Standardisation of river classifications:

Framework method for calibrating different biological survey results against ecological quality classifications to be developed for the Water Framework Directive

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Workpackage number 19:

Errors and variation associated with field protocols for the collection and application of macrophyte and hydro-morphological data

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Contents

List of abbreviations

CVS - Cover Value Score

CV – Coefficient of Variation

GIS - Geographic Information System

GPS - Global Positioning System

IBMR - Macrophyte Biological Index for Rivers

MTR – Mean Trophic Rank

RHS – River Habitat Survey

SCV - Species Cover Value

SD – standard deviation

STR - Species Trophic Rank

1 AIMS AND SCOPE

The **objectives** of this Workpackage were: (1) to estimate the different types of possible variability and/or errors that occur in macrophyte and hydromorphological assessment, (2) to support quality control of collected data and (3) to minimise the impact of errors on final result. For this purpose experiments based on replicate sampling were undertaken on Polish lowland rivers. Analysis based on the **series of experiments** carried out as a part of this Workpackage, several surveys were combined with the WP7 (Core stream types) and a few comparisons with the STAR hydromorphological database were included. Concerning **macrophyte** methods, much attention was paid to the main STAR macrophyte method - Mean Trophyic Rank (MTR). Although, several analyses of variability of other methods were conducted. Concerning **hydromorphological** assessment, studies were focused on the main STAR hydromorphological method – River Habitat Survey (RHS). The workpackage provided an error estimations. Also the vulnerability of the tested methods were analysed and guidance for quality assurance was delivered**.** It supplements STAR error module in error estimations of MTR and RHS. The computer program module based on the developed set of criteria was prepared for quality support in hydromorphological assessment.

2 GENERAL DESCRIPTION

Analyses based on the **series of experiments** were carried out from Spring 2003 to Summer 2004. Several surveys, which had been undertaken in 2003, were combined with the WP7 (Core stream types). Also several comparisons with the STAR hydromorphological database were included.

2.1 Staff

The Workpackage was mainly completed by nine members of the staff of the Department of Ecology and Environmental Protection of August Cieszkowski Agricultural University in Poznan. Some support was gained by scientists from the Department of Agrometeorology and from the Department of Land Improvement, Environmental Development and Geodesy. Site selection process was partly carried out in cooperation with the University of Lodz group. Full list of involved staff was presented in the Appendix 1.

To ensure high quality of surveys, Training Workshop was organised. The course: *River morphology assessment (RHS) and macrophytes as bioindicators (MTR)* took place between 31st of May and 9th of June 2003. It was organised by the August Cieszkowski Agricultural University in Poznan (ACAU) and the University of Lodz. Among 26 participants of the workshop 11 were contributors of the Workpackage. Details about the Workshop are presented in Appendix 6.

2.2 Field survey

The **macrophyte** studies took place from June to September 2003 and from June to August 2004. Field surveys were carried out according to Mean Trophic Rank (MTR) methodology. Concerning **hydromorphological** assessment, studies were carried out in three periods: Summer 2003, Autumn 2003 and Summer 2004. Field surveys were carried out according to River Habitat Survey (RHS). **Chemical samples** were collected together with hydromorphological studies in the same three periods: Summer 2003, Autumn 2003 and Summer 2004. Sites surveyed in 2004 were sampled only once. **Hydrological measurements** for most of sites were carried out twice at Spring and Summer 2004. Several sites included in WP7 were also surveyed additionally in Autumn 2003.

2.3 Research area

2.4 Site selection

The site selection was started in March 2003 together with the WP7 site selection procedure and the initial group of 25 lowland rivers was selected. More survey sites were selected during 2003 an 2004. The list of all 43 survey sites is attached in Appendix 2. The site distribution is presented in the Fig. 1.

The main **criteria** of site selection was to reach possibly wide range of the eutrophication gradient, which was the major degradation gradient studied in Poland. Additionally, wide range of hydromorphological degradation gradient was reached. The range of RHS metrics was very wide - for the HQA it varied between 24.7 and 61.7 and for HMS it was varying even wider: from 0 to 73. One of the main priorities was to reach possibly broad geographical distribution. Additional principle for the site selection was the abundance of plants.

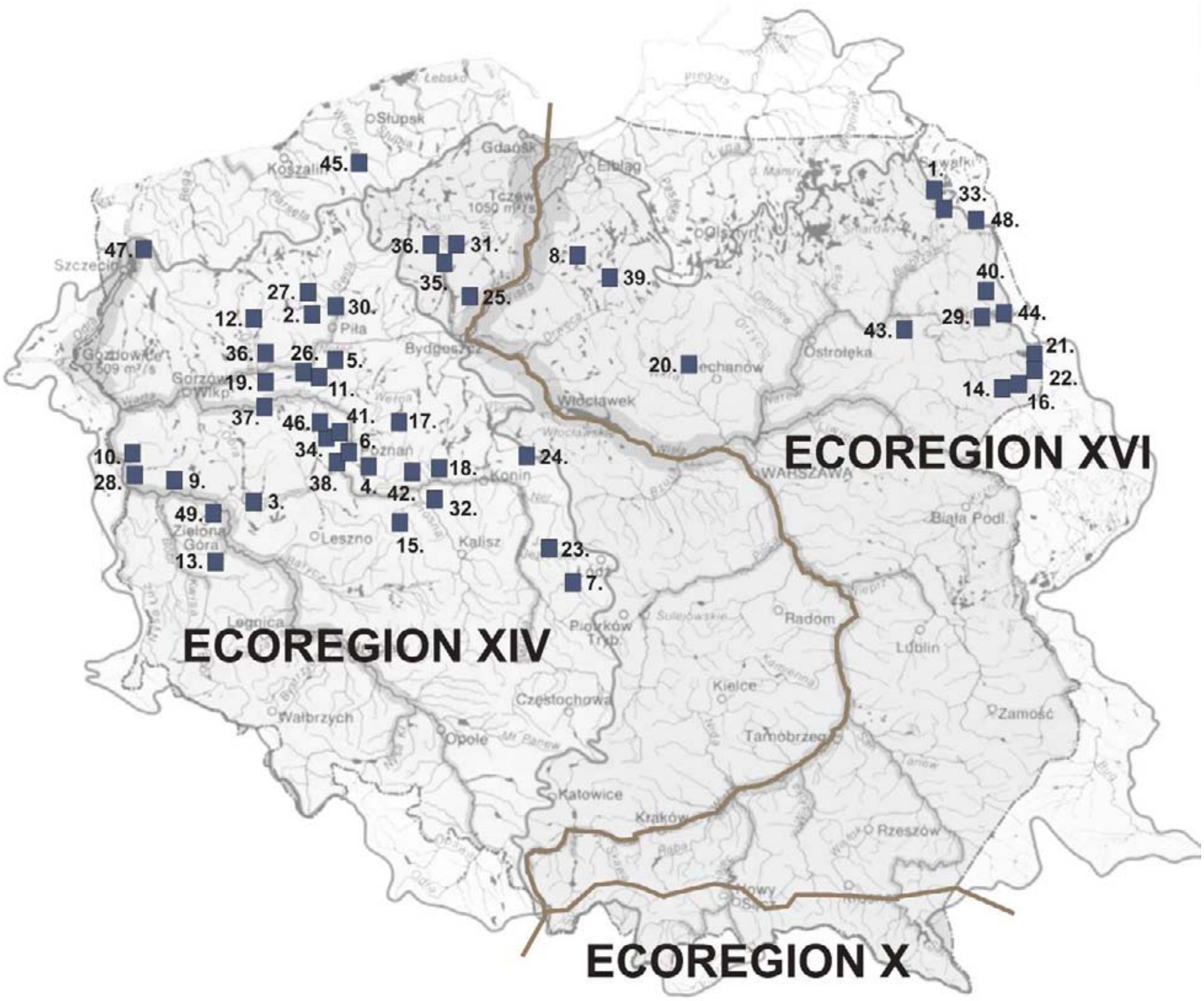


Fig. 1 Sites surveyed for the WP19 purpose. Details in the Appendix 2.

