



NMD project report: Development and evaluation of common Nordic freshwater types 2002–2004

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**NMD project report: Development and evaluation of common Nordic freshwater types
2002–2004**

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Preface

Implementation of the Water Framework Directive (WFD) needs co-operation between involved countries in order to achieve the aims of the directive. It is also important to consider the special nature conditions of the Nordic countries when implementing the directive. One step in that direction is the work that has been done in the project Development and Evaluation of Common Nordic Freshwater Types 2002–2004, financed by the Nordic Council of Ministers (NCM). In the project participants from Sweden, Finland, Norway, Denmark and Iceland (listed below) have been collaborating in the aim to develop comparable ecological quality assessment systems and harmonised ecological quality criteria for surface waters according to the Water Framework Directive. This report presents the background for the project, the working process and the main results and conclusions as well as remaining challenges and future prospects. The report represents the status of the national, Nordic and European work on freshwater typology, monitoring methodology and ecological quality assessment systems by the end of 2004. Results from implementation projects finalised or published after 2004 have not been included.

The report was edited by the Swedish Environmental Protection Agency (2002–2003) and Ann Kristin Schartau, NINA (2004 and final editing), with contributions from all participants. The project has been managed and coordinated from Sweden by the project leader Håkan Marklund and the project coordinators Frida Löfström, 2002–June 2004, and by Anette Björölin from June 2004.

Participating national agencies and institutions:

The following institutions and people are not a complete list of all people that has participated in the project, but the core of the project participants that has taken part in several workshops and actively contributed to the project. * indicates national project coordinator. Authors of the country wise presentations are given in bold.

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Summary

The project “Development and evaluation of common Nordic freshwater types” was initiated in the light of the Water Framework Directive that calls for common methods and approaches to assess the ecological quality of waters. Sweden, Finland, Norway, Denmark and Iceland have participated in the project with the aim to create a basis for development of comparable ecological quality assessment systems and harmonised ecological quality criteria for surface waters according to the Water Framework Directive.

Based on existing national typology systems, information from the draft guidance documents from EU-Working groups 2.3 (REFCOND) and 2.5 (Intercalibration) together with expert judgement, a preliminary Nordic typology system for lakes and rivers has been developed within the project. This typology applies System B in the Water Framework Directive. A set of preliminary Nordic Core Types was selected on the basis of the Nordic typology system. These types may represent one or several national types. Secondly, the preliminary Nordic Core Types were evaluated and have been revised continuously throughout the project. The last step in evaluating the usefulness of the Nordic Core Types was to investigate if intercalibration sites could be selected within the types. This step has been done nationally, by each country, and the types¹ and intercalibration sites² were reported to EU in 2004. A first result shows that intercalibration sites could be found for a restricted number of Nordic Core Types. Seven lake types and six river types have a total of at least five sites representing more than one country on at least one boundary and are, thus, suitable for intercalibration. Some of the types have too few sites submitted for a certain pressure and/or boundary, and others only have sites submitted from one country.

Denmark joined the project in 2003, which has led to work on selection of Central Core Types for a possible intercalibration between Denmark and Sweden in the Central Ecoregion (according to the Water Framework Directive). Central Core Types have been chosen only for rivers. In 2004 Denmark withdrew from the project due to the focus of the activities in 2004 was on the Nordic core types. Instead Iceland joined the project with status as an observer.

Nutrient/organic loading and acidification were identified as the most relevant pressure types in the intercalibration of Northern lake and river

¹ EU WFD document “Overview of common Intercalibration types”, final version 5.1, dated 23 April 2004.

² Intercalibration register, final version. Official Journal of the European Union 2005/646/EC dated 17 August 2005.

types. Whereas nutrient loading is one of the most severe treats to the maintenance of good water quality in Europe, acidification is affecting large areas in the Nordic countries and is partly unique for this region. Based on the selection of pressure types and the results from the compilation and comparison of monitoring data selection of quality elements, metrics and parameters/indices were performed. For nutrient/organic loading phytoplankton was considered as the most relevant quality element for lakes and macroinvertebrates for rivers. Also macrophytes might be included for lakes. For acidification macroinvertebrates should be included both for lakes and rivers whereas fish might be included for lakes.

To facilitate the intercalibration exercise the Guidance on the intercalibration process (WFD CIS guidance document No. 14)³ outlines three different options for the intercalibration process. For the the Northern intercalibration group option 2 (boundaries are set for one simple common assessment method, which then is used to calibrate national assessment systems) are probably most applicable for both eutrophication and acidification, including both lakes and rivers. The calibration of national indices will be finalised during the intercalibration exercise.

Six Nordic workshops, with participants from research institutes and national EPAs, have been performed within the project. These workshops have been of vital importance for the process and the result of the project. At the workshops information of national and international activities has been exchanged, results have been presented, problems have been discussed and continued common work has been decided. In addition, there have been activities in each country between the workshops, which also have involved a large degree of ongoing coordination and exchange of information. Result from the project has been used in the EU coordination process of the intercalibration work, and the intercalibration types suggested for the Northern ecoregion (performed by the Northern geographical intercalibration group) has almost entirely been based on the Nordic Core Types. Also the selection of pressure types, quality elements, metrics and parameters/indices are based on the results from the Nordic project.

This report represents the status of the national, Nordic and European work on freshwater typology, monitoring methodology and ecological quality assessment systems by the end of 2004. After the finalization of this project further evaluation and development of freshwater typology, monitoring methodology and classification systems have taken place at the national, Nordic and European levels. Results from these activities are presented elsewhere.

³ Guidance documents produced as a part of the Common Implementation Strategies for the Water Framework Directive (2000/60/EC) are available at <http://forum.europa.eu.int/Public/irc/env/wfd/library>

1. Introduction

The Water Framework Directive (WFD) requires that Member States differentiate the relevant surface water bodies with respect to type and that Member States establish type-specific reference conditions for these types. Deviation from reference conditions is then used as the basis for the classification of ecological status of the surface water bodies. The classifications will subsequently be included in the River Basin Management Plans that will be reported to the EU Commission for the first time in 2010. The purpose of surface water body types will be to facilitate comparisons of the classifications between different Member States. Another important use of types is for the selection of intercalibration sites (draft register 2003, final register 2004) to be included in the intercalibration exercise during 2005–2006.

The main aim of the project has been to develop and evaluate a Nordic typology system for lakes and rivers according to be applicable and useful in the international intercalibration exercise according to the WFD.

Another objective of the project was to compile information on and discuss comparability of national methods and metrics. The purpose was to calibrate national indices used for assessing ecological status to reach a preliminary Nordic approach for ecological status assessment of lakes and rivers. Identification of biological indices possibly to be used as common metrics in the intercalibration was a part of this work.

The reasons for having a Nordic project with cooperation on the process of implementing the WFD and especially for the intercalibration process are many. Implementation of the WFD must be performed by the Nordic countries as members of the European Union or through the EES agreement. However, there is no demand for co-operation of the work performed in neighbouring countries. Still there is a lot to gain through coordination of the Nordic work, since the implementation work includes many problems and difficult questions, of which some are specific for the Northern region. The Nordic countries have a very large number of water bodies to handle compared to most other countries in Europe. The environmental conditions are relatively comparable and the main pressure types (e.g. acidification and watercourse regulations) are also common and partly unique for the Nordic countries. Since similar problems exist in the Nordic countries a lot can be won by close cooperation, coordination of efforts and exchange of information and ideas. It is also important that the Nordic approach can be taken into account with adequate weight in the European process of implementing the WFD. This is especially important in the intercalibration process, since the result from the inter-

calibration exercise can have a large effect on the countries assessment systems and even affect the future water quality in the Nordic countries.

2. WFD and the intercalibration process

WFD requires that Member States differentiate the relevant surface water bodies with respect to type and that Member States establish type-specific reference conditions for these types. Deviation from reference conditions is then used as the basis for the classification of ecological status of the surface water bodies. The classifications will subsequently be included in the River Basin Management Plans that will be reported to the EU Commission for the first time in 2009. The purpose of surface water body types will be to facilitate comparisons of the classifications between different Member States. Another important use of types is for the selection of intercalibration sites (draft register 2003, final register 2004) to be included in the intercalibration exercise during 2005–2006. The purpose of intercalibration in the WFD is to ensure comparable ecological status assessment systems and harmonised ecological status criteria for surface waters in the EU Member States. This will be done by establishing harmonised Ecological Quality Ratio (EQR) values for the two key quality class boundaries high/good and good/moderate.

3. Typology according to the directive

Typology is needed both for intercalibration, for characterisation of water bodies and for monitoring.

The types shall be differentiated using either "System A" or "System B". The two systems overlapping in structure as the same obligatory factors are to be used in both: geographic position, altitude, size, geology and, for lakes, depth. The difference is that System A prescribes how water bodies shall be aggregated spatially (ecoregions) and with respect to specific altitude, size and depth intervals, and that System B, besides lacking this prescription, permits the use of additional factors. System A is simple and easy to adopt but has the potential disadvantage of giving a lower level of precision of reference values. System A may be used for reporting although system B is used for characterisation of water bodies. It is up to Member States to decide on what system to use, and most countries, including the Nordic countries, has indicated that they prefer System B.

The Directive requires that System B, if used, must result in at least the number of water body types as would have been identified in a Member State if System A had been used. This could be interpreted to mean that if System B is used, it must result in at least the same number of water body types as would be identified and represented in the territory of a Member State if System A had been used. However, if it can be demonstrated that the same or a lower degree of variability in reference condition values may be achieved with a lower number of types, this should be acceptable, since the main purpose of typing is to establish type-specific reference conditions as precisely as possible.

System B provides, as indicated above, a more free choice of how to designate types and, subsequently, to designate type-specific conditions with, possibly, a lower variability and a better applicability to the sensitivity of the quality elements. The starting point is a sound database. It should contain the obligatory factors and those other factors that the Member State may find useful. All or some of the Directives optional factors may be included here, but other factors may also occur. In the Nordic countries, for example, the highest coastline during the last glacial period and the tree line might be considered ecologically more relevant than using the fixed altitude classes, 200 m and 800 m, prescribed in System A. Furthermore, some chemical measure of humic substances (colour, absorbance or TOC) and calcareous content (Ca or alkalinity) are consid-

ered more relevant than the prescribed geology classes “organic” and “calcareous”.

Based on the data available, types may be delimited using various mathematical-statistical clustering methods or using more intuitive methods, including expert opinion. The combination of factors used should of course result in as ecologically meaningful types as possible, which includes a low degree of variability within types, without an excessive number of types being designated.

4. The intercalibration exercise

The value for the boundary between the classes of high and good status, and the value for the boundary between good and moderate status shall be harmonised through an *intercalibration exercise as demanded in the directive*. The results of the intercalibration exercise determine the numerical (EQR) values for the high-good and the good-moderate boundaries in each Member State's classification system (figure 1). Values for the other two class boundaries are established by the Member States themselves. As part of this exercise the Commission shall facilitate an exchange of information between Member States leading to the identification of a range of sites in each ecoregion in the Community; these sites will form an *intercalibration network*. The network shall consist of sites selected from a range of surface water body types present within each ecoregion. For each surface water body type selected, the network shall consist of at least two sites corresponding to the boundary between the normative definitions of high and good status, and at least two sites corresponding to the boundary between the normative definitions of good and moderate status. The sites shall be selected by expert judgement based on joint inspections and all other available information.

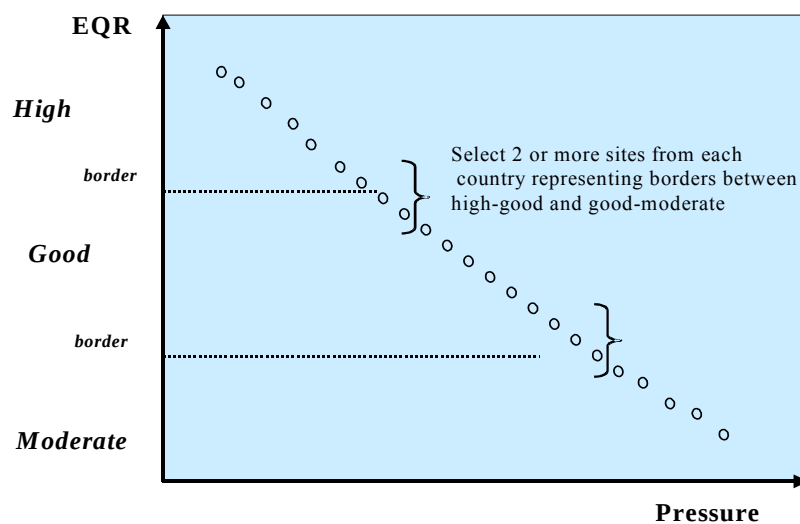


Figure 1 Illustration of the ranking of the estimated ecological quality of the sites (varying as a function of certain pressure). The Member States evaluate their data, and select 2 or more sites provisionally representative for the borders between high/good and good/moderate from each country for each type selected for the intercalibration network. Figure from the WFD CIS guidance document No. 6³.

The criteria for selecting intercalibration sites has been discussed by expert groups on lakes, rivers and coastal waters at EU-level. Based upon this work it is recommended to intercalibrate within larger regions consisting of countries sharing a similar ecology and climate. In 2004 five Geographical Intercalibration Groups (GIGs) (Northern, Central/Baltic, Alpine, Eastern Continental and Mediterranean), each including several Member States, were established for rivers. For lakes six intercalibration regions (Northern, Atlantic, Central/Baltic, Alpine, Eastern Continental and Mediterranean) were established. Sweden, Finland and Norway belong to the Northern intercalibration group, while Denmark belongs to the Central group as do the southern part of Sweden. It is expected that groups of Member States will share the same water body types in different sub-regions or ecoregions. This would allow two or more Member States to carry out intercalibration using intercalibration sites in the same type.

To facilitate the intercalibration exercise the Guidance on the intercalibration process (WFD CIS guidance document No. 14)³, outlines three different options for how to perform the intercalibration exercise, as well as hybrid options:

- Option 1 means that all countries within a GIG use the same assessment method(s) for estimation of ecological status (same metric, same methods for sampling and analysis and same EQR-scale). This is the most straightforward option since the difficulties and uncertainties involved in comparing the results of different assessment methods are avoided. Comparability between Member States is assured. In this case there is no actual need of intercalibration.
- Option 2 require that common metric(s) (simple common assessment method) should be identified that can be used for assessment of ecological status across the GIG. Boundaries are set for the common assessment method, which then are used to calibrate national assessment systems.
- Option 3 is a mutual comparison of national methods using data from the other countries' intercalibration sites. Same kind of data is needed from all intercalibration sites.

A number of hybrid options may be possible; for example:

- It may be possible to identify a simple common metric(s) method (see option 2) to underpin the development of the boundary setting procedure, but to follow Option 3 for the application of the procedure to each Member State's data, establishing boundary EQR values. This would have the advantage compared to option 3 of allowing the Working Group 2A Ecological Status to more readily monitor the

application of, and iteratively refine, the setting of the class boundaries.

- Boundary values are first established with national classification assessment methods (as in Option 3). The subsequent comparison of the boundary values could then be done with the help of a common metrics method (as in Option 2).

All options also include the use of a “boundary setting protocol”, which has the purpose of getting the countries within the GIG to agree on definitions of reference conditions, high and good status and boundary conditions for the intercalibration types.

5. Development and evaluation of common core types

The work in the NMD-project during 2002 was mainly focused on agreeing on a common Nordic typology (see appendix 1). Issues as what typology factors and categories that should be used mainly occupied the discussions. However, some preliminary checking of which of the possible common types that exists in the countries was also performed. The knowledge of which types that is common in the different countries provided an important base for the selection of preliminary Nordic Core Types in October 2002. These preliminary Nordic Core Types were then further checked and evaluated during the next two years. Selection of intercalibration sites was performed by each country in 2003 and 2004. However, since Denmark did join the project only in 2003, less effort has been put into the work with common Central types.

6. Development of a Nordic typology system

Recommendations regarding typology for inland surface waters are given in the guidance documents of working groups 2.3 (REFCOND, see WFD CIS guidance document No. 10)³ and 2.5 (Intercalibration, see WFD CIS guidance document No. 6)³ under the Common Implementation Strategy⁴. However, in the existing guidance documents no common European typology for inland surface waters is suggested. Instead, Member States are encouraged to engage activities to harmonise typology for inland waters on the most appropriate regional scale (e.g. the Nordic countries) in order to facilitate the selection of sites to be included in the intercalibration network.

Whether mathematical methods or more intuitive methods are used to define typology, it is important to realise that the designation of types involves the consideration of, sometimes, mutually incompatible factors and that the result is a compromise between these. What may be considered, as a good type with respect to one variable may not be the ideal one with respect to other variables. This is easily demonstrated by use of various multivariable techniques. Hence, a typology common to all variables is likely to be “the least bad alternative” for the purpose of deriving reference conditions of a multitude of variables. So to define Nordic Core Types is really to find the common typology that is the least bad alternative for the included countries.

There was an agreement within the project to use system B for the selection of Nordic Core Types, however, some categories from the obligatory factors in system A could still be used if needed. Information from the WFD CIS guidance documents No. 6 and 10³, together with expert judgement, were used in the development of the Nordic typology system. Evaluation and discussion on the possible typology categories and borders were performed at the first and second Nordic workshop in 2002. The result is presented below.

⁴ In May 2001 Member States, Norway and the European Commission agreed a Common Implementation Strategy to provide support to the implementation of the Water Framework Directive by developing coherent and common understanding and guidance on key elements of this Directive.

6.1 Typology criteria and categories

6.1.1 *Ecoregions and geographical factors*

The spatial variation of ecological parameters such as species composition is mainly related to climatic gradients. The variation with latitude and altitude is obvious, but there is often also a variation with longitude. In the Nordic countries the longitudinal variation is related to the distance to the Nordic Sea (e.g. coastal versus continental climate) and therefore most relevant to Norway. While the geographical variation often is continuous, sometimes more discontinuous changes are found (due to e.g. dispersion barriers), justifying division of the landscape into ecoregions with different ecological characteristics. One such border is the “limes norrlandicus” which coincide with the border between the ecoregions Central Plain and the Fenno-Scandian shield in Sweden. Ecoregions and geographical variables are strongly correlated to each other in the Nordic countries and a strict application of the obligatory factors of system B in the WFD will result in a vast number of types whereof most will only contain a few objects and the types will hardly have significantly different reference conditions.

As an alternative to fixed altitude classes the Nordic countries consider using the highest coastline during the last glacial period (HC) and the tree limit. These two factors encompass the altitude and latitude parameters. Recent marine deposits are only found below HC while fine sediment has been washed out from areas above HC. This is resulting in e.g. lower buffer capacity and thereby higher sensitivity to acidification above HC. The tree line distinguishes the forested areas above HC from the alpine areas, which is not always the case for the 800 m limit (System A). The tree line is also considered as more relevant ecologically than the 800 m limit in for describing e.g. organic input to riverine ecosystems.

However, it is not sure that the highest coast line and the tree line are the factors that best correspond to the ecoregional variations in all countries. Instead the altitude regions: below 200 m, between 200-800 m and above 800 m, might be more useful factors in some countries. In the end it was suggested that either the coast line/tree line or 200 m/800 m limit could be used depending on what factor the countries found to be most appropriate. To use somewhat different factors will not be a problem as long as the countries chose sites that are clearly within a certain region (lowland, boreal and highland) and avoid borderline sites.

