,90	1	1

Table A.3 *(continued)*

Alosa caspia							1
Alosa fallax	600	Intermediate	Intol2	0,015	2,80	1	1
Alosa killarnensis							1
Alosa macedonica							1
Alosa maeotica							1
Alosa pontica	390	Tolerant	Tol2				1
Alosa tanaica							1
Alosa vistonica							1
Clupeonella cultriventris	120						1
Cobitidae							
Cobitis arachthosensis							3
Cobitis bilineata							3
Cobitis calderoni	107	Intolerant	Intol1			1	3
Cobitis elongata	160						3
Cobitis elongatoides	140	Intermediate	Tol2			1	3
Cobitis hellenica		Tolerant	Tol2				3
Cobitis megaspila	130						3
Cobitis meridionalis							3
Cobitis paludica	162	Intermediate	Medium			1	3
Cobitis peschevi							3
Cobitis punctilineata							3
Cobitis rhodopensis							3
Cobitis stephanidisi							3
Cobitis strumicae							3
Cobitis taenia	160	Intermediate	Medium	0,004	3,26	1	3
Cobitis trichonica							3
Cobitis vardarensis							3
Cobitis vettonica	100	Tolerant	Tol2				3
Misgurnus anguillicaudatus	300	Tolerant	Tol2				4
Misgurnus fossilis	300	Tolerant	Tol2	0,007	3,04	1	3
Sabanejewia aurata	100	Intermediate	Medium			1	3
Sabanejewia balcanica	155	Intermediate	Intol2			1	3
Sabanejewia bulgarica	120						3
Sabanejewia larvata	100	Intermediate	Tol2			1	3
Sabanejewia romanica	100						3
Coregonidae							
Coregonus albula	450	Intolerant	Intol1	0,006	3,16	1	1
Coregonus autumnalis							1
Coregonus lavaretus	790	Intolerant	Intol1			1	1
Coregonus maraena	1300	Intermediate	Intol2	0,002	3,45		1
Coregonus muscun							1
Coregonus oxyrinchus	500	Intermediate	Intol2				1
Coregonus peled	700	Tolerant	Tol1	0,003	3,50	1	1
Coregonus pidschian							1
Coregonus trybomi							1
Cottidae							

Table A.3 *(continued)*

Cottus gobio	700	Intolerant	Intol1	0,010	3,09	1	3
Cottus koshewniko							3
Cottus petiti	65						3
Cottus poecilopus	160	Intolerant	Intol1			1	3
Triglopsis quadricornis	600	Tolerant	Tol2			1	3
Cyprinidae							
Abramis ballerus	350	Tolerant	Tol2	0,007	3,06	1	2
Abramis brama	867	Tolerant	Tol2	0,006	3,18	1	2
Abramis sapa	350	Tolerant	Tol2	0,009	3,00	1	2
Achondrostoma arcasii	242	Tolerant	Tol2	0,008	3,14	1	1
Achondrostoma occidentale	93	Tolerant	Tol2			1	1
Achondrostoma oligolepis	171	Tolerant	Tol2			1	1
Alburnoides bipunctatus	180	Intolerant	Intol1	0,009	3,10	1	2
Alburnus albidus	140	Tolerant	Tol2			1	1
Alburnus alburnus	310	Tolerant	Tol2	0,008	3,05	1	1
Alburnus alburnus alborella							1
Anaecypris hispanica	75	Intermediate	Tol2			1	1
Aristichthys nobilis	1120	Tolerant	Tol2			1	1
Aspius aspius	1120	Intermediate	Intol2	0,005	3,12	1	1
Aulopyge huegelii							1
Barbaus carpaticus							3
Barbus albanicus	600	Tolerant	Tol2				1
Barbus balcanicus							3
Barbus barbus	1400	Intolerant	Intol2	0,016	2,94	1	3
Barbus bocagei	1070	Tolerant	Tol2	0,006	3,19	1	1
Barbus caninus	220					1	3
Barbus comizo	1050	Tolerant	Tol2			1	3
Barbus cyclolepis	350	Intermediate	Intol2				3
Barbus euboicus							1
Barbus graecus		Tolerant	Tol2				3
Barbus graellsii	800	Intermediate	Medium			1	3
Barbus guiraonis	800	Intermediate	Medium			1	1
Barbus haasi	300	Intolerant	Intol2			1	3
Barbus macedonicus							3
Barbus meridionalis	380	Intolerant	Intol2			1	3
Barbus microcephalus	500	Intermediate	Medium	0,019	3,12	1	1
Barbus peloponnesius	300	Intermediate	Intol2			1	1
Barbus petenyi	264					1	3
Barbus plebejus	800	Intermediate	Medium			1	1
Barbus prespensis							1
Barbus sclateri	800	Tolerant	Tol2	0,010	3,04	1	1
Barbus steindachneri							3
Barbus tauricus							3
Barbus tyberinus	450	Intermediate	Intol2			1	3
Blicca bjoerkna	485	Tolerant	Tol2	0,027	3,15	1	2
Carassius auratus	590	Tolerant	Tol1	0,018	3,08	1	2

