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TRIWA project - The River Torne International WAtershed

Development of a common typology for surface waters of River Torne international river basin district

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Front page: Lake Olosjärvi, photo Noora Salonen.

1. INTRODUCTION

According to the EU Water Framework Directive (WFD) 2000/60/EG, the River Torne in northern Sweden and Finland has to be established as an international River Basin District. This means that the two countries have a mutual responsibility to manage and administrate the lakes and rivers in this area. This requires cooperation between the Swedish and Finnish authorities. Today the monitoring of water quality is carried out nationally on each side of the river. Two different monitoring systems make it difficult to attain an overall picture of the state of the area. A joint system would be more cost-effective and facilitate evaluations of the results. Northern regional authorities in Sweden and Finland have therefore initiated the TRIWA-project as a step towards a common river basin management. The three northernmost counties of Norway (Troms, Nordland and Finnmark) are participating the project as observers.

The environmental goals demanded by the WFD will be achieved by building a cooperation network between regional and local authorities as well as other stakeholders. In the future, this project will lead towards common river basin management and measure plans, which in a cost-effective way ensure a long-term sustainable water use in the area.

This report describes the background and aims of the TRIWA–project and presents the preliminary results of the subproject concerning the development of harmonized typology for the River Torne watershed. The typology subproject was partly financed by the North Calotte Council.

2. THE TRIWA –PROJECT

The TRIWA-project is a collaboration between the County Administrative Board of Norrbotten in Sweden and Lapland Regional Environment Centre in Finland. The aim of TRIWA is to build a foundation for a coordinated system for monitoring and administration of water resources, and to characterize reference conditions for the different lake and river types of the River Torne watershed according to the EU Water Framework Directive. The system must be based on a mutual view on the aquatic status, as this is the starting point in developing a common Finnish-Swedish monitoring program. The work is performed in close contact with national authorities as well as water protection organizations and local authorities.

The TRIWA-project consists of two subprojects. The first is "Developing a harmonized typology for lakes and rivers in the River Torne watershed" (partly financed by The North Calotte Council). The other is "Reference Conditions in Lakes and Streams in River Torne International Watershed- a Step Towards a Harmonized Monitoring Programme" (partly financed by the EU Regional Development Fund, INTERREG IIIA Nord).

There are five tasks altogether in the TRIWA-project: 1) Development of common typology, 2) Field investigations, 3) Identification of reference conditions, 4) Estimation of ecological state and anthropogenic pressures, and 5) Recommendations for a harmonized monitoring program. In addition, one object is to increase public awareness of the ecological values in the area.

TRIWA is carried out by a working group from the Lapland Regional Environment Centre and the County Administrative Board of Norrbotten. In addition, several people have been involved in the project during the field inventories.

2.1. Background

Collaboration between Lapland Regional Environment Centre and County Administrative Board of Norrbotten started in the mid 1990´s. The aim was to identify the water quality, ecological state and anthropogenic pressures of the River Torne watershed. The collaboration produced a report published in both countries: The River Tornio – state and loading of river system (Torne älv - tillstånd och belastning (SWE), Tornionjoki - vesistön tila ja kuormitus (FIN)). Experiences from the 1990's project showed the need for more effective co-operative monitoring. Further, the need for harmonization of the monitoring methods was recognized.

2.2. Watershed characteristics

The catchment area of the River Torne is 40 157 km^2 with 1309 lakes larger than 0,2 km^2 and 469 lakes larger then 0,5 km^2. The area contains 320 river sub-catchments larger than 50 km^2 and 93 areas larger than 200 km^2. In addition, there are thousands of smaller water bodies. Figure 1 shows the location of River Torne on the border between Finland and Sweden.

The main channels are unregulated and the river has special value as one of the remaining watersheds with natural Baltic salmon reproduction. Human impact is minor in the Northern parts of the watershed but more severe in the Southern parts. One objective in the TRIWA–project was to select pristine lakes and rivers to act as reference areas for different types of surface water. This was exceedingly difficult in the Southern parts of the watershed due to human impact.