2.5 Water chemistry of rivers

Water samples were collected three times: Summer 2003, Autumn 2003 and Summer 2004. Sites surveyed in 2004 were sampled only once. Filtered (0.45 μm) and unfiltered water samples were collected, stored in isolated ice boxes and analysed within 24 hours. Analyses were undertaken in ACAU laboratory.

List of examined water parameters:

- pH reaction – pH-meter ELMETRON CPI-551,
- conductivity – electrometrically, ELMETRON CC-551,
- BOD 5 days – Winkler method,
- nitrates – colourimetrically, cadmium reduction method, filtered using 0.45 μm pore size,
- ammonia nitrogen – colourimetrically, Nessler method, filtered using 0.45 μm pore size,
- soluble reactive phosphates – colourimetrically, ascorbic acid method, filtered using 0.45 μm pore size,
- total phosphorous – acid persulphate digestion method,
- alkalinity – colourimetrically, with sulfuric acid.

2.6 Environmental conditions of studied rivers

Basic hydrological characteristics of selected rivers were estimated for their potential role in explanation of variability sources of RHS and MTR results. Catchment area, catchment geology, catchment land use and flood plain land use, mean annual discharge, slope, altitude, distance to the source and Strahler system were calculated using hydrographic and physiographic maps (scales 1:25 000, 1:50 000, 1:100 000) and hydrographic annual. Detailed information about WP19 sites is presented in the Appendix 2, 3 and 4.

During field work water discharge was measured using propeller current meter and float. Hydrological measurements were undertaken in Spring and Summer 2004. In case of sites combined with WP7, additional hydrological measurements were also recorded in Autumn 2003.

Several WP19 environmental data were collected together with WP7 – detailed list in the Appendix 2.

3 MACROPHYTES

3.1 Methods

Macrophyte variability surveys based on replicate sampling experiments were carried out in Polish lowland rivers in 2003 and 2004, during the period when river vegetation is well developed (5 June – 30 September).

Field surveys were carried out according to STAR macrophyte field survey procedure (Dawson 2002). It is based on Mean Trophic Rank (MTR), field sampling procedure created by NTH Holmes (Holmes et al. 1999) for the needs of biological monitoring under the EC Urban Waste Water Treatment Directive. The method based on the plant species with known indicative value for nutrient enrichment occurred in watercourses.

STAR macrophyte field survey procedure was designed mainly to deliver MTR score but this type of survey enabled to estimate other metrics which are widely applied in the vegetation sciences. In this way experiments based on the STAR protocol estimated variation of MTR score as well as the Macrophyte Biological Index for Rivers - IBMR (Haury et al. 2002), Ellenberg nitrogen index (Ellenberg et al. 1992), number of species and Shannon's index (Shannon & Weaver 1949).

Plant examination

A macrophyte was defined as "any plant observable with the naked eye and nearly always identifiable when observed" (Holmes & Whitton 1977). This definition includes all higher aquatic plants, vascular cryptograms and bryophytes, together with groups of algae which can be seen to be composed predominantly of a single species.

All macrophytes seen submerged or partly submerged in the river, were considered. At the river sides all macrophytes attached or rooted on parts of the substrata which are likely to be submerged for more than 85% of the year were included.

The presence of each macrophyte which meets these criteria was recorded and quantitive estimates of percentage cover were made. Identified plant species were recorded during field studies using 9 point cover scale on the river length of 100 m. Most of the sites were surveyed by wade along the channel except one river (Sokolda) which was too deep to wade – it was walked along bank and grapnel was used to retrieve macrophyte species. All taxa were identified individually by each surveyor. Algae samples after identification by surveyors were additionally sent to the University of Lodz to confirm identification.

The replicate sampling field work was carried out by the group of six trained surveyors who attended sampling course. It was focused to assure uniform sampling conditions for subsequent surveyors by avoiding plant removal (especially for scarce species).

Recording of physical variables

During macrophyte assessment the survey length was re-traversed to recorde physical characteristics according to the MTR methodology (Holmes et al. 1999, Dawson 2002). All variables were recorded in protocol as actual percentages.

A percentage of the channel **width** and **depth** of a survey length was recorded. The area percentage of channel **substrate** and **habitat** categories were recorded basing on STAR hydromorphology classes distinguishing eight substrata categories (*Bedrock, Boulders/Cobbles, Pebbles/Gravel, Sand, Silt, Clay, Peat, Artificial*) and ten habitat types (*Free-fall, Chute, Chaotic, Broken standing waves, Unbroken standing waves, Ripppled, Upwelling, Smooth, No perceptible, No water*). Percentage of channel area in three **water clarity** categories was recorded (*Clear, Cloudy, Turbid*). The percentage of the channel area in each of four **bed stability** categories was estimated (*Solid/Firmly bedded, Stable, Unstable, Soft/Sinking*).

Sketch map was drawn for each of the survey site, showing the general physical characteristic of the site including important vegetation stands, and permanent reference features and any unusual features such as 'islands' of substrate supporting vegetation. A colour **photographs** was taken of the survey length to visually record its general character. Additional photographs were also taken to illustrate differentiation in vegetation and habitat between sites.

Design of experiments

The possible **inter-surveyor variability** was tested in the Summer 2003 in the replicate sampling experiment where three fully trained surveyors carried out independent survey on 26 river sites (matrix n=26 x 3). All of them studied the same reach and to avoid the effect of the spatial alteration between the surveys, the starting point was coordinated with GPS, maps and detailed drawn plans. Field examination was taken during the same visit although surveyors did it independently with a difference of about an hour – it was easy to organise while sharing duties on RHS, hydrolological measurements, collecting and filtering water sample was always time consuming.

The series of experiments enabled for **natural background variation** assessment, focusing on temporal source of variation (differences between years and seasons of the year), and influence of physical parameters as hydromorphological degradation and shading.

Concerning the variation **between years,** studies based on the field survey in June/July 2003 and in the same period in 2004 on 26 river sites (n=26 x 2). Impact of year season was estimated by surveys in two **different seasons** during vegetation period. It was tested in the year 2003 where vegetation in the early Summer (June/July) was compared with the early Autumn growth (September) (n=23 x 2). The same surveyor did field examination in both periods to estimate temporal source of variation. To avoid effect of spatial alteration between surveys, starting point was coordinated with GPS, maps and detailed drawn plans.

Influence of shading as well as **hydromorphological degradation** was estimated in the separate experiments in 2004 (5 June – 10 August). Majority of sites were additionally selected to have set of suitable pairs of river locations.

Impact of **shading** was estimated basing on 23 pairs of river sites (n=23 x 2). In this experiment macrophytes were surveyed in two localities of the same river within the distance of several hundred meters. It was focused to reach uniform environmental conditions as depth and width, current velocity, hydromorphological conditions and substrate. Absence of pollution discharge between pairs was checked. Twenty-three pairs of sites were selected for the sampling.

