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ICP Waters Report 144/2020

Biological intercalibration: Invertebrates 2020

International Cooperative Programme on Assessment and Monitoring Effects of Air Pollution on Rivers and Lakes

Convention on Long-Range Transboundary Air Pollution

Norwegian Institute for Water Research

REPORT

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Summary

The 24th biological intercalibration of invertebrates in ICP Waters included three laboratories. The intercalibration is important for harmonizing taxonomic work across countries, to ensure high quality data in the ICP Waters database and to increase the taxonomic skill of the participants. The laboratories correctly identified a high proportion of the specimens in the test samples. In total, 97.3 % of the species and 97.7 % of the genera were correctly identified. The mean Quality assurance index ranged between 91 and 97.3. No laboratories had a mean value below 80, which is the limit for acceptable taxonomic work.
The intercalibration under the ICP Waters programme was the first regular test of species level identification. Here, we present trends in the intercalibration of invertebrates from the initial intercalibration in 1992 up to the present. The average number of laboratories that took part on each occasion was 4.75. The results show that the Qi has remained above 80% for the full period, suggesting skilled taxonomists in the laboratories affiliated to ICP Waters.

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CONVENTION OF LONG-RANGE
TRANSBOUNDARY AIR POLLUTION

INTERNATIONAL COOPERATIVE PROGRAMME ON ASSESSMENT AND MONITORING EFFECTS OF AIR POLLUTION ON RIVERS AND LAKES

Biological Intercalibration: Invertebrates 2020

Prepared at the ICP Waters Programme Subcentre
NORCE AS
Bergen, November 2020

Preface

The International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes (ICP Waters) was established under the Executive Body of the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) in July 1985. Since then, ICP Waters has been an important contributor to document the effects of implementing the Protocols under the Convention. ICP Waters has prepared numerous assessments, reports and publications that address the effects of long-range transported air pollution.

ICP Waters and its Programme Centre is chaired and hosted by the Norwegian Institute for Water Research (NIVA), respectively. A programme subcentre is established at NORCE (previously known as Uni Research), Bergen. ICP Waters is supported financially by the Norwegian Environment Agency and the Trust Fund of the UNECE LRTAP Convention.

The main aim of the ICP Waters programme is to assess, on a regional basis, the degree and geographical extent of the impact of atmospheric pollution, in particular acidification, on surface waters. More than 20 countries in Europe and North America participate in the programme on a regular basis.

An objective of the ICP Waters programme is to establish and maintain an international network of surface water monitoring sites and promote international harmonisation of monitoring practices. A tool in this work are inter-laboratory quality assurance tests. Here biases between analyses carried out by individual participants of the programme are identified and controlled. The tests are also a valuable tool for taxonomic discussions and the exchange of identification keys among the participating laboratories, thereby improving the taxonomic skill.

Here we report the results from the 24th intercalibration of invertebrate fauna. We also compare results from all 24 intercalibrations.

Bergen, November 2020

Gaute Velle
ICP Waters Programme Subcentre

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Summary

The 24th biological intercalibration of invertebrates in the ICP Waters programme included three laboratories. The intercalibration is important for harmonizing taxonomic work across countries and is of high value in programmes where the focus is on community analyses, e.g. for the classification of ecological status according to the EU Water Framework Directive. The intercalibration under the ICP Waters programme was the first regular test of species level identification.

The laboratories correctly identified a high proportion of the specimens in the test samples. In total, 97.3 % of the species and 97.7 % of the genera were correctly identified. The mean Quality assurance index ranged between 91 and 97.3. No laboratories had a mean value below 80 – the limit for acceptable taxonomic work.

We also present trends in biological intercalibration of invertebrates from the initial intercalibration in 1992 up to the present. The average number of laboratories that took part on each occasion was 4.75. The results show that the Qi has remained above 80% for the full period, suggesting skilled taxonomists in the laboratories affiliated to ICP Waters. When the Qi is broken into individual invertebrate groups, it is clear that the laboratories, on average, perform best for caddis flies (Trichoptera) and worst for stoneflies (Plecoptera). The mean Qi was lower between 2015 and 2017. According to the taxonomists that participate in the intercalibration, the drop in quality may mostly be due to an increase in difficulty.

1 Introduction

The purpose of the biological intercalibration of invertebrates is to evaluate the quality of the biological data delivered to the Programme centre. The data are used nationally and by ICP Waters to indicate environmental conditions from the species and their tolerances (Raddum et al. 1988, Fjellheim and Raddum 1990, Raddum 1999, Velle et al. 2013, 2016). The significance of potential trends in biotic indices, both for a specific site/watershed and for comparisons of trends among regions or among countries, can be evaluated once the data quality is known. The data are also used in numerical analyses (Larsen *et al.* 1996, Skjelkvåle *et al.* 2000, Halvorsen *et al.* 2002, Halvorsen *et al.* 2003), and in analyses of biodiversity (Velle *et al*., 2013, Velle *et al*. 2016). The results from such data analyses are especially sensitive to the quality of the species identifications. The biological intercalibration focuses on the taxonomic skills of the participants and is a tool for improving the quality of work at the different laboratories, as well as harmonisation of the biological database.

The methods for the intercalibration of biological material were outlined in 1991 at the seventh ICP Waters Task Force meeting in Galway, Ireland. The test is based upon the principle that the participating countries/laboratories should know the fauna in their country. Since the fauna vary according to geographical regions, it is necessary to prepare specific samples for each participating laboratory, based on their native fauna. Hence, we cannot use standardised samples for all participants. Therefore, each laboratory sends identified samples of invertebrates from their own monitoring sites to the Programme subcentre. The Programme subcentre adds species known to be present in the region of the specific laboratory. Based on this, each laboratory receives individual test samples composed of species representing their own monitoring region. Each participant is therefore tested on their ability to identify taxa that are known to them.

The taxonomic skill of the different participants is measured by using a quality assurance index (Raddum 2005). This index evaluates the skill of participants when identifying species and genera. It also takes into account the effort of identifying all specimens in the sample. The highest index score is 100, while a value of 80 is set as the limit of good taxonomic work.

2 Methods

Preparation of the test-samples

Samples of identified invertebrates were sent from all participating laboratories to the organiser at the ICP Waters subcentre. These samples were used to compose test samples, with the addition of specimens from earlier exercises and from collections at the subcentre. The geographical distribution of the taxa was checked by the use of the Fauna Europaea Web Service 2013 (http://www.faunaeur.org). This is a database of the scientific names and distribution of multicellular European land and fresh-water animals (see example in Figure 1).