***Table A.3** (continued)*

Carassius carassius	640	Tolerant	Tol1	0,009	3,35	1	2
Carassius gibelio	450	Tolerant	Tol2	0,010	3,19	1	2
Chalcalburnus belvica							2
Chalcalburnus chalcoides	400	Tolerant	Tol2				2
Chondrostoma arrigonis	250	Intolerant	Intol2			1	1
Chondrostoma genei	250	Intolerant	Intol2			1	1
Chondrostoma knerii							1
Chondrostoma miegii	253	Intermediate	Intol2			1	1
Chondrostoma nasus	595	Intolerant	Intol2	0,011	3,03	1	1
Chondrostoma phoxinus							1
Chondrostoma prespense							1
Chondrostoma soetta	400	Intermediate	Intol2			1	1
Chondrostoma toxostoma	300					1	1
Chondrostoma turiense		Intermediate	Intol2			1	1
Chondrostoma vardarense							1
Ctenopharyngodon idella	1500	Tolerant	Tol2	0,008	3,15	1	1
Cyprinus carpio	1300	Tolerant	Tol2	0,008	3,26	1	2
Eupallasella perenurus	185	Tolerant	Tol2				
Gobio albipinnatus	140	Intermediate	Intol2	0,011	2,84	1	3
Gobio banarescui							
Gobio benacensis							
Gobio elimeius							
Gobio gobio	224	Intermediate	Intol2	0,012	2,95	1	3
Gobio kesslerii	130	Intermediate	Intol2	0,015	2,66	1	3
Gobio lozanoi	246	Intermediate	Medium	0,017	3,07	1	1
Gobio uranoscopus	150	Intermediate	Intol2			1	3
Hypophthalmichthys molitrix	1050	Tolerant	Tol2			1	2
Iberochondrostoma almacai	148	Intolerant	Intol2			1	1
Iberochondrostoma lemmingii	149	Intermediate	Medium	0,005	3,15	1	1
Iberochondrostoma lusitanicum	151	Intermediate	Tol2			1	1
Iberocypris palaciosi	50	Intermediate	Intol2				1
Ladigesocypris ghigii	90	Tolerant	Tol2				1
Leucaspius delineatus	150	Tolerant	Tol2	0,007	3,08	1	1
Leuciscus borysthenicus	150						1
Leuciscus burdigalensis							1
Leuciscus cephalus	800	Tolerant	Tol2	0,007	3,15	1	1
Leuciscus idus	880	Intermediate	Medium	0,004	3,35	1	2
Leuciscus illyricus							
Leuciscus keadicus	250	Intermediate	Tol2				
Leuciscus leuciscus	526	Intermediate	Medium	0,006	3,16	1	1
Leuciscus lucumonis	450	Tolerant	Tol2			1	1
Leuciscus microlepis							
Leuciscus montenigrinus							1
Leuciscus muticellus	210					1	1
Leuciscus pleurobipunctatus	220						
Leuciscus polylepis							

Table A.3 *(continued)*

Leuciscus souffia	280	Intolerant	Intol1	0,007	3,06	1	1
Leuciscus svallize	250	Intermediate	Tol2				
Leuciscus turskyi							
Leuciscus ukliva							
Leuciscus zrmanjae							
Mylopharyngodon piceus							1
Pachychilon macedonicum							1
Pachychilon pictum	205	Tolerant	Tol2			1	1
Parabramis pekinensis							2
Pelecus cultratus	600	Intermediate	Tol2			1	1
Phoxinellus adspersus							1
Phoxinellus alepidotus							1
Phoxinellus croaticus							
Phoxinellus epiroticus							
Phoxinellus fontinalis							
Phoxinellus metohiensis							
Phoxinellus prespensis							
Phoxinellus pstrossii							
Phoxinus phoxinus	140	Intolerant	Intol2	0,010	3,03	1	1
Pimephales promelas	100	Tolerant	Tol1				1
Pseudochondrostoma duriense	400	Intermediate	Medium			1	1
Pseudochondrostoma polylepis	393	Intermediate	Medium	0,006	3,19	1	1
Pseudochondrostoma willkommii	423	Intermediate	Medium			1	1
Pseudophoxinus beoticus		Intolerant	Intol2				
Pseudophoxinus minutus							
Pseudophoxinus stymphalicus		Tolerant	Tol2				1
Pseudorasbora parva	120	Tolerant	Tol2	0,006	3,25	1	2
Rhodeus amarus	112	Intolerant	Intol2	0,008	3,18	1	2
Romanogobio antipai	90						3
Romanogobio banaticus	80						3
Romanogobio belingi	140	Intermediate	Intol2	0,012	2,78	1	3
Romanogobio vladykovi		Intermediate	Intol2				3
Rutilus aula	299	Intermediate	Tol2			1	1
Rutilus basak							1
Rutilus frisii	900	Intermediate	Tol2	0,011	2,93		1
Rutilus heckelii							2
Rutilus karamani							2
Rutilus meidingeri							1
Rutilus ohridanus							2
Rutilus pigus	800	Intermediate	Intol2	0,012	2,97	1	2
Rutilus prespensis							1
Rutilus rubilio	200	Intermediate	Medium			1	1
Rutilus rutilus	843	Tolerant	Tol2	0,007	3,20	1	2
Rutilus ylikiensis		Tolerant	Tol2				
Scardinius acarnanicus							1
Scardinius erythrophthalmus	565	Tolerant	Tol2	0,004	3,38	1	2

***Table A.3** (continued)*

Scardinius graecus	400	Tolerant	Tol1				1
Scardinius racovitzai	120						1
Scardinius scardafa							2
Squalius alburnoides	442	Intermediate	Tol2	0,013	3,02	1	1
Squalius aradensis	131	Intermediate	Medium			1	1
Squalius carolitertii	328	Intermediate	Medium	0,003	3,68	1	1
Squalius malacitanus						1	1
Squalius pyrenaicus	240	Intermediate	Medium	0,003	3,47	1	1
Squalius torgalensis	162	Intermediate	Medium			1	1
Squalius valentinus							1
Tinca tinca	850	Tolerant	Tol2	0,015	2,47	1	2
Tropidophoxinellus hellenicus		Tolerant	Tol2				1
Tropidophoxinellus spartiaticus		Intermediate	Intol2				1
Vimba melanops							1
Vimba vimba	600	Intermediate	Intol2	0,014	2,92	1	1
Cyprinodontidae							
Aphanius baeticus							1
Aphanius fasciatus	70	Intermediate	Tol2				1
Aphanius iberus							1
Esocidae							
Esox lucius	1500	Intermediate	Tol2	0,008	3,04	1	1
Fundulidae							
Fundulus heteroclitus	150	Tolerant	Tol1				1
Gasterosteidae							
Gasterosteus aculeatus	110	Tolerant	Tol2	0,008	3,04	1	1
Gasterosteus crenobiontus							1
Gasterosteus gymnurus	71	Tolerant	Tol2			1	1
Pungitius hellenicus							1
Pungitius platygaster							1
Pungitius pungitius	115	Tolerant	Tol2	0,006	3,18	1	1
Gobiidae							
Benthophiloides brauneri	70						3
Benthophilus stellatus	130						3
Caspiosoma caspium							3
Economidichthys pygmaeus	55	Tolerant	Tol2				3
Economidichthys trichonis							3
Gobius cobitis							3
Gobius niger							3
Knipowitschia cameliae	30						3
Knipowitschia caucasica	50	Tolerant	Tol2	0,004	3,25		3
Knipowitschia goerneri							3
Knipowitschia longecaudata							3
Knipowitschia milleri							3
Knipowitschia panizzae	40	Intermediate	Medium			1	3
Knipowitschia punctatissima	65	Intolerant	Intol2			1	3
Knipowitschia thessala	45	Tolerant	Tol2				3