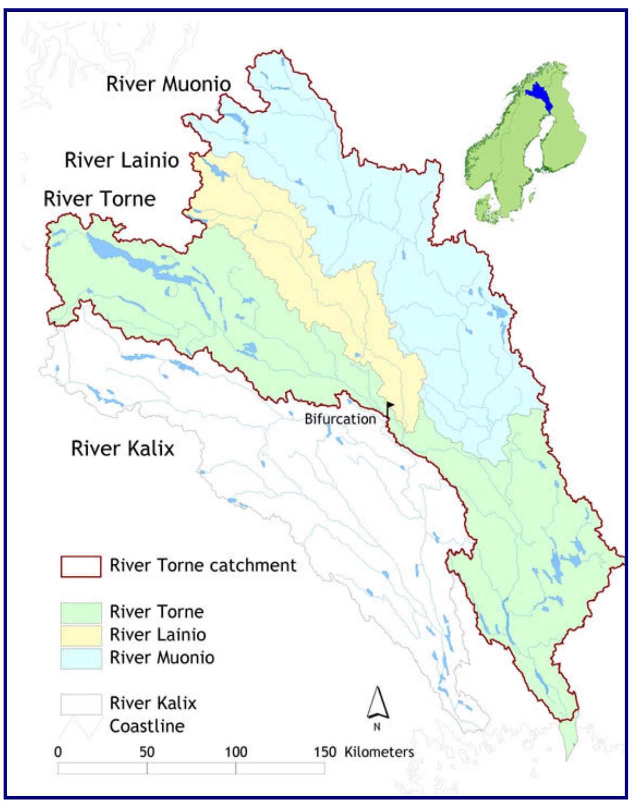

Figure 1. The River Torne Watershed.
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3. TYPOLOGY GUIDELINES

The WFD requires that member states differentiate the relevant surface water bodies with respect to their natural type, and that member states establish type specific reference conditions for these types. Deviation from the reference conditions is then used as a base for the classification of the ecological state of the surface water bodies. The classifications will be subsequently included in the river basin management plans that will be reported to the EU Commission for the first time in 2009.

The types shall be classified using either system A or system B (Annex II in the 2000/60/EG Directive). The two systems are similar in the way that 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 with preset categories how water bodies shall be aggregated spatially (ecoregions) and with respect to specific altitude, size and depth intervals. The system B, besides lacking strict prescription, permits the use of additional factors. It is up to member states to decide what system to use. Hence, the member states can develop their own specific guidelines for the typology according to system B. Most member states, including the Nordic countries, have indicated to prefer the system B.

The differences in national typologies and GIS-data (Geographical Information System) in Finland and Sweden launched the need for development of a harmonized typology system for the River Torne International watershed. Lack of water chemistry data required for the typology (water colour) also induced the need for alternative methods. Further, the serious lack of preliminary biological data made the work even more challenging.

3.1. Comparison of Finnish and Swedish typologies

The national typologies have been made according to available knowledge of different biological lake- and river types, distributions of regional quality factors in water bodies and the correlation between aquatic organisms and environmental factors.

The preliminary national typology in Sweden contains 96 theoretical types. When rare types with less than 10 existing water bodies are excluded, 47 types remain. 21 types are present in the Northern areas. Respectively it contains 48 theoretically river types. The factors used in the Swedish typologies are (preliminary):

1. Ecoregion	- 4 regions: Central plain, Fenno-Scandian shield below 200 m.a.s.l., Fenno-Scandian shield above 200 m.a.s.l and Borealic uplands. The ecoregions were classified according to map A in Annex XI in the WFD. Alternative classifying factors used for the Swedish typology were the tree limit for the demarcation of the alpine region and the border between the Central Plain and the Fenno-Scandian shield. The border follows the southern border of the catchment area of the river Dalälven and the northern border of the catchment area of river Klarälven in the west.
2. Size classes	- 4 classes for lakes (<0,5 km^2, 0,5-2 km^2, 2-10 km^2, >10 km^2) - 3 classes for rivers (10-100 km^2, 100-1000 km^2, >1000 km^2)

3. Mean depth for lakes - deep lakes with mean depth >3m (represents lakes with possible thermal stratification)
- shallow lakes with mean depth <3m

4. Geology - "siliceous"
- organic ($Abs_{F450/5}$>0,06)
- calcareous (Ca>0,5meq/l)
- mixed calcareous and organic

The national typology in Finland contains 10 lake types and 5 subtypes (figures 2 and 3). Respectively it contains 11 river types and 5 subtypes. The factors used in the Finnish typology are:

1. Altitude -mountain lakes >250 m.a.s.l)
2. Geology - calcareous for lakes
- organic, siliceous and clayey for rivers
3.Colour for lakes - <30 mgPt/l, 30-90 mgPt/l, >90 mgPt/l
4.Size -3 classes for lakes (<5 km^2, 5-40 km^2, >40 km^2)
-4 classes for rivers (small 10-100 km^2, medium 100-1000 km^2, large 1000-10000 km^2, very large >10000 km^2)
5. Trophic level - natural nutrient rich lakes
6. Possible stratification for lakes.