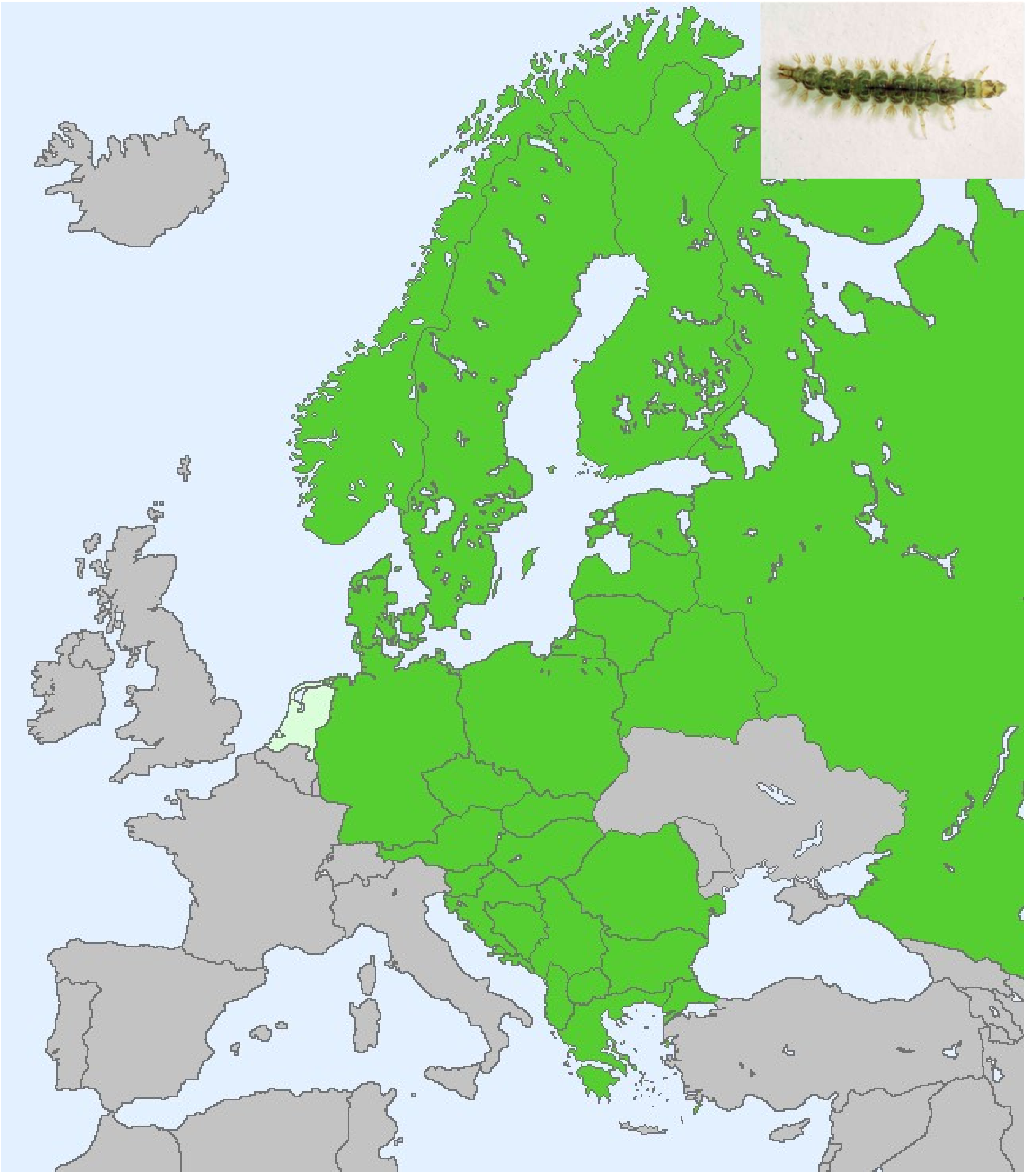

Figure 1. Geographical distribution of the caddisfly *Rhyacophila nubila* in Europe. This species is widely distributed but is absent from several West-European countries. Map after Fauna Europaea Web Service, http://www.faunaeur.org, Photo: Arne Fjellheim

Identification

To minimise possible faults, the following procedure is used in preparing the test samples:

- The participating laboratory first identifies the source material for the test samples and ships the specimens to the organiser.
- Two persons from the organising institution verify the identification of the specimen as far as possible without damaging the individuals.
- The content of two test samples per participant is listed in a table. Two persons control that the correct numbers and species are placed in the test samples according to the table.

Damage to the material

The quality of the test material may be reduced during handling and shipping. Taxonomically important parts of the body, such as gills, legs, cerci and mouthparts can be lost or damaged during identification, handling and transportation. Contamination of larvae from other samples may also occur during these processes, as well as during the identification work at the participating laboratories. All above-mentioned possibilities for faults could influence on the results of the identifications and influence the results negatively.

Evaluation

The participants are invited to comment on the results before the report is published. In this way, we can remove potential bias - for example misidentification caused by damaged test material. In cases of disagreement between the participant and the organiser, the material may be checked again by the organiser. This procedure may act educational for both parts.

For calculation of errors, we take into account possible degradation of the material. Further, a misidentified species counts as only one fault, even if the sample includes many individuals of the species. We encourage participants to give comments on matters that may impede the identification. For example, a misidentification will not count as a fault if a specimen lacks important taxonomic characters. Such comments must be made before the results are sent to the organiser.

We have discriminated between short-comings in identification, probably due to damaged material, and true errors (wrong species – or genus). Due to this, some subjective evaluation of the results has to be made. The number of errors is therefore subject to some degree of expert judgement.

The organiser also notes how many specimens a participant has identified per sample. This is called *percent identified*. A low percent means that many individuals were not identified and will consequently reduce the value of the taxonomic work.

In cases where more specimens are identified then sent to the laboratories, each excess specimen will count as one error.

Available material for making test samples vary. Normally, each laboratory receives between 60 and 130 species in the two samples. Samples with low diversity are easier to handle than samples with high diversity (see Appendix tables). This should also be kept in mind when the results are evaluated. Small samples should be avoided, as only a few misidentifications could result in a low score.

According to Fauna Europapaea, the total number of European species of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) in 2015 was 1814. However, the biodiversity differs between countries. Generally, the number of species decreases along a gradient from

Southern to Northern Europe. This is also a fact to bear in mind when judging taxonomical capacity. As an example of this, the freshwater fauna of Switzerland is much richer than in Norway and Sweden – despite the fact that the area of Switzerland is approximately 1/10 of the two Nordic countries (Figure 2).

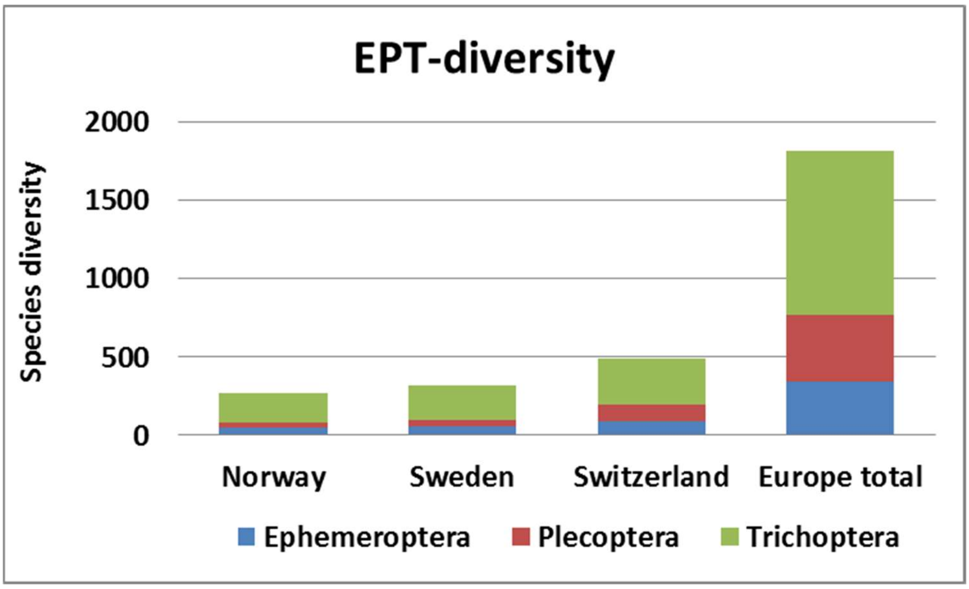

Figure 2. Species diversity of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) in Norway, Sweden and Switzerland (after Fauna Europaea Web Service, http://www.faunaeur.org.

Quality assurance index

We have calculated the Quality assurance index, Qi, for important groups of invertebrates as well as the mean index for each participant. The Qi integrates the separate levels of the identifications as follows:

Qi = (% correct species/10) * (% correct genus/10) * (% identified individuals/100)

Qi will be a number between 0 and 100 with increasing skill. A score ≥ 80 is regarded as good and thus acceptable taxonomical work.

Test of the subcentre

The ICP Waters subcentre in Bergen is tested with the help from the Swedish participant every second year. The Swedish University of Agricultural Sciences in Uppsala prepares and evaluates the test of the subcentre. Methodology and implementation are otherwise identical to the other tests.

3 Results and discussion

Three laboratories participated in the intercalibration of invertebrates in 2020 (Appendix A). The species lists and the identification results are shown in Appendix B, Tables 1 – 3.

Mayflies

The identification of the mayflies (Figure 3) was excellent for Laboratory 1 with no misidentifications. The results were above the acceptable limit for Laboratory 2 and 3. Laboratory 2 did not identify one of the specimens in sample 2, while Laboratory 3 assigned one specimen to the wrong species and also to the wrong genus.