Impact of **hydromorphological modification** was estimated basing on 16 pairs of river sites (n=16 x 2). In this experiment surveys were undertaken on two localities of the same river representing different status of hydromorpological degradation (Table 4). Pairs of localities were selected within the distance of one kilometer. The selected sites were differentiated according to the hydromorphological degradation confirmed by large difference in HMS and HQA of the RHS survey. Depth and width, current velocity and shading were very similar. The absence of the pollution discharge between pairs was checked during the visit**.**

3.2 Overview of the analysed database

The twenty-seven sites were selected on different rivers where inter-surveyor (26 sites) and temporal variability (26 sites) was tested (Appendix 3). Twenty-five of them were selected jointly with WP7 and two of them were additional. These sites represent the wide range of trophic conditions present in Polish Lowlands. The scale of the gradient is evident according to chemical parameters (Fig. 2) as well as biological MTR (Fig. 3).

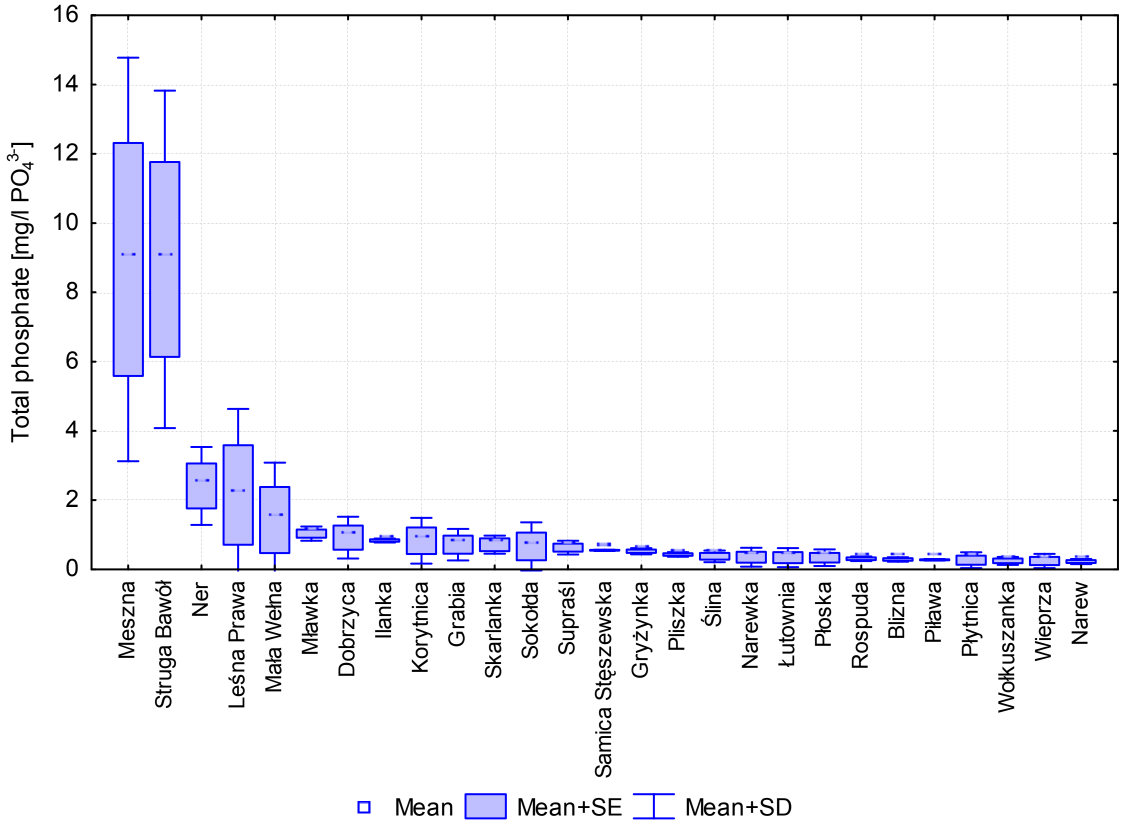


Fig. 2 Total phosphate among experimental river sites.

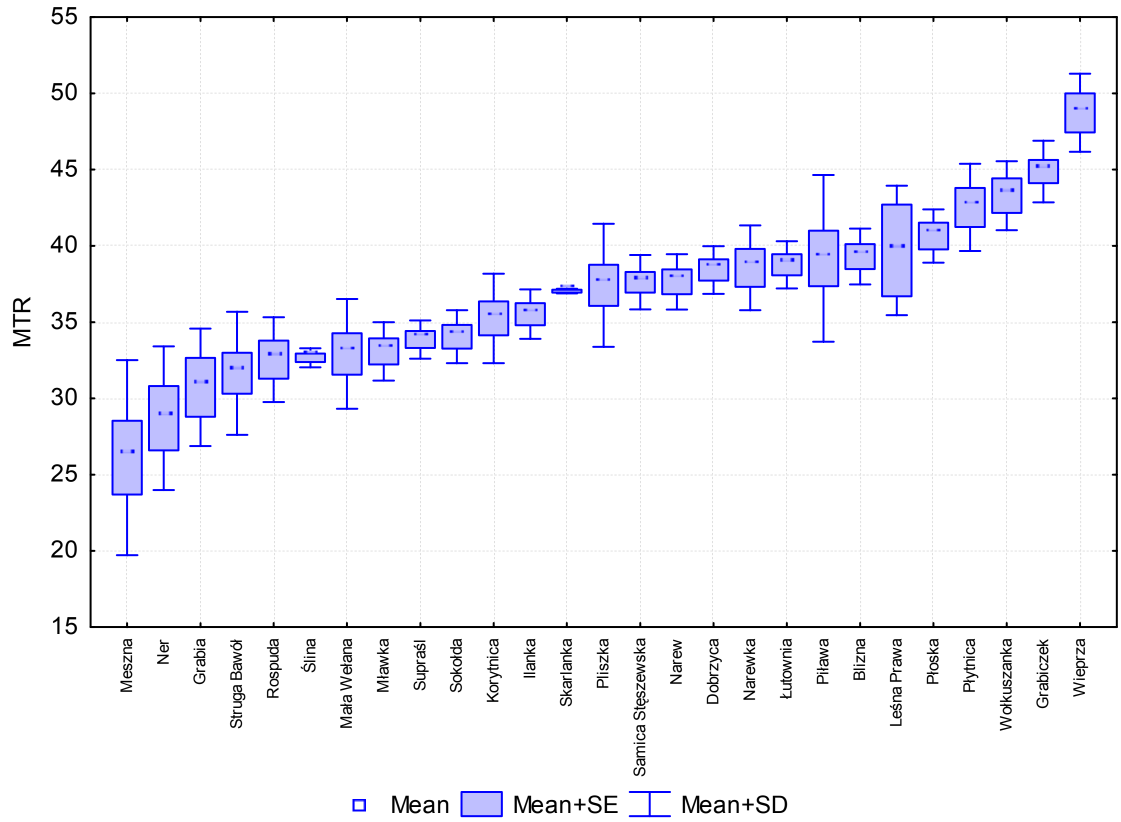


Fig. 3 Distribution of the MTR scores among experimental river sites

Additionally, differentiated gradient of hydromorphological degradation was also reached and the range of RHS metrics was very large - for the HQA it was 24.7 - 61.7 and for HMS it was even larger varying from 0 to 73.