In River Torne catchment area, the national typologies proved to be in many cases complicated and impractical to use. Both typologies had their advantages and disadvantages. For instance, Swedish typology has ecologically sound boundaries for ecoregions, but the number of types is overwhelming. Finnish system has a practicable number of types, but the strict altitude limit for mountain lakes can lead to misleading classification. National typologies may be suitable on the national scale, but are often impracticable and inaccurate for the northern watersheds.

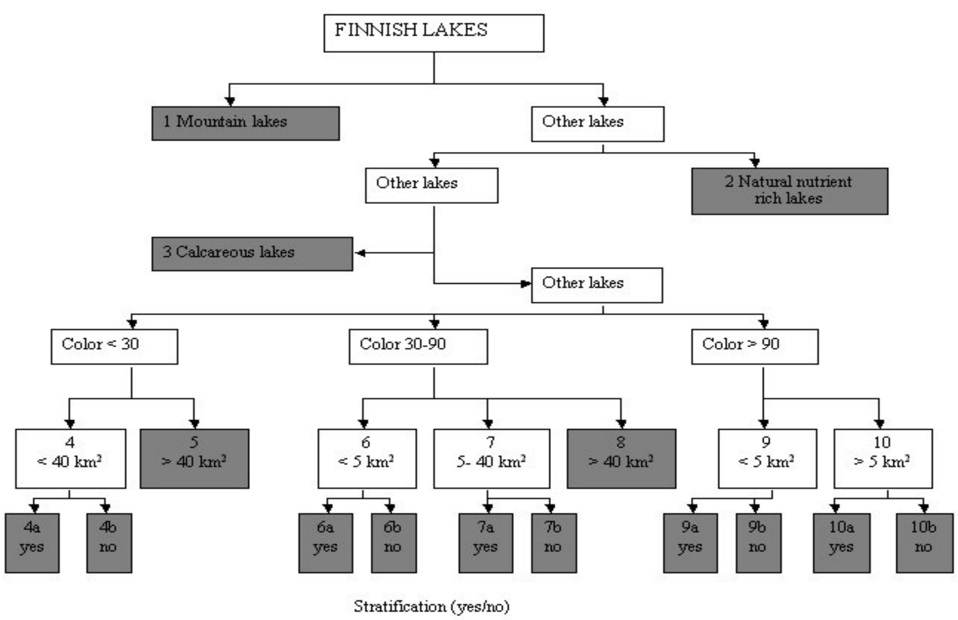

Figure 2. The Finnish typology for lakes.