6.1.2 *Identification of geology categories*

According to System A, water bodies are either dominated by siliceous, calcareous or organic geology in the catchment. A high content of calcareous bedrock in the catchment results in hard water systems with char-

acteristic flora of macrophytes and phytoplankton. Hard waters are also resistant against acidification. The problem in the Nordic countries is that the fine material from calcareous bedrock was transported and deposited at distant locations during the last glacial period. Since it is rather the soil than the bedrock that defines the chemistry in runoff it is more relevant to look for the presence of calcareous minerals in the soil. There are, however, no geological maps with soil mineral content covering the Nordic countries. It is therefore suggested that the impact of calcareous geology should be defined by Ca content or alkalinity in the water. A drawback by using a measured variable for typing is that it may be affected by anthropogenic impact (acidification and liming). Both Ca and alkalinity can, however, be corrected for this impact and it is the calculated preindustrial concentrations that should be used in the classification. It was therefore suggested that monitoring data should be used to distinguish water bodies according to Ca-content (measured as Ca, alkalinity or ANC) and humic content (measured as Pt-colour, TOC or AbsF). Ca identifies the contribution from the mineral soil and bedrock and the humic content identifies the contribution from organic soils. This approach gave a minimum of four geology (chemical) categories, which were called:

Low alkalinity		Moderate alkalinity
High humus	Low alkalinity, high humic content	Moderate alkalinity, high humic content
Low humus	Low alkalinity, low humic content	Moderate alkalinity, low humic content

- Moderate alkalinity, high humic content (mixed geology - rare water type in the Nordic countries)
- Moderate alkalinity, low humic content (siliceous, moderate alkalinity, clear)
- Low alkalinity, high humic content (organic)
- Low alkalinity, low humic content (siliceous, low alkalinity, clear)

Moderate alkalinity was in the beginning of the project called high calcareous content or high alkalinity. This term was changed due to the fact that the European definition of calcareous waters was defined by a higher alkalinity level (above 1 meq/l) than the one used within the Nordic project (0.2-1 meq/l). To make the Nordic typology compliant with the European definitions the categories were changed into: Siliceous with low alkalinity (<0.2 meq/l) and Siliceous with moderate alkalinity (0.2-1 meq/l), in combination with high humic content (> 30 mg Pt/l) giving the following categories: Organic (alk <0.2 meq/l) and Mixed (alk: 0.2-1 meq/l). However, the used alkalinity categories did not change, just the terms.

6.1.3 Identification of size categories, Rivers:

Size (of the catchment) or co-varying factors is important for typing of rivers. For rivers, three size classes are considered (10-100, 100-1000 and $>1000 \text{ km}^2$). There have to be flexibility to include smaller rivers ($<10 \text{ km}^2$) for management purposes but for the Nordic Core Types the lower size limit should be 10 km^2 .

6.1.4 Identification of depth and size categorie, Lakes:

Lake depth is the most important factor controlling the mixing characteristics of lakes. Depth is strongly correlated to lake area, so that there will be very few objects in types with small area and large depth and vice versa. Three lake depth categories are considered for the Nordic countries (< 3 , 3-15 and $> 15 \text{ m}$ mean depth), and size categories should be at least three ($0.5\text{--}5$, $5\text{--}40$ and $> 40 \text{ km}^2$). Additional information on stratification and mixing conditions should be included when necessary. In general, when information on mixing conditions is missing, lakes with mean depth $>3 \text{ m}$ are considered as stratified. Lakes smaller than 0.5 km^2 will be dealt with on a national basis, and should not be included in the Nordic Core Types.

6.1.5 Optional factors

Optional factors that are considered important for Nordic lakes are residence time and water level fluctuations (most relevant for heavily modified water bodies, for Norwegian lakes with natural high water level fluctuations, and for lakes with large littoral zones - e.g. headwater lakes in Finland). Furthermore background nutrient conditions and turbidity are considered important factors for lowland lakes. Slope is considered as the perhaps most important optional factor for rivers. The share of lake area in the catchment, which affects the sedimentation rate in the whole system, is considered important for both lakes and rivers. However, no optional factors were included in the Nordic typology. The reasons were lack of methodology or knowledge, which makes it hard to define categories on a Nordic level. Also, many factors were only considered important in one of the countries, which make them more suitable to include in the national typology.

The decided typology is presented in table 1 and 2.

Table 1 Common Nordic lake typology

Altitude	Mean depth (m)	Geology Alkalinity (meq/l) Colour (mg Pt/l)	Lake size (km ²)
Lowland < 200 m or HC	< 3	Siliceous (low alkalinity) Alk < 0.2 Colour < 30	0.5 - 5
Boreal Between lowland and highland	3–15	Organic (humic) Alk < 0.2 Colour > 30	5 - 40
Highland > 800 m or treeline	> 15	Siliceous (moderate alkalinity) Alk 0.2-1 Colour < 30 Mixed geology Alk 0.2-1 Colour > 30	> 40

HC = highest coastline during the last glaciation.

Table 2 Common Nordic river typology

Altitude	Geology Alkalinity (meq/l) Colour (mg Pt/l)	Catchment area (km ²)
Lowland < 200 m or HC	Siliceous (low alkalinity) Alk < 0.2 Colour < 30	10–100
Boreal Between lowland and highland	Organic (humic) Alk < 0.2 Colour > 30	100–1000
Highland > 800 m or treeline	Siliceous (moderate alkalinity) Alk 0.2-1 Colour < 30 Mixed geology Alk 0.2-1 Colour > 30	> 1000

HC = highest coastline during the last glaciation.

6.2 Selection of Nordic Core Types

The typology creates a great number of possible Nordic river and lake types (see appendix 2). From this set of possible types Nordic Core Types were selected as described in the following section.

There are different ways to select Nordic Core Types, for instance by selection of:

- Common types (types with common occurrence in at least two of the countries).
- Special Nordic types (unique for Nordic countries).
- Types that have available data from at least two of the countries.

Highest priority is given to types that are common for at least two countries and given high priority by at least one of these. It was decided that only small and medium sized rivers should be included, since larger riv-

ers demand many samples. The term Nordic Core Types includes both lake and river types and has been the basis for the selection of Northern IC types.

Evaluation of possible Nordic Core Types in the end of 2002 gave eight Nordic lake types and seven Nordic river types with priority 1 (see appendix 2). The suitability of these types was evaluated based on output of the preliminary IC register in 2003. Suggestions from the Northern intercalibration group for the paneuropean intercalibration network were also taken into consideration. As a result two river types (R-N4 and R-N8) were added in March 2003 at the third Nordic workshop. In March 2004, at the fifth Nordic workshop, two lake types (L-N4 and L-N7) and two river types (R-N6 and R-N8) was excluded as Northern IC types whereas one new lake type (L-N8) and one river type (R-N9) were included. At the same time the lake type L-N2 was split into two subtypes (shallow and deep lakes). Although these types are supposed to be identical in reference condition, different response to pressures, especially nutrient loading, should be expected. By the time of the establishment of the IC register (October 2004) seven Northern Lake types (Table 3) and seven Northern River types (Table 4) were presented. However, not all types are represented in the IC register (see table 12-13) and some might be deleted at a later stage.

Table 3 Northern IC types based on Nordic Core Types: Lakes. Note: lake types L-N4 and L-N7 were not included in the final version of the intercalibration register (2005/646/EC). HC: highest coastline.

Nordic type	EU type	Lake characterization (international)	Altitude & geomorphology	Lake size (km ²)	Mean depth (m)*	Alkalinity (meq/l)	Colour (mg Pt/l)
L5	L-N1	Lowland, shallow, siliceous (moderate alkalinity), clear, large	< 200 m or HC	> 0.5*	3–15	0.2 – 1	< 30
L6+L10	L-N2a	Lowland, shallow, siliceous (low alkalinity), clear, large	< 200 m and HC	> 0.5	3–15	< 0.2	< 30
L13	L-N2b	Lowland, deep, siliceous (low alkalinity), clear, large	< 200 m and HC	> 0.5	>15	< 0.2	< 30
L7+L11	L-N3	Lowland, shallow, siliceous (low alkalinity), organic, large	< 200 m and HC	> 0.5	3-15	< 0.2	> 30
B1	L-N4	Boreal, very shallow, siliceous (low alkalinity), large	Between lowland and highland	> 0.5	< 3	< 0.2	< 30
B4, B11	L-N5	Boreal, shallow, siliceous (low alkalinity), clear, large	Between lowland and highland	> 0.5**	3-15	< 0.2	< 30
B5	L-N6	Boreal, shallow, siliceous (low alkalinity), organic, large	Between lowland and highland	> 0.5*	3-15	< 0.2	> 30
H4+H7	L-N7	Highland, shallow, siliceous (low alkalinity), clear, large	Above treeline	> 0.5	3-15	< 0.2	< 30
L8+L12	L-N8	Lowland, shallow, mixed geology (moderate alkalinity, organic), large	< 200 m and HC	> 0.5	3-15	0.2 - 1	> 30

* Focus on the following lake size (Nordic subdivision): 0.5-5 km², ** Focus on the following lake size (Nordic subdivisions): 0.5-5 km² and 5-40 km².

Table 4 Northern IC types based on Nordic Core Types: Rivers. Note: river types R-N6 and R-N8 were not included in the final version of the intercalibration register (2005/646/EC). HC: highest coastline.

Nordic Type	EU Type	River characterization (International)	Altitude & geomorphology	Catchment area (of stretch)	Alkalinity (meq/l)	Colour (mg Pt/l)
L1	R-N1	Lowland, small, siliceous (moderate alkalinity), clear	< 200 m and HC	10–100 km ²	0.2 - 1	< 30
L2	R-N2	Lowland, small, siliceous (low alkalinity), clear	< 200 m and HC	10–100 km ²	< 0.2	< 30
L3	R-N3	Lowland, small, organic	< 200 m and HC	10–100 km ²	< 0.2	> 30
L4	R-N4	Lowland, medium, siliceous (moderate alkalinity), clear	< 200 m and HC	100–1000 km ²	0.2 - 1	< 30
B2	R-N5	Boreal, small siliceous (low alkalinity), clear	Between lowland and highland	10–100 km ²	< 0.2	< 30
B5	R-N6	Boreal, medium, siliceous (low alkalinity), clear	Between lowland and highland	100–1000 km ²	< 0.2	< 30
H2	R-N7	Highland, small, siliceous (low alkalinity), clear	Above treeline	10–100 km ²	< 0.2	< 30
H3	R-N8	Highland, small, organic	Above treeline	10–100 km ²	< 0.2	> 30
B3+B6	R-N9	Boreal, small-medium, organic	Between lowland and highland	10–1000 km ²	< 0.2	> 30

6.3 Selection of Central Core Types

Denmark joined the project only in 2003 and has therefore not been a part of the work performed during 2002 and 2004. Denmark and the southern most part of Sweden belong to the Central intercalibration group and the objective has been to find Central Core Types, which can be used for intercalibration between the countries. Other countries, mostly in central Europe, also belong to the Central IC group, but focus in this project has been on the Nordic areas of the central region and possible intercalibration between Denmark and Sweden. Based on a suggestions for intercalibration types for the Central IC group produced by work on EU-level, two river types was selected as preliminary Central Core Types for rivers (see table 5). To select Central Core Types for lakes was more difficult and it seemed not possible to find any common lake types with available monitoring data from both Sweden and Denmark.

Table 5 Central Core Types for rivers.

Nordic Type	EU Type	River characteristics	Catchment area	Altitude & geomorphology	Alkalinity (meq/l)
C4	R-C4	Lowland, medium, mixed	10–1000 km ²	lowland, sandy to gravel substrate, 8–25 m width (bankfull size)	Medium alkalinity
C6	R-C6	Lowland, small, calcareous	10–100 km ²	lowland, gravel width substrate (limestone), 3–10 m (bankfull size)	High alkalinity

7. Evaluation of core types

Evaluation of the core types is a stepwise procedure. The applicability and usefulness of the core types in the intercalibration exercise depends on several criteria.

The criteria for one core type can be described as follows:

1. The type exists in more than one country.
2. Available monitoring data exists for more than one country.
3. Monitoring data is comparable (data exists for the same quality element) between the countries.
4. Methods and metrics used are comparable between the countries.
5. Preliminary intercalibration sites can be identified for more than one country.
6. The identified intercalibration sites are affected by the same pressures (acidification or eutrophication) and of course have data for the same quality elements.
7. Together the countries should have at least 5 sites on each border (high/good and good/moderate) with a minimum of at least two sites per country.

The Nordic project has focused mainly on step 1-4 (step 1 already during 2002). However, in 2004 there has been also a focus on step 5-7. For the Central lakes, however, Sweden has not passed step 2. National classification criteria will probably be revised since many of the countries haven't finished development of type-specific reference conditions and status classes yet, which might lead to that points 5-7 have to be repeated since the sites might not reflect the boundaries anymore. The revision of national criteria for setting boundaries is expected to be finalized during the intercalibration exercise.

7.1 Availability of monitoring data

A compilation of metadata was performed within the project during year 2003 and the result was presented at the fourth Nordic workshop (see appendix 1). Moreover, which methods and metrics the countries use were also compiled (see appendix 6 and 7 and section 'Comparability of monitoring data'). The general impression of data availability was that several quality elements exist in more than one country which should give a good foundation for finding comparable intercalibration sites in the suggested core types (see table 6, 7 and 8). However, due to missing infor-

mation about data availability for some quality elements and countries, a complete evaluation of potential core types was not possible.

Table 6 Available monitoring data in Nordic Core Types – Lakes

Quality elements – Lakes	Finland	Norway	Sweden
Phytoplankton	X	X	X
Macroinv. littoral	-	X	X
Macroinv. profundal	X	-	X
Fish	Data not compiled yet	X	X

Table 7 Available monitoring data in Nordic Core Types – Rivers

Quality elements – Rivers	Finland	Norway	Sweden
Phytobenthos	Data not compiled yet	X	-
Macroinvertebrates	X	X	X
Fish	Data not compiled yet	Data not compiled yet	X

Table 8 Existing data in Central Core Types – Rivers

Quality elements - Rivers	Denmark	Sweden
Macroinvertebrates	X	X
Fish	-	Data not compiled yet

When data availability for each Nordic core type was compiled the result was less positive. Only four lake types and two river types had matching data in at least two countries (see table 9 and 10 below). A prioritizing of which Nordic Core Types that seemed possible to use for selection of intercalibration sites were done based on the result of the data compilation. First priority is given to Nordic Core Types that seem to have sufficient amount of comparable data in at least two countries, which makes them most likely to be useful in the intercalibration exercise (if border sites exists). Second priority is given to types that need to be investigated further; there is not known if enough sites with data exist for more than one country. Some types were not prioritized since there was no available data at all or not enough data in all countries. For Central types focus is placed on possible intercalibration of macroinvertebrates, since data on macroinvertebrates exists in both Denmark and Sweden.

Table 9 Data availability for different quality elements in Nordic Core Types for lakes based on state of knowledge in October 2004.

Nordic type (EU)	Quality Element	FI	NO	SE	Priority
L5 (L-N1)	Phytoplankton	-	X	-	2
	Macrophytes		X*		
	Macroinv. littoral	-	?	X*	
	Fish	?	X*	?	
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
L10 (L-N2)	Phytoplankton	X	X	-	2
	Macroinv. littoral	-	?	X	
	Macroinv. profundal	X	-	X	
	Fish	?	X*	?	
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
L7 (L-N3)	Phytoplankton	X	X	X	1
	Macrophytes	?	X*	X*	
	Macroinv. littoral	-	X*	X	
	Macroinv. profundal		-	X	
	Fish	?	X*	?	
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
B1 (L-N4)	No available data	-	-	-	No
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
B4 (L-N5)	Phytoplankton	-	X	X*	1
	Macrophytes			X*	
	Macroinv. littoral	-	X	X	
	Macroinv. profundal	-	-	?	
	Fish	?	X	X	
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
B11 (L-N5)	Not enough data	-	-	-	No
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
B5 (L-N6)	Phytoplankton	-	X	X	1
	Macroinv. littoral	-	X	X	
	Macroinv. profundal	-		X	
	Fish	?	X	X	
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
H4 (L-N7)	Not enough data	-	-	-	No
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
L12 (L-N8)	Phytoplankton	X	X	-	Not considered

? Data not compiled yet- Too few sites are available. X Sites exists. * Data on the indicated quality element only available for some few sites

Table 10 Data availability for different quality elements in Nordic Core Types for rivers based on state of knowledge in October 2004.

Nordic type (EU)	Quality Element	FI	NO	SE	Priority
L1 (R-N1)	Macroinvertebrates	-	-	X	2
	Phytobenthos	?	X	-	
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
L2 (R-N2)	Phytobenthos	-	X	-	2
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
L3 (R-N3)	Macroinvertebrates	X	X*	X	2
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
L4 (R-N4)	Macroinvertebrates	-	-	X	2
	Phytobenthos	?	?	-	
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
B2 (R-N5)	Macroinvertebrates	X	X	X	1
	Phytobenthos	?	X	-	
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
B5 (R-N6)	Macroinvertebrates	?	-	X	2
	Phytobenthos	?	X	-	
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
H2 (R-N7)	Macroinvertebrates	-	X	X	1
	Phytobenthos	?	X	-	
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
H3 (R-N8)	No available data	?	-	-	No
Nordic type (EU)	Quality Element	FI	NO	SE	Priority
B3+B6 (R-N9)	Macroinvertebrates		X	?	2
	Phytobenthos	?	X	-	

? It is not known if monitoring data is available. - Too few sites with available monitoring data. X Sites with available monitoring data exists (sometimes however very few). * Data on the indicated quality element only available for some few sites

For the purpose of the intercalibration exercise it is necessary to include only types and quality elements for which there exists monitoring data representing the relevant boundaries (high/good and good/moderate).

7.2 Comparability of monitoring data

The intercalibration is carried out in order to ensure that the national classification systems based on biological data are consistent with the normative definitions of the WFD Annex V. Further the biological classification need to be comparable between different countries, so that the definition of the good ecological quality follows the same ecological criteria in all regions/countries that share the same water body type. This implies that the Nordic countries do not have to use the same methods to perform the intercalibration exercise since the focus is on comparing the classification

borders high/good status and good/moderate status. However, the interpretation will be easier if the methods and metrics used are comparable. Any noted deviation between the countries when borders are compared can then be assumed to depend on different assessments of where the borders should be placed on an ecological scale.

The first step in this process was to compile the methods and metrics used in the different Nordic countries. This metadata compilation was performed at the fourth Nordic workshop in June 2003.

Since the metadata compilation focused on the core types in the Northern IC region, Denmark's methods and metrics have so far not been included. Finland was not able to compile their metadata for rivers by the end of this project and their methods and metrics for rivers are therefore not included in the compilation. The results can be viewed in appendix 6 for rivers and appendix 7 for lakes. Only the quality elements that are included in the monitoring in at least two Nordic countries have been included in the appendices. Excluded quality elements are macrophytes in lakes (data available mainly from Sweden) and phytobenthos in rivers (data available only from Norway). Nevertheless, these QEs may be included in the future IC as two or more countries included in the Northern GIG have indicated that they have relevant monitoring data (see table 12 and 13).

Compilation of methods and metrics used in the different monitoring programs revealed some differences between the Nordic countries. These differences mainly constitutes of different monitoring strategies (for instance sampling frequency versus number of replicates per site). Sampling frequency depends for instance on how available national funds for monitoring is prioritized. Although the national monitoring programs show some methodological differences, the Nordic methods are still quite similar which should make comparison of monitoring results possible. However, improvements by increased coordination of the countries' monitoring strategies are possible. The metrics (e.g. taxonomic composition and diversity) and indices (e.g. Medin acidification index and Danish Stream Fauna index) used differ also between countries. The differences are partly related to how the parameters are defined – for instance, Shannon-Wiener index has been used as a measure of taxonomic composition but also as a measure of species diversity. Some metrics are only measured in one country, which does not make them useful in the intercalibration exercise. A test of the comparability between indices is planned to be performed during the intercalibration exercise.

The noted differences will have to be evaluated further to find out which differences that are of importance for the comparability of data. A state of the art comparison is presented below:

Rivers:

Macroinvertebrates (Sweden, Norway and Finland):

Sweden, Norway and Finland use the kick-sampling method but there are slight differences. To some degree, different metrics are also used for measuring taxonomic composition. Otherwise a lot seem to be comparable (at least between some monitoring programs), one example is measurement of abundance.

Fish (Sweden, Norway and Finland):

The same standard sampling method (established as a result of Nordic cooperation) is used and also the metrics used are highly comparable. The main differences are related to the low species richness in Norwegian rivers compared with the other countries, leading to some differences concerning indicator taxa and indices based on these taxa.

Lakes:

Phytoplankton (Sweden, Finland and Norway):

A lot of metadata is comparable, for instance sampling frequency and level of taxonomic composition. However, the parameters used for measuring of taxonomic composition are somewhat different.

Macroinvertebrates, littoral (Sweden and Norway):

Many aspects seem to be comparable, but one of the important differences is how taxonomic composition is measured.

Macroinvertebrates, profundal (Sweden and Finland):

The monitoring programs on profundal macroinvertebrates in Sweden and Finland are comparable with regard to sampling method (Ekman grab) although Finland also uses a core sampler in some cases. However, the parameters used for measurement of taxonomic composition differ.

Fish (Sweden, Norway and Finland):

Sweden's and Finland's monitoring programs and Norway's monitoring of acidification effects seem highly comparable, even the same standard method is used. The main differences are related to the low species richness in Norwegian rivers compared with the other countries, leading to some differences concerning indicator taxa and indices based on these taxa. However, Norway's National Eutrophication Survey differs a lot from the other programs.