Table A.3 *(continued)*

Mesogobius batrachocephalus							3
Neogobius cephalargoides	250						3
Neogobius eurycephalus							3
Neogobius fluviatilis	220	Tolerant	Tol2			1	3
Neogobius gymnotrachelus	200	Tolerant	Tol2			1	3
Neogobius kessleri	220	Tolerant	Tol2	0,012	3,01	1	3
Neogobius melanostomus	250	Tolerant	Tol2	0,067	3,10	1	3
Neogobius syrman							3
Neogonius ratan							
Padogobius bonelli							3
Padogobius martensii	110	Intermediate	Medium			1	3
Padogobius nigricans	100	Intermediate	Medium			1	3
Pomatoschistus microps	50					1	3
Pomatoschistus minutus	110	Intermediate	Medium			1	3
Proterorhinus marmoratus	120	Intermediate	Tol2	0,009	3,08	1	3
Zosterisessor ophiocephalus	250	Tolerant	Tol2				3
Ictaluridae							
Ameiurus melas	660	Tolerant	Tol1	0,017	2,97	1	1
Ameiurus nebulosus	550	Tolerant	Tol1	0,009	3,07	1	1
Ameiurus punctatus		Tolerant	Tol2				1
Lotidae							
Lota lota	1800	Intermediate	Tol2	0,022	2,83	1	3
Moronidae							
Dicentrarchus labrax	1030	Intermediate	Medium			1	1
Morone saxatilis							1
Mugilidae							
Chelon labrosus	600	Tolerant	Tol1			1	1
Liza aurata	590	Tolerant	Tol1			1	1
Liza ramada	700	Tolerant	Tol1			1	1
Liza saliens	300	Tolerant	Tol1				1
Mugil cephalus	1200	Tolerant	Tol1			1	1
Nemacheilidae							
Barbatula barbatula	410	Intermediate	Medium	0,036	2,77	1	3
Barbatula bureschi							3
Odontobutidae							
Perccottus glenii	280	Tolerant	Tol2			1	1
Osmeridae							
Osmerus eperlanus	450	Intermediate	Tol2	0,004	3,24	1	1
Percidae							
Gymnocephalus baloni	170	Intermediate	Tol2			1	2
Gymnocephalus cernuus	300	Tolerant	Tol2	0,006	3,29	1	2
Gymnocephalus schraetser	300	Intermediate	Tol2	0,012	3,03	1	1
Perca fluviatilis	640	Tolerant	Tol2	0,008	3,20	1	2
Percarina demidoffi							1
Romanichthys valsanicola	110						3
Sander lucioperca	1300	Tolerant	Tol2	0,003	3,34	1	1

Table A.3 *(continued)*

Sander volgensis	500	Tolerant	Tol2			1	1
Zingel asper	220	Intolerant	Intol2			1	1
Zingel balcanicus							1
Zingel streber	250	Intermediate	Intol2	0,003	3,26	1	1
Zingel zingel	550	Intermediate	Intol2	0,003	3,33	1	1
Petromyzonidae							
Eudontomyzon danfordi	300	Intolerant	Intol2			1	4
Eudontomyzon hellenicus							4
Eudontomyzon mariae	240	Intolerant	Intol2	0,004	2,66	1	4
Eudontomyzon stankokaramani							4
Eudontomyzon vladykovi	210	Intolerant	Intol2				4
Lampetra fluviatilis	500	Intolerant	Intol2	0,001	3,25	1	4
Lampetra planeri	600	Intolerant	Intol1	0,003	2,83	1	4
Lethenteron camtschaticum							4
Lethenteron zanandreai	150	Intolerant	Intol2				4
Petromyzon marinus	1200	Intermediate	Intol2	0,004	3,01	1	4
Pleuronectidae							
Platichthys flesus	600	Intermediate	Tol2	0,016	2,94	1	2
Pleuronectes platessa	1000			0,011	3,01	1	2
Poeciliidae							
Gambusia affinis	70	Tolerant	Tol1			1	1
Gambusia holbrooki	70	Tolerant	Tol1	0,005	3,59	1	1
Poecilia reticulata							1
Polyodentidae							
Polyodon spathula	2210	Tolerant	Tol2	0,006	3,28		1
Salmonidae							
Hucho hucho	1500	Intolerant	Intol1	0,005	3,15	1	1
Oncorhynchus gorbuscha	760	Intolerant	Intol1				1
Oncorhynchus kisutch	1080	Intolerant	Intol1	0,011	3,00		1
Oncorhynchus mykiss	1200	Intermediate	Intol2	0,009	3,02	1	1
Oncorhynchus tschawytscha	1600	Intolerant	Intol1	0,013	3,00		1
Salmo labrax							1
Salmo macedonicus							1
Salmo marmoratus	1081	Intermediate	Intol2			1	1
Salmo salar	1500	Intolerant	Intol1	0,007	3,06	1	1
Salmo trutta fario	1000	Intolerant	Intol1	0,014	2,96	1	1
Salmo trutta lacustris	1400	Intolerant	Intol1	0,011	2,95	1	1
Salmo trutta macrostigma	600	Intermediate	Intol2			1	1
Salmo trutta trutta	1400	Intolerant	Intol1	0,024	3,13	1	1
Salmothymus obtusirostris							1
Salvelinus alpinus	600	Intolerant	Intol1	0,004	3,25	1	1
Salvelinus fontinalis	860	Intolerant	Intol1	0,009	3,04	1	1
Salvelinus namaycush	900	Intolerant	Intol1			1	1
Salvelinus umbla	600	Intolerant	Intol1	0,004	3,25	1	1
Siluridae							
Silurus aristotelis							4