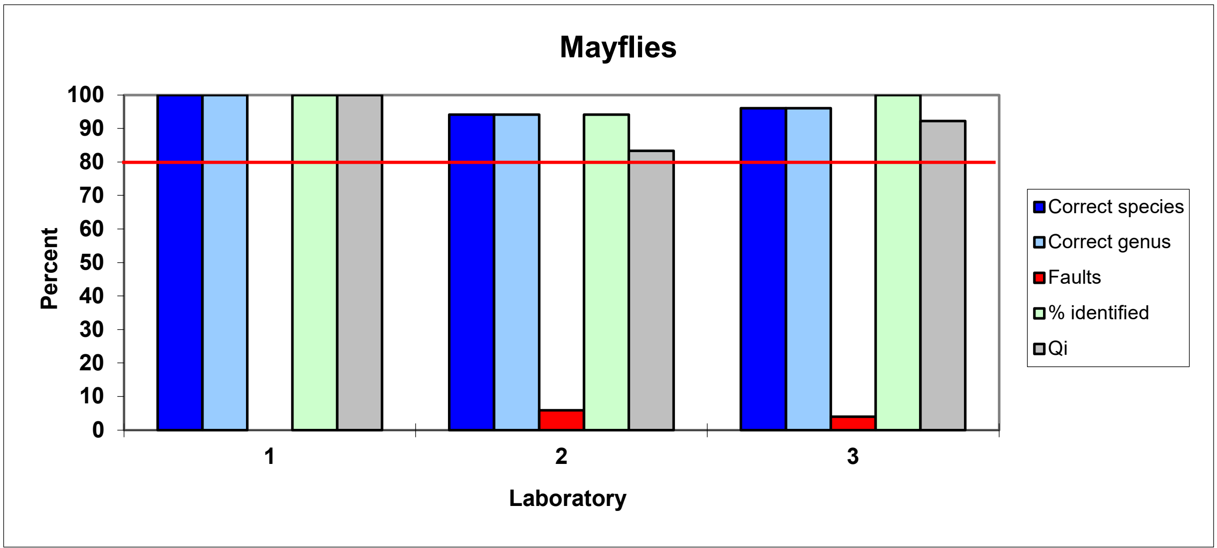

Figure 3. Results from the identification of mayflies. The red line indicates the limit for good taxonomic work.

Stoneflies

The identification of the stoneflies is shown in Figure 4. Laboratory 2 had no misidentifications, while Laboratory 1 and 3 had some misidentifications. All results were still above the acceptable limit. Laboratory 1 and 3 both assigned one specimen to the wrong species and also to the wrong genus.

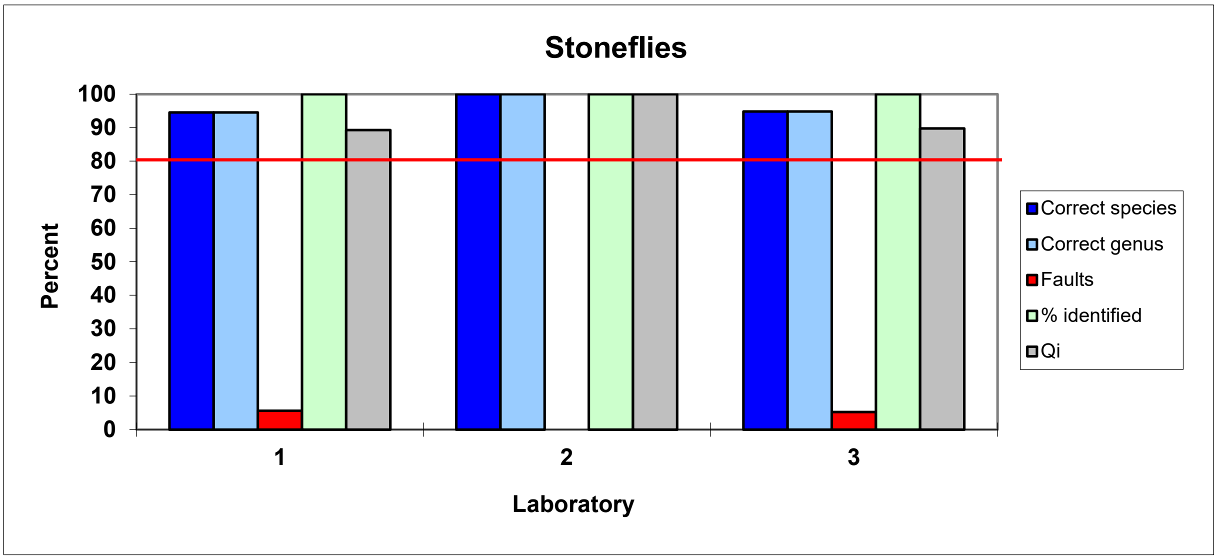

Figure 4. Results from the identification of stoneflies. The red line indicates the limit for good taxonomic work.

Caddisflies

The identifications of the caddisflies were excellent for Laboratory 1 and 2 (Figure 5) with no misidentifications. The identification of the caddisflies was also above the acceptable limit for Laboratory 3. Laboratory 3 assigned one specimen to the wrong species to the wrong genus.

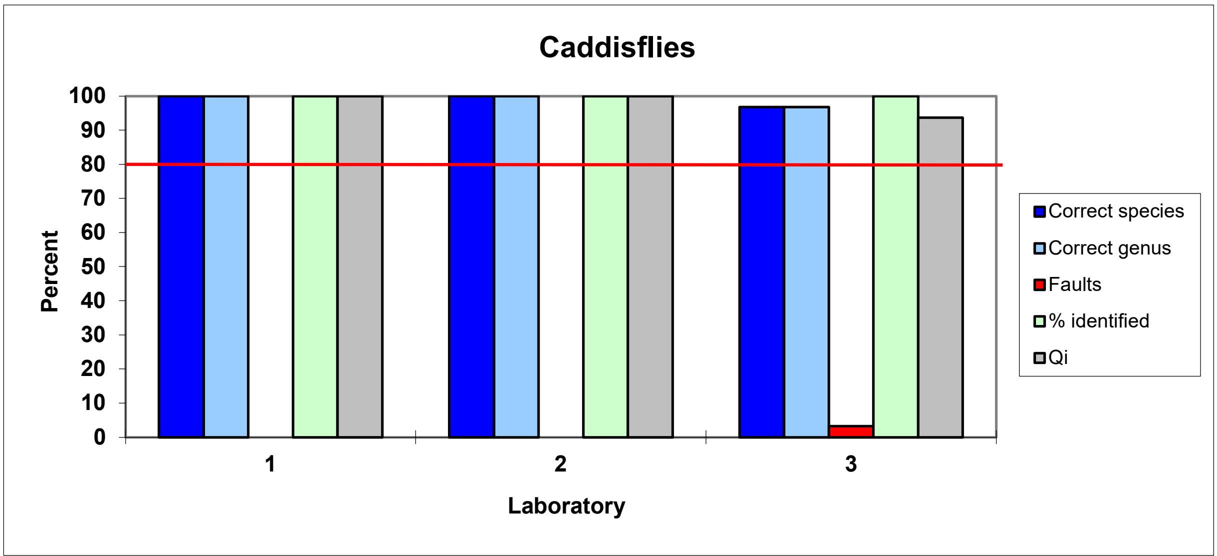

Figure 5. Results from the identification of caddisflies. The red line indicates the limit for good taxonomic work.

Other groups

The miscellaneous group included water beetles (Coleoptera), larger crustaceans (Malacostraca), leeches (Hirudinea), molluscs (Gastropoda), dragonflies (Odonata), water boatmen (Corixidea), midges and flies (Diptera), butterflies and moths (Lepidoptera) and true bugs (Heteroptera). Both larvae and imagines were included. Leeches, molluscs and larger crustaceans are sensitive to acid water and important for the evaluation of acidification. The tolerance of some species of Coleoptera, Megaloptera and Diptera is poorly known, but they are often regarded as tolerant to acidic water and of low importance for the evaluation of acidity indices. However, all species are important for invertebrate community analysis.

The identifications made by both Laboratory 1 and 2 were excellent and with no misidentifications. The identifications were also above the acceptable limit for Laboratory 3. Laboratory 3 assigned three specimens to the wrong species, of which also two also were assigned to the wrong genus. One wrongly identified species was present in both samples, and therefore only counted as one error. In sum, Laboratory 3 was given two errors for identifying two specimens to the wrong species and wrong genus, and one error for identifying one specimen to the wrong species.