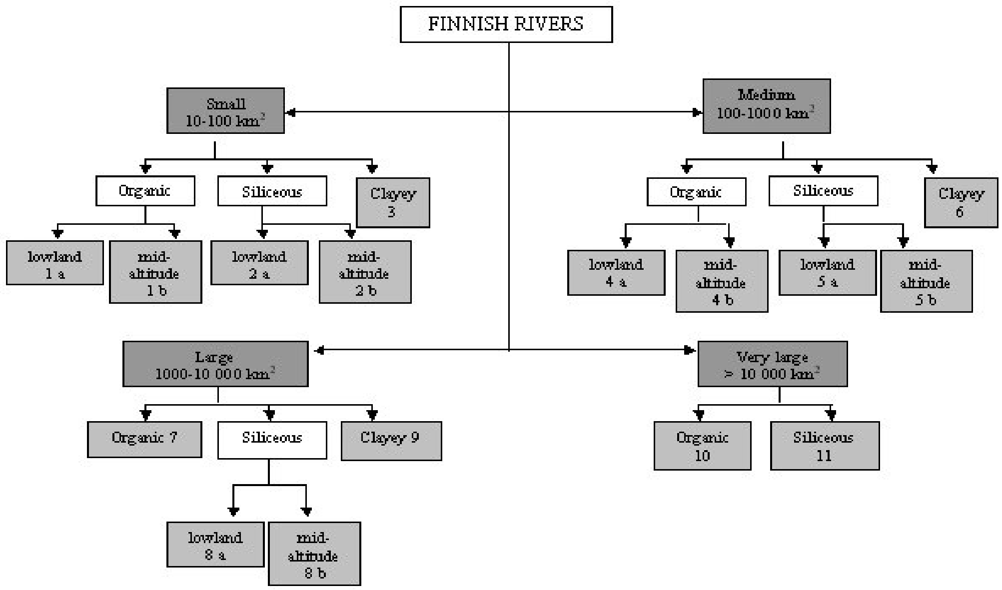

Figure 3. The Finnish typology for rivers.

4. HARMONIZED TYPOLOGY FOR THE RIVER TORNE WATERSHED

Identification and outlining of boundaries of surface water bodies was the initial task. Due to the large number of small water bodies in the River Torne watershed, only lakes larger than 0,5 km^2 and river catchments larger than 200 km^2 were considered for the harmonized typology.

Next step was to classify lakes and rivers into the different water types depending on e.g. geographic location/ecoregion, size and geology. The different approaches of Swedish and Finnish typologies were compared and applied in the River Torne area in order to develop a harmonized typology system appropriate for this watershed particularly.

One aim in the development of common typology was to set the number of different lake and river types moderately low, in order to create a practicable method for characterization of different water bodies. However, the number of types had to be sufficient to portrait the whole range of ecologically different surface waters in the River Torne watershed.

4.1. Main factors of the TRIWA typology

The ecoregion factor was defined into three classes: mountain, inland and coastal regions. Mountain waters were defined to be above the conifer tree limit which represents a climate limit. The conifer tree line is comparable to the limit between the borealic upland and the fenno-scandian shield. The classification by a constant altitude, as in the Finnish definition of mountain lakes, resulted in many forest land inland lakes being classified into the mountain lake-category. The highest coastline (HC) since last glacial period (Lake Ancylus), which is located approximately 200 meters above the present sea level in the River Torne area, was used to differentiate the inland and coastal waters

(Figures 6 and 7). It is an ecologically relevant limit for e.g. fish and zooplankton (though zooplankton is not included in the Directive) and it also represents differences in catchment geology and water chemistry of waters above or below HC.

Separation of different size classes for the lakes (3 classes) and river catchments (3 classes) was done in a similar way as the national typologies.

Additionally, a "geology" factor was used to characterize the humic content of the water, which is greatly influenced by the share of peat land (wetland) in the catchment area. The factor was determined using the measured or estimated water colour for lakes, and estimated peat land cover of the catchment area for rivers. The limit values for the two classes (clear/brown) were determined using the results of a regression analysis (se 4.2 below). Calcareous waters are scarce in the River Torne watershed and thus excluded in the suggested typology for the time being.

Lake depth-factor was discarded due to lack of depth measurements on many lakes on the River Torne watershed, especially on the Swedish area. Further, the use of constant depth limit (mean depth 3 m in Swedish typology) seemed rather artificial in biological point of view. Depth limit should perhaps be related to some biologically valid variable, for instance the thickness of lake's productive layer (secchi depth). Estimation of lake's thermal stratification (a factor in Finnish typology) using only depth data was also regarded unreliable.

4.2. Modeling of the geology factor

Water chemistry data from Sweden and Finland was available for 141 of 469 lakes larger than 0,5 km^2. The problem of missing water colour observations needed for the geology classification, was solved using several methods. Using existing data, a regression was calculated between the water colour of water bodies and peat land (wetland) cover of their catchment areas. Further, missing water colours of lakes were estimated using the available water colour values of neighbouring water areas. This was done using an IDW –method (Inverse Distance Weight) with GIS-program ArcView 3.2a. The method is based on spatial interpolation. Finally, expert judgement was used with problematic cases (water bodies with strong human impact etc.).

Regression between lake water colour and catchment's peat land cover was calculated using data of 30 frequently monitored, nearly pristine Finnish lakes. Further, similar regression was calculated for Swedish river data. The results indicated that almost all lakes and rivers with peat land cover more than 20 % of their catchment area had a water colour around or over 60 mg Pt/l. The regression gives a small overestimation of colour for water bodies with low peat area coverage (Figures 4 and 5). Also, the water retention time is a factor affecting the water colour of a lake. However, data of retentions times is scarce in both Finland and Sweden and could not be included in the calculations.