Table A.3 *(continued)*

Silurus glanis	5000	Tolerant	Tol2	0,027	2,79	1	4
Sparidae							
Sparus aurata	700	Intermediate	Medium				2
Syngnathidae							
Nerophis ophidion							4
Syngnathus abaster	210	Intermediate	Medium				4
Syngnathus typhle		Intermediate	Medium				4
Thymallidae							
Thymallus baicalensis							1
Thymallus thymallus	650	Intolerant	Intol1	0,007	3,13	1	1
Umbridae							
Umbra krameri	170	Tolerant	Tol2			1	1
Umbra pygmaea	160	Tolerant	Tol1	0,008	3,22	1	1
Valenciidae							
Valencia hispanica							1
Valencia letourneuxi							1

ANNEX III

Table A.4 *Denomination of European freshwater fish species adapted from Kottelat & Freyhof (2007) and the denomination of the same species used in the EFI+ project (species with stars are supposed to be alien)*

Species name in EFI+	Species name in FAME	Species name Kottelat&Freyhof
Acipenseridae		
Acipenser baeri	*Acipenser baeri*	*Acipenser baerii* *
Acipenser gueldenstaedtii	*Acipenser gueldenstaedtii*	*Acipenser gueldenstaedtii*
Acipenser naccarii	*Acipenser naccarii*	*Acipenser naccarii*
Acipenser nudiventris	*Acipenser nudiventris*	*Acipenser nudiventris*
Acipenser oxyrinchus	*Acipenser oxyrinchus*	*Acipenser oxyrinchus*
Acipenser ruthenus	*Acipenser ruthenus*	*Acipenser ruthenus*
Acipenser stellatus	*Acipenser stellatus*	*Acipenser stellatus*
Acipenser sturio	*Acipenser sturio*	*Acipenser sturio*
Huso huso	*Huso huso*	*Huso huso*
Anguillidae		
Anguilla anguilla	*Anguilla anguilla*	*Anguilla anguilla*
Atherinidae		
Atherina boyeri	*Atherina boyeri*	*Atherina boyeri*
Atherinopsidae		
Odonthestes bonariensis	*Odonthestes bonariensis*	*Odonthestes bonariensis* *
Blenniidae		
Salaria fluviatilis	*Salaria fluviatilis*	*Salaria fluviatilis*
Catostomidae		
Ictiobus bubalus	*Ictiobus bubalus*	*Ictiobus bubalus* *
Ictiobus cyprinellus	*Ictiobus cyprinellus*	*Ictiobus cyprinellus* *
Ictiobus niger	*Ictiobus niger*	*Ictiobus niger* *
Centrarchidae		
Ambloplites rupestris	*Ambloplites rupestris*	*Ambloplites rupestris* *
Lepomis gibbosus	*Lepomis gibbosus*	*Lepomis gibbosus* *
Micropterus salmoides	*Micropterus salmoides*	*Micropterus salmoides* *
Cichlidae		
Australoheros facetus	*Herichthys facetum*	*Australoheros facetus* *
Hemichromis fasciatus	*Hemichromis fasciatus*	*Hemichromis fasciatus* *
Oreochromis niloticus	*Oreochromis niloticus*	*Oreochromis niloticus* *
Tilapia zillii	*Tilapia zillii*	*Tilapia zillii* *
Clupeidae		
Alosa agone	*Alosa agone*	*Alosa agone*
Alosa alosa	*Alosa alosa*	*Alosa alosa*
Alosa caspia	*Alosa caspia*	*Alosa caspia*
Alosa fallax	*Alosa fallax*	*Alosa fallax*
Alosa pontica	*Alosa pontica*	*Alosa immaculata*
Alosa killarnensis	*Alosa killarnensis*	*Alosa killarnensis*
Alosa macedonica	*Alosa macedonica*	*Alosa macedonica*
Alosa maeotica	*Alosa maeotica*	*Alosa maeotica*
Alosa tanaica	*Alosa tanaica*	*Alosa tanaica*
Alosa vistonica	*Alosa vistonica*	*Alosa vistonica*
Clupeonella cultriventris	*Clupeonella cultriventris*	*Clupeonella cultriventris*
Cobitidae		
Cobitis arachthosensis	*Cobitis arachthosensis*	*Cobitis arachthosensis*
Cobitis bilineata	*Cobitis bilineata*	*Cobitis bilineata*