During the survey 227 taxa of macrophytes were recorded. Monocotylodynes and dicotylodynes were dominating. Among Pteridiophytes three species were found, and seven Bryophytes. Seventy of identified taxa are indicators of MTR method. They represent full range of water trophy gradient – from oligotrophic (STR = 9 – 10) to eutrophic (STR = 1 – 2).

Among twenty four most abundant species 18 are MTR scoring plants. Most common were *Elodea canadensis* and *Lemna minor* (Fig. 4).

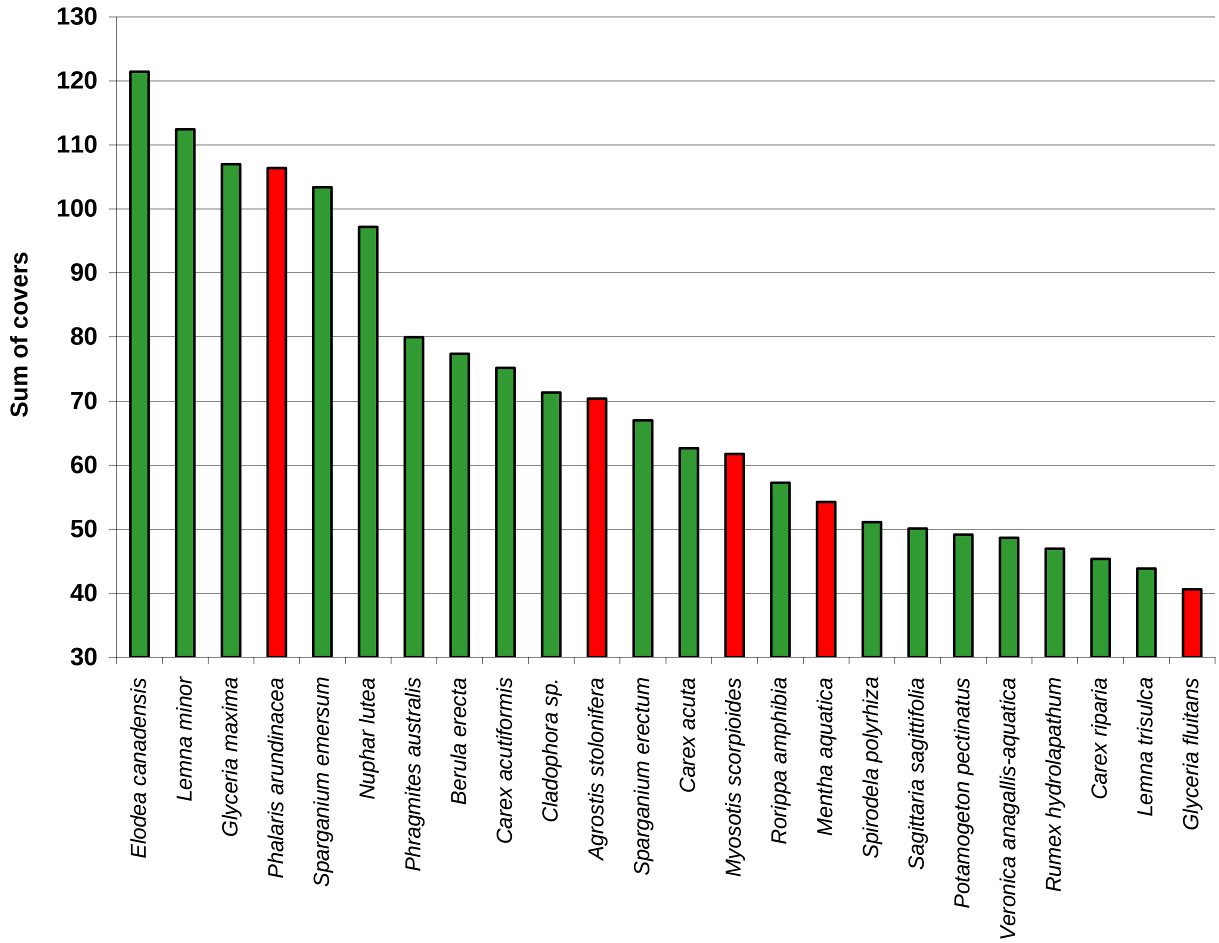


Fig. 4 Most abundant macrophyte species identified (MTR scoring plants in green).

Analysed rivers were rich in macrophyte species (from 17 to 85 taxa per MTR survey section). The largest number of species was identified in high quality Pilawa river, whereas the lowest number of species was in degradated Ner river (Fig. 5). Species diversity positively influences river assessment preciseness (Enviroment Agency 1996, Holmes et al. 1999, Dawson et al. 1999).

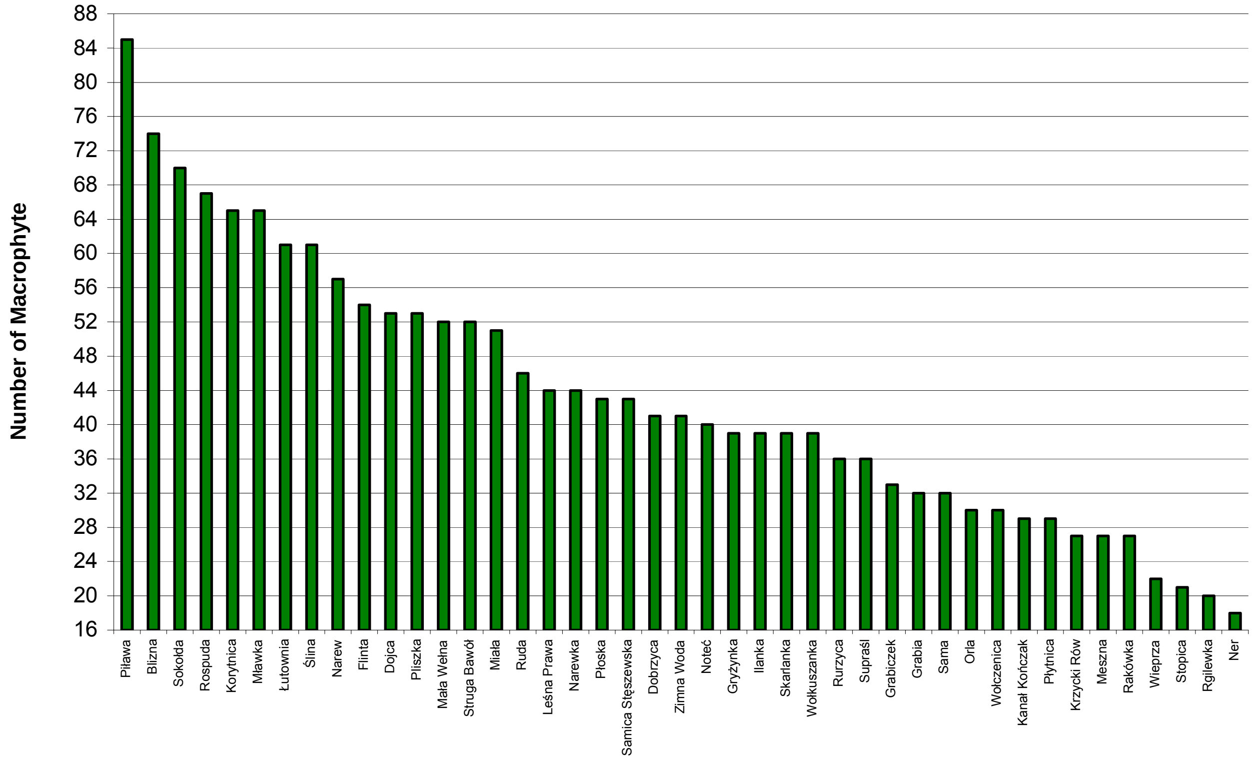


Fig. 5 Number of macrophyte species identified in the surveyed sites.