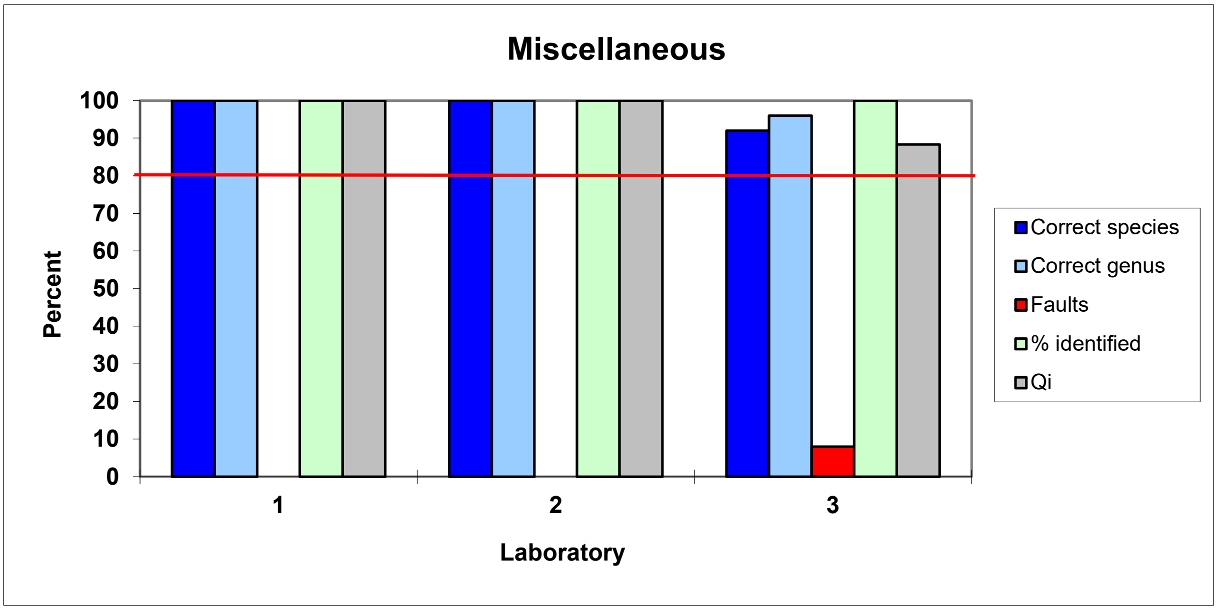

Figure 6. Results from the identification of miscellaneous groups of invertebrates. The red line indicates the limit for good taxonomic work.

Total number of species in the sample
A total of 268 individuals were sent to the three laboratories. Of these, all specimens but one were reported to the program subcentre.

4 Evaluation

The laboratories correctly identified a high portion of the total number of species in the test samples. The mean skill of identifying species, genus and Qi- score per laboratory is shown in Figure 7. The mean Qi was 97.3 for Laboratory 1, 95.8 for Laboratory 2 and 91.0 for Laboratory 3. This means that Laboratory 1 identified all but one specimen correctly, Laboratory 2 identified all but one specimen, and Laboratory 3 identified all but six specimens correctly, of which two specimens were the same species.

The biological intercalibration is important for harmonizing biological material/databases and will be of high value in projects that focus on community analyses, or where the ecological status of waterbodies should be determined. The biological intercalibration under the ICP Waters programme was the first regular test aiming to test taxonomic skills in identifying benthic invertebrates. Today, similar tests are run by the North American Benthological Society (http://www.nabstcp.com) and by the Natural History museum, London (Identification Qualifications – IdQ test). The invertebrate groups covered in the latter test are those used in the BMWP water quality score system (Armitage et al., 1983) and include groups used for monitoring freshwater environments under the EU water framework directive (Schartau et al. 2008). In 2017-2018, NORCE also organized an intercalibration for Norwegian laboratories that identify benthic invertebrates on a regular basis. The result from the Norwegian test indicated that the participants assigned specimens from an identical sample to a significant different number of taxa and species compositions (Velle *et* al. 2018). The differences resulted in a classification of ecological status that to some extent was person-dependent. These results highlight the importance of quality assurance and coordination of species identifications. Because of the results of the intercalibration in Norway, regular intercalibrations will be performed in the future. Also, the Norwegian Environment Agency use participations in intercalibrations as part of the evaluation criteria when assigning companies to new projects (Velle *et* al. 2020).

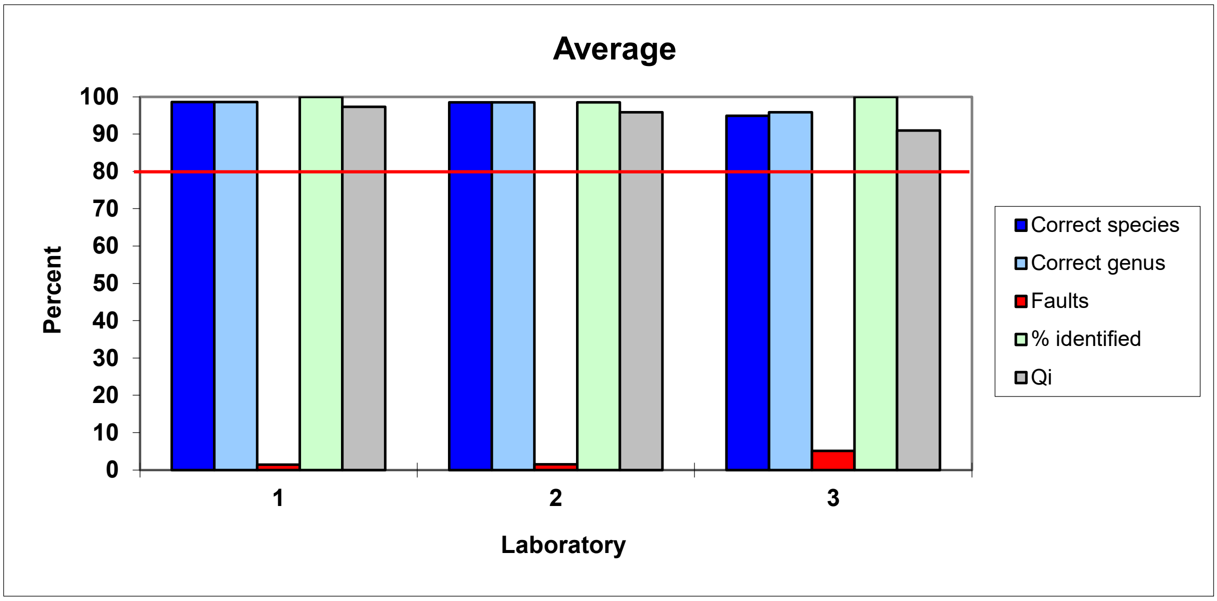

Figure 7. Mean skill in percent of identifying species and genus, and mean Qi for each laboratory. The red line indicates the acceptable limit.

5 Trends over time

The invertebrate intercalibration in ICP Waters started in 1992. An overall high of 11 laboratories participated in the first intercalibration (Figure 8). Since then, the average has been five participants per year. Twenty different laboratories from 17 countries have participated over the years, including Austria, Belgium, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Norway, Russia, Sweden, Switzerland and UK.

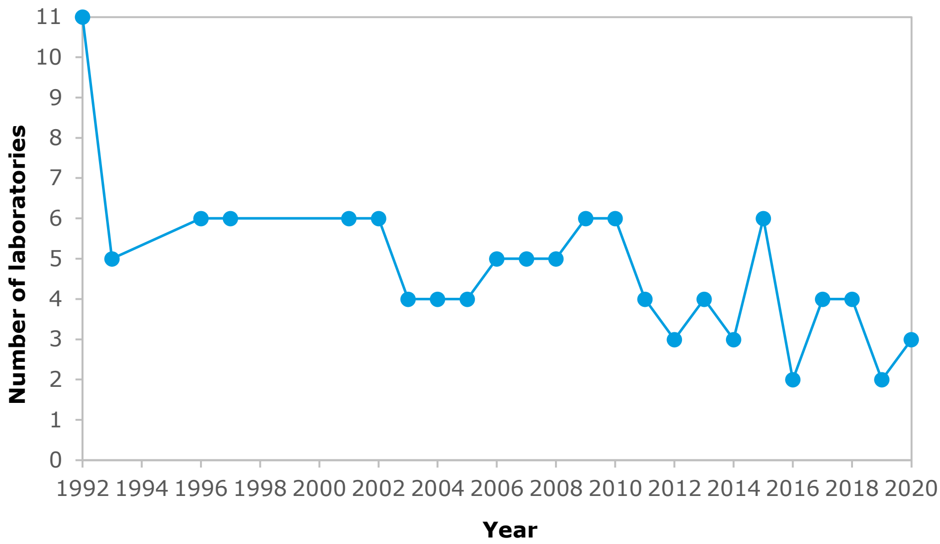

Figure 8. The number of participating laboratories in the ICP Waters invertebrate intercalibration since the first intercalibration in 1992.

The intercalibration laboratory protocol is unchanged since 1992, while the quality assurance index (Qi) has been used since it was introduced in 2005 (Raddum, 2005). After back calculating the Qi for the period prior to 2005 the Qi now is available from 1992 and up to the present (Figure 9). Trends in the Qi-score show that the mean has remained above 80%, suggesting good taxonomic work and skilled taxonomists in the laboratories affiliated to ICP Waters. When the Qi is broken into individual invertebrate groups, it is clear that the laboratories, on average over the years, perform best for caddisflies and worst for stoneflies (Figure 10). This suggests that many laboratories may benefit from focusing their future efforts on the identification of stoneflies.