Table A.4 *(continued)*

Cobitis calderoni	*Cobitis calderoni*	*Cobitis calderoni*
Cobitis elongata	*Cobitis elongata*	*Cobitis elongata*
Cobitis elongatoides	*Cobitis elongatoides*	*Cobitis elongatoides*
Cobitis hellenica	*Cobitis hellenica*	*Cobitis hellenica*
Cobitis meridionalis	*Cobitis meridionalis*	*Cobitis meridionalis*
Cobitis paludica	*Cobitis paludica*	*Cobitis paludica*
Cobitis punctilineata	*Cobitis punctilineata*	*Cobitis punctilineata*
Cobitis stephanidisi	*Cobitis stephanidisi*	*Cobitis stephanidisi*
Cobitis strumicae	*Cobitis strumicae*	*Cobitis strumicae*
Cobitis taenia	*Cobitis taenia*	*Cobitis taenia*
Cobitis trichonica	*Cobitis trichonica*	*Cobitis trichonica*
Cobitis vardarensis	*Cobitis vardarensis*	*Cobitis vardarensis*
Cobitis vettonica	*Cobitis vettonica*	*Cobitis vettonica*
Misgurnus anguillicaudatus	*Misgurnus anguillicaudatus*	*Misgurnus anguillicaudatus* *
Misgurnus fossilis	*Misgurnus fossilis*	*Misgurnus fossilis*
Sabanejewia balcanica	*Sabanejewia balcanica*	*Sabanejewia balcanica*
Sabanejewia aurata	*Sabanejewia aurata*	*Sabanejewia baltica*
Sabanejewia bulgarica	*Sabanejewia bulgarica*	*Sabanejewia bulgarica*
Sabanejewia larvata	*Sabanejewia larvata*	*Sabanejewia larvata*
Sabanejewia romanica	*Sabanejewia romanica*	*Sabanejewia romanica*
Coregonidae		
Coregonus albula	*Coregonus albula*	*Coregonus albula*
Coregonus autumnalis	*Coregonus autumnalis*	*Coregonus autumnalis*
Coregonus lavaretus	*Coregonus lavaretus*	*Coregonus lavaretus*
Coregonus maraena	*Coregonus maraena*	*Coregonus maraena*
Coregonus muscun	*Coregonus muscun*	*Coregonus muksun*
Coregonus oxyrinchus	*Coregonus oxyrinchus*	*Coregonus oxyrinchus*
Coregonus peled	*Coregonus peled*	*Coregonus peled*
Coregonus pidschian	*Coregonus pidschian*	*Coregonus pidschian*
Coregonus trybomi	*Coregonus trybomi*	*Coregonus trybomi*
Cottidae		
Cottus gobio	*Cottus gobio*	*Cottus gobio*
Cottus koshewniko	*Cottus koshewniko*	*Cottus koshewnikowi*
Cottus petiti	*Cottus petiti*	*Cottus petiti*
Cottus poecilopus	*Cottus poecilopus*	*Cottus poecilopus*
Triglopsis quadricornis	*Triglopsis quadricornis*	*Triglopsis quadricornis*
Cyprinidae		
Abramis brama	*Abramis brama*	*Abramis brama*
Achondrostoma arcasii	*Achondrostoma arcasii*	*Achondrostoma arcasii*
Achondrostoma occidentale	*Achondrostoma occidentale*	*Achondrostoma occidentale*
Achondrostoma oligolepis	*Achondrostoma oligolepis*	*Achondrostoma oligolepis*
Alburnoides bipunctatus	*Alburnoides bipunctatus*	*Alburnoides bipunctatus*
Alburnus albidus	*Alburnus albidus*	*Alburnus albidus*
Alburnus alburnus	*Alburnus alburnus*	*Alburnus alburnus*
Alburnus alburnus alborella	*Alburnus alburnus alborella*	*Alburnus arborella*
Chalcalburnus belvica	*Chalcalburnus belvica*	*Alburnus belvica*
Chalcalburnus chalcoides	*Chalcalburnus chalcoides*	*Alburnus chalcoides*
Anaecypris hispanica	*Anaecypris hispanica*	*Anaecypris hispanica*
Aspius aspius	*Aspius aspius*	*Aspius aspius*
Aulopyge huegelii	*Aulopyge huegelii*	*Aulopyge huegelii*
Abramis ballerus	*Abramis ballerus*	*Ballerus ballerus*
Abramis sapa	*Abramis sapa*	*Ballerus sapa*
Barbus balcanicus	*Barbus balcanicus*	*Barbus balcanicus*
Barbus barbus	*Barbus barbus*	*Barbus barbus*

Table A.4 *(continued)*

Barbus caninus	*Barbus caninus*	*Barbus caninus*
Barbaus carpaticus	*Barbaus carpaticus*	*Barbus carpathicus*
Barbus cyclolepis	*Barbus cyclolepis*	*Barbus cyclolepis*
Barbus euboicus	*Barbus euboicus*	*Barbus euboicus*
Barbus haasi	*Barbus haasi*	*Barbus haasi*
Barbus macedonicus	*Barbus macedonicus*	*Barbus macedonicus*
Barbus meridionalis	*Barbus meridionalis*	*Barbus meridionalis*
Barbus peloponnesius	*Barbus peloponnesius*	*Barbus peloponnesius*
Barbus petenyi	*Barbus petenyi*	*Barbus petenyi*
Barbus plebejus	*Barbus plebejus*	*Barbus plebejus*
Barbus prespensis	*Barbus prespensis*	*Barbus prespensis*
Barbus tauricus	*Barbus tauricus*	*Barbus tauricus*
Barbus tyberinus	*Barbus tyberinus*	*Barbus tyberinus*
Blicca bjoerkna	*Abramis bjoerkna*	*Blicca bjoerkna*
Carassius auratus	*Carassius auratus*	*Carassius auratus*
Carassius carassius	*Carassius carassius*	*Carassius carassius*
Carassius gibelio	*Carassius gibelio*	*Carassius gibelio*
Chondrostoma knerii	*Chondrostoma knerii*	*Chondrostoma knerii*
Chondrostoma nasus	*Chondrostoma nasus*	*Chondrostoma nasus*
Chondrostoma phoxinus	*Chondrostoma phoxinus*	*Chondrostoma phoxinus*
Chondrostoma prespense	*Chondrostoma prespense*	*Chondrostoma prespense*
Chondrostoma soetta	*Chondrostoma soetta*	*Chondrostoma soetta*
Chondrostoma vardarense	*Chondrostoma vardarense*	*Chondrostoma vardarense*
Ctenopharyngodon idella	*Ctenopharyngodon idella*	*Ctenopharyngodon idella **
Cyprinus carpio	*Cyprinus carpio*	*Cyprinus carpio*
Phoxinellus adspersus	*Phoxinellus adspersus*	*Delminichthys adspersus*
Phoxinellus pstrossii	*Phoxinellus pstrossii*	*Delminichthys ghetaldii*
Gobio gobio	*Gobio gobio*	*Gobio gobio*
Gobio lozanoi	*Gobio lozanoi*	*Gobio lozanoi*
Hypophthalmichthys molitrix	*Hypophthalmichthys molitrix*	*Hypophthalmichthys molitrix **
Aristichthys nobilis	*Aristichthys nobilis*	*Hypophthalmichthys nobilis **
Iberochondrostoma almacai	*Iberochondrostoma almacai*	*Iberochondrostoma almacai*
Iberochondrostoma lemmingii	*Iberochondrostoma lemmingii*	*Iberochondrostoma lemmingii*
Iberochondrostoma lusitanicum	*Iberochondrostoma lusitanicum*	*Iberochondrostoma lusitanicum*
Iberocypris palaciosi	*Iberocypris palaciosi*	*Iberocypris palaciosi*
Ladigesocypris ghigii	*Ladigesocypris ghigii*	*Ladigesocypris ghigii*
Leucaspius delineatus	*Leucaspius delineatus*	*Leucaspius delineatus*
Leuciscus burdigalensis	*Leuciscus burdigalensis*	*Leuciscus burdigalensis*
Leuciscus idus	*Leuciscus idus*	*Leuciscus idus*
Leuciscus leuciscus	*Leuciscus leuciscus*	*Leuciscus leuciscus*
Barbus albanicus	*Barbus albanicus*	*Luciobarbus albanicus*
Barbus bocagei	*Barbus bocagei*	*Luciobarbus bocagei*
Barbus comizo	*Barbus comizo*	*Luciobarbus comizo*
Barbus graecus	*Barbus graecus*	*Luciobarbus graecus*
Barbus graellsii	*Barbus graellsii*	*Luciobarbus graellsii*
Barbus guiraonis	*Barbus guiraonis*	*Luciobarbus guiraonis*
Barbus microcephalus	*Barbus microcephalus*	*Luciobarbus microcephalus*
Barbus sclateri	*Barbus sclateri*	*Luciobarbus sclateri*
Barbus steindachneri	*Barbus steindachneri*	*Luciobarbus steindachneri*
Mylopharyngodon piceus	*Mylopharyngodon piceus*	*Mylopharyngodon piceus **
Pachychilon macedonicum	*Pachychilon macedonicum*	*Pachychilon macedonicum*
Pachychilon pictum	*Pachychilon pictum*	*Pachychilon pictum*
Parabramis pekinensis	*Parabramis pekinensis*	*Parabramis pekinensis **
Chondrostoma arrigonis	*Chondrostoma arrigonis*	*Parachondrostoma arrigonis*