7.3 Selection of pressure types, quality elements and metrics for intercalibration

Nutrient/organic loading and acidification were identified as the most relevant pressure types to include in the intercalibration for the Northern Ecoregion. Whereas nutrient loading overall is one of the most severe threats to the maintenance of good water quality in Europe, acidification is affecting large areas in the Nordic countries and is partly unique for this region. Based on the selection of pressure types and the results from the compilation and comparison of monitoring data selection of quality elements, metrics and parameters/indices were performed. These issues were focused in 2004, at the fifth and sixth Nordic workshops, and the results of these discussions are presented in table 11.

Table 11 Overview of which pressures, biological quality elements, metrics and parameters/indices that are suggested to be included in the intercalibration exercise for the Northern Intercalibration Group.

Pressure	Quality element	Metric	Parameter/Index
Nutrient loading - Lakes	Phytoplankton Macrophytes?	Abundance Composition ?	Chl a Biovolume (BioV) % Cyanobacteria % Chrysophytes ?
Nutrient loading – Rivers	Macroinvertebrates	Sensitive taxa	ASTP DSFI AQEM approach?*
Acidification - Lakes	Macroinvertebrates (littoral) Fish?	Sensitive taxa Abundance Composition Sensitive taxa	Raddum index, I and 2 Medin index AQEM approach?*CPUE Total number of species % acidity sensitive species
Acidification - Rivers	Macroinvertebrates	Sensitive taxa	Raddum index, I and 2 Medin index AQEM approach?*

Relative abundance of Cyanobacteria (%) may be a relevant parameter in the assessment of eutrophication. However, it is pointed out that this may not work in the high alkalinity lowland lakes. Clear water blooming taxa like *Merismopedia* and two cyanobacterians, *Anabaena lemmermanni* and *Anabaena flos-aquae*, should be subtracted to make this parameter applicable. Relative abundance between chrysophytes and cyanobacteria could also be useful.

Norway and Sweden have some data on macrophytes (lakes: eutrophication). However, it is uncertain if there is enough data available to include this quality element in the intercalibration. The same may be true for fish (lakes: acidification), although both Norway and Sweden have indicated that fish data is available from some of the intercalibration sites. The reported intercalibration sites probably include only some few sites

on the boundaries for fish, since the intercalibration sites have not been selected based on fish criteria.

It was decided to investigate the possibilities of using the AQEM⁵ approach to compare/calibrate national methods. The AQEM approach can be used for both eutrophication and acidification pressures. A AQEM assessment software is designed to assess the ecological status of 28 river types throughout Europe.

7.4 Selection of intercalibration sites

The types suggested for the Northern intercalibration group at EU-level in the beginning of 2004 were to a high extent the same as the first version of the Nordic Core Types (types given priority 1, see appendix 2). Only one lake type (L-N8) and two river types (R-N4 and R-N9) were suggested through the paneuropean intercalibration network and, of these, two types had already been suggested as Nordic Core Types (types given priority 2, see appendix 2). After the fourth Nordic workshop preliminary intercalibration sites in the Nordic and Central Core Types were identified by each country. After the fifth Nordic workshop the countries revised the intercalibration register that was finalized in October 2004. How the Nordic countries have selected their intercalibration sites can be viewed in appendix 5.

To perform the intercalibration exercise it is necessary that at least two countries have comparable monitoring data (data exists for the same quality elements and comparable metrics are used) from comparable types affected by the same pressure type. Acidification and eutrophication was identified as the most important pressures for the Nordic lake and river types through discussions at the third Nordic workshop. Stream modification was also thought to be important for some river types, but to identify water bodies that mainly are affected by this pressure was considered difficult. For Central rivers, eutrophication and stream modification (especially important in Denmark) was thought to be the main pressures. There has to be a total of at least five sites from at least two countries on a specific pressure boundary, moreover each country needs at least two sites at the same boundary. As shown below some types have no sites submitted, some types have too few sites submitted for a certain pressure and/or boundary and others only have sites submitted from one country. However, through the intercalibration exercise all countries seek to include more sites, both to increase the number of sites at the high/good and good/moderate borders and to broaden the pressure gradient.

⁵ 5th Framework Programme: The Development and Testing of an Integrated Assessment System for the Ecological Quality of Streams and Rivers throughout Europe using Benthic Macroinvertebrates

7.4.1 Nordic lake types

Currently, there are six types which have at least five sites from more than one country on a specific pressure boundary with two or more sites in each country and are, thus, suitable for intercalibration (see table 12). Some of the types have too few sites submitted for a certain pressure and/or boundary, and others only have sites submitted from one country. So far sufficient number of sites exists for type L-N1 (eutrophication: both borders), L-N2a (eutrophication: both borders), L-N2b (eutrophication: high/good border), L-N3 (eutrophication: both borders; acidification: good/moderate border) L-N5 (eutrophication: high/good border; acidification: both borders) and L-N6 (acidification: both borders), L-N8 (eutrophication: good/moderate border)

The geographical distribution of the selected Nordic lake sites belonging to the Northern IC types are presented in figure 2 and 3.

7.4.2 Nordic river types

Currently, there are six river types which have at least five sites from more than one country on a specific pressure boundary with two or more sites in each country and are, thus, suitable for intercalibration (see table 13). Some of the types have too few sites submitted for a certain pressure and/or boundary. At this stage it appears that there are sufficient sites in R-N1 (eutrophication; both borders), R-N2 (acidification: both borders), R-N3 (eutrophication: both borders), R-N4 (eutrophication, good/moderate border), R-N5 (acidification: both borders) and R-N9 (acidification: good/moderate border).

The geographical distribution of the selected Nordic river sites belonging to the Northern IC types are presented in figure 4 and 5.

Table 12 Northern lakes: Overview of numbers of intercalibration sites with selected pressures by country based on the intercalibration register established in October 2004 with some later amendments in the final version (2005/646/EC). Only IC relevant biological QE (nutrient loading: phytoplankton and macrophytes; acidification: macroinvertebrates and fish) are indicated.

Type	Lake characterisation	Nutrient loading				
		FI	SE	NO	UK	IE
L-N1	Lowland, shallow, siliceous (moderate alkalinity), clear large			2 E1 + 4 E2 Phytoplank Macrophyt*	4 E1 + 3 E2 Phytoplank Macrophyt	2 E1 + 2 E2 Phytoplank Macrophyt*
L-N2a	Lowland, shallow, siliceous (low alkalinity), clear, large			2 E1 + 0 E2 Phytoplank	5 E1 + 6 E2 Phytoplank Macrophyt	3 E1 + 2 E2 Phytoplank Macrophyt*
L-N2b	Lowland, deep, siliceous (low alkalinity), clear, large			3 E1 + 0 E2 Phytoplank	8 E1 + 2 E2 Phytoplank Macrophyt	
L-N3	Lowland, shallow, organic, large	4 E1 + 4 E2 Phytoplank	1 E1 + 2 E2 Phytoplank Macrophyt*	4 E1 + 4 E2 Phytoplank Macrophyt*		
L-N5	Boreal, shallow, siliceous (low alkalinity), clear, large		3 E1 + 0 E2 Phytoplank Macrophyt*	2 E1 + 1 E2 Phytoplank		
L-N6	Boreal, shallow, organic, large		2 E1 + 0 E2 Phytoplank	2 E1 + 0 E2 Phytopl		
L-N8	Lowland, shallow, mixed geology (moderate alkalinity, organic), large	1 E1 + 3 E2 Phytoplank		1 E1 + 7 E2 Phytoplank		

Type	Lake characterisation	Acidification				
		FI	SE	NO	UK	IE
L-N3	Lowland, shallow, organic, large		0 A1 + 4 A2 Macroinv	0 A1 + 2 A2 Macroinv Fish		
L-N5	Boreal, shallow, siliceous (low alkalinity), clear, large		4 A1 + 2 A2 Macroinv Fish*	3 A1 + 5 A2 Macroinv Fish	4 A1 + 3 A2 Macroinv	
L-N6	Boreal, shallow, organic, large		4 A1 + 3 A2 Macroinv Fish*	2 A1 + 5 A2 Macroinv Fish		

A1 Acidification is the most important pressure, site classified as at the quality class boundary 'High-Good'. **A2** Acidification is the most important pressure, site classified as at the quality class boundary 'Good-Moderate'. **1** Eutrophication is the most important pressure, site classified as at the quality class boundary 'High-Good' **E2** Eutrophication is the most important pressure, site classified as at the quality class boundary 'Good-Moderate' * Data only available for some few sites.

Table 13 Northern rivers: Overview of numbers of intercalibration sites with selected pressures by country based on the intercalibration register established in October 2004 with some later amendments in the final version (2005/646/EC). Only IC relevant biological QE (macroinvertebrates and phyto-benthos) are indicated.

Type	River characterisation	Organic and nutrient loading				
		FI	SE	NO	UK	IE
R-N1	Lowland, small, siliceous (moderate alkalinity), clear			1 E1 + 2 E2 Macroinv Phytobenthos*	5 E1 + 4 E2 Macroinv Phytobenthos	2 E1 + 2 E2 Macroinv Phytobenthos
R-N2	Lowland, small, siliceous (low alkalinity), clear		1 E1 + 0 E2 Macroinv	4 E1 + 2 E2 Macroinv	0 E1 + 2 E2 Macroinv Phytobenthos	
R-N3	Lowland, small, organic	4 E1 + 4 E2 Macroinv	2 E1 + 3 E2 Macroinv	4 E1 + 1 E2 Macroinv Phytobenthos*	4 E1 + 3 E2 Macroinv Phytobenthos	2 E1 + 2 E2 Macroinv Phytobenthos
R-N4	Lowland, medium, siliceous (moderate alkalinity), clear			1 E1 + 9 E2 Macroinv Phytobenthos*	5 E1 + 4 E2 Macroinv Phytobenthos	
R-N5	Boreal, small siliceous (low alkalinity), clear		1 E1 + 0 E2 Macroinv	3 E1 + 0 E2 Macroinv		
R-N9	Boreal, small-medium, organic		1 E1 + 0 E2 Macroinv	2 E1 + 1 E2 Macroinv		

Type	River characterisation	Acidification				
		FI	SE	NO	UK	IE
R-N2	Lowland, small, siliceous (low alkalinity), clear			3 A1 + 4 A2 Macroinv	6 A1 + 4 A2 Macroinv Phytobenthos	
R-N3	Lowland, small, organic			0 A1 + 1 A2 Macroinv		
R-N5	Boreal, small siliceous (low alkalinity), clear			3 A1 + 7 A2 Macroinv	3 A1 + 3 A2 Macroinv Phytobenthos	
R-N9	Boreal, small-medium, organic		2 A1 + 3 A2 Macroinv	2 A1 + 5 A2 Macroinv		

A1 Acidification is the most important pressure, site classified as at the quality class boundary 'High-Good'
A2 Acidification is the most important pressure, site classified as at the quality class boundary 'Good-Moderate'
E1 Eutrophication is the most important pressure, site classified as at the quality class boundary 'High-Good'
E2 Eutrophication is the most important pressure, site classified as at the quality class boundary 'Good-Moderate'. Data only available for some few sites.

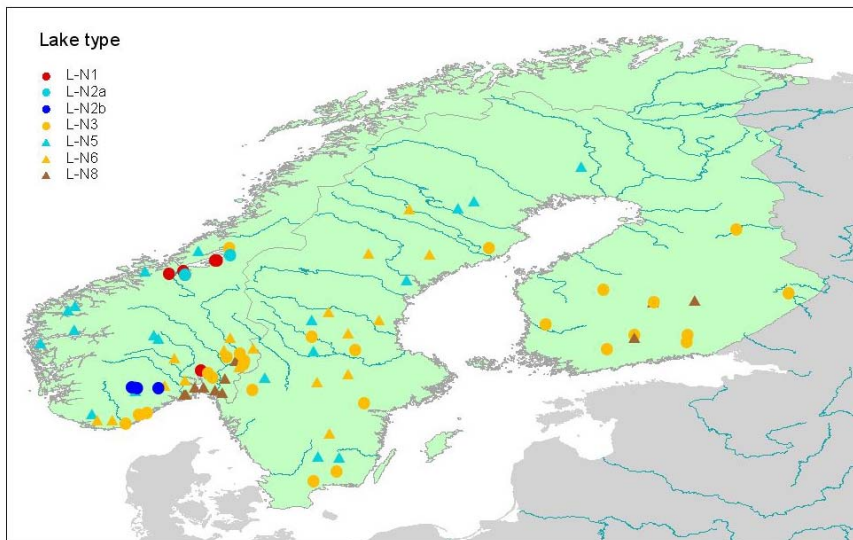


Figure 2 Geographical distribution of Nordic sites belonging to the Northern lake types which have been selected for intercalibration. The sites are sorted according to lake type (see table 12 for further explanation).

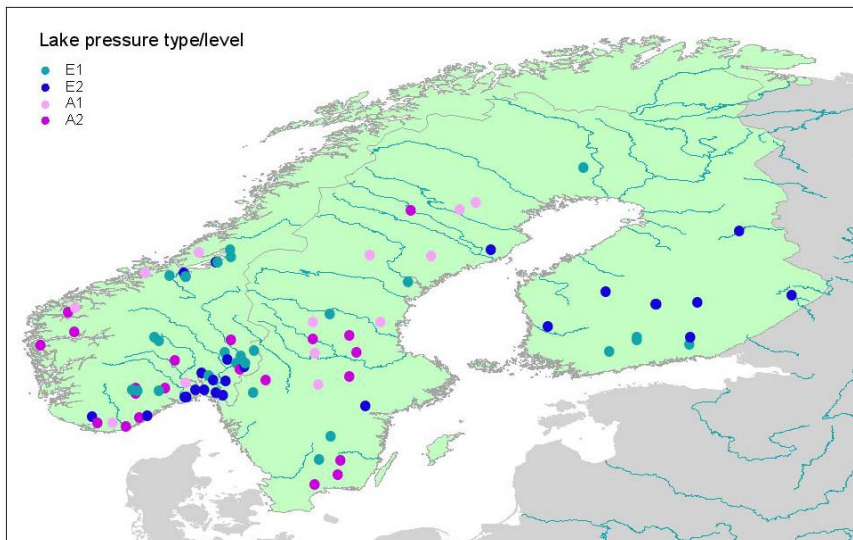


Figure 3 Geographical distribution of Nordic sites belonging to the Northern lake types which have been selected for intercalibration. The sites are sorted according to pressure type and level (see table 12 for further explanation).

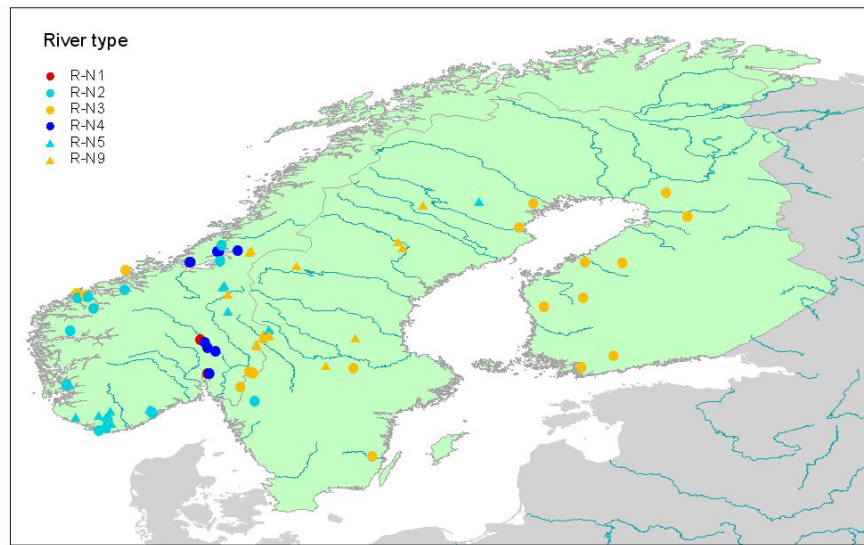


Figure 4 Geographical distribution of Nordic sites belonging to the Northern river types which have been selected for intercalibration. The sites are sorted according to river type (see table 13 for further explanation).

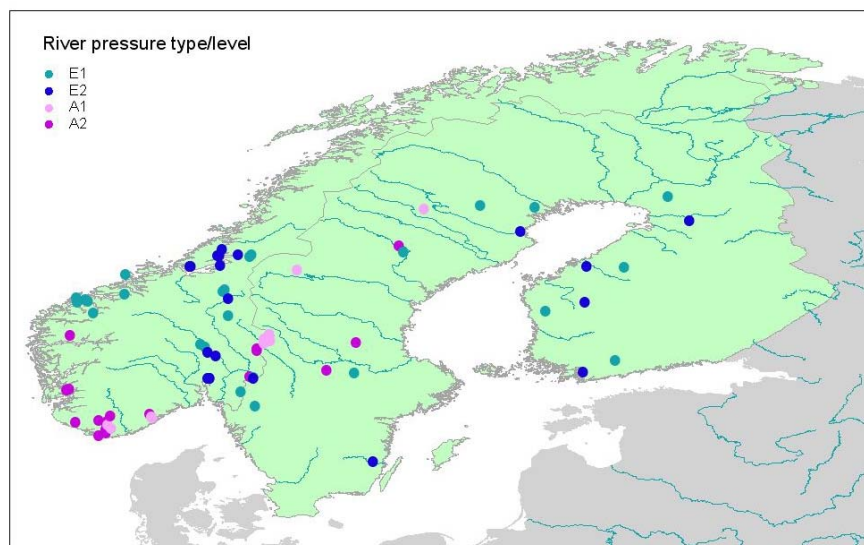


Figure 5 Geographical distribution of Nordic sites belonging to the Northern river types which have been selected for intercalibration. The sites are sorted according to pressure type and level (see table 13 for further explanation).

7.4.3 Central river types

Sweden has preliminary reported two sites on each boundary for type R-C6, as has Denmark (pressure eutrophication). However, no R-C6 sites are included in the IC register for Sweden or for Denmark. Sweden has included two sites belonging to R-C1 (eutrophication) whereas Denmark has included a substantial number of sites for R-C1 as well as R-C3, R-C4 and R-C5. It is therefore unsure whether Sweden will take place in the intercalibration of Central IC types.

8. Assessment of options for intercalibration

Possible options for the intercalibration process were discussed in 2004, at the fifth Nordic workshop. The conclusion was that option 2 (boundaries are set for one simple common assessment method, which then is used to calibrate national assessment systems) should be tested for both eutrophication and acidification, including both lakes and rivers. For the intercalibration of eutrophication chlorophyll a and biovolume (lakes) and ASTP (rivers) might be used as common metrics. Option 1 might be possible to test if two or more countries use the same assessment method. For eutrophication there seems not to be anything like a "Scandinavian" assessment method, neither for lakes or rivers. For instance, the macroinvertebrates and their response to pressures depend highly on the habitat, and the sampling habitat does differ somewhat between countries.

Raddum index and Medin index should be tested for acidification. Option 1 might be applicable for acidified lakes and rivers with the selection of Raddum index as a common method for clear types (L-N5 and R-N5) and Medin index for humic types (L-N6 and R-N9).

It should be kept in mind that depending on what countries that will intercalibrate a specific type different method might be chosen. For instance, one method might be best for intercalibrating Norway, Sweden and Finland and another for UK, Ireland and Norway. Also, intercalibration between neighbouring countries might give the best result. Then other countries might be intercalibrated indirectly if they are intercalibrated with a third, common country.

9. Discussion

By the end of the project (2004) intercalibration sites were only found in a restricted number of the suggested Nordic Core Types. This might seem like a poor result, but it is not very surprising since a lot of factors have to match to make a type possible to use in the intercalibration exercise. The first difficulty is the Nordic Core Types are represented with few sites with available monitoring data. The establishment of core types gives rise to comparable types, but also eliminates many of the existing monitoring sites, which for different reasons do not fit into the types. However, it is a requirement in the WFD that the intercalibration shall take place between similar types, and the use of types cannot be avoided. It can of course be possible to make broader types by combining categories (for instance combining very shallow, shallow and deep lakes into one category including all depth), as long as this allows ecological important factors to be taken into consideration in the assessment of ecological status. What is of ecological importance in the respect of ecological assessment is continuously being evaluated in the Nordic countries and the result might provide information that can lead to formation of broader or more narrow types in the future.