It might be **concluded** that sites selected for replicate sampling are rich in macrophyte species and represent wide environmental gradient. Such conditions can be regarded as favourable for high quality studies and they also enable high confidence of studies and represents a wide range of European habitats.

3.3 Variation of MTR score

Results of the experiment focused on **inter-surveyor variation** on MTR are presented in Table 1 and figure 6. Relatively low variation caused by surveyors was found except single outstanding value (CV=25.29) which was observed on Meszna River. This river represents outstanding habitat conditions where dark and cloudy water and scarce macrophyte cover makes precise survey difficult. Average value of Coefficient of Variation was 4.74 and after excluding outlier - only 3.92. The inter-surveyor factor appeared as a minor source of variation comparing with other sources (Table 21).

Table 1 Variation of MTR score between surveyors

Stream Name	MTR score			MTR SD	MTR CV
	Surveyor 1	Surveyor 2	Surveyor 3		
Blizna	36.8	38.2	39.8	1.50	3.92
Dobrzyca	38.3	36.0	39.6	1.83	4.83
Grabia	29.1	27.1	30.6	1.71	5.92
Grabiczek	45.7	42.9	41.8	2.02	4.64
Ilanka	34.4	38.2	34.4	2.16	6.05
Korytnica	34.6	36.0	35.8	0.79	2.22
Lutownia	40.4	38.1	36.7	1.91	4.98
Mala Welna	36.8	34.3	32.0	2.41	7.02
Meszna	18.0	30.0	23.3	6.01	25.29
Mlawka	34.7	31.6	32.7	1.57	4.76
Narew	37.2	36.4	35.9	0.69	1.88
Narewka	41.3	40.8	38.1	1.72	4.30
Ner	26.0	25.0	25.0	0.58	2.28
Pilawa	36.2	34.5	35.8	0.89	2.50
Pliszka	42.7	43.5	38.8	2.54	6.10
Ploska	40.3	39.3	39.8	0.50	1.26
Plytnica	45.0	39.6	40.0	3.02	7.27
Rospuda	33.1	35.9	31.6	2.20	6.55
S.Steszewska	39.8	38.8	39.3	0.49	1.26
Skarlanka	36.9	37.0	37.2	0.15	0.40
Sokolda	35.7	35.9	33.3	1.42	4.07
Struga Bawol	36.3	36.3	32.3	2.34	6.70
Suprasl	34.7	33.2	33.8	0.77	2.27
Slina	33.3	32.9	32.1	0.62	1.88
Wieprza	48.0	50.0	-	1.41	2.89
Wolkuszanka	42.67	41.2	42.8	0.88	2.08
			Mean	**1.62**	**4.74**
			Minimum	**0.15**	**0.40**
			Maximum	**6.01**	**25.29**

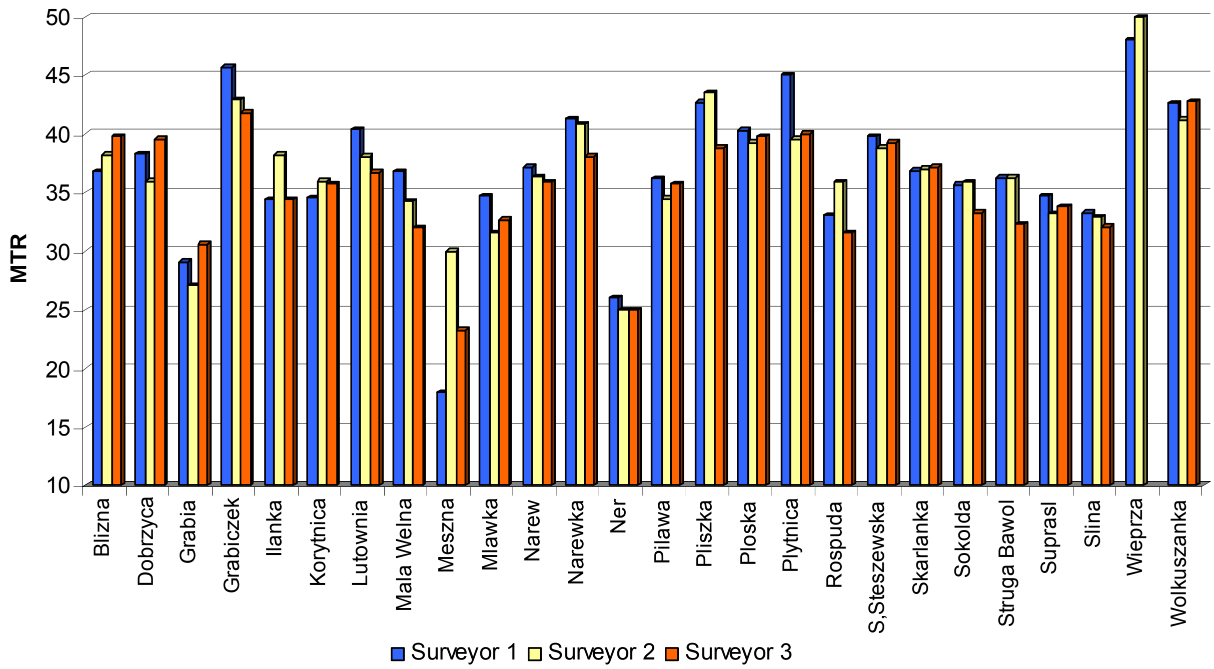


Fig. 6 Variation of MTR score between surveyors.

Concerning **natural background variation,** temporal source of MTR variation (differences between years and seasons of the year) and influence of physical parameters as hydromorphological degradation and shading were considered.

Results of experiment focused on variation **between years** are presented in Table 2 and Figure 7. The average variation was 6.89 (CV). The lowest differences were observed in case of Mlawka River (CV=1.46) and the highest in Grabia River (CV=20.05). The between years factor appeared as the most important source of variation comparing with other considered factors (Table 22) although the Wilkoxon's test showed lack of its statistical significance (Table 23) .

To determine differences of MTR score **between seasons** of the vegetation period surveys carried out in the early Summer were compared with surveys recorded in early Autumn. Observed variation was slightly lower (CV=6.07) comparing with the variation discovered between years. Smaller variation was observed in case of oligotrophic and mesotrophic rivers (Pilawa, Korytnica) whereas higher variation was observed in case of rivers with higher trophic status (Meszna, Mala Welna and Lesna Prawa). The between season factor appeared as a relatively important source of variation (Table 22) although the Wilkoxon's test showed that compared seasons do not differ significantly (Table 23).