Table A.4 *(continued)*

Chondrostoma miegii	*Chondrostoma miegii*	*Parachondrostoma miegii*
Chondrostoma toxostoma	*Chondrostoma toxostoma*	*Parachondrostoma toxostoma*
Chondrostoma turiense	*Chondrostoma turiense*	*Parachondrostoma turiense*
Phoxinellus epiroticus	*Phoxinellus epiroticus*	*Pelasgus epiroticus*
Pseudophoxinus minutus	*Pseudophoxinus minutus*	*Pelasgus minutus*
Phoxinellus prespensis	*Phoxinellus prespensis*	*Pelasgus prespensis*
Pseudophoxinus stymphalicus	*Pseudophoxinus stymphalicus*	*Pelasgus stymphalicus*
Pelecus cultratus	*Pelecus cultratus*	*Pelecus cultratus*
Leuciscus borysthenicus	*Leuciscus borysthenicus*	*Petroleuciscus borysthenicus*
Phoxinellus alepidotus	*Phoxinellus alepidotus*	*Phoxinellus alepidotus*
Phoxinus phoxinus	*Phoxinus phoxinus*	*Phoxinus phoxinus*
Pimephales promelas	*Pimephales promelas*	*Pimephales promelas* *
Chondrostoma genei	*Chondrostoma genei*	*Protochondrostoma genei*
Pseudochondrostoma duriense	*Pseudochondrostoma duriense*	*Pseudochondrostoma duriense*
Pseudochondrostoma polylepis	*Pseudochondrostoma polylepis*	*Pseudochondrostoma polylepis*
Pseudochondrostoma willkommii	*Pseudochondrostoma willkommii*	*Pseudochondrostoma willkommii*
Pseudorasbora parva	*Pseudorasbora parva*	*Pseudorasbora parva* *
Rhodeus amarus	*Rhodeus amarus*	*Rhodeus amarus*
Eupallasella perenurus	*Eupallasella perenurus*	*Rhynchocypris percnurus*
Gobio albipinnatus	*Gobio albipinnatus*	*Romanogobio albipinnatus*
Romanogobio antipai	*Romanogobio antipai*	*Romanogobio antipai*
Romanogobio belingi	*Romanogobio belingi*	*Romanogobio belingi*
Gobio benacensis	*Gobio benacensis*	*Romanogobio benacensis*
Gobio elimeius	*Gobio elimeius*	*Romanogobio elimeius*
Gobio kesslerii	*Gobio kesslerii*	*Romanogobio kesslerii*
Gobio uranoscopus	*Gobio uranoscopus*	*Romanogobio uranoscopus*
Romanogobio vladykovi	*Romanogobio vladykovi*	*Romanogobio vladykovi*
Rutilus aula	*Rutilus aula*	*Rutilus aula*
Rutilus basak	*Rutilus basak*	*Rutilus basak*
Rutilus frisii	*Rutilus frisii*	*Rutilus frisii*
Rutilus heckelii	*Rutilus heckelii*	*Rutilus heckelii*
Rutilus karamani	*Rutilus karamani*	*Rutilus karamani*
Rutilus meidingeri	*Rutilus meidingeri*	*Rutilus meidingeri*
Rutilus ohridanus	*Rutilus ohridanus*	*Rutilus ohridanus*
Rutilus pigus	*Rutilus pigus*	*Rutilus pigus*
Rutilus prespensis	*Rutilus prespensis*	*Rutilus prespensis*
Rutilus rubilio	*Rutilus rubilio*	*Rutilus rubilio*
Rutilus rutilus	*Rutilus rutilus*	*Rutilus rutilus*
Rutilus ylikiensis	*Rutilus ylikiensis*	*Rutilus ylikiensis*
Scardinius acarnanicus	*Scardinius acarnanicus*	*Scardinius acarnanicus*
Scardinius erythrophthalmus	*Scardinius erythrophthalmus*	*Scardinius erythrophthalmus*
Scardinius graecus	*Scardinius graecus*	*Scardinius graecus*
Scardinius racovitzai	*Scardinius racovitzai*	*Scardinius racovitzai*
Scardinius scardafa	*Scardinius scardafa*	*Scardinius scardafa*
Squalius aradensis	*Squalius aradensis*	*Squalius aradensis*
Squalius carolitertii	*Squalius carolitertii*	*Squalius carolitertii*
Leuciscus cephalus	*Leuciscus cephalus*	*Squalius cephalus*
Leuciscus illyricus	*Leuciscus illyricus*	*Squalius illyricus*
Leuciscus keadicus	*Leuciscus keadicus*	*Squalius keadicus*
Leuciscus lucumonis	*Leuciscus lucumonis*	*Squalius lucumonis*
Squalius malacitanus	*Squalius malacitanus*	*Squalius malacitanus*
Leuciscus microlepis	*Leuciscus microlepis*	*Squalius microlepis*
Squalius pyrenaicus	*Squalius pyrenaicus*	*Squalius pyrenaicus*
Leuciscus svallize	*Leuciscus svallize*	*Squalius svallize*