Another problem that eliminates several monitoring sites is that the countries do not monitor the same quality elements. In the future it is possible that harmonization of the countries' monitoring programs will take place in at least a selected number of stations that can be used for calibration between the countries. This could eventually lead to a larger number of comparable monitoring sites, but does not solve the problem at hand.

Several difficulties rise also with the definition of intercalibration sites. First the countries have to have sites that are estimated to be on the relevant borders in the selected Nordic Core Types. That there will be sites on the borders are not obvious since different monitoring programs were created for different reasons. Examples is monitoring of reference sites that are unlikely to experience a high degree of pressure or sites selected to be affected by a specific pressure, which therefore are unlikely to be affected by other pressures. Secondly more than one country has to have intercalibration sites in the same type, at the same boundary, influenced by the same pressure and of course data for the same quality element. Due to all the criteria that have to be fulfilled it is quite remarkable that any of the core types seem possible to use in the intercalibration exercise.

The goal is to achieve full sets of data for intercalibration, meaning at least five sites at each boundary including essential elements for the rele-

vant pressure, for as many core types as possible. Continued evaluation of possible intercalibration sites and other sites to facilitate the intercalibration (although not included in the IC register), will take place during the intercalibration exercise. Even though the usage of common Nordic Core Types leaves few possible types in the end, it is still believed to be the most efficient way of locating common intercalibration types. That the evaluation process excludes many types along the way is believed to be impossible to avoid due to all the criteria that has to be fulfilled.

Compilation of methods and metrics used in the different monitoring programs revealed some differences between the Nordic countries. These differences mainly constitute of different monitoring strategies (for instance sampling frequency versus number of replicates per site) but, for some quality elements and pressures, also the metrics and indices used differ between countries. Nordic methods are still quite similar which should make comparison of monitoring results possible. However, improvements by harmonization and adjustment of the countries' monitoring strategies are possible. This was the objective of a Nordic project on Coordination of intercalibration, reference sites and monitoring methods which took place in 2005–2006.

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Norsk sammendrag

Prosjektet “Utvikling og evaluering av felles nordiske ferskvannstyper” ble etablert for å kunne imøtekomme kravet fra Vannrammedirektivet med hensyn på sammenlignbare metoder og tilnærmingsmåter for vurdering av økologisk status til vann. Sverige, Finland, Norge, Danmark og Island har deltatt i prosjektet. Målet for prosjektet har vært å etablere en basis for utvikling av sammenlignbare vurderingssystemer for fastsettelse av økologisk status og harmonisering av økologiske kvalitetskriterier for overflatevann.

Basert på eksisterende nasjonale typologisystemer, informasjon fra veiledere utarbeidet av EUs arbeidsgrupper 2.3 (REFCOND) og 2.5 (Intercalibration) samt ekspertvurderinger er det utviklet en foreløpig nordisk typologi for innsjøer og elver. Denne typologien bygger på System B i Vannrammedirektivet. Innsjø- og elvetyper som er antatt å være vanlige i minst to av de nordiske landene er forelått som nordiske kjernetyper og utgjør basisen i interkalibreringstypene innenfor Northern Intercalibration Group (Northern GIG). Hver enkelt kjernetype representerer en eller flere nasjonale ferskvannstyper. Forslaget til nordiske kjernetyper har gjennomgått en kontinuerlig evaluering og revidering gjennom prosjektperioden. Avslutningsvis ble kjernetyperne evaluert ved å undersøke om det var mulig å finne tilhørende overvåkingslokaliteter som kunne inngå i interkalibreringen. Dette ble gjort nasjonalt og typene samt interkalibreringslokalitetene ble rapportert til EU våren 2004. I første omgang ble et tilstrekkelig antall interkalibreringslokaliteter funnet kun for et begrenset antall nordiske kjernetyper. Syv innsjøtyper og seks elvetyper ble vurdert å kunne inngå i interkalibreringen. Disse tilfredsstillende følgende kriterier:

- totalt finnes det minimum fem overvåkingslokaliteter tilhørende typen som representerer samme grense mhp. økologisk status (høy/god, god/moderat), og
- minimum to land har overvåkingslokaliteter som representerer den samme grensen, og
- *hvert land har minimum to lokaliteter per grense.*

For enkelte typer er det totale antall overvåkingslokaliteter for lavt mens andre kun er representert med overvåkingsdata fra ett land.

Danmark kom med i prosjektet fra 2003. Arbeidet ble da utvidet til også å gjelde kjernetyper som grunnlag for en mulig interkalibrering mellom Danmark og Sverige i Central GIG. Få kjernetyper tilhørende denne økoregionen er etablert og for innsjøer har det ikke vært mulig å etablere noen felles svensk-danske typer. På grunn av prosjektets fokusering på

nordiske kjernetyper valgte Danmark å trekke seg ut av arbeidet i 2004 og samtidig kom Island inn som observatør.

Eutrofiering/organisk belastning og forsurening er identifisert som de mest relevante påvirkningstypene i interkalibrering av nordiske ferskvannstyper. Mens eutrofiering generelt er en av de mest alvorlige truslene i forhold til opprettholdelsen av god vannkvalitet i Europa så påvirker forsurening store arealer i de nordiske landene og er delvis unikt for denne regionen.

Med utgangspunkt i de valgte påvirkningstypene og resultater fra sammenstilling og sammenligning av overvåkingsdata er kvalitetselementer, parametre og indekser for bruk i interkalibreringen valgt ut. For eutrofiering/organisk belastning er planteplankton vurdert som det mest relevante kvalitetselementet mhp. innsjøer og for elver er invertebrater mest relevant. Også høyere vannplanter (makrofytter) vurderes som relevant for innsjøer. Med hensyn på forsurening er invertebrater foreslått både for innsjøer og elver mens fisk vurderes også som relevant for innsjøer.

Tre ulike alternativer for gjennomføring av interkalibreringen er presentert i dokumentet "Guidance on the intercalibration process". For interkalibreringen i Northern GIG vurderes alternativ 2 (grenseverdier er satt med basis i en felles vurderingsmetode som deretter benyttes for å kalibrere nasjonale vurderingssystemer) som mest aktuelt, både for eutrofiering/organisk belastning og forsurening. Kalibrering av nasjonale indekser vil derfor først ferdigstilles gjennom interkalibreringsøvelsen.

Det er avholdt seks nordiske arbeidsmøter med deltagelse fra forskningsinstitutter og nasjonale miljøforvaltningsetater. Disse arbeidsmøtene har vært av avgjørende betydning for prosessen og resultatene fra prosjektet. På møtene har informasjon om nasjonale og internasjonale aktiviteter blitt utvekslet, resultater har blitt presentert, problemer diskutert og det er fattet enighet om videre aktiviteter og framdrift. I tillegg har det vært aktivitet i hvert enkelt land mellom møtene, noe som også har betydd en høy grad av løpende koordinering og informasjonsutveksling. Resultater fra prosjektet har blitt brukt i den EU koordinerte prosessen for interkalibreringsarbeidet. Interkalibreringstypene foreslått for den nordiske økoregionen (interkalibreringen gjennomføres av Northern GIG) har nesten i sin helhet blitt basert på nordiske kjernetyper. Også utvalget av påvirkningstyper, kvalitetselementer, parametre og indekser som er foreslått inkludert i interkalibreringen er basert på resultater fra det nordiske prosjektet.

Appendix 1: Nordic Workshops on Freshwater Typology

Workshop 1	
Title	First Nordic workshop on Freshwater Typology
Date	17–18 June 2002
Venue	SFT Conference Centre, Helsefyr, Oslo, Norway
Local organiser	Norwegian Institute for Water Research, Norwegian Institute for Nature Research, Norwegian Directorate for Nature Management, Norwegian Pollution Control Authority
Objective	To elaborate drafts for a common Nordic typology for lakes and rivers to be used for implementation of the Water Framework Directive (WFD).
Workshop 2	
Title	Second Nordic Workshop on Freshwater Typology
Date	9–10 October 2002
Venue	Swedish Environmental Protection Agency, Stockholm, Sweden
Local organiser	Swedish Environmental Protection Agency
Objective	To continue the work of the Oslo workshop with trying to find a reduced amount of common types for the Nordic countries, which could be used for the intercalibration of lakes and rivers. To complete the application to the Nordic Council of Ministers (NMD) about a joint Nordic project with the purpose to evaluate common Nordic core types, and to agree on a strategy for future work.
Workshop 3	
Title	Third Nordic Freshwater Typology Workshop
Date	6–7 March 2003
Venue	Finnish Environment Institute, Helsinki, Finland
Local organiser	Finnish Environment Institute
Objective	The objective for the workshop was to continue the work of earlier workshops in Oslo and Stockholm in 2002. Trying to find a reduced amount of common types for the Nordic countries, which could be used for the intercalibration of lakes and rivers. More specifically the aim was to continue revising the proposed core types, to give some preliminary estimation of existing core types and their distribution in the Nordic countries, discuss pressure types, data needs and joint collaboration possibilities towards selecting intercalibration sites. Also Nordic revisions to the preliminary lake and river typologies presented in Lake and river expert meeting in JRC, Ispra 19 - 21.2.2003 were defined. Nordic Council of Ministers has given financial support for the Nordic Core Typology Project for the year 2002 and again for 2003 and the work in the project was preliminarily planned for this year.

Workshop 4	
Title	Fourth Nordic Workshop on Freshwater Typology
Date	12 - 13 June 2003
Venue	Swedish Environmental Protection Agency, Stockholm, Sweden
Local organiser	Swedish Environmental Protection Agency
Objective	To see which data that is available for the selected common Nordic core types for lakes and rivers, leading to a selection of the types that the countries will report possible intercalibration sites from. Evaluation of the methods used and for which types that joint reference sites can or needs to be used shall also take place. To discuss further work, such as writing of project report and the possibility to apply for a new NMD project to continue the Nordic cooperation.
Workshop 5	
Title	Fifth Nordic Workshop on Freshwater Typology
Date	15 -16 March 2004
Venue	Swedish Environmental Protection Agency, Stockholm, Sweden
Local organiser	Swedish Environmental Protection Agency
Objective	To evaluate suggested new Nordic core (intercalibration) types based on the result of data availability compilation. To discuss and agree on a process for performing a test of the intercalibration exercise and for calibration of national indices that will be used for establishment of ecological status. To discuss suggested options for intercalibration (ECOSTAT draft guidance on intercalibration) and agree on proposal for Northern GIG. To discuss comparability of methods and metrics. Agree on the organisation of upcoming work within the Northern GIG (Geographical Intercalibration Group)
Workshop 6	
Title	Sixth Nordic Workshop on Freshwater Typology
Date	3 - 5 November 2004
Venue	Norwegian Pollution Control Authority, Oslo, Norway
Local organiser	Norwegian Pollution Control Authority
Objective	The main purpose of the workshop was to start the intercalibration pilot test of selected types. The objective of the test intercalibration was to: - discuss and agree on a preliminary understanding of the principles of defining reference conditions - achieve a clearer picture of possible class boundaries - discuss the boundary setting protocol, - agree on which quality elements should be intercalibrated. Further objective was to formulate a detailed work plan for the rest of the intercalibration exercise and to discuss the way forward of the NMD-project.

Appendix 2: Possible Nordic Types

Lakes

Index	Altitude	Size	Depth	Geology	Priority	
L1	L	s	Vs	Ca	2	Altitude L = lowland (below 200 m or highest coast line/Littorina sea) B = boreal H = highland (above 800 m or tree line)
L2	L	s	Vs	Si		
L3	L	s	Vs	SP	2	
L4	L	s	Vs	CP		
L5	L	s	S	Ca	1	
L6	L	s	S	Si	2	Size s = small (0,5 – 5 km ²) m = medium size (5 – 40 km ²) l = large (> 40 km ²)
L7	L	s	S	SP	1	
L8	L	s	S	CP		
L9	L	m	S	Ca		
L10	L	m	S	Si	1	
L11	L	m	S	SP		
L12	L	m	S	CP		
L13	L	m	D	Si	2	
L14	L	l	D	Si		
Index	Altitude	Size	Depth	Geology	Priority	
B1	B	s	Vs	Si	1	Depth Vs = very shallow (<3 m) S = shallow (3 – 15 m) D = > 15 m
B2	B	s	Vs	SP		
B3	B	s	S	Ca	2,5	
B4	B	s	S	Si	1	
B5	B	s	S	SP	1	
B6	B	s	S	CP		Geology Ca = calcareous (alk. > 0,2 meq/l) Si = siliceous (alk. < 0,2 meq/l) SP = siliceous, peat (alk. < 0,2 meq/l and humus > 30 mg Pt/l) CP = calcareous, peat (alk. > 0,2 meq/l and humus > 30 mg Pt/l) = mixed geol.
B7	B	s	D	Si		
B8	B	s	D	SP		
B9	B	m	Vs	SP		
B10	B	m	S	Ca		
B11	B	m	S	Si	1	Priority Highest priority (=1) is given to lake types that are common for at least two countries, and given high priority by at least one of these.
B12	B	m	S	SP	2	
B13	B	m	D	Si		
B14	B	m	D	SP		
B15	B	l	S	Si		
B16	B	l	S	SP		
B17	B	l	D	Si		
Index	Altitude	Size	Depth	Geology	Priority	

H1	H	s	Vs	Si	2
H2	H	s	S	Ca	
H3	H	s	S	SP	2
H4	H	s	S	Si	1
H5	H	s	S	CP	
H6	H	s	D	Si	
H7	H	m	S	Si	2
H8	H	m	S	CP	
H9	H	m	D	Si	2
H10	H	l	D	Si	

Rivers

Index	Altitude	Size	Geology	Priority
L1	L	s	Ca	1
L2	L	s	Si	1
L3	L	s	SP	1
L4	L	m	Ca	
L5	L	m	Si	
L6	L	m	SP	
L7	L	l	Ca	
L8	L	l	Si	
L9	L	l	SP	

Altitude
 L = lowland (below 200 m or highest coast line/Littorina sea)
 B = boreal (between lowland and highland)
 H = highland (above 800 m or tree line)

Size
 s = small (0 – 100 km²)
 m = medium size (100 – 1000 km²)
 l = large (1000 - 10000 km²)

Index	Altitude	Size	Geology	Priority
B1	B	s	Ca	
B2	B	s	Si	1
B3	B	s	SP	2
B4	B	m	Ca	
B5	B	m	Si	1
B6	B	m	SP	
B7	B	l	Ca	
B8	B	l	Si	
B9	B	l	SP	

Geology
 Ca = calcareous (alk. > 0,2 meq/l)
 Si = siliceous (alk. < 0,2 meq/l)
 SP = siliceous, peat (alk. < 0,2 meq/l and humus > 30 mg Pt/l)

Index	Altitude	Size	Geology	Priority
H1	H	s	Ca	
H2	H	s	Si	

H3	H	s	SP
H4	H	m	Ca
H5	H	m	Si
H6	H	m	SP
H7	H	l	Ca
H8	H	l	Si
H9	H	l	SP

Appendix 3: Description of typology and monitoring systems

To give a background of the different conditions in the countries a description of existing typology and monitoring systems is here given. These different conditions were the platform (starting point) of the project and show that coordination of the Nordic efforts is vital to reach useful and comparable result in the intercalibration exercise. The descriptions given here varies between the different countries, for example there is no description of the Norwegian monitoring system here, but some information is instead included in the thorough description of methods and metrics in Appendix 4. Generally, if some information is missing here it is possible that it can be found under Appendix 4 instead.

Typology in Norway

Methods used for revising the preliminary national typology

Preliminary proposal for Norwegian typology for lakes and rivers was presented in 2002 (Lyche-Solheim et al. 2003) and revised in 2004 (Lyche-Solheim & Schartau 2004). The preliminary typology from 2002 has been revised according to results from further statistical testing (correspondence analysis, reciprocal averaging) combined with expert judgment of the differences between the biological communities in lakes and rivers assumed to be in reference conditions. The main biological characteristic used in the revision of the typology is species composition, whereas biomass or abundance has been used only for phytoplankton. Species diversity has been used for benthic fauna, and age structure has been used for fish.

As a starting point for the revision of the lake typology, we have used a database with lake data from the large national monitoring programmes (acidification and eutrophication) (Skjelkvåle et al. 2003). This database includes relevant parameters used in the typology, such as geographic location, altitude, size, depth, Ca (or alkalinity) and colour (or TOC). For sites where data on Ca (or alkalinity) and colour (or TOC) were missing, these parameters were estimated from a geostatistical model using a large dataset with Nordic water chemistry from 3500 lakes in Norway, Sweden and Finland as input data (Henriksen et al. 1998). The model results were found to be correct for 80% of the sites.

Norwegian ecoregions

Norway has chosen system B for typology, since the ecoregions used in system A (Illies ecoregions) does not correspond to the biological distribution patterns and climatic variation found in Norway. The Norwegian ecoregions has been defined according to the boundaries between major river basins and biological distribution patterns (figure 3.1). The ecoregions thus defined are:

- Eastern Norway (border between Eastern Norway and Southern Norway follows the western border of Telemark county)
- Southern Norway (border between Southern Norway and Western Norway is set west of Egersund; Jæren area is included in Western Norway)
- Western Norway (border between Western Norway and Central Norway is set at River Rauma)
- Central Norway (border between Central Norway and Northern Norway is set in the mountain area Saltfjellet)
- Northern Norway, coastal areas
- Northern Norway, inland areas

It is only two of these ecoregions: eastern and mid-Norway, which is comparable to the natural conditions found in the selected Nordic core types. Thus all the sites selected for intercalibration within the Northern intercalibration group have to be within these two ecoregions. Norway may intercalibrate western Norway with Scotland and Ireland.

Lake types

The revised typology yields up to 23 lake types of common occurrence per ecoregion. These types represent the large majority of Norwegian lakes. Many of the biological elements are not significantly different in the different ecoregion (i.e. phytoplankton). The reference conditions thus will be similar for these elements regardless of ecoregion. For other elements, such as fish and benthic fauna, the differences are significant between ecoregions, and accordingly these elements will be different in the same lake types in different regions. Due to insufficient depth data the relevance of lake depth in characterization of lake types have only been tested statistically against phytoplankton composition. However, based on expert judgment we do not expect any major differences between deep and shallow lakes for any of the biological elements included in the typology so far. The only exception is the fish community, which is different in very shallow, versus deeper lakes in some of the ecoregions (i.e. Central Norway). Another argument for excluding depth in the Norwegian typology is that < 5% of Norwegian lakes > 0.5 km² are very shallow. Our data does not include benthic profundal fauna. It is likely that

this biological element will be different in deep versus shallow lakes. Our analyses have so far not included diversity and abundance characteristics. If later analyses of these characteristics show depth response, then some of the lake types must be split into depth categories.

It is likely that deep and shallow lakes will respond differently to pressures (esp. for eutrophication), which means that although the reference conditions are rather similar, the indices to be developed in the future classification system will have to distinguish between deep and shallow lakes, when defining boundaries between the different classes of ecological status.

Concerning lake size, both small (0.5–5 km²) and very small (0.02–0.5 km²) lakes are merged in the revised Norwegian typology, due to lack of significant biological differences. Medium sized (5–40 km²) and large lakes (> 40 km²) are also merged for the same reason. Again the exception is fish, which are different in large versus medium sized lakes. For the largest lakes in Norway this problem can be circumvented by using site specific instead of type specific reference conditions. This is in line with the Swedish typology (Fölster et al. 2003). If future analyses of diversity and abundance suggest size differences, the present lake types should be split into size categories at some later stage in the implementation process.

Lakes with moderate alkalinity (Alk: 0.2–1 meq/L; Ca: 4–20 mg/L) are also merged with calcareous lakes (Ca > 20 mg/L) since only macrophytes differ between these two categories and calcareous lakes are rare in Norway. If later analyses show that calcareous lakes have different flora and fauna, then separate description of their reference conditions will be necessary.

River types

The revision of the preliminary typology concluded with up to 14 significantly different river types of common occurrence for each ecoregion in Norway. The types are separated according to catchment size, alkalinity and colour (humic content or peat geology). If including slope as a criterion, the number of types increases to maximum 28 common types per ecoregion. Since most rivers in Norway shifts between fast-flowing and slow-flowing parts over very short distances, slope has not been found useful when identifying water bodies in rivers. For river reaches including both fast-flowing and slow-flowing parts, both habitats should however be included in the description of reference conditions.