Table 2 Temporal variation of MTR score

Stream Name	MTR score			Years		Season	
	Period 1 (summer 2004)	Period 2 (summer 2003)	Period 3 (autumn 2003)	MTR SD	MTR CV	MTR SD	MTR CV
Blizna	41.5	38.2	40.2	2.34	5.86	0.92	2,33
Dobrzyca	40.0	36.0	38.2	2.83	7.44	1.29	3,47
Grabia	36.1	27.1	-	6.34	20.05	-	-
Grabiczek	47.0	45.7	44.0	0.91	1.96	2.12	4,73
Ilanka	34.7	38.2	35.9	2.49	6.82	0.88	2,37
Korytnica	34.8	35.8	35.5	0.71	2.02	0.49	1,38
Lesna Prawa	42.7	38.3	36.7	3.05	7.54	4.23	11,29
Lutownia	40.2	36.7	38.4	2.53	6.58	1.27	3,39
Mala Welna	37.9	32.0	31.8	4.18	11.97	4.32	13,55
Meszna	28.8	30.0	36.7	0.88	3.01	5.60	16,79
Mlawka	35.4	34.7	31.0	0.51	1.46	3.10	9,45
Narew	38.2	35.9	40.5	1.63	4.39	1.64	4,29
Narewka	38.3	41.3	34.3	2.10	5.27	2.80	7,41
Ner	32.5	25.0	35.0	5.30	18.45	1.77	5,89
Pilawa	34.8	35.8	34.7	0.70	1.99	0.12	0,33
Pliszka	36.4	38.8	34.9	1.65	4.40	1.08	2,93
Ploska	43.2	39.8	-	2.45	5.89	-	-
Plytnica	45.9	40.0	42.1	4.18	9.73	2.66	6,48
Rospuda	28.4	31.6	33.7	2.22	7.39	3.71	11,39
S.Stęszewska	35.4	39.3	37.4	2.75	7.36	1.41	3,67
Sokolda	31.8	33.3	33.5	1.10	3.38	1.20	3,60
Struga Bawol	27.4	36.3	30.3	6.32	19.84	2.09	6,26
Suprasl	35.4	33.8	32.2	1.14	3.29	2.24	6,80
Slina	33.1	32.1	31.9	0.75	2.31	0.87	2,71
Wieprza	51.4	48.0	45.5	2.42	4.88	4.22	9,04
Wolkuszanka	46.5	42.8	-	2.64	5.91	-	-
			Mean	**2.47**	**6.89**	**2.18**	**6.07**
			Minimum	**0.51**	**1.46**	**0.12**	**0.33**
			Maximum	**6.34**	**20.05**	**5.60**	**16.79**

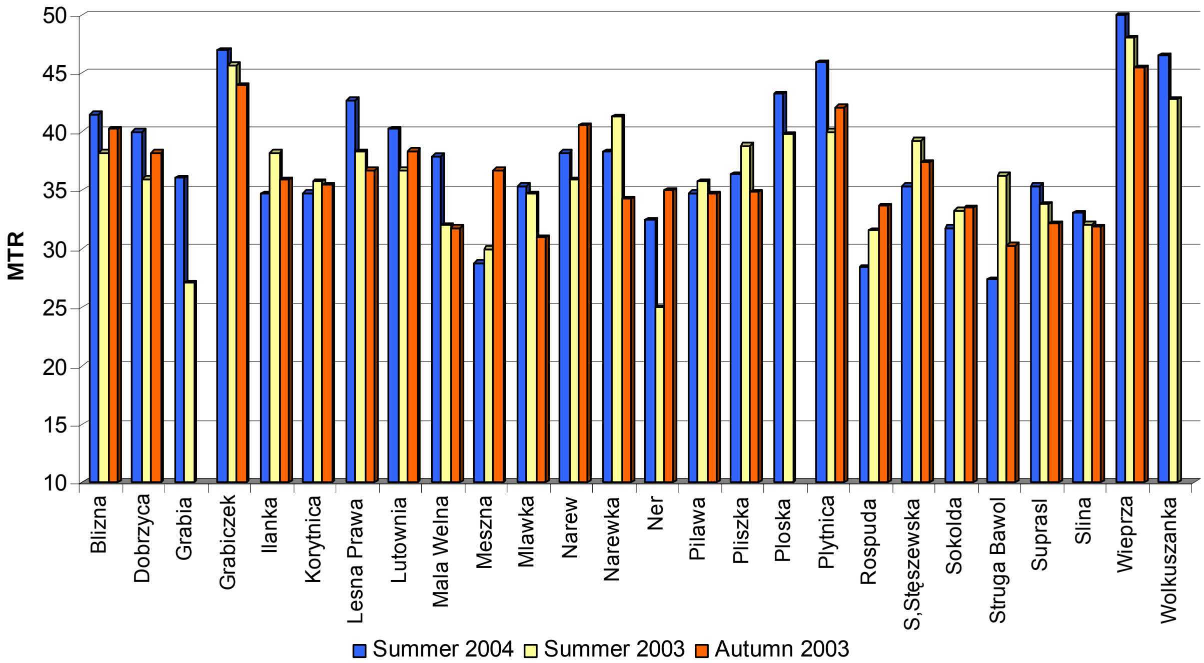


Fig. 7 Variation of MTR score between surveyors.

Impact of shading was estimated in the experiment where macrophytes were surveyed in two localities of the same river within the distance of several hundred meters (Table 3, Figure 8). It was found that shade caused mainly by trees on banks caused decreases of MTR score (in average for about 1.4 %). Average MTR score for all shaded sites was equal to 34.6 and MTR for matched unshaded sites was equal to 35.1. The statistical test showed that it was not significant (Table 23). The highest variation was observed on rivers with different ecological status and different species abundances (e.g. eutrophic and poor in species Meszna River as well as high quality and taxa rich Pilawa).

Table 3 Influence of channel shading on MTR score

Stream Name	Shaded section	Unshaded section	MTR SD	MTR CV
Dojca	36.4	35.9	0.35	0.98
Miloslawka Trib.	31.0	33.2	1.56	4.85
Flinta I	35.5	35.3	0.14	0.40
Flinta II	35.8	38.0	1.56	4.22
Gluszynka	29.2	29.2	0.00	0.00
Gryzynka	44.6	41.9	1.90	4.40
Kanal Konczak	36.3	35.8	0.39	1.10
Krzycki Row	44.0	38.8	3.68	8.88
Lutynia	28.0	34.6	4.67	14.91
Meszna	26.0	20.0	4.24	18.45
Miala	40.0	38.5	1.06	2.70
Orla	28.0	28.7	0.51	1.79
Ostroroga	27.0	25.8	0.85	3.21
Pilawa	37.6	46.8	6.49	15.38
Pliszka	32.2	37.2	3.50	10.08
Rakowka	40.0	39.2	0.54	1.37
Row Wyskoc	33.6	33.1	0.35	1.06
Ruda	31.8	34.9	2.21	6.63
Sama	31.5	35.4	2.74	8.20
S.Steszewska	37.2	35.4	1.28	3.53
Stopica	41.3	38.9	1.67	4.17
Wolczenica	33.5	35.0	1.04	3.03
Zimna Woda	35.7	35.8	0.10	0.27
		Mean	**1.78**	**5.20**
		Minimum	**0.00**	**0.00**
		Maximum	**6.49**	**18.45**