Calculations of land use (wetland cover) for all lake and river catchments were performed in Sweden (based on Lantmäteriet's vegetation maps). In Finland, Finnish Evironment Institute's land use database for small-scale river catchments gave sufficiently accurate estimate for peat land cover of the lake catchments. The lack of water colour observations for the remaining 328 lakes was complemented using expert judgement, IDW-method and regression analysis (colour vs. peat %).

The geology factor was tested using different number of classes and colour/peatland limits. Separation of water bodies into more than two colour classes raised the number of types impractically high. Further, use of three or more colour classes often led to erroneous typing of lakes and rivers with scarce data or strong human impact. The ecological relevance of the decided limits (</>60 mg Pt/l or </>20% wetland) will be evaluated in coming field studies.

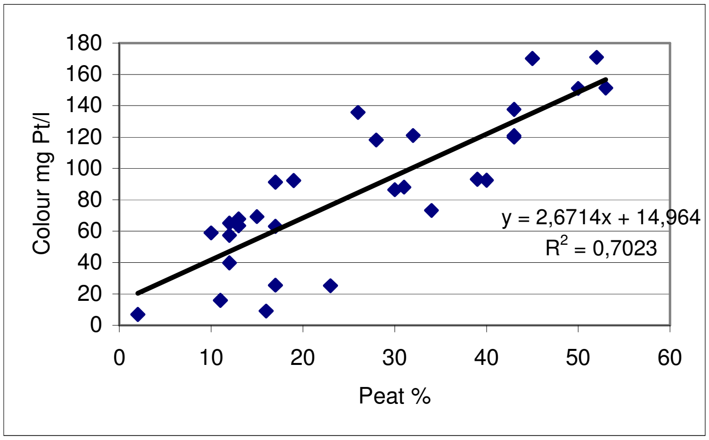

Figure 4. Regression analysis between water colour and peat land (wetland) cover of catchment area for lakes. No. of lakes >10 observations=30.

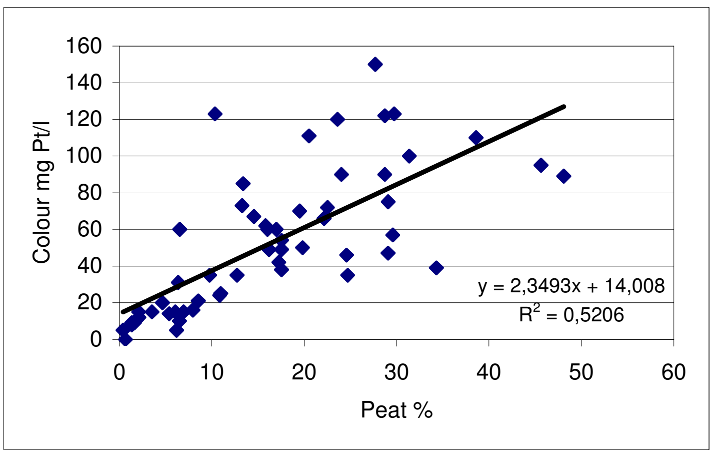

Figure 5. Regression analysis between water colour and peat land cover of catchment area for rivers. No. of rivers =56.

4.3. Suggested typology for lakes

Ecoregion

- Mountain lakes: above the conifer tree line.
- Inland lakes: below the conifer tree line, above the highest coastline (HC).
- Coastal lakes: below the HC.

Size

- Small lakes (0,5-2 km^2)
- Medium lakes (2-10 km^2)
- Large lakes (>10 km^2).

Geology

"Geology" is based on the regression between water colour and the peat % of catchment area. The lakes were classified as clear (colour less than 60 mg Pt/l) and brown (colour more than 60 mg Pt/l).