Table A.4 *(continued)*

Squalius torgalensis	*Squalius torgalensis*	*Squalius torgalensis*
Squalius valentinus	*Squalius valentinus*	*Squalius valentinus*
Leuciscus zrmanjae	*Leuciscus zrmanjae*	*Squalius zrmanjae*
Pseudophoxinus beoticus	*Pseudophoxinus beoticus*	*Telestes beoticus*
Phoxinellus croaticus	*Phoxinellus croaticus*	*Telestes croaticus*
Phoxinellus fontinalis	*Phoxinellus fontinalis*	*Telestes fontinalis*
Phoxinellus metohiensis	*Phoxinellus metohiensis*	*Telestes metohiensis*
Leuciscus montenigrinus	*Leuciscus montenigrinus*	*Telestes montenigrinus*
Leuciscus muticellus	*Leuciscus muticellus*	*Telestes muticellus*
Leuciscus pleurobipunctatus	*Leuciscus pleurobipunctatus*	*Telestes pleurobipunctatus*
Leuciscus polylepis	*Leuciscus polylepis*	*Telestes polylepis*
Leuciscus souffia	*Leuciscus souffia*	*Telestes souffia*
Leuciscus turskyi	*Leuciscus turskyi*	*Telestes turskyi*
Leuciscus ukliva	*Leuciscus ukliva*	*Telestes ukliva*
Tinca tinca	*Tinca tinca*	*Tinca tinca*
Tropidophoxinellus hellenicus	*Tropidophoxinellus hellenicus*	*Tropidophoxinellus hellenicus*
Tropidophoxinellus spartiaticus	*Tropidophoxinellus spartiaticus*	*Tropidophoxinellus spartiaticus*
Vimba melanops	*Vimba melanops*	*Vimba melanops*
Vimba vimba	*Vimba vimba*	*Vimba vimba*
Cyprinodontidae		
Aphanius baeticus	*Aphanius baeticus*	*Aphanius baeticus*
Aphanius fasciatus	*Aphanius fasciatus*	*Aphanius fasciatus*
Aphanius iberus	*Aphanius iberus*	*Aphanius iberus*
Esocidae		
Esox lucius	*Esox lucius*	*Esox lucius*
Fundulidae		
Fundulus heteroclitus	*Fundulus heteroclitus*	*Fundulus heteroclitus* *
Gasterosteidae		
Gasterosteus aculeatus	*Gasterosteus aculeatus*	*Gasterosteus aculeatus*
Gasterosteus crenobiontus	*Gasterosteus crenobiontus*	*Gasterosteus crenobiontus*
Gasterosteus gymnurus	*Gasterosteus gymnurus*	*Gasterosteus gymnurus*
Pungitius hellenicus	*Pungitius hellenicus*	*Pungitius hellenicus*
Pungitius platygaster	*Pungitius platygaster*	*Pungitius platygaster*
Pungitius pungitius	*Pungitius pungitius*	*Pungitius pungitius*
Gobiidae		
Benthophiloides brauneri	*Benthophiloides brauneri*	*Benthophiloides brauneri*
Benthophilus stellatus	*Benthophilus stellatus*	*Benthophilus stellatus*
Caspiosoma caspium	*Caspiosoma caspium*	*Caspiosoma caspium*
Economidichthys pygmaeus	*Economidichthys pygmaeus*	*Economidichthys pygmaeus*
Economidichthys trichonis	*Economidichthys trichonis*	*Economidichthys trichonis*
Gobius cobitis	*Gobius cobitis*	*Gobius cobitis*
Gobius niger	*Gobius niger*	*Gobius niger*
Knipowitschia cameliae	*Knipowitschia cameliae*	*Knipowitschia cameliae*
Knipowitschia caucasica	*Knipowitschia caucasica*	*Knipowitschia caucasica*
Knipowitschia goerneri	*Knipowitschia goerneri*	*Knipowitschia goerneri*
Knipowitschia longecaudata	*Knipowitschia longecaudata*	*Knipowitschia longecaudata*
Knipowitschia milleri	*Knipowitschia milleri*	*Knipowitschia milleri*
Knipowitschia panizzae	*Knipowitschia panizzae*	*Knipowitschia panizzae*
Knipowitschia punctatissima	*Knipowitschia punctatissima*	*Knipowitschia punctatissima*
Knipowitschia thessala	*Knipowitschia thessala*	*Knipowitschia thessala*
Mesogobius batrachocephalus	*Mesogobius batrachocephalus*	*Mesogobius batrachocephalus*
Neogobius eurycephalus	*Ponticola eurycephalus*	*Neogobius eurycephalus*
Neogobius fluviatilis	*Neogobius fluviatilis*	*Neogobius fluviatilis*
Neogobius gymnotrachelus	*Neogobius gymnotrachelus*	*Neogobius gymnotrachelus*