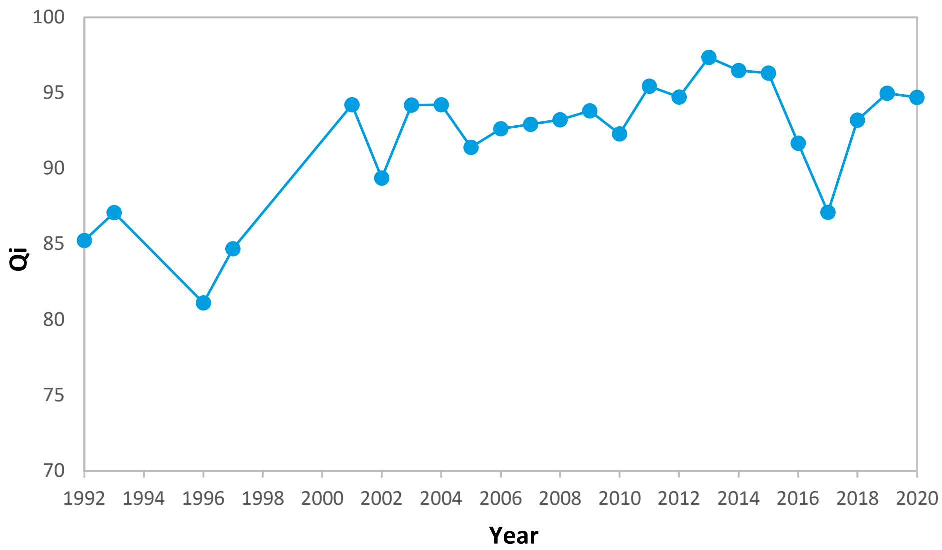

Figure 9. The mean quality assurance index for the invertebrate intercalibration through time.

One of the aims of the intercalibration is to improve the taxonomic skill of the participating laboratories. The mean Qi has increased since the intercalibration started, suggesting that the skills have indeed improved (Figure 9). Still, at least four issues influence the Qi:
1) The Qi varies according to the skills of the participants. A consequence is that the Qi often decreases when new labs participate or if a skilled taxonomist retires. As an example, the expert on the miscellaneous group retired from Laboratory 2 in 2018, which resulted in a low Qi.
2) The Qi varies according to the difficulty of the test, which mostly depends on the size of the specimen and the rarity of the species. For example, more species in the miscellaneous group were included in the intercalibration around 2005 since new acidification indices demanded a higher taxonomic resolution for this group. Hence, the Qi subsequently dropped for some years before it gradually increased (Figure 10). The increase likely reflects improved taxonomic skill.
3) There is inevitably some chance involved. For example, samples have occasionally dried out, a taxonomist may have overlooked a specimen or forgotten to make comments on a damaged specimen.
4) Some years, the participants send too few specimens from their home region to the intercalibration organizer. This may influence the results since the organizer then needs to include specimen from other regions to the test of that specific participant. It is therefore important that the participants send an abundance of specimens to the organizer.

The mean Qi has decreased during 2012-2017, more steeply between 2015 and 2017, to increase again in 2018-2020. According to the taxonomists, the difficulty increased during 2015-2017, and especially for stoneflies. In addition, it seems some other abovementioned factors apply; there was a new participant, one key taxonomist retired, one sample dried out and one laboratory sent too few specimens from their home region. Hopefully, the abundance of such events will decline during forthcoming intercalibrations.

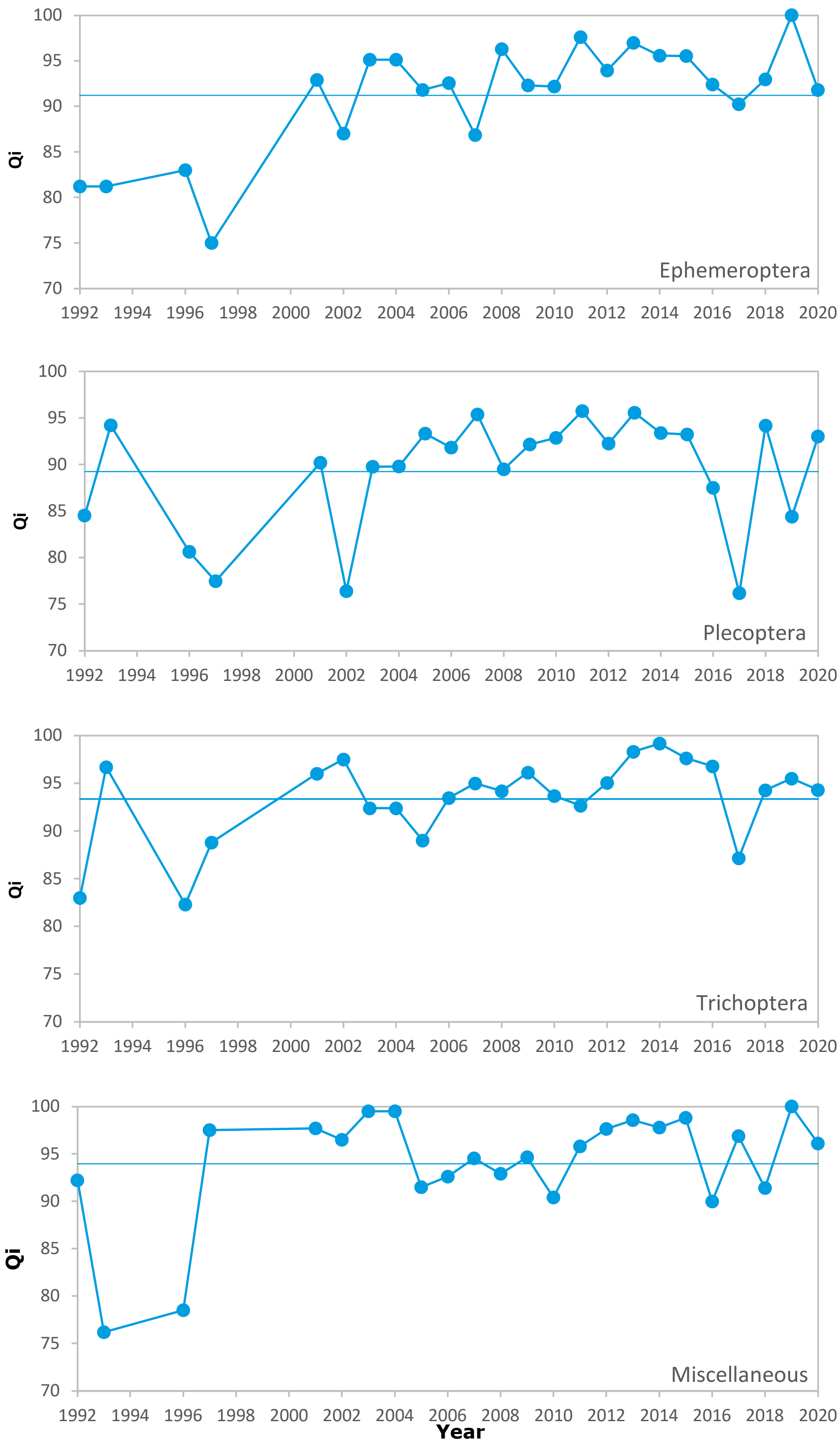

Figure 10. The mean quality assurance index (Qi) of the intercalibrations through time for mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichoptera) and miscellaneous groups of invertebrates. The straight line represents the overall mean Qi for each invertebrate group. Qi above 80 is regarded as good and thus acceptable taxonomical work.

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Appendix A. Responsible laboratories

Each participating laboratory is identified by a number, which is identical with the table number in the Appendix and laboratory numbers in the report. Laboratories participating in the intercalibration of invertebrates in 2020 are:

1. Estonian Environmental Research Centre, Tartu Department, Vaksali 17a, 50419 Tartu, **Estonia**. Responsible taxonomists: Dr. Urmas Kruus and Dr. Lilian Varblane.

2. Swedish University of Agricultural Sciences, Dept. of Environmental Assessment, P.O. Box 7050, S-75007 Uppsala, **Sweden**. Responsible taxonomist: Dr. Magda-Lena Wiklund.

3. Norwegian Research Centre AS, P.O. box 7810 N-5020 Bergen, **Norway**. Responsible taxonomists: Torunn S. Landås and Arne Johannessen.

Appendix B. Species lists

Table B. 1. Identified species/genus in sample 1 and 2 by Laboratory 1.