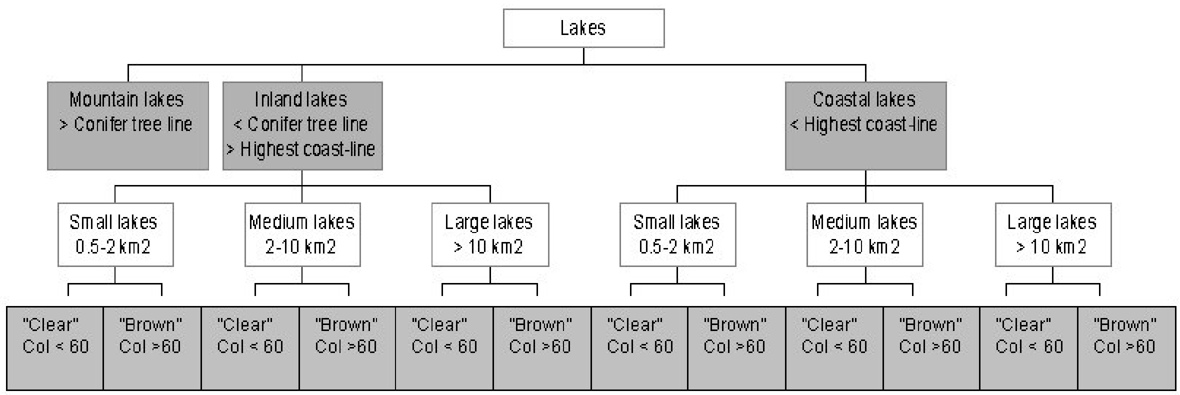

Figure 6. The suggested typology for lakes in the River Torne Watershed.

4.4. Suggested typology for rivers

Ecoregion for rives was defined using the same regions as with lakes.

Size

- Small rivers: catchment area <1000 km^2
- Large rivers: catchment area >1000 km^2
- Very large rivers: catchment area > 10 000 km^2

Geology

The geology classes are based on the regression between watercolour and the peat % of catchment area. The border value for peat land (wetland) cover was estimated to be approximately 20%. Rivers were classified as clear (peat cover less than 20%) and brown (peat cover more than 20%).

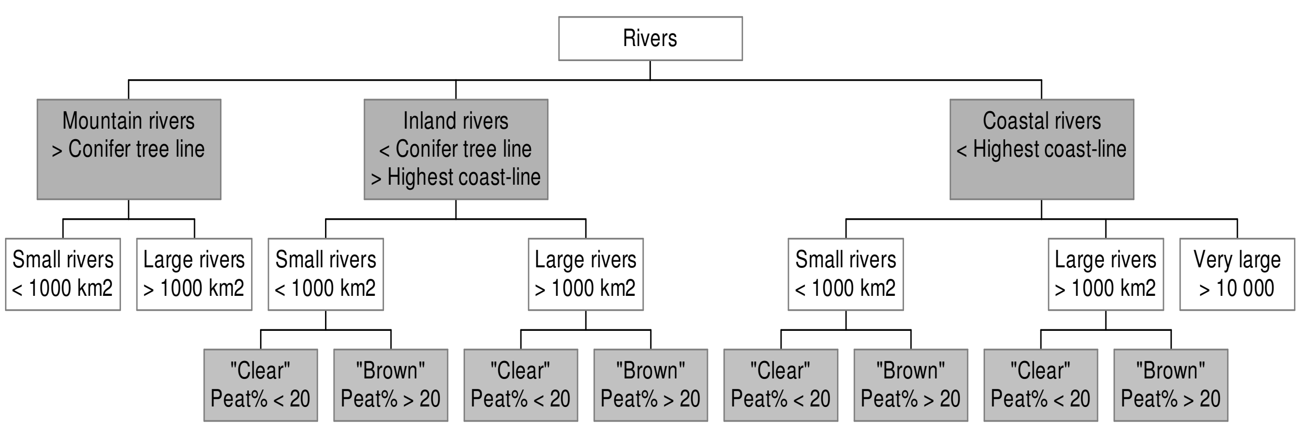

Figure 7. The suggested typology for rivers in the River Torne Watershed.

4.5 Surface water types of River Torne watershed according to TRIWA typology

The suggested typology was applied on the water bodies of the River Torne watershed. The results are presented in tables 1 and 2 for lakes and rivers, respectively. The most common lake types are mountain lakes (type 1), small clear-water and brown-water inland lakes (type 2 and 3) and small brown-water costal lakes (type 9). All together twelve of the thirteen possible lake types are present in the watershed. No large brown-water inland lakes (type 7) have been identified. However, some water bodies with scarce data, strong human impact or indirect water colour estimation (using regression and other methods) may be included in a wrong type. As the amount of data increases, the typing of water bodies will be updated and corrected.

Table 1. The lake types and number of lakes in the River Torne watershed.