Small and medium sized rivers are merged, due to lack of significant biological differences. Rivers with moderate alkalinity in boreal areas have been assumed to be rare, and this river type is thus not included in the present typology. New data indicate however that boreal rivers with moderate alkalinity (clear and humic) should be included in the revised typol-

ogy. Rivers in highland areas with moderate alkalinity or high humic concentration are also rare in Norway, and these types are thus excluded from the present typology.

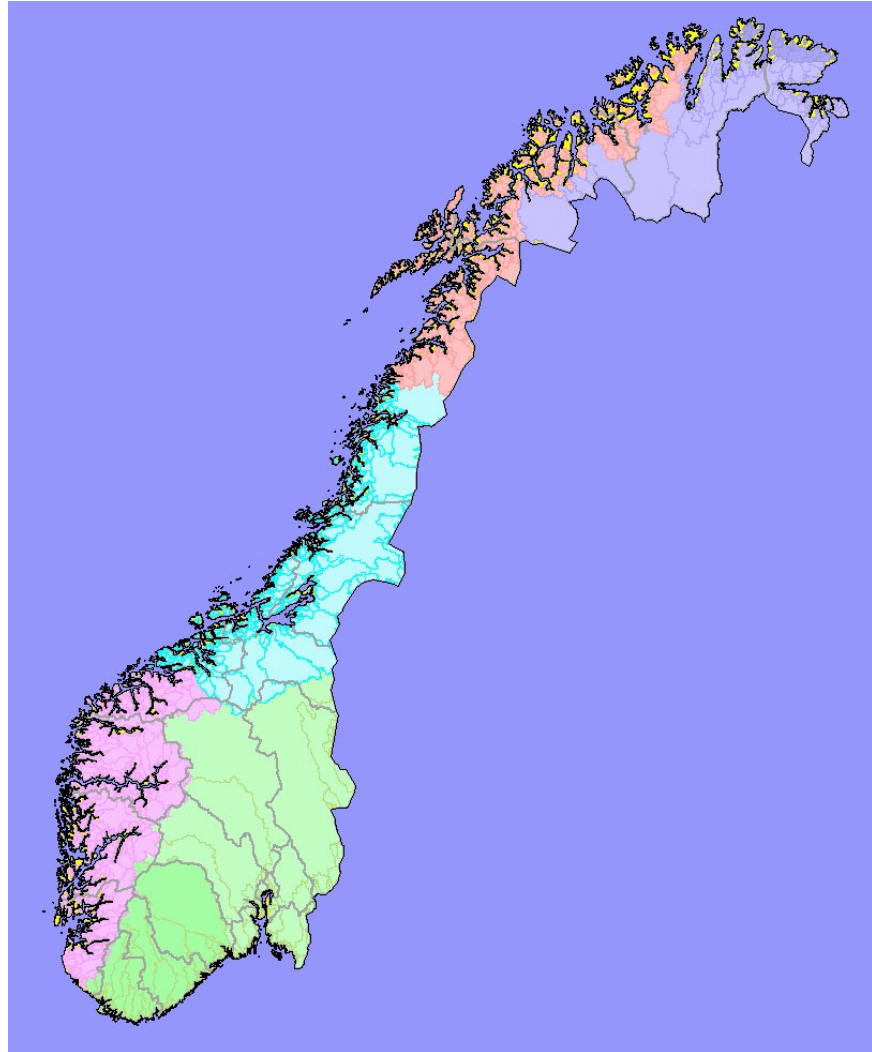


Figure 3.1. Norwegian geographical regions ("ecoregions"), based upon biological distribution patterns and major river basin boundaries. Grey lines show county boundaries.

Typology and monitoring in Finland

Status of the national development of typology

Preliminary proposal of Finnish typology was presented in 2002 (Pilke et al. 2002). River typology was based on system B of the WFD (EU 2000), using obligatory factors of the directive: size of catchment, geology (siliceous, organic, clay soil) and altitude. According to the proposal there were altogether 16 river types. Also the lake typology was based on system B. Following obligatory factors were used: altitude or latitude for differentiating lakes of northernmost Lapland, geology (nutrient richness, calcium, organic soil) and area of the lake. Major part of lakes will be differentiated with the help of lake area and water humic content. As regards number of lakes, small and middle-sized lakes of medium or high humic content are the most frequent types, but measured by area large lakes with low or medium humic content have the dominating percentage. Several additional factors have been proposed to be examined in the future work: depth or summer stratification characteristics, residence time, waterlevel fluctuation. According to the preliminary proposal lake typology using summer stratification as additional factor would define 15 lake types.

The principles of typology are elaborated during the development of national ecological classification system. In 2003 the proposal for typology was tested in several river basins. In these tests focus has to a large extent been on the working methods of the actual differentiation of water bodies to types. However, the feed-back is needed and essential also for the overall development of classification principles.

Issues of importance for the national typology are originating in the typical features of water bodies in Finland. The percentage of water area in many catchments is high, especially in the lake district in eastern and central Finland. This is a common feature for the Fenno-Scandian countries. But in Finland the phenomenon is most extreme, because e.g. terrain is relatively flat. Number of very large lakes (area larger than 100 km²) is high, 47 lakes. These very large and also other large lakes, both of which often have extremely high values of shoreline development, are challenging in typology and classification. Another important issue is related to the high percentage of peat land in drainage basins. It is also common characteristic in the North and very extreme in Finland. The median TOC concentration in the Nordic Lake Survey was 1.87 mg/l in Norway, 6.07 mg/l in Sweden, 7.40 mg/l in Denmark and 7.64 in Finland (Henriksen et al. 1998). The 95th percentiles were correspondingly 10.54 mg/l, 19.73 mg/l, 19.04 mg/l and 22.90 mg/l (Kortelainen 1999).

Status in the development of monitoring programmes

Finnish national monitoring programmes have been established for the years 2003–2005 (Niemi & Heinonen 2003). In water status monitoring the river network includes some 190 sites and the lake network some 250 sites. Both are based on an earlier monitoring programmes originating from the 1960s. In addition to water quality, phytoplankton is being monitored on lake sites. For the year 2003 the needs of the WFD could be taken into account only indicative of the overall principles, because of the early phase of development of classification. However, the programme for the remaining years will be adjusted in minor details, according to development and monitoring resources.

In Finland the local pollution control monitoring produces a considerable part of the water quality and biological data. This monitoring is paid by the polluter and is mostly carried out by consultants. There are altogether more than 4000 river, lake and coastal water sites in this monitoring. Biological elements are monitored on ca. 300 sites (Vuoristo & Pilke 2002). The guidelines of this monitoring need to be adapted also to the requirements of the WFD. Working groups are facilitating this task.

Rivers

In 2002, a proposal on river typology was given in a report of the project 'developing river monitoring system for implementation of the WFD in Finland'. The outcome was a rather simple typology resulted in 16 river types for the Illies ecoregion 22, which covers nearly the whole Finland excluding only small corners in the northern highlands (region 20) of the country. Despite of to be tested, the same typology system was proposed to be used for the ecoregion 20.

The typology factors were as follows:

- catchment size: 10–100 (small), 100–1000 (mid size), 1000–10000 (large) and > 10000 (very large) km²
- altitude: < 200 (lowland), 200–800 (mid-altitude) and > 800 m asl
- geology: siliceous (clear, peatland < 25% of the catchment), organic (humic, peatland > 25% of the catchment) and clayey (coastal rivers in south-western Finland)

The Finnish rivers were divided into types by using the National Environmental Database of the FEI (Finnish Environment Institute, SYKE) where all the Finnish rivers (74 catchments with an area > 200 km² with subdivisions and additionally smaller catchments) are stored with satellite image information on land use of the totally over 6000 catchments (figure 3.2). Naturally, small rivers are much larger in numbers than the other size classes.

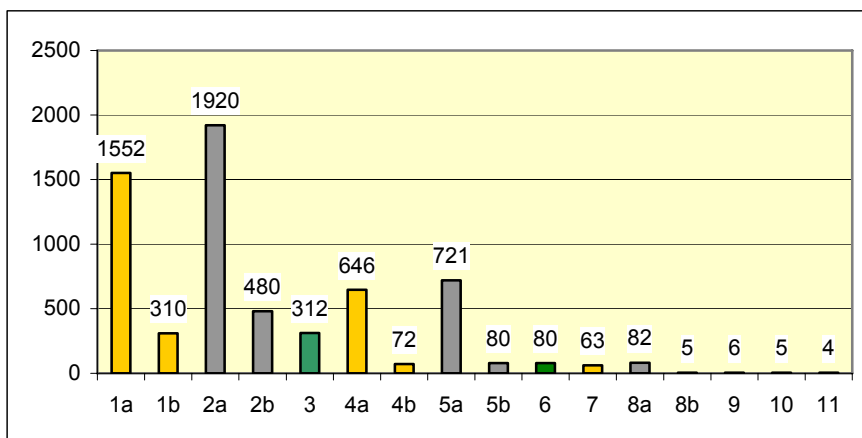


Figure 3.2 The number of catchments divided into types in Finland. Organic (humic) rivers belong to the type 1 (small), 4 (mid size), 7 (large) and 10 (very large); clear rivers to the types of 2, 5, 8 and 11 in the same size order like naturally rich clayey rivers in types 3, 6 and 9 (no very large rivers). Altitude separation indicated by a (lowland) and b (mid-altitude) in some river types.

There is no official national biological monitoring programme for Finnish rivers, but in several projects and in local/regional statutory monitoring data is gathered during the last decades. These include periphyton, macroinvertebrate and fish data, and especially the latter two ones cover rather well different river types in Finland. For instance macroinvertebrate data collection has been performed in the 80's and 90's especially for small rivers with low human impact (over 100 sites) and in western Finland (nearly 100 sites) in rivers impacted by regulation and diffuse loading. Nation-wide fish data are currently going on to be collected in its own database for the future WFD purpose. The sampling methods used follow the common Nordic approach using mostly riffles/rapids as the key habitat.

Typology and monitoring in Sweden

Status of the national development of typology

A preliminary proposal to a typology for Swedish inland surface waters, based on System B in the WFD, is presented in Fölster et al. (2004). A simple tool (excel macro) has also been developed in order to automatically classify surface water body types in accordance with this preliminary proposal (Göransson & Wallin 2004). This tool also includes a specific typology for fish.

The preliminary proposal to a typology for lakes includes 4 ecoregions, 2 depth classes, 3 lake area classes and 4 geology (geochemical) classes (see table 3.1 below). For practical reasons, only lakes $>0.5 \text{ km}^2$ are included. The suggestion includes 96 theoretical lake types, which can be compared to 324 theoretical types according to System A. A class of lakes $<0.5 \text{ km}^2$ will add another 32 theoretical types if added to the system.

Table 3.1 Preliminary proposal to Swedish lake types according Fölster et al. (2004).

Ecoregion	Altitude ^{a)}	Mean depth	Lake area	Geology
Borealic uplands	< 200 m a s l	< 3 m	0,5 – 2 km ²	siliceous
Fennoscandian shield	≥ 200 m a s l	≥ 3 m	2 – 10 km ²	organic
Central plain			≥ 10 km ²	calcareous mixed

^{a)} only lakes in the Fennoscandian shield

Water chemistry used as indirect measure of different geology classes:

Siliceous Ca<0,5 mekv/l AbsF_{420/5}<0,06

Organic Ca<0,5 mekv/l AbsF_{420/5}≥0,06

Calcareous Ca≥0,5 mekv/l AbsF_{420/5}<0,06

Mixed Ca≥0,5 mekv/l AbsF_{420/5}≥0,06

In the specific typology for fish southern Sweden (Central plain) is divided into two regions, one for the western part and one for the eastern part. Furthermore, the highest coastline during the last glaciation is used instead of 200 m for altitude classification. The fish typology will include 144 theoretical types for lakes >0.5 km².

For many of the types there will be no or very few objects, e.g. large brown lakes in the Borealic uplands. To sort out types with no or few objects, the typology was applied to all Swedish lakes >0.5 km² in the Swedish national register of lakes (SMHI 1996). The distribution between geological classes within each class defined by ecoregion, depth and size, is applied from the national survey 1995.

If types with <10 objects are removed from the lake typology, 47 types remains. The number of lakes is only a rough estimation where the largest error probably is in the distribution into depth classes. For most lakes, the lake mean depth is not known and depth is estimated from lake area and geographical location (SMHI 1996). This will probably mean that the number of lakes with unusual relation between area and depth, such as large shallow and small deep lakes, will be underestimated.

The preliminary proposal to a typology for rivers is based on the same ecoregions as for lakes. Further the rivers are distributed into 3 size classes, and 4 geological classes (table 3.2). The preliminary river typology includes 48 theoretical classes. The national registers of rivers and catchments are at present not in the state that the “real” frequency of objects for the types can be estimated.

Table 3.2 Preliminary proposal to Swedish river types according Fölster et al. (2004).

Ecoregion	Altitude ^{a)}	River catchment area	Geology
Borealic uplands	< 200 m a s l	10–100 km ²	siliceous
Fennoscandian shield	≥ 200 m a s l	100–1000 km ²	organic
Central plain		≥ 1000 km ²	calcareous mixed

Status in the development of monitoring programmes

The Swedish national monitoring program for lakes and watercourses has a three-tiered nested design, including synoptic surveys (providing insight in large-scale variability), time-series lakes and streams (providing insight in temporal variability), and integrated trophic-level monitoring (allowing for the assessment of trophic interactions in Swedish inland waters). Beside the national program, the monitoring of regional time-series lakes and streams are run by regional county authorities. Data are stored at a national data host (the Department of Environmental Assessment at SLU) and can be viewed and downloaded from the Internet (<http://www.ma.slu.se>)

Monitoring has been done since 1988 as annual monitoring of some 185 time-series lakes (partly in national and partly in regional programs) and some 35 time-series streams. Sampling for water chemistry is performed 4x per year, whereas samples for phytoplankton and macroinvertebrates are collected once per year, in August and in the autumn, respectively. In addition to this sampling with a higher temporal resolution is done in 15 lakes and 15 streams (referred to as “intensive” lakes and streams) with samples for water chemistry collected monthly between February and October and phytoplankton samples collected seven times per year. In addition to this, national surveys are held every 5th year. Before 1995, these surveys encompassed only water chemistry samples for some 3000 lakes, but since 1995 also some 700 lakes (littoral) and 700 streams (riffles) have been sampled for macroinvertebrates.

Typology and monitoring in Denmark

Status on the existing typology and monitoring in Danish streams

Generally, Danish streams can be characterised as small and productive. They typically have high densities of macroinvertebrates, high biomass of macrophytes and are in most cases dominated by salmonids. Typically, the bottom substrate is dominated by sand or gravel. Only a few small streams are pristine as most streams are more or less impacted by human activities (sewage water, regulation, weed-cutting etc.).

The existing monitoring programme includes both physico-chemical and biological measurements (table 3.3). Biological monitoring is mainly based on macroinvertebrates (1053 sites) but this quality element is supplemented with macrophytes and fish in a limited number of small streams (80 sites).

Table 3.3 Monitoring in Danish streams in 1998-2003 (NOVA 2003 programme). Numbers of stream sites are shown. *) identification is only to the genus or family level. **) identification is to the species level (if possible).

	Extensive net	Intensive net
Physical characterisation	limited	detailed
Water chemistry	120	80
Macroinvertebrates	1053*	80**
Macrophytes	-	80
Fish	-	80

In the extensive net all stream types are represented (stream size, geographic location, soil types, different pressures, etc.). The site selection has been performed by the regional authorities based on guidelines from the National Environmental Research Institute. Macroinvertebrates are sampled every year in the period February to May.

The intensive net only represents small streams in open areas (farmland). A more detailed monitoring are being performed every second year in order to clarify the reasons to unacceptable conditions in many streams in agricultural areas.

Changes made in the new monitoring programme (NOVANA)

A number of changes have been made in the new monitoring programme for the period 2004–2009 (Friberg et al. 2005). Most important is that the programme has been designed to fulfil the requirements of the Water Framework Directive. Therefore, the major difference is that all biological elements (macrophytes, macroinvertebrates and fish) are monitored and supplemented with physico-chemical and hydromorphological measurements on all sites (all stream sizes). Another difference is that some new elements as hydrological regime, soil chemistry, plant communities in riparian areas and a more comprehensive physical registering are introduced generally into the monitoring programme. And a third thing is that a reference network of 130 sites is incorporated into the programme. Because true reference sites do not exist, “best available streams” will be used as references. No doubt this new reference network has to be supplemented with monitoring data from similar stream types in nearby countries (Baltic countries, Sweden etc). Data from the reference network will later be used to develop predictive models i.e. to change to a “system B” approach.

Appendix 4: Description of methods and metrics

The Nordic countries generally use very comparable methods and metrics. However, there are still differences that can be of importance to the comparability of monitoring results and ecological classification results. The Nordic countries do not have to use the same methods to perform the intercalibration exercise since the purpose is to compare methods and classification borders (borders between high/good status and good/moderate status). However, focus is on comparing the classification borders and the result from the intercalibration exercise will be easier to interpret if the methods and metrics used are comparable. Any found deviation between the countries when borders are compared could then be assumed to depend on different assessments of where the borders should be placed on an ecological scale.

Methods and metrics used in Norway

Rivers

Phytobenthos: Benthic algae are used in assessment of organic pollution and acidification of shallow, fast flowing rivers. The number and location of sampling sites varies according to the individual survey aims and the extent of the survey. The "macroscopic benthic algae" are studied by wading of a defined reach of 10 m along the riverbank and as far out from the bank as safety regulations allow, depending on depth and current velocity. An aqua scope may be used for observations. The sampling of microscopic elements is done as for benthic diatoms (EN 13946). At each site at least 5 cobbles are sampled and all algae from an area of at least 5x5 cm on the upper surface of each cobble are collected. Reference sites are included wherever available. Normally annually studies are performed with one sampling occasions each year; late summer (August-September) at low water-level.

The phytobenthos are preferentially identified to the species level and species composition, relative abundances (a simple 5-level descriptor scale) and indicator species are used in the assessment of ecological status. An acidification index, based on the sensitivity of the various taxa, is used to assess the effects of acidification (Lindstrøm, 2002).

Knowledge on phytobenthos in Norwegian rivers is based on the national monitoring program on liming (7 rivers including limed and non-

limed sites), various acidification studies and surveys related to effects of local pollution and river regulations (total number of sites: ca 300).

Macrophytes: Submerged and floating leaved plants; including vascular plants, stoneworts (charophytes) and mosses is used in the assessment of eutrophication and acidification of slow-running waters. Surveying of river macrophytes follows a standardized method (EN 14184). The number and location of sampling sites varies according to the structure of the macrophyte community, individual survey aims and the extent of the survey. The plants are recorded using an aqua scope and collected by a grab. Normally annually or biannually studies are performed with one sampling occasion each year; late summer (August-September) at low water-level.

The macrophytes are identified to the species level. Species composition, relative abundances (a simple 5-level descriptor scale), diversity and indicator species are used in the assessment of ecological status.

Knowledge on macrophytes in Norwegian rivers is based on the national monitoring program on liming (7 rivers including limed and non-limed sites), various acidification studies and conservation studies.

Macroinvertebrates: Macroinvertebrates from rivers are used in the assessment of organic pollution, acidification, heavy metal pollution and effects of hydropower regulations. Samples of benthic macroinvertebrates are collected using standardized kick sampling (ISO 7828) by help of a hand-net (250 or 500 µm mesh-size). In some few studies additional quantitative samples are taken by a Surber sampler (ISO 8265). The number and location of sampling sites varies according to the individual survey aims and the extent of the survey. Typically, two – ten sites (mostly riffles) are sampled in each river and one sample (120 sec kicks) is taken from each site. Reference sites are included wherever available. Normally annually or biannually studies are performed with two sampling occasions each year; spring (May-June) and autumn (September-November depending on the temperature conditions).

The macroinvertebrates are preferentially identified to the species level and species composition, relative abundances (individuals per unit effort), indicator species and diversity are used in the assessment of ecological status. An acidification index, based on the sensitivity of the various taxa, is used to assess the effects of acidification (Raddum & Fjellheim, 1984; Fjellheim & Raddum, 1990, Raddum 1999). The classification system is modified to cover acidification of organic rivers (Bækken & Kjellberg, 1999). In eutrophication studies different indices like Modified Trent index, BMWP, ASTP, Shannon- Wiener are used.

Knowledge on Norwegian river macroinvertebrates is based on national monitoring programs on acidification (3 rivers) and liming (21 rivers including limed and non-limed sites), reference river for aquatic biodiversity (1 river) and various surveys related to effects of local pollution and river regulations (app. 900 sites). Data from the latter studies are mainly from the 1970- and 1980ties. The national programs have been

run for four to 20 years whereas other studies are normally restricted to one to two years.