	Sample 1		Sample 2	
	Delivered	**Identified**	**Delivered**	**Identified**
Ephemerpotera	1	1		
Alainites muticus	1	1		
Ametropus fragilis	1	1		
Baetis buceratus	1	1	1	1
Baetis niger	1	1		
Baetis rhodani			1	1
Baetis vernus	1	1		
Caenis horaria			1	1
Caenis luctuosa			1	1
Centroptilum luteolum			1	1
Ephemera vulgata			1	1
Ephemerella mucronata	1	1		
Eurylophella karelica			1	1
Leptophlebia marginata			1	1
Paraleptophlebia submarginata			1	1
Potamanthus luteus			1	1
Procloeon bifidum	1	1		
Plecoptera				
Amphinemura borealis	1	1	1	1
Brachyptera braueri			1	1
Brachyptera risi	1	1	1	1
Capnia bifrons			1	1
Capnopsis schilleri	1	1		
Diura nanseni	1	1	1	1
Isogenus nubecula	1	1	1	1
Isoperla difformis	1	1		
Isoptena serricornis			1	1
Leuctra hippopus	1	1		
Nemoura avicularis				1
Nemoura cinerea	1	1	1	1
Nemurella pictetii			1	
Siphonoperla burmeisteri			1	1
Trichoptera				
Agrypnia pagetana	1	1		
Anabolia consentrica			1	1
Athripsodes cinereus			1	1
Ceraclea nigronervosa	1	1	1	1

Grammotaulius nigropunctatus	1	1		
Hydropsyche contubernalis	1	1		
Lasiocephala basalis	1	1	1	1
Leptocerus interruptus	1	1	1	1
Limnephilus bipunctatus	1	1	1	1
Limnephilus fuscicornis	1	1	1	1
Limnephilus sparsus	1	1	1	1
Limnephilus stigma			1	1
Limnephilus subcentralis			1	1
Micrasema setiferum	1	1		
Molannodes tinctus	1	1		
Notodobia ciliaris			1	1
Oecetis lacustris	1	1		
Oecetis testacea			1	1
Oligotricha striata	1	1		
Polycentropus flavomaculatus			1	1
Semblis phalaenoides			1	1
Miscellanous				
Coleoptera				
Elmis aenea	1	1	1	1
Hydrobius fuscipes			1	1
Laccophilus hyalinus	1	1	1	1
Macronychus quadrituberculatus			1	1
Nebrioporus assimillis	1	1		
Riolus cupreus			1	1
Malacostraca				
Gammarus lacustris	1	1	1	1
Diptera				
Antocha vitripennis	1	1	1	1
Phalacrocera replicata	1	1		
Gastropoda				
Gyraulus crista	1	1	1	1
Hippeutis complanatus	1	1		
Potamopyrgus antipodarum	1	1	1	1
Corixoidea				
Callicorixa wollastoni	1	1		
Sigara (Microsigara) hellensii	1	1	1	1
Hirudinea				
Alboglossiphonia heteroclita	1	1		
Dina lineata	1	1		
Theromzon tessulatum	1	1	1	1
Odonata				
Aeshna grandis	1	1		

Brachytron pratense	1	1	1	1
Coenagrion hastulatum			1	1
Ischnura elegans	1	1		
Lepidoptera				
Parapoynx stratiotata			1	1

Table B. 2. Identified species/genus in sample 1 and 2 by Laboratory 2

	Sample 1		Sample 2	
	Delivered	**Identified**	**Delivered**	**Identified**
Ephemerpotera				
Ephemera danica	1	1		
Baetis rhodani	1	1	1	1
Baetis muticus	1	1		
Caenis horaria	1	1	1	1
Caenis luctuosa	1	1	1	1
Centroptilum luteolum	1	1		
Ephemerella ignita	1	1		
Heptagenia fuscogrisea			1	1
Leptophlebia vespertina			1	
Caenis rivulorum			1	1
Ephemera vulgata			1	1
Ameletus inopinatus			1	1
Rhithrogena germanica			1	1
Ephemerella aurivilli			1	1
Plecoptera				
Taeniopteryx nebulosa	1	1	1	1
Siphonoperla burmeisteri	1	1	1	1
Diura nanseni	1	1	1	1
Leuctra fusca	1	1	1	1
Leuctra nigra	1	1		
Amphinemura borealis	1	1		
Capnopsis schilleri			1	1
Protonemura meyeri			1	1
Nemoura cinerea			1	1
Nemoura flexuosa			1	1
Trichoptera				
Molanna anguatata	1	1	1	1
Micrasema setiferum	1	1		
Glossosoma intermedium	1	1		
Hydropsyche pellucidula	1	1	1	1
Oecetis testacea	1	1		
Lepidostoma hirtum	1	1	1	1
Athripsodes aterrimus	1	1	1	1
Sericostoma personatum	1	1		
Ceraclea annulicornis	1	1		
Agapetus ochripes			1	1
Setodes argentipunctatus			1	1
Chimarra marginata			1	1
Hydropsyche siltalai			1	1

Cheumatopsyche lepida			1	1
Silo pallipes			1	1
Neureclipsis bimaculata			1	1
Miscellanous				
Coleoptera				
Nebrioporus depressus	1	1	1	1
Stenelmis canaliculata	1	1	1	1
Limnius volckmari	1	1		
Laccophilus hyalinus	1	1		
Elmis aenea			1	1
Gastropoda				
Bithynia tentaculata	1	1		
Radix auricularia	1	1		
Physa fontinalis	1	1	1	1
Bithynia leachii			1	1
Gyraulus crista			1	1
Potamopyrgus antipodarum			1	1
Gyraulus albus			1	1
Radix balthica			1	1
Heteroptera				
Aphelocheirus aestivalis	1	1		
Malacostraca				
Monoporeia affinis	1	1	1	1
Gammarus pulex			1	1
Diptera				
Eloeophila sp.			1	1
Dicranota sp.			1	1
Hirudinea				

Table B. 3. Identified species/genus in sample 1 and 2 by Laboratory 3.

	Sample 1		Sample 2	
	Delivered	**Identified**	**Delivered**	**Identified**
Ephemerpotera				
Alainites muticus			1	1
Ameletus inopinatus	1	1	1	1
Baetis rhodani	1	1	1	1
Caenis horaria	1	1		
Caenis lactea	1	1		
Caenis luctuosa	2	2	1	1
Caenis rivulorum			1	1
Centroptilum luteolum				1
Procloeon bifidum			1	
Ephemera danica	1	1		
Ephemera vulgata	1	1	1	1
Ephemerella aurivilli	1	1	1	1
Ephemerella ignita			1	1
Heptagenia dalecarlica	1	1	1	1
Heptagenia sulphurea	1	1	2	2
Leptophlebia vespertina	1	1		
Nigrobaetis niger			1	1
Plecoptera				
Amphinemura borealis	1	1		
Amphinemura sulcicollis	1	1	1	1
Brachyptera risi	1	1	1	1
Capnia atra	1	1		
Capnia sp.				1
Dinocras cephalotes	1	1		
Diura nanseni	1	1	1	1
Leuctra fusca	1	1		
Leuctra nigra			2	1
Nemoura avicularis	1	1	1	1
Nemurella pictetii			1	1
Perlodes dispar			1	1
Protonemura meyeri			2	2
Taeniopteryx nebulosa	1	1		
Trichoptera				
Arctopsyche ladogensis			1	1
Athripsodes aterrimus	1	1	1	1
Athripsodes cinereus			1	1
Athripsodes commutatus	1	1		
Beraeodes minutus	1	1		
Chaetopteryx villosa/salhbergi	1	1		

Crunoecia irrorata			1	1
Cyrnus flavidus			1	1
Cyrnus trimaculatus			1	1
Glossosoma intermedium			1	1
Goera pilosa	1	1		
Hydropsyche pellucidula	1	1		
Lepidostoma hirtum	1	1	1	1
Micrasema gelidum	1	1	1	1
Micrasema setiferum	1	1		
Mystacides azurea			2	2
Neureclipsis bimaculata	1	1	1	1
Notidobia ciliaris			1	
Oecetis testacea	1	1	1	1
Polycentropus flavomaculatus	2	2		
Polycentropus irroratus			1	1
Psychomyia pusilla	1	1		
Rhyacophila nubila	1	1		
Sericostoma personatum	1	1		1
Miscellanous				
Coleoptera				
Platambus maculatus	1	1		
Oulimnius tuberculatus	1	1	1	1
Elmis aenea	1	1	1	1
Nebrioporus depressus	1	1	1	1
Laccophilus hyalinus			1	1
Diptera				
Chaoborus flavicans	1	1		
Atherix ibis			1	1
Antocha vitripennis	1	1		
Malacostraca				
Asellus aquaticus	1	1	1	1
Pontoporeia (Monoporeia) affinis			1	1
Odonata				
Cordulegaster boltonii	1	1	1	1
Onychogomphus forcipatus			1	1
Hirudinea				
Helobdella stagnalis	1	1	1	1
Gastropoda				
Gyraulus acronicus	1	1		
Radix balthica	1	1		
*Lymnaea truncatula**		1		1
Gyraulus sp.		1		
Gyraulus albus	1			

Ancylus fluviatilis			1	1
Potamopyrgus antipodarum	1		1	

* Laboratory 3 assigned these specimens in sample 1 and sample 2 to the wrong species and also to the wrong genus. Because the species was present in both samples, this only counted as one error.