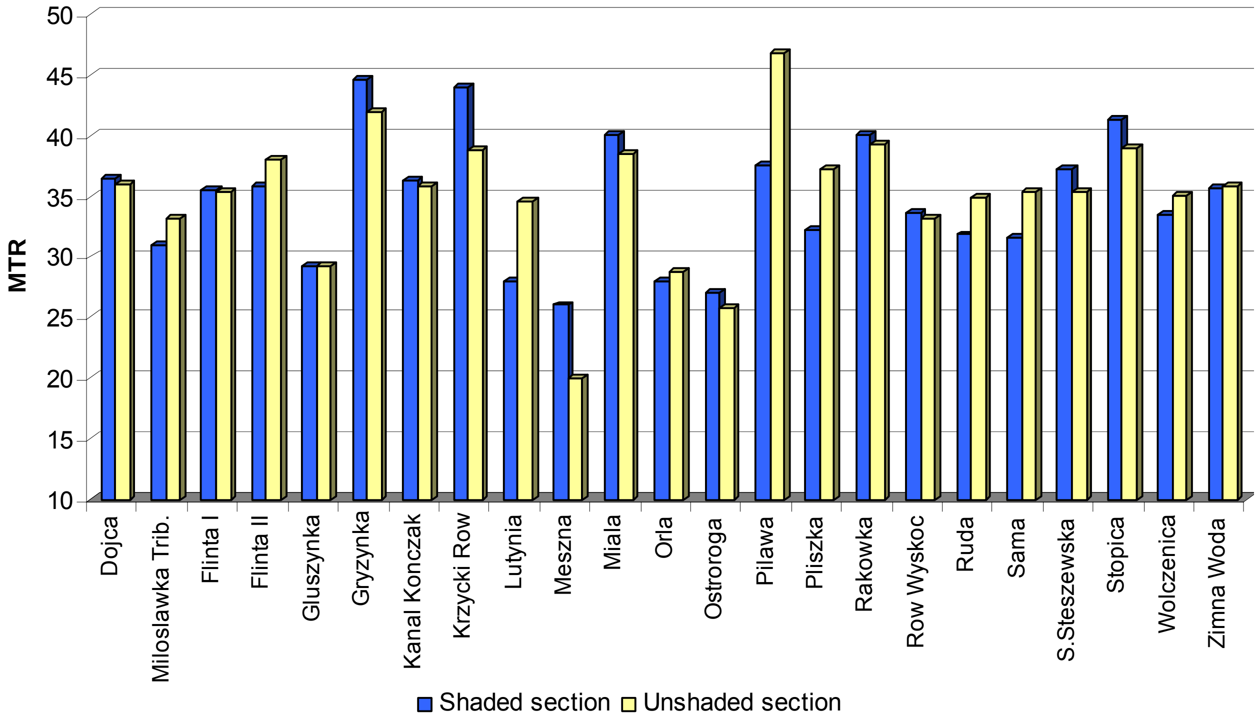


Fig. 8 Variation of MTR score between surveyors.

Impact of the **hydromorphological modification** on MTR score was estimated in another experiment where macrophytes were surveyed on two localities of the same river representing different status of hydromorpological degradation (Table 4, Figure 9). It was alsofound that hydromorphological factor influenced taxa composition but the MTR score became resistant and the detected differences between two tested groups were not significant (Table 21). It was found that variability was quite differentiated between sites and in some cases despite of floral change the MTR score was exacely the same (Mala Welna) and in some cases the difference was larger (Korytnica and Pliszka). Estimated effect of habitat modification on the total MTR variance was very low comparing to other tested factors (Table 22).

Table 4 Influence of channel modifications on MTR score

Stream Name	Modified section	Unmodified section	MTR SD	MTR CV
Dojca	36.4	36.0	0.26	0.71
Flinta	36.5	34.6	1.39	3.90
Grabiczek	45.7	47.0	0.91	1.96
Korytnica	30.0	40.0	7.07	20.20
Mala Welna	28.8	28.8	0.00	0.00
Miala	34.7	36.7	1.41	3.97
Notec	25.9	28.0	1.47	5.44
Ostroroga	33.8	29.7	2.90	9.13
Pilawa	45.4	46.8	1.01	2.19
Pliszka	38.8	32.2	4.62	13.01
Rgilewka	36.7	34.6	1.45	4.07
Row Wyskoc	41.7	46.9	3.68	8.30
Rurzyca	35.2	38.2	2.12	5.79
Struga Bawol I	27.4	26.0	0.98	3.69
Struga Bawol II	35.2	33.6	1.12	3.25
Wirynka	37.7	36.6	0.78	2.09
		Mean	**1.95**	**5.48**
		Minimum	**0.00**	**0.00**
		Maximum	**7.07**	**20.20**

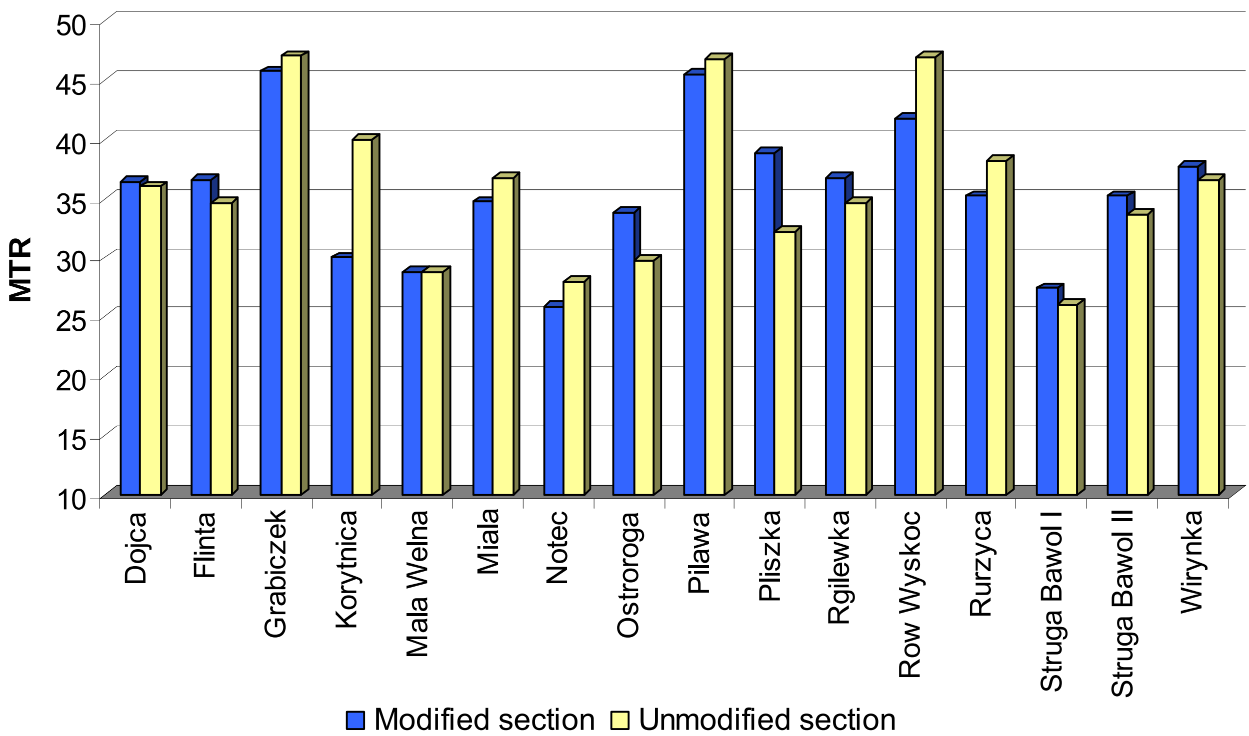


Fig. 9 Variation of MTR score between surveyors.

3.4 Variation of other macrophyte metrics

Nitrogen Ellenberg index

Plant species recorded during MTR surveys were used also for testing other macrophyte metrics. In case of nitrogen Ellenberg index the **inter-surveyors** variability was presented in Table 5 and Figure 10. The coefficient of variance calculated for analysed rivers was quite low (CV=1.78). The variability between individual sites was relatively uniform without major outliers. Comparison of calculated **inter-surveyor** variation and total variation one of the dataset showed that this factor plays marginal role (Table 23).