Fish: Data on fish populations are used in the assessment of acidification and hydropower regulations. The monitoring is mainly restricted to shallow rivers and tributaries. Sampling of fish is performed by means of electrofishing (EN 14011). The number and location of sampling sites varies according to the individual survey aims and the extent of the survey. Typically, six – 18 stations are sampled in each river. Minimum size of the sampling site: 100 m². Reference sites are included wherever available. Normally annually studies are performed with one sampling occasion each year; autumn (August-October depending on the temperature conditions).

Densities of young fish (individuals per 100 m²), and age-structure are used in the assessment of ecological status.

Knowledge fish fauna in Norwegian rivers are based on national monitoring programs on acidification (1 river) and liming (22 rivers including mainly limed sites), reference river for aquatic biodiversity (1 river), reference rivers for salmonides (7 rivers) and surveys related to regulations (no common national database) and salmon parasites.

Lakes

Phytoplankton: Phytoplankton is primarily used in the assessment of lake eutrophication but also in acidification studies. One quantitative sample is taken from an integrated depth interval in the epilimnion (down to the thermocline). The sampling station is located to the deepest part of the lake. In lakes with more than one depth basin one sample is taken from each basin. Normally annually studies are performed with four to six sampling occasions each year; monthly sampling throughout the ice-free period.

Species composition, abundance of indicator species, total mean biomass and total maximum biomass are used in the assessment of ecological status. Our knowledge on phytoplankton is based on data from about 400 Norwegian lakes collected mainly through the national eutrophication survey which lasted from 1988–2001.

Macrophytes: Submerged and floating leaved plants; including vascular plants, stoneworts (charophytes) and mosses are used in the assessment of lake eutrophication and acidification. The number and location of sampling sites varies according to the lake size, structure of the macrophyte community, individual survey aims and the extent of the survey but generally localities representing different erosion conditions, outlet, inlet, shallow and deep area are included. The plants are recorded using a water tube (aqua scope) and collected by dredging from the boat. In some studies a standardized method for underwater photographic sampling by scuba divers are used. The photos are taken from squares (0.25m²) ran-

domly distributed along transects, from approximately 0.5m depth down to the lower growth limit. Normally annually or biannually studies are performed with one sampling occasions each year; late summer (August-September) at low water-level.

The macrophytes are identified to the species level. Species composition, relative abundances (a simple 5-level descriptor scale or % coverage determined from photos), diversity and indicator species are used in the assessment of ecological status.

Knowledge on Norwegian lake macrophytes is based on biodiversity inventories and various surveys related to effects of local pollution (total number of lakes: app. 100).

Macroinvertebrates: Macroinvertebrates from lakes are used in the assessment of eutrophication (profundal), acidification (littoral) and effects of hydropower regulations (littoral). In the “acidification” program samples of littoral macroinvertebrates are collected using standardized kick sampling (ISO 7828) by help of a hand-net (250 µm mesh-size). Three sampling stations are established in each lake; one in the main inlet river, one in the outlet river and one station in the littoral part of the lake. One sample (120 sec kicks) is taken from each site. In other studies littoral macroinvertebrates are sampled by an Eckman grab (ISO 9391). Samples are taken along a depth gradient from the littoral and sub-littoral zones (3–5 depth). Profundal samples (three to seven replicates) are taken by an Eckman grab (ISO 9391) or a Kajak-sampler (diameter: 0.07 m) at the deepest part of the lake. Reference sites are included wherever available. Normally two sampling occasions are performed each year; spring (May-June) and autumn (September-November depending on the temperature conditions). In some studies sampling is restricted to one sampling occasion in the autumn.

The macroinvertebrates are preferentially identified to the species level (chironomids: species, genus or family level depending on the aim of the study and the resources). Species composition, abundances (individuals per unit effort), diversity and indicator species are used in the assessment of ecological status. An acidification index, based on the sensitivity of the various taxa, is used to assess the effects of acidification (Raddum & Fjellheim, 1984; Fjellheim & Raddum, 1990, Raddum, 1999). A trophic index, based on the species composition of chironomids, has been developed for Norwegian lakes (Sæther, 1979; Aagaard, 1986). The ratio oligochaetes : chironomids is also used to assess the effects of nutrient loading.

Knowledge on Norwegian lake macroinvertebrates is based on the national monitoring program on acidification (app. 100 lakes) and various surveys related to effects of local pollution and hydropower regulations (no common national database). The national acidification program has been run for 8 years; annually samples have been taken from 20 of the

lakes whereas the other 80 lakes are sampled each fourth year. Other studies are normally restricted to one to two years.

Littoral crustaceans: Microcrustaceans (pelagic and littoral species) are used in the assessment of lake eutrophication, acidification and effects of hydropower regulations (littoral). Samples of littoral crustaceans are collected as horizontal plankton hauls (2–30 m, depending on the lake productivity) using a plankton-net (90 µm mesh-size). Two - three littoral sampling stations are established in each lake and the sampling is performed at 0–1 m depth. Pelagic samples are taken as vertical plankton hauls from the whole water column. The sampling station is located to the deepest part of the lake. Normally two to three sampling occasions are performed each year; spring (May-June), mid-summer (July-August) and autumn (August-September depending on the temperature conditions). In some studies sampling is restricted to spring and autumn.

The crustaceans are identified to the species level. Species composition, abundances (individuals per unit effort), diversity and indicator species are used in the assessment of ecological status.

Knowledge on Norwegian lake crustaceans is based on national monitoring programs on acidification and liming (app. 110 lakes) as well as various surveys related to effects of local pollution and hydropower regulations. A national database on microcrustaceans from approximately 2800 Norwegian lakes is established. The national acidification program has been run for 8 years; annually samples have been taken from 20 of the lakes whereas the other 80 lakes are sampled each fourth year. In the “liming program” the lakes have been monitored for five to ten years. Other studies are normally restricted to one to two years.

Fish: Data on fish populations are used in the assessment of acidification and hydropower regulations. Sampling of fish is performed by standardized test-fishing using multi-mesh gill nets (Appelberg et al., 1995). The number of sampling sites varies according to the size of the lake and the individual survey aims. Reference sites are included wherever available. In some few lakes annually sampling has been conducted, but normally sampling are performed each second to fourth year with one sampling occasion each year, in autumn (August-October depending on the temperature conditions). Questionnaires are performed to get information on fish status (species composition, relative abundance and changes in abundance) from a large number of lakes (Hesthagen et al., 1993). The questionnaires are performed once, eventually repeated each tenth year.

Species composition as well as abundances (catch per unit effort) and age-structure of dominant species are used in the assessment of ecological status.

Knowledge on fish fauna in Norwegian lakes are based on national monitoring programs on acidification and liming (app. 70 non-limed lakes), other acidification studies (app. 130 lakes) and surveys related to hydropower regulations (no common national database). Data on fish

status based on questionnaires are collected from approximately 32 000 lakes.

Methods and metrics used in Finland

Lakes

In phytoplankton monitoring frequency varies from 1 - 6 times during growth season. In national monitoring July is the month used for surveys once in summer. In more intensive monitoring samples are taken 5/6 times between May and September. Month August is used especially in pollution control monitoring. Sampling depth is usually 0–2 meters. In sampling and processing of samples Nordic methodology (Blomqvist et al. 1998) is used slightly modified.

In Finnish lake monitoring in general macroinvertebrate studies are mostly targeted to profundal areas. In national monitoring 15 lake deeps are being sampled. Ekman sampler (SFS 5076) or tube sampler (SFS 5730) is used. The most commonly used mesh size is 0.5 mm. Samples are taken during autumn (September - October), often every third year. Abundance is measured as number of individuals, frequently also as biomass. Sampling in the littoral area is not commonly used in Finland and does not occur in national monitoring at present.

The standard method for sampling freshwater fish with Nordic multi-mesh gillnet (EN 14757) or methods with series of gill-nets have been used in fisheries research. However, there is a limited number of lakes having both fish data and other biological data.

Rivers

In biological sampling common ISO and CEN standards used in Finland. Periphyton studies are especially used in small and mid-size coastal rivers with species composition and eutrophy indication metrics. For macroinvertebrates kick sampling (riffles/rapids) is common throughout the country, using species composition and index metrics (e.g. BMWP/ASPT) and more sophisticated modelling approaches indicating acidification and eutrophy. In some areas of southern Finland the Finnish ROCI (River Oligochaeta-Chironomidae Index) values are used for evaluation of eutrophy in lowland slowly flowing rivers (pool sections). In the current WFD work EQR-values are created for some river types based on taxa richness and expected species composition in riffles/rapids (kick netting). The latter one seems to be the most promising and reliable metrics for the WFD monitoring of macroinvertebrates. Electrofishing is the common methods often parallelly used with macroinvertebrate kick-netting. Data on species composition and taxa richness can be used for impact evaluation.

Methods and metrics used in Sweden

In national and regional programs ISO and CEN standard methods are used (see appendix 6 and 7). Methods are described in detail in the Handbook of Environmental Monitoring provided by the Swedish EPA (available as pdf-files at <http://www.naturvardsverket.se>). Details on the sampling techniques have been given elsewhere in this report. Earlier work financed by the Nordic Council of Ministers has shown a high degree of comparability between the Nordic methods of macroinvertebrate sampling in lakes and streams (Friberg and Johnson 1995, Skriver 2001).

Environmental quality criteria (Swedish EPA, 2000) include assessment tables for nutrients/eutrophication, oxygen and light conditions, acidity/acidification, metal concentrations (water and sediment), planktonic algae, aquatic macrophytes, epiphyton (streams only), benthic macroinvertebrates (litoral and profundal in lakes, riffles sites in streams), as well as fish. Assessments based on water chemistry variables should be done on three year-average values, while assessments based on biological variables can be done for single observations (with some restrictions for the time of sampling). Common for all these variables is that assessment is done on a 5-grade scale reflecting the state of the environment. Beside this, a “deviation from a reference value” can be calculated for the majority of variables. To do this the user is supposed to supply an appropriate reference value from unperturbed systems, from historical data, or by using the standardized region- or water body-specific reference values that are given for some variables. Also the deviation from a reference value can be assessed on a 5-grade scale, where 1 is “no or minor deviation” and 5 is “very large deviation”. For macroinvertebrates the 5 grades linked to the descriptions of effects along a gradient of perturbation that were presented by Nixon and coworkers in their report on harmonised monitoring and classification of ecological quality of surface waters in the EU (Nixon et al. 1996).

Methods and metrics used in Denmark

Rivers

The existing monitoring programme, NOVA 2003 (1998–2003) is described in a technical report from the National Environmental Research Institute and includes parameters, frequencies and methods for all single quality elements (Skriver et al. 1999). In cases where acceptable standard methods were available these have been used (ISO standards for chemical analyses, CEN standard for hand-net sampling, national standard for electric fishing etc.). But new methods were also introduced for some elements like macrophytes and for the description of substrate composition and physical variables. An overview of the methods used is given below (table 4.1).

Table 4.1 Physical, chemical and biological methods used in the Danish Monitoring Programme NOVA 2003 (1998-2003).

Quality element	Reference	Comments
Physical characterisation	Baattrup-Pedersen et al. 2001	Quadrat-frequency method (quantitative method)
Water chemistry	ISO standards	
Macroinvertebrates	Skriver et al. 2000	Hand-net sampling. Biotic index
Macrophytes	Baattrup-Pedersen et al. 2001	Quadrat-frequency method (quantitative method)
Fish	Mortensen & Geertz-Hansen 1996	Quantitative electric fishing

Initiating the new programme for the period 2004–2009 some new methods have been developed. One example is introduction of the Danish Habitat Index to describe hydromorphological features (Pedersen & Baattrup-Pedersen 2003).

Appendix 5: Evaluation of Common Nordic types and selection of intercalibration sites

Norway

Evaluation of common Nordic types

The revision of the Norwegian typology (see appendix 3) causes difficulties of separation between some of the Common Nordic types. This is presented in the tables below (table 5.1 and 5.2), and is due to the merging of size and depth categories in the lake and river types in the Norwegian typology. For instance lake types L10 (medium sized (5–40 km²), low alkalinity, clear lakes) and L14 (large sized (> 40 km²), low alkalinity, clear lakes), which are not significantly different according to our data analyses. The Norwegian typology also includes a separate alkalinity category (< 1 mg Ca/L corresponding to < 0.05 meq/L alkalinity), which is very common in Norway, but does not correspond to any of the common Nordic types. Also glacial lakes and rivers are defined as a separate lake or river type in Norway, but cannot be found in the other Nordic countries (except Iceland).

The deep lakes are common in Norway, but are missing in the common Nordic typology. Norway may intercalibrate these with similar lakes in Scotland, unless Sweden can find some of their deep lakes to be relevant for intercalibration. Although the reference conditions seem relatively similar in deep and shallow lakes, these depth types will most likely follow different response trajectories when subject to pressure. Thus for intercalibration the deep lakes should not be mixed with the shallow lakes.

Very shallow lakes are relatively rare in Norway, at least within the lake population > 0.5 km². Since we have found very little difference between these lakes and the shallow lakes, it may still be possible to use very shallow lakes in the other countries (Finland) and intercalibrate these with shallow lakes of the same geological types in Norway and Sweden.

Table 5.1 Norwegian lakes types which is common occurring (Lyche-Solheim & Schartau, 2004).

Ecoregion	Altitude	Type-no	Nordic type	EU-type	Type-description	Size	Calcium	Humus
	region	(Norway)	index	(JRC)		km ²	mg/L	mgPt/L
Lowland	1	L6	L-N2		small, low alkalinity, clear	< 5	1-4	< 30
	2	L7	L-N3		small, low alkalinity, humic	< 5	1-4	> 30
	3	L5	L-N1		small, moderate alkalinity, clear	< 5	> 4	< 30
	4	L8			small, moderate alkalinity, humic	< 5	> 4	> 30
	5				large, very low alkalinity, clear	> 5	< 1	< 30
	6	L10 + L14	L-N2		large, low alkalinity, clear	> 5	1-4	< 30
	7	L11	L-N3		large, low alkalinity, humic	> 5	1-4	> 30
	8				large, moderate alkalinity, clear	> 5	> 4	< 30
	9	L9			large, moderate alkalinity, humic	> 5	> 4	> 30
Boreal	10				small, very low alkalinity, clear	< 5	< 1	< 30
	11				small, very low alkalinity, humic	< 5	< 1	> 30
	12	B4	L-N5		small, low alkalinity, clear	< 5	1-4	< 30
	13	B5	L-N6		small, low alkalinity, humic	< 5	1-4	> 30
	14	B3	(L-N4)		small, moderate alkalinity, clear	< 5	> 4	< 30
	15				small, moderate alkalinity, humic	< 5	> 4	> 30
	16				large, very low alkalinity, clear	> 5	< 1	< 30
	17	B11 + B15	L-N5		large, low alkalinity, clear	> 5	1-4	< 30
	18				large, low alkalinity, humic	> 5	1-4	> 30
	19	B10			large, moderate alkalinity, clear	> 5	> 4	< 30
Highland	20				large, moderate alkalinity, humic	> 5	> 4	> 30
	21				very low alkalinity, clear	all	< 1	< 30
	22	H4	(L-N7)		low alkalinity, clear	all	1-4	< 30
	23				glacial lakes (turbid, cold)	all	1-4	< 30

Table 5.2 Norwegian river types which is common occurring (Lyche-Solheim & Schartau 2004).

Eco-region	Altitude region	Typeno.	Nordic type	EU-type (JRC)	Type description	Catchment size	Ca	Humus
						km2	mg/L	mg Pt/L
Lowland		1	L2+L5	R-N2	small-medium, low alkalinity, clear	10–1000	1–4	< 30
		2	L3+L6	R-N3	small-medium, low alkalinity, humic	10–1000	1–4	> 30
		3	L1+L4	R-N1	small-medium, moderate alkalinity, clear	10–1000	> 4	< 30
		4			small-medium, moderate alkalinity, humic	10–1000	> 4	> 30
		5			small-medium, moderate alkalinity, turbide	10–1000	> 4	< 30
		6	L8		large, low alkalinity, clear	> 1000	1–4	< 30
		7	L7	R-N4	large, moderate alkalinity, clear	> 1000	> 4	< 30
Boreal		8			small-medium, very low alkalinity, clear	10–1000	< 1	< 30
		9	B2+B5	R-N5 + R-N6	small-medium, low alkalinity, clear	10–1000	1–4	< 30
		10	B3+B6	R-N9	small-medium, low alkalinity, humic	10–1000	1–4	> 30
		11	B8		large, low alkalinity, clear	> 1000	1–4	< 30
Highland		12			small-medium, very low alkalinity, clear	10–1000	< 1	< 30
		13	H2+H5	R-N7	small-medium, low alkalinity, clear	10–1000	1–4	< 30
		14			glacial rivers (small-medium, low alkalinity, turbide)	10–1000	1–4	< 30

Selection of intercalibration sites

Description of the site selection process

The selection process is described in the following schematic five step procedure, in which step five is illustrated in figure 5.1:

1. starting point: Databases with national monitoring data on eutrophication and acidification (1500 lakes)
2. removed all strongly polluted sites, i.e. all sites in class V in Norwegian classification system
3. removed all reference sites, i.e. lakes in pristine areas (forest and mountain areas north of acid deposition area), class I in Norwegian classification system

4. the remaining sites were kept as potential IC-sites
5. for these sites the actual IC sites proposed were selected according to the following procedure:

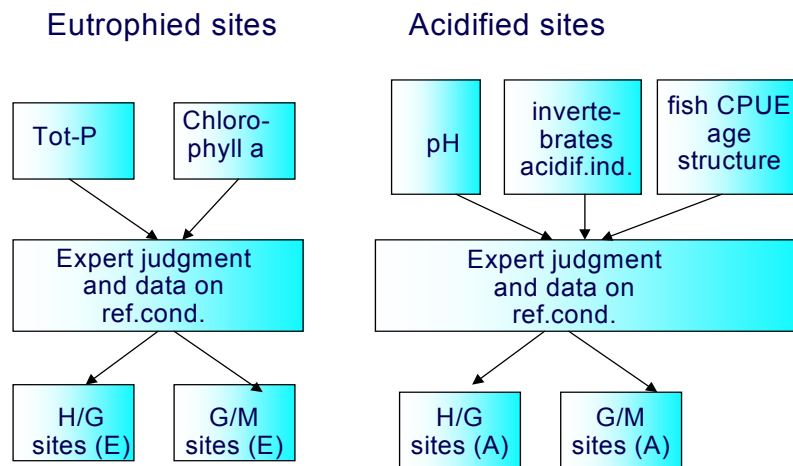


Figure 5.1 Parameters and methods used to select the Intercalibration sites to be entered into the metadata register at JRC, Ispra.

The data available from these sites are summarized in figure 5.2.

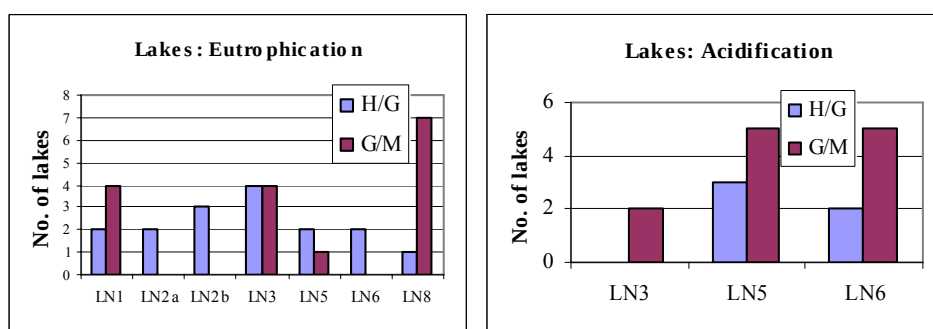
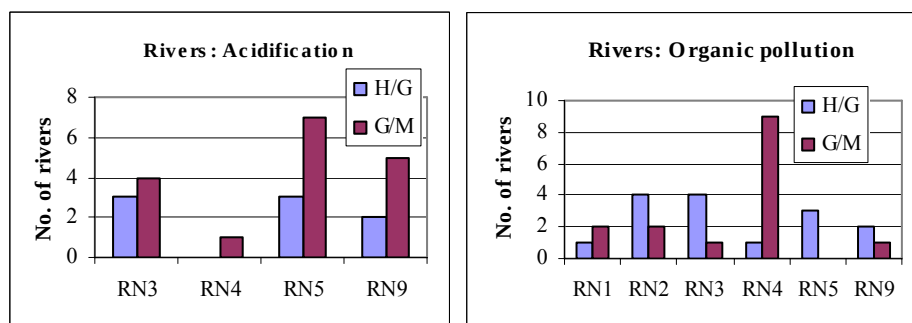
Eutrophied sites			Acidified sites		
Elements	Frequency (per year)	years	Elements	Frequency (per year)	Years
nutrients	4 - 6	2 - 5	pH, alk., ANC	1	2 - 5
phytoplankton	4 - 6	2 - 5	invertebrates	1	2 - 5
zooplankton	4 - 6	2 - 5	fish	1	2 - 5

Figure 5.2 Summary of metadata from the selected IC sites.