Appendix C. Reports and publications from the ICP Waters programme

All reports from the ICP Waters programme from 2000 up to present are listed below. Reports before year 2000 can be listed on request. All reports are available from the Programme Centre. Reports and recent publications are also accessible through the ICP Waters website; http://www.icp-waters.no/

Gundersen, C.B. 2020. Intercomparison 2034: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Tot-P, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA SNO 7445-2019. **ICP Waters report 143/2019.**

Garmo, Ø., Arle, J., Austnes, K. de Wit, H., Fölster, J., Houle, D., Hruška, J., Indriksone, I., Monteith, D., Rogora, M., Sample, J.E., Steingruber, S., Stoddard, J.L., Talkop, R., Trodd, W., Ulańczyk, R.P. and Vuorenmaa, J. 2020. Trends and patterns in surface water chemistry in Europe and North America between 1990 and 2016, with particular focus on changes in land use as a confounding factor for recovery. NIVA report SNO 7479-2020. **ICP Waters report 142/2020**

Gundersen, C.B. 2019. Intercomparison 1933: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Tot-P, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA SNO 7445-2019. **ICP Waters report 141/2019.**

Velle, G., Birkeland, I.B., Johannessen, A. and Landås, T.S. 2019. Biological intercalibration: Invertebrates 2019. NIVA SNO 7433-2019. **ICP Waters report 140/2019**

Garmo, Ø., Austnes, K. and Vuorenmaa, J. (editors) 2019. Proceedings of the 35th Task Force meeting of the ICP Waters Programme in Helsinki, June 4-6, 2019. NIVA report SNO 7437-2019. **ICP Waters report 139/2019**

Velle, G., Johannessen, A. and Landås, T.S. 2018. Biological intercalibration: Invertebrates 2018. NIVA report SNO 7314-2018. **ICP Waters report 138/2018**

Escudero-Oñate, C. 2018. Intercomparison 1832: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Tot-P, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 7316-2018. **ICP Waters report 137/2018.**

Garmo, Ø., Ulańczyk, R. and de Wit, H. (eds.) 2018. Proceedings of the 34th Task Force meeting of the ICP Waters Programme in Warsaw, May 7-9, 2018. NIVA report SNO 7298-2018. **ICP Waters report 136/2018.**

Austnes, K. Aherne, J., Arle, J., Čičendajeva, M., Couture, S., Fölster, J., Garmo, Ø., Hruška, J., Monteith, D., Posch, M., Rogora, M., Sample, J., Skjelkvåle, B.L., Steingruber, S., Stoddard, J.L., Ulańczyk, R., van Dam, H., Velasco, M.T., Vuorenmaa, J., Wright, R.F., de Wit, H. 2018. Regional assessment of the current extent of acidification of surface waters in Europe and North America. NIVA report SNO 7268-2018. **ICP Waters report 135/2018**

Escudero-Oñate, C. 2017. Intercomparison 1731: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO7207-2017. **ICP Waters report 134/2017**.

Halvorsen, G.A., Johannessen, A. and Landås, T.S. 2017. Biological intercalibration: Invertebrates 2017. NIVA report SNO 7198-2017. **ICP Waters report 133/2017**.

Braaten, H.F.V., Åkerblom, S., de Wit, H.A., Skotte, G., Rask, M., Vuorenmaa, J., Kahilainen, K.K., Malinen, T., Rognerud, S., Lydersen, E., Amundsen, P.A., Kashulin, N., Kashulina, T., Terentyev, P., Christensen, G., Jackson-Blake, L., Lund, E. and Rosseland, B.O. 2017. Spatial and temporal trends of mercury in freshwater fish in Fennoscandia (1965-2015). NIVA report SNO 7179-2017. **ICP Waters report 132/2017**.

Garmo, Ø., de Wit, H. and Fölster, J. (eds.) 2017. Proceedings of the 33rd Task Force meeting of the ICP Waters Programme in Uppsala, May 9-11, 2017. NIVA report SNO 7178-2017. **ICP Waters report 131/2017**.

Anker Halvorsen, G., Johannessen, A. and Landås, T.S. 2016. Biological intercalibration: Invertebrates 2016. NIVA report SNO 7089-2016. **ICP Waters report 130/2016**.

Escudero-Oñate, C. 2016. Intercomparison 1630: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA report SNO 7081-2016. **ICP Waters report 129/2016.**

De Wit, H. and Valinia, S. (eds.) 2016. Proceedings of the 32st Task Force meeting of the ICP Waters Programme in Asker, Oslo, May 24-26, 2016. NIVA report SNO 7090-2016. **ICP Waters report 128/2016**.

Velle, G., Mahlum, S., Monteith, D.T., de Wit, H., Arle, J., Eriksson, L., Fjellheim, A., Frolova, M., Fölster, J., Grudule, N., Halvorsen, G.A., Hildrew, A., Hruška, J., Indriksone, I., Kamasová, L., Kopáček, J., Krám, P., Orton, S., Senoo, T., Shilland, E.M., Stuchlík, E., Telford, R.J., Ungermanová, L., Wiklund, M.-L. and Wright, R.F. 2016. Biodiversity of macro-invertebrates in acid-sensitive waters: trends and relations to water chemistry and climate. NIVA report SNO 7077-2016. NIVA report SNO 7077-2016. **ICP Waters report 127/2016**.

De Wit, H., Valinia, S. and Steingruber, S. 2015. Proceedings of the 31st Task Force meeting of the ICP Waters Programme in Monte Verità, Switzerland 6th –8th October, 2015. NIVA report SNO 7003-2016. **ICP Waters report 126/2015**.

De Wit, H., Hettelingh, J.P. and Harmens, H. 2015. Trends in ecosystem and health responses to long-range transported atmospheric pollutants. NIVA report SNO 6946-2015. **ICP Waters report 125/2015**.

Fjellheim, A., Johannessen, A. and Landås, T.S. 2015. Biological intercalibration: Invertebrates 1915. NIVA report SNO 6940-2015. **ICP Waters report 124/2015**.

Escudero-Oñate, C. 2015 Intercomparison 1529: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 6910-2015. **ICP Waters report 123/2015**.

de Wit, H., Wathne, B. M. (eds.) 2015. Proceedings of the 30th Task Force meeting of the ICP Waters Programme in Grimstad, Norway 14th –16th October, 2014. NIVA report SNO 6793-2015. **ICP Waters report 122/2015**.

Fjellheim, A., Johannessen, A. and Landås, T.S. 2014. Biological intercalibration: Invertebrates 1814. NIVA report SNO 6761-2014. **ICP Waters Report 121/2014**.

Escuedero-Oñate. 2014. Intercom¬parison 1428: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 6718-2014. **ICP Waters Report 120/2014**.

De Wit, H. A., Garmo Ø. A. and Fjellheim A. 2014. Chemical and biological recovery in acid-sensitive waters: trends and prognosis. **ICP Waters Report 119/2014**.

Fjellheim, A., Johannessen, A. and Landås, T.S. 2013. Biological intercalibration: Invertebrates 1713. NIVA report SNO 6662-2014. **ICP Waters Report 118/2014**.

de Wit, H., Bente M. Wathne, B. M. and Hruśka, J. (eds.) 2014. Proceedings of the 29th Task Force meeting of the ICP Waters Programme in Český Krumlov, Czech Republic 1st –3rd October, 2013. NIVA report SNO 6643-2014. **ICP Waters report 117/2014**.

Escuedero-Oñate, C. 2013. Intercomparison 1327: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA report SNO 6569-2013. **ICP Waters Report 116/2013**.

Holen, S., R.F. Wright and Seifert, I. 2013. - Effects of long-range transported air pollution (LTRAP) on freshwater ecosystem services. NIVA report SNO 6561-2013. **ICP Waters Report 115/2013**.