Type	Description	Swedish	Finnish	Total
1	Mountain lakes	155	58	213
2	Small clear-water inland lakes	63	18	81
3	Small brown-water inland lakes	25	9	33
4	Medium clear-water inland lakes	12	3	15
5	Medium brown-water inland lakes	2	5	7
6	Large clear-water inland lakes	3	2	5
7	Large brown-water inland lakes	-	-	-
8	Small clear-water coastal lakes	6	10	16
9	Small brown-water costal lakes	14	52	66
10	Medium clear-water costal lakes	-	8	8
11	Medium brown-water costal lakes	4	16	20
12	Large clear-water coastal lakes	-	1	1
13	Large brown-water coastal lakes	1	3	4

For rivers the most common types are small mountain rivers (type 1) and small brown-water inland and coastal rivers (types 4 and 8). Of the eleven possible types there are nine types present in the watershed (table 2). As with the typing of lakes, some of the rivers with insufficient data might be in the wrong type. In figure 8 the surface water type in the watershed are illustrated in maps.

Table 2. The river types and the number of rivers in the River Torne watershed.

Type	Description	Swedish	Finnish	Shared	Total
1	Small mountain rivers	33	10	-	43
2	Large mountain rivers	4	1	1	6
3	Small, clear-water inland rivers	6	3	-	9
4	Small, brown-water inland rivers	17	7	-	24
5	Large, clear-water inland rivers	-	-	-	-
6	Large, brown-water inland rivers	3	-	1	4
7	Small, clear-water coastal rivers	2	1	-	3
8	Small, brown-water coastal rivers	3	16	-	19
9	Large, clear-water coastal rivers	-	-	-	-
10	Large, brown-water coastal rivers	-	2	-	2
11	Very large coastal rivers	-	-	1	1