The number of sites are given in table 5.3, and the distribution of sites per type, pressure and boundary are given in figures 5.3 and 5.4.

Table 5.3 Summary of selected IC sites from Norway, October 2004. H/G means high/good status boundary, G/M means good/moderate boundary.

LAKES	H/G	G/M	Total
Total	21	28	49
Eutrophied	16	16	32
Acidified	5	12	17
RIVERS	H/G	G/M	Total
Total	23	32	55
Eutrophied	15	15	30
Acidified	8	17	25

*Figure 5.3 Distribution of selected lakes on the different Intercalibration types and boundaries.**Figure 5.4 Distribution of selected rivers on the different Intercalibration types and boundaries.*

Finland

Evaluation of Common Nordic types

Natural conditions in the Nordic countries are similar on a large scale. However, there are features typical of especially Finnish water bodies. Therefore the needs of national and Nordic typologies are not totally overlapping. This emphasises the importance of common Nordic approach to typology and classification.

Below the Nordic typology factors and types are evaluated.

Lakes – typology factors

Altitude

In the Nordic typology work altitude has been used in categories lowland, mid-altitude and high. In the preliminary Finnish typology only the lakes located in the highest (northernmost) part of Finland were differentiated from other Finnish lakes. The actual variable for this differentiation is still under preparation, but altitude might be used for this purpose.

For the boundary between low and mid-altitude lakes two factors have been suggested in the Nordic typology work: altitude 200 m and the highest coastline. In Finland highest coastline is quite complicated in shape. In southern Finland there are several smallish areas above it. Mainly the *supra-aquatic* areas are located in the eastern and north-eastern parts of the country. There are not many studies that would point out relevant differences in lakes located on both sides of the highest coast line. Until now it has also been considered that it would be difficult to use this factor in the actual type determination of lakes. 200 m boundary is easier to define than the highest coastline. However, the relevance of neither of these boundaries is not quite obvious for Finland. A vast majority (81 %) Finnish lakes (area larger than 0.5 km²) are situated below the altitude of 200 m.

Also the coastline of the Litorina sea was considered for the boundary between lowland and mid-altitude. Geology may have major impacts on water quality in these lowland areas, where clay soil or bare rock is common. However, the use of this factor for type differentiation would also be complicated and not necessarily adequate for a certain water body.

Because there are only a few lakes above 800 m in Finland, some other boundary would be more relevant for demarcating the high altitude lakes. Tree line (forest line of pine) was used in this study. Pine forms coniferous timber line in Finland.

For the lake typology in this Nordic project altitude of a lake was calculated using digital elevation model (DEM). Model gives altitude of lake with an accuracy of 1 m.

Size

There are three lake size classes in the Nordic typology with the borders 5 km² and 40 km². These are the same borders used in the Finnish suggestion to a national typology. Large lakes in Finland are usually very fragmented which makes it possible to divide some of the large lakes into smaller lake basins.

Depth

In the national lake register there are mean depth data only from a minority of lakes (> 0.5 km²). For lakes without this data, mean depth has been

estimated using correlation of maximum depth and mean depth calculated with a database of several hundred lakes. For substitute of maximum depth the lowest sampling depth has also been used. Finnish lakes are shallow. In Finland there are only a handful of lakes with mean depth over 15 m. Thus this boundary is not considered to be very relevant in Finland.

Water colour

In the national water quality database there are water colour data from a majority of all lakes larger than 0.5 km². Finnish lakes have generally high humus content. Water colour is often higher than the lower boundary of brown water lakes (30 mg Pt/l) in the Nordic typology. In the suggested national typology of Finland there is a type of highly humic waters (lower boundary 90 mg Pt/l).

Water humic content can be impacted by human influence. That is why long term trends were used together with general pressure information in order to be able to estimate the natural humic content.

Alkalinity

Alkalinity data are available from more than a half of lakes larger than 0.5 km². Approximately 8 % of these lakes have alkalinity higher than 0.4 meq/l. Lakes are mainly situated in the areas of calcareous bedrock or calcareous minerals in the soil. However, also human impacts can be the cause of alkalinity changes. Long-term trends of alkalinity values were used together with general pressure information in order to be able to estimate the natural alkalinity.

As was agreed in Nordic typology, lakes with alkalinity less than 0.2 meq/l were prioritised in the search of intercalibration types and sites. Alkalinity range between 0.2 - 0.4 was considered to be less robust basis.

Selected types

For the purposes of type identification distributions of Finnish lake data were under inspection on a broad scale. In order to find relevant types containing at least some potential sites, the characteristics of about five hundred sites were analysed. Primarily and more thoroughly this was done to lake sites of the national monitoring (about 250 sites).

L5 was only prioritised Nordic lake type that there were biological data. However, for most sites of this type data were scarce. The Finnish national monitoring programme has to a large extent focused on large lakes. Also in mandatory monitoring, which is an obligation to the polluter, the significant biological programmes are often targeted to parts of medium-sized or large lakes. Because of this focusing the most promising type for Finland was type L11, which was originally not prioritised.

In type L11 the overall number of sites is rather high. As the national monitoring has to be focused on natural background, many lakes of type L11 are expected to be in high status. Whereas sites estimated to be near

especially the good - moderate boundary are scarce. For the type L5 also the number of monitored reference sites is low, as well as number of sites altogether.

Rivers – typology factors

Due to the differences in the typology system there are some difficulties in reaching to match the Finnish types into the Nordic approach. This problem is apparent especially in how to handle humic rivers defined in Finland as the catchment characteristics and in the other countries by water quality parameters (like colour, mg Pt/l). In rivers all the water quality parameters tend to be very variable in time, and it is hard to decide if one uses e.g. average yearly values or some other approximations. In general, it is, however, possible to find common understanding for different river typologies between the Nordic countries. The other point is here, how to handle chain-lake systems, very common in Finland.

Selection of intercalibration sites in Finland

Lakes

Inspections of all available data of the site was used in order to get an estimate of the future classification: characteristics of the site, characteristics of possible reference sites in similar waters, supporting quality elements, biological results from previous studies, national water classification, indices, pressures. Some preliminary exercises on EQRs have been used as additional information.

Rivers

So far, only macroinvertebrate data can be used for intercalibration, although other bioelements may also be included later, after compilation of periphyton and especially fish data, which is currently going on (by the Finnish Game and Fisheries Research Institute). The selection of intercalibration sites is mostly based on the project work creating and testing river types in Finland. A part of IC-sites are directly proposed by the project and calculations on EQR-macroinvertebrate values situating mostly in western Finland. To reach a wider coverage of the spatial variation more sites were included from the southern and northern part of the country. Some difficulties in selection of the sites were the current changes in impact volume and character – the intercalibration sites are naturally more or less in regions, where different interest in human use are conflicting.

Sweden

The procedure below describes the selection of Swedish lakes and streams/rivers for intercalibration, which has been used for the Nordic core types and the Central core type. Water bodies for intercalibration were selected for eutrophication and acidification, i.e. the two anthropogenic pressures that were considered to be the most important for community structure and composition (as identified by the Expert meeting held at JRC in Ispra, Italy, in February 2003, and at the third Nordic workshop in Helsinki, Finland, in March 2003). The recommendation by the Expert meeting to include as a minimum the quality elements phytoplankton and macrophytes for eutrophication and macroinvertebrates for acidification was however not possible. Due to a lack of data for macrophytes, in particular from nutrient-rich lakes, only phytoplankton data were used for the selection of water bodies for intercalibration of eutrophication in Sweden.

Selection of reference sites – criteria

In accordance with the REFCOND guidance (WFD CIS guidance document No. 10)³, an expert panel decided on a number of inclusion/exclusion criteria to define reference conditions (table 5.4) (see meeting notes, SLU, Sweden, May 2003). Experts from SLU and other experts representing the different quality elements were present at the meeting (e.g. Björn Bergquist from Fiskeriverket also participated). Applying the reference criteria, lakes and streams were separated into two groups depending on whether or not the objects fulfilled the reference criteria. In the next step, deviations from ecoregional (macroinvertebrates) or lake-type specific (phytoplankton) reference values (i.e. EQR:s) were calculated and classified using the Swedish Environmental Quality Criteria (Swedish EPA 2000). For phytoplankton, biovolume seasonal means (where available) or summer values (August) were used. For macroinvertebrates, the metrics ASPT (Average Score Per Taxon, Armitage et al. 1983), Danish Stream Fauna Index (Skriver et al. 2000), and an Acidity Index (Henriksson and Medin 1986) were used in the classification phase. To be classified as a “true reference” a lake or river had to fulfill both the reference criteria presented in table 5.4 and be classified as either EQR-class 1 or 2 according to the Swedish Environmental Quality Criteria (Swedish EPA 2000). A schematic presentation of this procedure is presented in figure 5.5.

Table 5.4 Threshold criteria for reference conditions used in the selection procedure for intercalibration sites in Sweden. Note that the pressures in grey were not considered in the selection of intercalibration sites due to the fact that data were not available.

Pressure	Lakes		Streams/ivers	
	Concentration	Land use	Concentration	Land use
N and P from agriculture	Total-P<10µg/l		Total-P<10µg/l	
	If Total-P>10µg/l, then use relationship between Total-P and water color according to Swedish Environmental Quality Criteria*	<20% agriculture in the catchment.	If Total-P>10µg/l, then use relationship between Total-P (flow-weighted annual mean) and water color (slightly modified from Swedish Environmental Quality Criteria*.	<20% agriculture in the catchment.
N and P from forestry	Tot-P<10µg/l	<10% clear cuttings (not older than 5 years in Southern Sweden, not older than 10 years in Northern Sweden).	Tot-P<10µg/l	<10% clear cuttings (not older than 5 years in Southern Sweden, not older than 10 years in Northern Sweden).
	If total-P>10µg/l, then use relationship between Total-P and water color (as AbsF) (Reference-total-P = ((Mean AbsF x 27,2 + 5,2) + 8,1).	NB This quantifies effects of N only.	If Total-P>10µg/l, then use relationship between Total-P (flow-weighted annual mean) and water color (slightly modified from Swedish Environmental Quality Criteria*.	NB This quantifies effects of N only.
Acidification	pH ≥ 6.0		pH ≥ 6.0	
	If pH<6.0, then use F-factor according to Swedish Environmental Quality Criteria*.		If pH<6.0, then use F-factor according to Swedish Environmental Quality Criteria*.	
Urbanization		<0.1% population centres according to digital maps ("röda kartan").		<0.1% population centres according to digital maps ("röda kartan").
Metals	Status class 1 or 2 according to Swedish Environmental Quality Criteria*.		Status class 1 or 2 according to Swedish Environmental Quality Criteria*.	
Alterations of hydromorfology	No criteria available		No criteria available.	
Introduced species	No criteria available. Information can be obtained from local/regional authorities		No criteria available. Information can be obtained from local/regional authorities	

*Swedish EPA (2000).

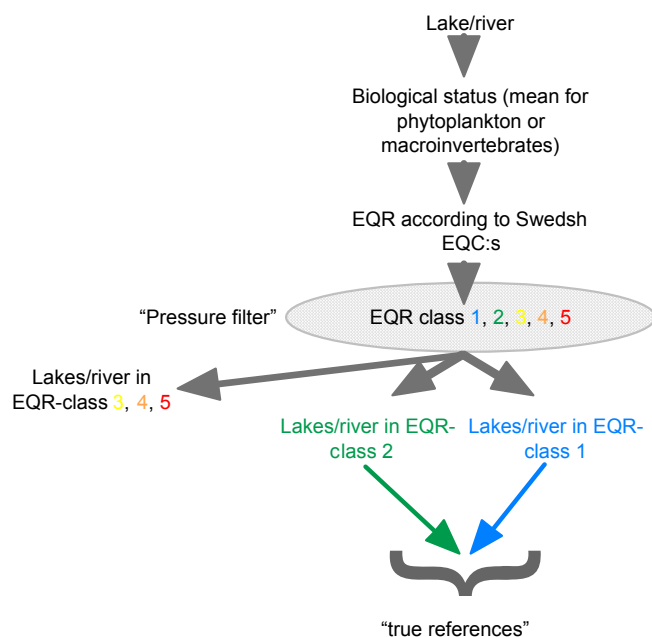


Figure 5.5 Schematic overview illustrating the procedure used in Sweden for selection of lakes and streams that are references both with respect to pressure criteria and biological quality elements (i.e. phytoplankton or macroinvertebrates). The population of “true” references was further used in the selection of sites for intercalibration. For further explanation see text.

Selection of Nordic types

Data stored in the national lake/stream database (<http://www.ma.slu.se>) was used to screen for potential intercalibration sites. This database consisted of 110 reference lakes and 30 streams/rivers, as well as some 700 lakes and 700 streams that were sampled in the national surveys of 1995 and 2000. For reference lakes and rivers/streams monitoring encompasses water chemistry, phytoplankton (lakes only), and macroinvertebrates, whereas the national surveys provide data on water chemistry and macroinvertebrates (see further description in appendix 4). These lakes and streams were classified according to Swedish and Nordic typology (Fölster et al. 2004). Pressure data consisted of land use (GIS) and water chemistry data. Only the work done on Nordic core types is presented here. Nordic lake types and frequency distribution among lakes with available data are presented in table 5.5 below. Similar data for streams/rivers are given in table 5.6. A relatively large number of lakes and streams were not classified to a Nordic lake or stream type. For example, only 5 of 31 reference streams were placed into a Nordic type. Furthermore, 44% of Swedish reference lakes are smaller than 0.5 km² and thus too small to classify according to the Nordic typology.

Table 5.5 Intercalibration types among Nordic lakes and data availability (number of lakes) in Swedish monitoring databases.

Type	Lake characterisation	Altitude & geomorphology	Mean depth (m)	Geology alkalinity (meq/l)	Lake size (km ²)	# In national survey data base	# In reference lakes' data base
L-N1	Lowland, shallow, siliceous, moderate alkalinity, large.	< 200 m or HC	3-15	0.2 - 1	0.5-5	6	1
L-N2	Lowland, shallow, siliceous, low alkalinity, large.	< 200 m and HC	3-15	< 0.2	5-40	6	0
L-N3a	Lowland, shallow, organic (humic), large, 0-5-5km ²	< 200 m and HC	3-15	Humic > 30 mg Pt/l	0.5-5	30	26
L-N3b	Lowland, shallow, humic, large, 5-40 km ²	< 200 m and HC	3-15	Humic > 30 mg Pt/l	5-40	0	0
L-N4	Boreal, very shallow, siliceous, moderate alkalinity, large	Between lowland and highland	< 3	0.2 - 1	0.5-5	0	0
L-N5	Boreal, shallow, siliceous, low alkalinity, large	Between lowland and highland	3-15	< 0.2	0.5-5 and 5-40	10	7
L-N6	Boreal, shallow, organic (humic), large	Between lowland and highland	3-15	Peat > 30 mg Pt/l	0.5-5	23	23
L-N7	Highland, shallow, siliceous, low alkalinity, large	Above treeline	3-15	< 0.2	0.5-5	4	1

Table 5.6 Intercalibration types among Nordic streams/rivers and data availability (number of streams) in Swedish monitoring databases.

Type	River characterisation	Catchment area (as km ²)	Altitude & geomorphology	Alkalinity (meq/l)	Organic material (mg Pt/l)	# In national survey data base	# In reference streams' data base
R-N1	Small lowland siliceous moderate alkalinity	10-100	< 200 m and HC*	0.2 - 1	< 30	1	0
R-N2	Small lowland siliceous	10-100	< 200 m and HC*	< 0.2	< 30	2	0
R-N3	Small lowland organic (humic)	10-100	< 200 m and HC*	< 0.2	> 30	60	2
R-N4	Medium/large lowland siliceous moderate alkalinity	100-10000	< 200 m and HC*	0.2 - 1	< 30	0	0
R-N5	Small mid-altitude siliceous	10-100	Between lowland and highland	< 0.2	< 30	8	1
R-N6	Medium mid-altitude siliceous	100-1000	Between lowland and highland	< 0.2	< 30	0	0
R-N7	Small highland siliceous	10-100	Above treeline	< 0.2	< 30	21	2
R-N8	Small highland organic (humic)	10-100	Above treeline	< 0.2	> 30	0	0

* highest coastline

Border high-good

Water bodies that could be used in the intercalibration exercise were selected using appropriate biological quality elements and current Environmental Quality Criteria (see above). In general, water bodies at the high–good border should (1) be a “true reference” and (2) should have mean deviations from reference values (EQR:s) for pressure-indicating quality elements that are close to the border of class 1 and 2 according to current Environmental Quality Criteria (Swedish EPA 2000). Having often access to several years of monitoring data, we further decided that deviations from reference values for water bodies should consistently be in deviation class 1 or 2 with respect to macroinvertebrates to be considered as potential water bodies for the intercalibration exercise. Furthermore, for benthic invertebrates, the additional criterion that the ASPT-index should be in class 1 or 2 (again, as deviations from reference values) was added. ASPT provides an indication of ecological quality that is not pressure-specific. In other words, the application of the ASPT-index in combination with the pressure-specific Acidity Index (acidification) and the Danish Fauna Index (nutrient loading/eutrophication) allowed us to detect specific responses to these two pressures and whilst avoiding omitting water bodies that might be misclassified due to low ecological quality caused by other factors. Detailed information about the criteria used for site selection is given in table 5.7.

Border good-moderate

Lakes and streams/rivers that supposedly lie on the border between good and moderate ecological status for both pressures to be intercalibrated were selected among sites that were close to deviation class 2 and 3 according to the current Environmental Quality Criteria (Swedish EPA, 2000). Once again, the criterion that ASPT was deviation class 1 was used to ensure that the sites generally had a good ecological quality and that responses to acidification and nutrient loading/eutrophication were pressure-specific. Criteria for the selection of intercalibration sites are summarized in table 5.7.

Table 5.7 Criteria used for the selection of Swedish intercalibration sites. EQR:s refer to the deviations from reference values for quality elements used in the Swedish Environmental Quality Criteria.

Water body	Pressure	Border	True reference	Mean BioV*-EQR	ASPT-EQR	DFI-EQR	Acidity index-EQR	Other
Lakes	Eutrophication	High-good	Yes	0.9–1.0	–	–	–	
	Eutrophication	Good-moderate	Not necessarily	2	–	–	–	
	Acidification	High-good	Yes	–	≥0.9	–	0.83–1.0	Poor–good Alkalinity**
	Acidification	Good-moderate	Not necessarily	–	≥0.9	–	0.50–0.67	Poor–no/insignificant Alkalinity
Streams/ rivers	Eutrophication	High-good	Yes	–	0.98–1.2	0.80	–	
	Eutrophication	Good-moderate	Not necessarily	–	0.83–0.92	0.80	–	
	Acidification	High-good	Yes	–	≥0.9	–	≥1.0	
	Acidification	Good-moderate	Not necessarily	–	≥0.9	–	0.5–0.83	

* Seasonal means, for intensively monitored lakes, otherwise summer values (August).

** according to status classification in Environmental Quality Criteria (Swedish EPA 2000).

Comments

Some Nordic core types were absent or poorly represented in Swedish databases for inland waters. Furthermore, the focus of national and regional monitoring programs in Sweden is on “reference” lakes/streams, which results in a poor representation of impacted lakes and streams/rivers. This is particularly true for eutrophication. National reference lakes are not a random (or stratified) selection of Swedish lakes, but are selected for monitoring the effects of acid deposition on water chemistry and biota, and these sites lack other pressures such as nutrient loading and other point source pollution. Consequently, most reference lakes are classified as small, situated in forest-dominated catchments, and has relatively low alkalinity and moderate/high water color.