Table A.4 *(continued)*

Neogobius kessleri	*Neogobius kessleri*	*Neogobius kessleri*
Neogobius melanostomus	*Neogobius melanostomus*	*Neogobius melanostomus*
Neogobius syrman	*Neogobius syrman*	*Neogobius syrman*
Padogobius bonelli	*Padogobius bonelli*	*Padogobius bonelli*
Padogobius nigricans	*Padogobius nigricans*	*Padogobius nigricans*
Pomatoschistus microps	*Pomatoschistus microps*	*Pomatoschistus microps*
Proterorhinus marmoratus	*Proterorhinus marmoratus*	*Proterorhinus semilunaris*
Zosterisessor ophiocephalus	*Zosterisessor ophiocephalus*	*Zosterisessor ophiocephalus*
Ictaluridae		
Ameiurus melas	*Ameiurus melas*	*Ameiurus melas* *
Ameiurus nebulosus	*Ameiurus nebulosus*	*Ameiurus nebulosus* *
Ameiurus punctatus	*Ameiurus punctatus*	*Ictalurus punctatus* *
Lotidae		
Lota lota	*Lota lota*	*Lota lota*
Moronidae		
Dicentrarchus labrax	*Dicentrarchus labrax*	*Dicentrarchus labrax*
Morone saxatilis	*Morone saxatilis*	*Morone saxatilis* *
Mugilidae		
Chelon labrosus	*Chelon labrosus*	*Chelon labrosus*
Liza aurata	*Liza aurata*	*Liza aurata*
Liza ramada	*Liza ramada*	*Liza ramada*
Liza saliens	*Liza saliens*	*Liza saliens*
Mugil cephalus	*Mugil cephalus*	*Mugil cephalus*
Nemacheilidae		
Barbatula barbatula	*Barbatula barbatula*	*Barbatula barbatula*
Barbatula bureschi	*Barbatula bureschi*	*Oxynoemacheilus bureschi*
Odontobutidae		
Perccottus glenii	*Perccottus glenii*	*Perccottus glenii* *
Osmeridae		
Osmerus eperlanus	*Osmerus eperlanus*	*Osmerus eperlanus*
Percidae		
Gymnocephalus baloni	*Gymnocephalus baloni*	*Gymnocephalus baloni*
Gymnocephalus cernuus	*Gymnocephalus cernuus*	*Gymnocephalus cernua*
Gymnocephalus schraetser	*Gymnocephalus schraetser*	*Gymnocephalus schraetser*
Perca fluviatilis	*Perca fluviatilis*	*Perca fluviatilis*
Percarina demidoffi	*Percarina demidoffi*	*Percarina demidoffii*
Romanichthys valsanicola	*Romanichthys valsanicola*	*Romanichthys valsanicola*
Sander lucioperca	*Sander lucioperca*	*Sander lucioperca*
Sander volgensis	*Sander volgensis*	*Sander volgensis*
Zingel asper	*Zingel asper*	*Zingel asper*
Zingel balcanicus	*Zingel balcanicus*	*Zingel balcanicus*
Zingel streber	*Zingel streber*	*Zingel streber*
Zingel zingel	*Zingel zingel*	*Zingel zingel*
Petromyzonidae		
Eudontomyzon danfordi	*Eudontomyzon danfordi*	*Eudontomyzon danfordi*
Eudontomyzon hellenicus	*Eudontomyzon hellenicus*	*Eudontomyzon hellenicus*
Eudontomyzon mariae	*Eudontomyzon mariae*	*Eudontomyzon mariae*
Eudontomyzon stankokaramani	*Eudontomyzon stankokaramani*	*Eudontomyzon stankokaramani*
Eudontomyzon vladykovi	*Eudontomyzon vladykovi*	*Eudontomyzon vladykovi*
Lampetra fluviatilis	*Lampetra fluviatilis*	*Lampetra fluviatilis*
Lampetra planeri	*Lampetra planeri*	*Lampetra planeri*
Lethenteron zanandreai	*Lethenteron zanandreai*	*Lampetra zanandreai*
Lethenteron camtschaticum	*Lethenteron camtschaticum*	*Lethenteron camtschaticum*
Petromyzon marinus	*Petromyzon marinus*	*Petromyzon marinus*

Table A.4 *(continued)*

Pleuronectidae		
Platichthys flesus	*Platichthys flesus*	*Platichthys flesus*
Pleuronectes platessa	*Pleuronectes platessa*	*Pleuronectes platessa*
Poeciliidae		
Gambusia holbrooki	*Gambusia holbrooki*	*Gambusia holbrooki* *
Poecilia reticulata	*Poecilia reticulata*	*Poecilia reticulata* *
Polyodentidae		
Polyodon spathula	*Polyodon spathula*	*Polyodon spathula* *
Salmonidae		
Hucho hucho	*Hucho hucho*	*Hucho hucho*
Oncorhynchus gorbuscha	*Oncorhynchus gorbuscha*	*Oncorhynchus gorbuscha* *
Oncorhynchus mykiss	*Oncorhynchus mykiss*	*Oncorhynchus mykiss* *
Salmo trutta macrostigma	*Salmo trutta macrostigma*	*Salmo cettii*
Salmo labrax	*Salmo labrax*	*Salmo labrax*
Salmo macedonicus	*Salmo macedonicus*	*Salmo macedonicus*
Salmo marmoratus	*Salmo trutta marmoratus*	*Salmo marmoratus*
Salmothymus obtusirostris	*Salmothymus obtusirostris*	*Salmo obtusirostris*
Salmo salar	*Salmo salar*	*Salmo salar*
Salmo trutta fario	*Salmo trutta fario*	*Salmo trutta*
Salmo trutta lacustris	*Salmo trutta lacustris*	*Salmo trutta*
Salmo trutta trutta	*Salmo trutta trutta*	*Salmo trutta*
Salvelinus fontinalis	*Salvelinus fontinalis*	*Salvelinus fontinalis* *
Salvelinus namaycush	*Salvelinus namaycush*	*Salvelinus namaycush* *
Salvelinus umbla	*Salvelinus umbla*	*Salvelinus umbla*
Siluridae		
Silurus aristotelis	*Silurus aristotelis*	*Silurus aristotelis*
Silurus glanis	*Silurus glanis*	*Silurus glanis*
Syngnathidae		
Nerophis ophidion	*Nerophis ophidion*	*Nerophis ophidion*
Syngnathus abaster	*Syngnathus abaster*	*Syngnathus abaster*
Thymallidae		
Thymallus baicalensis	*Thymallus baicalensis*	*Thymallus arcticus*
Thymallus thymallus	*Thymallus thymallus*	*Thymallus thymallus*
Umbridae		
Umbra krameri	*Umbra krameri*	*Umbra krameri*
Umbra pygmaea	*Umbra pygmaea*	*Umbra pygmaea* *
Valenciidae		
Valencia hispanica	*Valencia hispanica*	*Valencia hispanica*
Valencia letourneuxi	*Valencia letourneuxi*	*Valencia letourneuxi*

DECLARATION

ERKLÄRUNG

Hiermit erkläre ich, dass ich die vorliegende Diplomarbeit selbständig angefertigt habe. Es wurden nur die in der Arbeit ausdrücklich benannten Quellen und Hilfsmittel benutzt. Wörtlich oder sinngemäß übernommenes Gedankengut habe ich als solches kenntlich gemacht.

Ort, Datum

Unterschrift

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