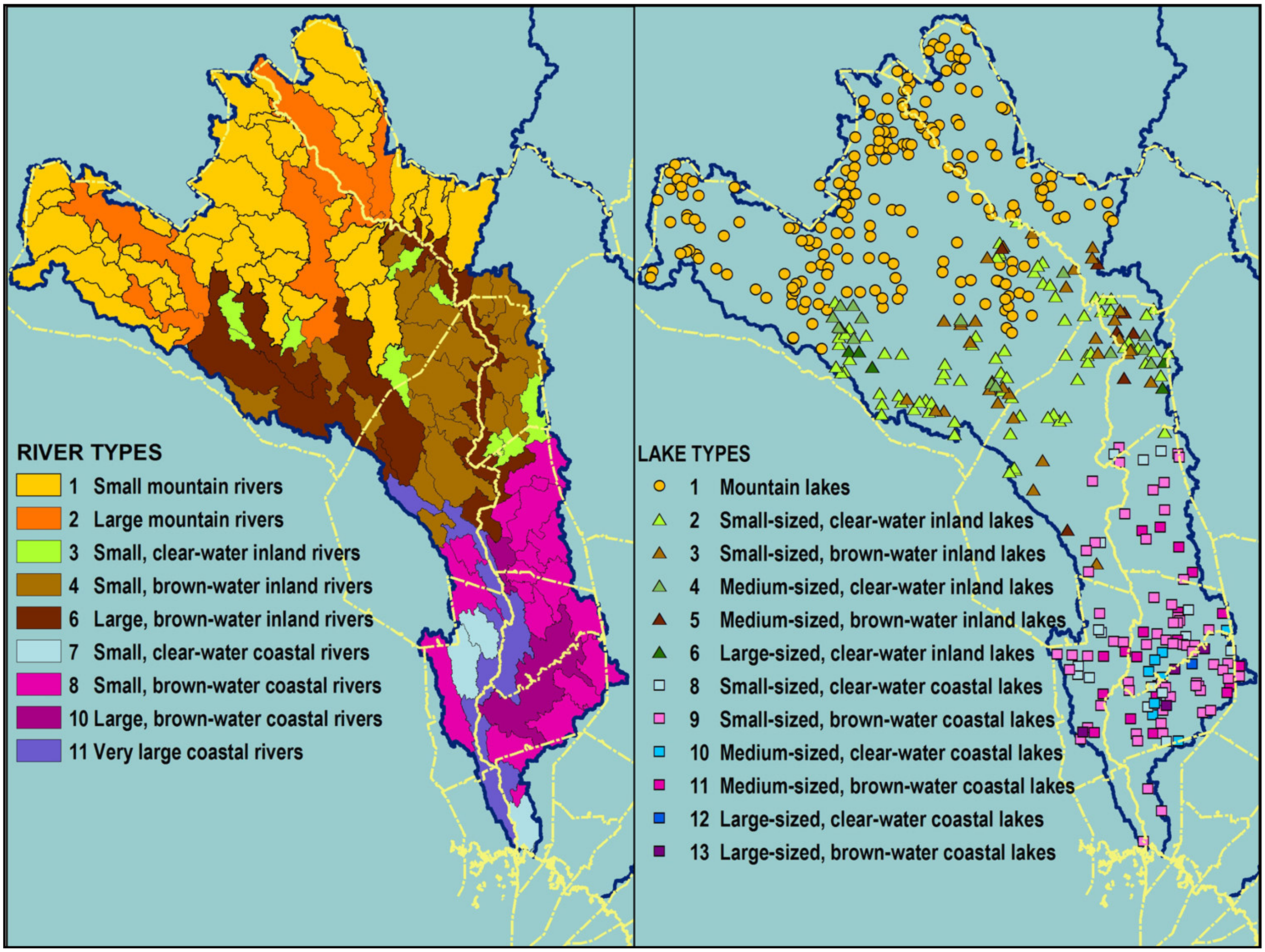

Figure 8. The different surface water types in the River Torne watershed according to the suggested TRIWA-typology.

5. FUTURE

The TRIWA project aims to define type-specific reference conditions for the most common lake and river types. The existing monitoring data from the River Torne watershed has been compiled and additional field surveys in the different lake and river types will provide new data for the characterisation. The results will be used to select possible reference lakes and rivers for the monitoring program. The reference sites will work as indicators of pristine ecological state for the water types they represent.

The goal of the field investigations is to assess the natural biological and chemical conditions in the most common lake and river types in the River Torne watershed. Moreover, the data will be used to test the validity of suggested typology. The sampling campaign will focus on the water chemistry, phytoplankton and benthic macro-invertebrates. Sampling and analyses will be done in accordance with standardised methods. The field surveys are carried out during 2004 and 2005. The lakes and rivers included in the study are listed in table 3. In 2005, additional lakes and rivers in the mountain region will be included. The results of the analyses should be ready in the end of 2005.

Table 3. Lakes and rivers included in the field studies (mountain lakes and rivers will be sampled in 2005).

	Finland	**Sweden**
Lakes	Keimiöjärvi (type 2)	Suolajärvi (type 2)
	Olosjärvi (type 2)	Naakajärvi (type 2)
	Isolompolo (type 2)	Kitkiöjärvi (type 3)
	Nivunkijärvi (type 3)	Pääjärvi (type 3)
	Nulusjärvi (type 3)	Pirttijärvi (type 9)
	Oustasjärvi (type 3)	Liehittäjäjärvi (type 9)
	Merijärvi (type 9)	Yli-Kuittasjärvi (type 9)
	Puolamajärvi (type 9)	
Rivers	Keräsjoki (type 4)	Parkajoki (type 4)
	Kuerjoki (type 4)	Käymäjoki (type 4)
	Naalastojoki (type 4)	Orjasjoki (type 8)
	Jerisjoki (type 8)	Jylhäjoki (type 8)
	Kuijasjoki (type 8)	Tupojoki (type 8)

Preliminary results concerning the water quality of the studied lakes and rivers indicate clear differences in nutrient, carbon and metal concentrations between different types. The suggested typology seems to be valid in separating water bodies with different catchment geology and chemical characteristics. However, the similar differences in ecological properties may not be so obvious. Analysis of the results of biological sampling will show the ecological validity of the suggested typology.

References

EU Water Framework Directive 2000/60/EG

Fölster J., Sandin L. & Wallin M. 2003: A suggestion to a typology for Swedish inland surface waters according to the EU Water Framework Directive. Sveriges Lantbruksuniversitet, Department of Environmental Assessment. 34 p.

Puro-Tahvanainen A., Viitala L., Lundvall D., Brännström G & Lundstedt L. 2001: Tornionjoki – vesistön tila ja kuormitus, Torne älv – tillstånd och belastning. 242 p.

Ympäristöministeriö 2002: Pintavesien luontaisten tyyppien määrittely Suomessa. 16 p.