Type-specific reference conditions were not used in the calculations of EQR:s, since these data were not available. Instead, EQR:s were calculated using regional-specific reference values given for benthic invertebrate indices and the reference values for mountain lakes, forest lakes and lowland lakes given for phytoplankton (Swedish EPA 2000). These reference values have their shortcomings and are recommended for use only if other more reliable assessments of reference condition are not available. However, working with large data sets, this approach was the best we could accomplish. An alternative way towards the determination of reference conditions is a modeling approach, where water body-specific refer-

ence conditions are quantified (similar to the RIVPACS approach in the UK). Appropriate models are presently available for lake and stream macroinvertebrates (Johnson and Sandin, 2001; Johnson 2003), however the programming is not in an easily accessible format for general use. Prediction is a promising approach for establishing water-body-specific reference conditions, in particular if communities are responding to environmental continua/gradients and not discrete variables.

Inter annual variability in the assessment of ecological status in the selection of potential intercalibration stations was considered only for macroinvertebrates. Here, we used a rather firm criterion that the quality element measuring the impact of acidification or eutrophication should not at any time be lower than EQR-class 2. Additionally, ASPT, reflecting general ecological quality, should be ≥ 0.9 (i.e. EQR-class 1). The latter was less tough, since most water bodies fulfilled this criterion.

Central river types

Presentation of result and some comments on the result from testing of central river types are needed: 4 sites were found for one type.

An analysis of potential common central river types for Sweden and Denmark has been done. The analysis shows that there exist 15 river stations in the Swedish national river survey for the central river type R-C6 (small lowland calcareous). No further analysis has, however, not been done on these rivers.

Denmark

Danish streams are placed in the Geographical Intercalibration Group “Central Rivers” representing the European lowland. Alkalinity in the streams is clearly linked to the prevailing soil type in the catchment. The western part of Denmark is completely dominated by siliceous soils. Streams in this area has an alkalinity < 1 meq/l. The eastern part of Denmark is a hilly moraine landscape with soils dominated by clay. Here, the streams typically have alkalinity values of 2–5 meq/l. Generally most Danish streams are small and only two streams have a catchment area of more than 1000 km². Therefore, sites for the intercalibration can only be found in the two categories 10–100 km² and 100–1000 km². As a consequence Denmark can contribute with monitoring data from the three stream types R-C1, R-C4 and R-C6 (table 5.8).

Table 5.8 Central rivers: intercalibration types found in Denmark.

Type	River characterisation	Catchment area	Altitude & geomorphology	Alkalinity
R-C1	small lowland siliceous sand	10-100 km ²	lowland, dominated by sandy substrate (small particle size), 3-8 m width (bankfull size)	Medium alkalinity
R-C4	medium lowland mixed	100-1000 km ²	lowland, sandy to gravel substrate, 8-25m width	Medium alkalinity
R-C6	small lowland calcareous	10-100 km ²	lowland, gravel substrate (limestone), 3-10m width (bankfull size)	High alkalinity

In the following a short presentation of these three stream types in Denmark is presented.

R-C1:

Small lowland streams in western part of Denmark (figure 5.6). The bottom substrate is dominated by sand. The alkalinity is in the range 0.5–1 meq/l. Macrophytes are often an important component. Macroinvertebrates are found in medium to high densities. Trout lives in these streams but typically only in low densities because of limited spawning areas.



Figure 5.6 Intercalibration type R-C1. Small lowland siliceous streams (10–100 km²). Width is 3-8 m. The bottom substrate is dominated by sand. The alkalinity is in the range 0.5–1 meq/l

R-C4:

Medium sized lowland streams in western Denmark (figure 5.7). The bottom substrate is dominated by sand but may also include gravel. The alkalinity is in the range 0,5-1 meq/l. Macrophytes typically are an important component. Macroinvertebrates are found in medium to high densities. Trout lives in these streams but typically only in low densities because of limited spawning areas.



Figure 5.7 Intercalibration type R-C4. Medium sized lowland streams (100–1000 km²). Width is 8–25 m. The bottom substrate is composed of sand and gravel. The alkalinity is in the range 0.5–1 meq/l.

R-C6:

Small lowland streams in the central and eastern parts of Denmark (figure 5.8). The bottom substrate is typically dominated by gravel. The alkalinity is high i.e. in the range 2-5 meq/l. In open areas macrophytes may be an important component. In forest areas macrophytes may be scarce and only represented by mosses. Macroinvertebrates occur in high densities. Trout are typically found in high densities because of a diverse habitat quality with numerous spawning areas.



Figure 5.8 Intercalibration type R-C6. Small calcareous lowland streams (10–100 km²). Width is 3–10 m. The bottom substrate is dominated by gravel but it also includes sand and stones. The alkalinity is in the range 2–5 meq/l.

Selection of intercalibration sites

So far macroinvertebrates is the only biological quality element that has been used for ecological stream classification in Denmark. The amount of macroinvertebrate data is comprehensive but there is in general a lack of reference data. The ecological classification is based on seven index values of the Danish Stream Fauna Index (DSFI) (Skriver et al. 2000). An index value of 7 indicates little or no impact whereas an index value of 1 indicates a strongly impacted macroinvertebrate community. Generally, the regional authorities have decided that a DSFI index value of 5 (a slightly impacted fauna) is satisfactory in order to fulfil the quality objectives in most streams.

With the present knowledge as well as administrative tradition the DSFI index values can be translated into the WFD ecological quality classes:

DSFI index values	WFD ecological classes
7	high quality
5–6	good quality
4	moderate quality
3	poor quality
1–2	bad quality

The border between DSFI index values 4 and 5 therefore is believed to represent the border between moderate and good ecological quality. Intercalibration sites representing this border will be selected on the basis of all of the following criteria:

The DSFI value have changed between 4 and 5 in the period 1998-2002

Boot-strap calculations on individual fauna lists from single occasions shows that the DSFI index value changes between 4 and 5.

Expert judgement: the overall fauna has been relatively stable over the period 1998-2002

Monitoring data on macrophytes and fish have not up till now been used for ecological classification and existing data are nearly all from impacted sites. Therefore macroinvertebrates are chosen as the only biological element for the selection of intercalibration sites.

It has been decided that two sites will be selected from each border high/good and good/moderate in each of the three intercalibration stream types in Denmark (R-C1, R-C4 and R-C6). Because two pressures are described for R-C1 and R-C4 streams (organic/nutrient pressure and stream modification) four sites representing the border good/moderate will be selected from each of these two intercalibration types (2+2).

Future perspectives

Some preliminary proposals have been developed on metrics for ecological classification using macrophytes, macroinvertebrates and fish in the context of the Water Framework Directive (Baatrup-Pedersen, et al. in press). In the coming years when monitoring data from the new NOVANA programme are available these proposals will be tested and further developed in order to fulfil the requirements of the directive that all biological quality elements are used in the final ecological classification.

Appendix 6: Compilation of methods and metrics for rivers

Table 6.1 Methods and metrics used in assessment of river macroinvertebrates in the Nordic countries.

Macro-invertebrates	Sweden 1	Sweden 2	Norway 1	Norway 2	Norway 3	Finland
Monitoring program	National Survey	Reference rivers	Reference rivers	National acidification survey	Surveys on effects of local pollution and river regulations	Various statutory monitoring programs, national survey in prep.
Sampling depth	littoral, 0–1	littoral, 0–1	littoral, 0–1	littoral, 0–1	littoral, 0–1	littoral, 0–1
Sampling frequency	every fifth year	annually	annually	annually – bi-annually	annually (seldom more than two years)	variable, every 3 rd year common
Time of sampling	autumn	autumn (spring until 1994?)	spring and autumn	spring and autumn	autumn	autumn or spring+autumn
Duration of monitoring: first year-last year	1995 and 2000	1988 or 1995-present	1986-present	1981 (1998)-present	variable	variable
Standard methods	SS-EN 27828	SS-EN 27828	ISO 7828	ISO 7828	ISO 7828	SFS-5077
Sampling methods qualitative (kick-sampling)	0.5 mm, 1m x 60 s	0.5 mm, 1m x 60 s	0.25 or 0.5 mm, variable time (time is registered)	0.25 mm, 120 s	0.25 or 0.5 mm, older studies: 120 s; newer studies: 3 m x variable time (time is registered)	0.5 mm, 1m x 30–60 s
Sampling methods, quantitatiiv	not available	not available	Surber-sampler	not available	In some cases Surber-sampler	not available
Level of taxonomic composition	lowest possible unit (not for oligochaetes), which generally is species?	lowest possible unit (not for oligochaetes), which generally is species?	lowest possible unit which generally is species (not for chironomids)	lowest possible unit which generally is species (not for chironomids)	lowest possible unit which generally is species (not for chironomids)	lowest possible unit (not for oligochaetes, simuliids & chironomids)
Taxonomic composition, used metric	ASPT, Danish faunaindex, Shannon, Medins acidity index. Note that a standardized list of 517 taxa	ASPT, Danish faunaindex, Shannon, Medins acidity index. Note that a standardized list of 517 taxa	relative bundance/species, Raddum's acidification index	relative abundance/species, Raddum's acidification index	relative abundance/specie, Shannon-Wiener, Modified Trent index, BMTP, ASTP	variable, common metrics include ASPT, functional feeding group composition

Macro-invertebrates	Sweden 1	Sweden 2	Norway 1	Norway 2	Norway 3	Finland
	is used for calculation of indicator metrics!	is used for calculation of indicator metrics!				
Size composition	not available but >0.5 mm	not available but >0.5 mm	not available but >0.5 mm	not available but >0.25 mm	not available but >0.5 mm	not available but >0.5 mm
Abundance (biomass or numbers)	CPUE	CPUE	CPUE (numbers)	CPUE (numbers)	CPUE (numbers)	total/group abundances
Species richness (number)	available, specify what metric/index!	available, specify what metric/index!	Total species numbers	Total species numbers	EPT	total species number, number of type specific species, number of EPT species
Species diversity	Shannon (log2)	Shannon (log2)	available, needs to be specified	not available	Shannon	Shannon (log2)
Indicator taxa	indicator scores according to the various indicator metrics (above)	indicator scores according to the various indicator metrics (above)	not available	indicator scores according to acidification index (above). Species list is given in Raddum & Fjellheim (1985) and Fjellheim & Raddum (1990).	not available	indicator scores according to the various indicator metrics (above)

Table 6.2 Methods and metrics used in assessment of river fish populations and communities in the Nordic countries.

Fish	Sweden	Norway	Finland
Monitoring program	National monitoring	National acidification survey	National river surveys and studies
Sampling depth	River segments of 100 m at depth 0.1-0.75 m	0.1-0.75 m	0.1-1 m
Sampling frequency	annually to every third year	annually	annually
Time of sampling	July-August	August-October	August-September
Number of sampling sites for each sampling occasion	varies	6-18 sites per river (anadromous sections)	1-5 sites per 10 km of river; 5-30 sites per river, max. 60-90 sites per river
Duration of monitoring: first year-last year	About 1985 - present	1986 (1998) - present	(1970s)-1980s- present
Standard methods	Swedish standard	EN 14011 (modified Swedish standard)	Close to Swedish Standard
Sampling methods	Electro fishing (three successive sampling from each area)	Electro fishing (area: minimum 100 m ² per segment, three successive sampling from each area).	Electro fishing
Level of taxonomic composition	Species	Species	Species
Taxonomic composition, used metric	Total abundance, abundance/species, species-richness	Total abundance, abundance/species, species-richness	Total abundance, abundance/species, species-richness
Age/size structure	length and weight	length and weight	Age: 0+ salmonids, Length: all species?
Abundance (biomass or numbers)	CPUE (numbers, biomass)	CPUE (numbers, biomass)	CPUE (numbers, biomass)
Specifying native species	Diversity-index	Available (species, abundance/species)	
Indicator taxa	Available	Mainly trout and salmon.	

Appendix 7: Compilation of methods and metrics for lakes

Table 7.1 Methods and metrics used in assessment of Lake Phytoplankton in the Nordic countries.

Phytoplankton	Sweden	Finland	Norway
Monitoring program	Time-series lakes (National monitoring)	National monitoring, local monitoring	National eutrophication survey
Sampling depth	epilimnion	epilimnion (at present 0 - 2 m)	epilimnion
Sampling frequency	Monthly or 4x per year	Monthly/once during the summer months	Monthly
Time of sampling	April/May– October	May–August/July or August	April/May–October
Duration of monitoring: first year–last year	1988–on going	varies depending on type of monitoring and on site/monitoring of some sites beginning in 1960s	1988–2001 (few lakes with more than 1–2 years of sampling)
Standard methods used	No, but thoroughly documented in SEPA report 4860* (common “Nordic methodology” since early 1990s)	No, but thoroughly documented in SEPA report 4860* with slight modifications, previous methods to a large extent similar	No, but thoroughly documented in SEPA report 4860* with slight modifications
Sampling methods – integrated or discrete	integrated	integrated	integrated
Level of taxonomic composition	generally species level	mainly species	generally species level
Taxonomic composition, used metric	species richness, composition, biomass per indicator (species/group)	abundance	biomass per indicator (species/group)
Size composition	not available	available	not available
Abundance (numbers)	not available	counting units in 100 ml	cells/L
Abundance (biomass)	mm ³ /l	mg/l	mg/l
Bloom frequency	not available	not available	not available
Proportion of toxic Species/taxa	not available	available	not available
Indicator taxa	diatoms, cyanobacteria (incl. toxin-producing species), <i>Gonyostomum semen</i> (all eutrophication)	Diatomophyceae, Cyanophyceae, Cryptophyceae, Raphidophyceae, others possible to add	diatoms, cyanobacteria (incl. toxin-producing species), <i>Gonyostomum semen</i> (all eutrophication), also other indicator species for acidification

* Blomqvist et al. 1998.

Table 7.2 Methods and metrics used in assessment of littoral lake macroinvertebrates in the Nordic countries.

Macroinvertebrates, littoral	Sweden 1	Sweden 2	Norway
Monitoring program	National Survey	Reference lakes	National acidification survey
Sampling depth	littoral, 0–1	littoral, 0–1	littoral, 0–1
Sampling frequency	every fifth year	annually	annually to every fourth year
Time of sampling	autumn	autumn (spring until 1994)	autumn (as well as spring in some lakes)
Duration of monitoring: first year-last year	1995 and 2000	1988 or 1995–present	1996 (1999)–present
Standard methods	SS-EN 27828 (ISO 7828)	SS-EN 27828 (ISO 7828)	Macroinvertebrates: NS-ISO 7828 (ISO 7828) Crustaceans: EN 15110 Macroinv: kick-sampling, 0.25 mm mesh size, 120 sec
Sampling methods qualitative (kick-sampling)	0.5 mm mesh size, 1 m x 20 sec	0.5 mm mesh size, 1 m x 20 sec	Crustaceans: plankton-net, 0.09 mm mesh size, 2–30 m
Sampling methods, quantitatiiv	not available	not available	not available
Level of taxonomic composition	lowest possible unit (not for oligochaetes), which generally is species	lowest possible unit (not for oligochaetes), which generally is species?	lowest possible unit (not for oligochaetes and chironomids) which generally is species
Taxonomic composition, used metric	ASPT, Danish faunaindex, Shannon, Medins acidity index. Note that a standardized list of 517 taxa is used for calculation of indicator metrics!	ASPT, Danish faunaindex, Shannon, Medins acidity index. Note that a standardized list of 517 taxa is used for calculation of indicator metrics!	Relative abundance/species, Raddum's acidification index, number of sensitive Ephemeropterans vs. tolerant Plecopterans
Size composition	not available but >0.5 mm	not available but >0.5 mm	not available but >0.25 mm
Abundance (biomass or numbers)			Relative abundance (numbers)
Species richness (number)	Species richness	Species richness	total number of species, number of sensitive species
Species diversity	Shannon (log2)	Shannon (log2)	not available
Indicator taxa	indicator scores according to the various indicator metrics (above)	indicator scores according to the various indicator metrics (above)	indicator scores according to acidification index (above). Species list is given in Raddum & Fjellheim (1985) and Fjellheim & Raddum (1990).

Table 7.3 Methods and metrics used in assessment of profundal lake macroinvertebrates in the Nordic countries.

Macroinvertebrates, profundal	Sweden	Finland
Monitoring program	reference lakes	surveys or nat. monitoring
Sampling depth	max depth	max depth, partly also other depths
Sampling frequency	annually	various
Time of sampling	autumn	autumn
Duration of monitoring: first year-last year	1985–present	varies depending on the monitoring type, some data from the 1970s
Standard methods	SS-028190	SFS-EN-ISO 9391 (ISO 9391) and SFS 5730
Sampling methods qualitative (kick-sampling)	not available	not available
Sampling methods, quantitativ	Ekman sampler, 0.025 m ²	Ekman sampler, in some cases also core sampler
Level of taxonomic composition	lowest possible unit - which generally is species (not oligochaetes) - not used in assessment protocols	lowest possible unit - which generally is species (not always for oligochaetes and chironomids)
Taxonomic composition, used metric	Benthic Quality Index (BQI), depth normalized Oligochaeta : Chironomidae ratio	Abundance, in some studies: Benthic Quality Index (BQI)
Size composition	not available but >0.5 mm	not available but >0.5 mm
abundance (biomass or numbers)	not in assessment protocols (but can be calculated: ind/m ² , g/m ²)	ind/m ² , g/m ²
species richness (number)	not used in assessment protocols (but can be calculated)	can be calculated
species diversity	not used in assessment protocols (but can be calculated)	can be calculated
indicator taxa	Chironomidae in BQI (eutrophication) Chironomidae: <i>Heterotrisscladius subpilosus</i> , <i>Paracladopelma</i> sp., <i>Micropsectra</i> sp., <i>Heterotanytarsus apicalis</i> , <i>Heterotrissocladius grimshawi</i> , <i>Heterotrissocladius marcidus</i> , <i>Heterotrissocladius maeaeeri</i> , <i>Sergentia coracina</i> , <i>Tanytarsus</i> sp., <i>Stictochironomus</i> sp., <i>Chironomus anthracinus</i> , <i>Chironomus plumosus</i>	several systems used by various studies, such as BQI, Chironomidae index

Table 7.4 Methods and metrics used in assessment of lake fish populations and communities in the Nordic countries.

Fish	Sweden	Norway 1	Norway 2	Finland
Monitoring program	National monitoring	National eutrophication survey	National acidification survey	National acid. and eutr. studies
Sampling depth	Littoral, profundal, pelagial	Variable	Littoral, profundal, pelagial	(Littoral,) profundal, pelagial
Sampling frequency	annually to every third year	Variable (mainly one year)	Annually to every fourth year	annually to every third year
Time of sampling	July-August	?	August-October	July-August
Number of sampling sites for each sampling occasion	4-16 nets/night	?	4-16 nets/night	3-12/night, 3-80/lake/year
Duration of monitoring: first year-last year	1985–present	Variable (mainly one year in the period 1988-present)	1982 (2000)-present	1985-
Standard methods	CEN/TC 230/WG 2/TG 4 N 28, 2nd Working draft	No	CEN/TC 230/WG 2/TG 4 N 28, 2nd Working draft	CEN/TC 230/WG 2/TG 4 N 28, 2nd Working draft (Modified)
Sampling methods	Nordic multi-mesh gillnets	Variable	Nordic multi-mesh gillnets	Nordic multi-mesh gillnets
Level of taxonomic composition	species	species	species	Species
Taxonomic composition, used metric	total abundance, abundance/species, species-richness	fish predation index	Total abundance, abundance/species, species-richness	Abundance/species
Age/size structure	length and weight	not available	length and weight	Age occasionally, length always
Abundance (biomass or numbers)	CPUE (numbers, biomass)	not available	CPUE (numbers, biomass)	CPUE (numbers, biomass)
Specifying native species	diversity-index	not available	Available (species, abundance/species)	Available
Indicator taxa	available	may be available	Mainly trout lakes. In SE-Norway: relative abundance of roach and cyprinids	Acid: roach Low O2: tench, cr-carp Eutr: various cyprinids

Abbreviations

CIS	Common Implementation Strategy
DK	Denmark
EPA	Environmental Protection Agency
EQR	Ecological Quality Ratio
FI	Finland
GIG	Geographical Intercalibration Group
GIS	Geographic Information System
HC	Highest coastline during the last glaciation
IC	Intercalibration
IE	Ireland
JRC	Joint Research Center
NCM	Nordic Council of Ministers
NMD	Nordiska arbetsgruppen för miljöövervakning och data
NO	Norway
REFCOND	Reference condition
SE	Sweden
SLU	Swedish University of Agricultural Sciences
UK	United Kingdom
WFD	Water Framework Directive