Velle, G., Telford, R.J., Curtis, C., Eriksson, L., Fjellheim, A., Frolova, M., Fölster J., Grudule N., Halvorsen G.A., Hildrew A., Hoffmann A., Indriksone I., Kamasová L., Kopáček J., Orton S., Krám P., Monteith D.T., Senoo T., Shilland E.M., Stuchlík E., Wiklund M.L., de Wit, H. and Skjelkvaale B.L. 2013. Biodiversity in freshwaters. Temporal trends and response to water chemistry. NIVA report SNO 6580-2013. **ICP Waters Report 114/2013**.

Fjellheim, A., Johannessen, A. and Landås, T.S. 2013. Biological intercalibration: Invertebrates 1612. **ICP Waters Report 113/2013**.

Skjelkvåle, B.L., Wathne, B.M., de Wit, H. and Rogora, M. (eds.) 2013. Proceedings of the 28th Task Force meeting of the ICP Waters Programme in Verbania Pallanza, Italy, October 8 – 10, 2012. NIVA report SNO 6472-2013. **ICP Waters Report 112/2013**.

Dahl, I. 2012. Intercomparison 1226: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA report SNO 6412-2012. **ICP Waters report 111/2012**.

Skjelkvåle, B.L., Wathne B. M. and Moiseenko, T. (eds.) 2012. Proceedings of the 27th meeting of the ICP Waters Programme Task Force in Sochi, Russia, October 19 – 21, 2011. NIVA report SNO 6300-2012. **ICP Waters report 110/2012**.

Fjellheim, A., Johannessen, A., Svanevik Landås, T. 2011. Biological intercalibration: Invertebrates 1511. NIVA report SNO 6264-2011. **ICP Waters report 109/2011**.

Wright, R.F., Helliwell, R., Hruska, J., Larssen, T., Rogora, M., Rzychoń, D., Skjelkvåle, B.L. and Worsztynowicz, A. 2011. Impacts of Air Pollution on Freshwater Acidification under Future Emission Reduction Scenarios; ICP Waters contribution to WGE report. NIVA report SNO 6243-2011. **ICP Waters report 108/2011**.

Dahl, I and Hagebø, E. 2011. Intercomparison 1125: pH, Cond, HCO3, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 6222-2011. **ICP Waters report 107/2011**.

Skjelkvåle B.L. and de Wit, H. (eds.) 2011. Trends in precipitation chemistry, surface water chemistry and aquatic biota in acidified areas in Europe and North America from 1990 to 2008. NIVA report SNO 6218-2011. **ICP Waters report 106/2011**.

ICP Waters Programme Centre 2010. ICP Waters Programme manual. NIVA SNO 6074-2010. **ICP Waters report 105/2010**.

Skjelkvåle, B.L., Wathne B. M. and Vuorenmaa J. (eds.) 2010. Proceedings of the 26th meeting of the ICP Waters Programme Task Force in Helsinki, Finland, October 4 – 6, 2010. NIVA report SNO 6097-2010. **ICP Waters report 104/2010**.

Fjellheim, A. 2010. Biological intercalibration: Invertebrates 1410. NIVA report SNO 6087-2010. NIVA report SNO 6087-2010. **ICP Waters report 103/2010**.

Hovind, H. 2010. Intercomparison 1024: pH, Cond, HCO_3, NO_3-N, Cl, SO_4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 6029-2010. **ICP Waters report 102/2010**.

De Wit, H.A. and Lindholm M. 2010. Nutrient enrichment effects of atmospheric N deposition on biology in oligotrophic surface waters – a review. NIVA report SNO 6007 - 2010. **ICP Waters report 101/2010**.

Skjelkvåle, B.L., De Wit, H. and Jeffries, D. (eds.) 2010. Proceedings of presentations of national activities to the 25th meeting of the ICP Waters Programme Task Force in Burlington, Canada, October 19-21 2009. NIVA report SNO 5995 - 2010. **ICP Waters report 100/2010**.

Fjellheim, A. 2009. Biological intercalibration: Invertebrates 1309. NIVA report SNO 5883-2009, **ICP Waters report 99/2009**.

Hovind, H. 2009. Intercomparison 0923: pH, Cond, HCO_3, NO_3-N, Cl, SO_4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 5845-2009. **ICP Waters report 98/2009**.

Ranneklev, S.B., De Wit, H., Jenssen, M.T.S. and Skjelkvåle, B.L. 2009. An assessment of Hg in the freshwater aquatic environment related to long-range transported air pollution in Europe and North America. NIVA report SNO 5844-2009. **ICP Waters report 97/2009**.

Skjelkvåle, B.L., Jenssen, M. T. S. and De Wit, H (eds.) 2009. Proceedings of the 24th meeting of the ICP Waters Programme Task Force in Budapest, Hungary, October 6 – 8, 2008. NIVA report SNO 5770-2009. **ICP Waters report 96/2009**.

Fjellheim, A and Raddum, G.G. 2008. Biological intercalibration: Invertebrates 1208. NIVA report SNO 5706-2008, **ICP Waters report 95/2008**.

Skjelkvåle, B.L., and De Wit, H. (eds.) 2008. ICP Waters 20 year with monitoring effects of long-range transboundary air pollution on surface waters in Europe and North-America. NIVA report SNO 5684-2008. **ICP Waters report 94/2008**.

Hovind, H. 2008. Intercomparison 0822: pH, Cond, HCO_3, NO_3-N, Cl, SO_4, Ca, Mg, Na, K, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 5660-2008. **ICP Waters report 93/2008**.

De Wit, H. Jenssen, M. T. S. and Skjelkvåle, B.L. (eds.) 2008. Proceedings of the 23rd meeting of the ICP Waters Programme Task Force in Nancy, France, October 8 – 10, 2007. NIVA report SNO 5567-2008. **ICP Waters report 92/2008**.

Fjellheim, A and Raddum, G.G. 2008. Biological intercalibration: Invertebrates 1107. NIVA report SNO 5551–2008. **ICP Waters report 91/2008**.

Hovind, H. 2007. Intercomparison 0721: pH, Cond, HCO3, NO3-N, Cl, SO4, Ca, Mg, Na, K, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 5486-2007. **ICP Waters report 90/2007**.

Wright, R.F., Posch, M., Cosby, B. J., Forsius, M., and Skjelkvåle, B. L. 2007. Review of the Gothenburg Protocol: Chemical and biological responses in surface waters and soils. NIVA report SNO 5475-2007. **ICP Waters report 89/2007**.

Skjelkvåle, B.L., Forsius, M., Wright, R.F., de Wit, H., Raddum, G.G., and Sjøeng, A.S.M. 2006. Joint Workshop on Confounding Factors in Recovery from Acid Deposition in Surface Waters, 9-10 October 2006, Bergen, Norway; Summary and Abstracts. NIVA report SNO 5310-2006. **ICP Waters report 88/2006**.

De Wit, H. and Skjelkvåle, B.L. (eds) 2007. Trends in surface water chemistry and biota; The importance of confounding factors. NIVA report SNO 5385-2007. **ICP Waters report 87/2007**.

Hovind, H. 2006. Intercomparison 0620. pH, K25, HCO3, NO_3 + NO_2, Cl, SO_4, Ca, Mg, Na, K, total aluminium, aluminium - reactive and nonlabile, TOC, COD-Mn. Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA report SNO 5285-2006. **ICP Waters report 86/2006**.

Raddum, G.G. and Fjellheim, A. 2006. Biological intercalibration 1006: Invertebrate fauna. NIVA report SNO 5314-2006, **ICP Waters report 85/2006**.

De Wit, H. and Skjelkvåle, B.L. (eds.) 2006. Proceedings of the 21th meeting of the ICP Waters Programme Task Force in Tallinn, Estonia, October 17-19, 2005. NIVA report SNO 5204-2006, **ICP Waters report 84/2006**.

Wright, R.F., Cosby, B.J., Høgåsen, T., Larssen, T. and Posch, M. 2005. Critical Loads, Target Load Functions and Dynamic Modelling for Surface Waters and ICP Waters Sites. NIVA report SNO 5166-2005. **ICP Waters report 83/2006**.

Hovind, H. 2005. Intercomparison 0317. pH, K25, HCO3, NO3 + NO2, Cl, SO4, Ca, Mg, Na, K, total aluminium, aluminium - reactive and nonlabile, TOC, COD-Mn. Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA report SNO 5068-2005. **ICP Waters report 82/2005**.

Raddum, G.G. 2005. Intercalibration 0307: Invertebrate fauna. NIVA report SNO 5067-2005. **ICP Waters report 81/2005**.

De Wit, H. and Skjelkvåle, B.L (eds.) 2005. Proceedings of the 20th meeting of the ICP Waters Programme Task Force in Falun, Sweden, October 18-20, 2004. NIVA report SNO 5018-2005. **ICP Waters report 80/2005**.

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