Table 5 Variation of Ellenberg index between surveyors

Stream Name	Ellenberg Index			Ellenberg Index SD	Ellenberg Index CV
	Surveyor 1	Surveyor 2	Surveyor 3		
Blizna	6.07	6.08	6.27	0.11	1.84
Dobrzyca	6.56	6.61	6.79	0.12	1.82
Grabia	6.59	6.62	6.67	0.04	0.61
Grabiczek	6.29	6.50	6.71	0.21	3.23
Ilanka	6.33	6.36	6.60	0.15	2.30
Korytnica	6.37	6.58	6.48	0.11	1.62
Lutownia	5.92	6.03	6.05	0.07	1.17
Mala Welna	6.62	6.76	6.77	0.08	1.25
Meszna	7.00	7.27	7.30	0.17	2.30
Mlawka	6.64	6.65	6.75	0.06	0.91
Narew	6.32	6.34	6.47	0.08	1.28
Narewka	5.73	5.78	5.88	0.08	1.32
Ner	6.83	7.00	7.00	0.10	1.41
Pilawa	6.38	6.55	6.58	0.11	1.66
Pliszka	6.20	6.30	6.33	0.07	1.08
Ploska	6.22	6.22	6.28	0.03	0.56
Plytnica	6.33	6.73	6.96	0.32	4.78
Rospuda	6.24	6.36	6.55	0.16	2.45
S.Steszewska	6.28	6.30	6.32	0.02	0.32
Skarlanka	6.51	6.52	6.52	0.01	0.09
Sokolda	6.31	6.56	6.60	0.16	2.42
Struga Bawol	6.40	6.47	6.64	0.12	1.90
Suprasl	6.42	6.44	6.54	0.06	0.99
Slina	5.97	6.20	6.35	0.19	3.10
Wieprza	5.40	5.75	-	0.25	4.44
Wolkuszanka	6.14	6.27	6.33	0.10	1.55
			Mean	**0.11**	**1.78**
			Minimum	**0.01**	**0.09**
			Maximum	**0.32**	**4.78**

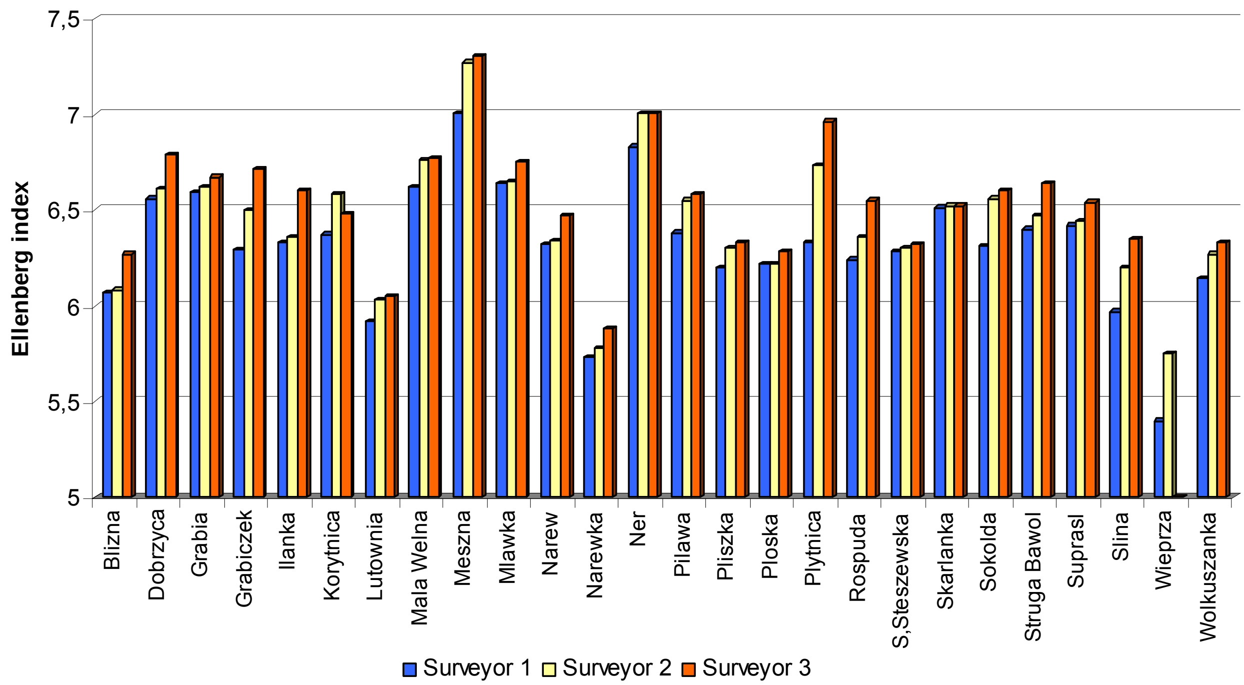


Fig. 10 Variation of MTR score between surveyors.

Analysis revealed that among **temporal sources** of Ellenberg index variation the seasonal changes are more important than differences between years (Table 22), but statistical analysis between surveys carried out in different time were always not significant (Table 23). Small values of the coefficient of variance for all surveyed rivers were found (Table 6, Figure 11). The largest variation of Ellenberg index between seasons was observed in case of eutrophic rivers as Lesna Prawa, Meszna, Mala Welna, Struga Bawol, Ner and Rospuda.

Table 6 Temporal variation of Ellenberg index

Stream Name	Ellenberg Index			Years		Season	
	Period 1 (Summer 2004)	Period 2 (Summer 2003)	Period 3 (Autumn 2003)	Ellenberg Index SD	Ellenberg Index CV	Ellenberg Index SD	Ellenberg Index CV
Blizna	6.06	6.07	6.11	0.01	0.12	0.03	0.46
Dobrzyca	6.73	6.79	6.48	0.04	0.63	0.22	3.30
Grabia	6.56	6.62	-	0.04	0.64	-	-
Grabiczek	6.52	6.71	6.92	0.13	2.03	0.15	2.18
Ilanka	6.47	6.36	6.48	0.08	1.21	0.08	1.32
Korytnica	6.48	6.37	6.36	0.08	1.21	0.01	0.11
Lesna Prawa	6.04	6.45	5.80	0.29	4.64	0.46	7.50
Lutownia	5.87	5.92	5.97	0.04	0.60	0.04	0.59
Mala Welna	6.36	6.77	6.95	0.29	4.42	0.13	1.86
Meszna	6.50	7.00	6.67	0.35	5.24	0.23	3.41
Mlawka	6.67	6.65	6.84	0.01	0.21	0.13	1.99
Narew	6.28	6.32	6.61	0.03	0.45	0.21	3.17
Narewka	5.87	5.88	6.37	0.01	0.12	0.35	5.66
Ner	7.50	7.00	6.70	0.35	4.88	0.21	3.10
Pilawa	6.62	6.58	6.71	0.03	0.43	0.09	1.38
Pliszka	6.37	6.33	6.58	0.03	0.45	0.18	2.74
Ploska	6.32	6.22	-	0.07	1.13	-	-
Plytnica	6.35	6.33	6.50	0.01	0.22	0.12	1.87
Rospuda	6.88	6.24	6.89	0.45	6.90	0.46	7.00
S.Steszewska	6.22	6.32	6.32	0.07	1.13	0.00	0.00
Sokolda	6.50	6.60	6.68	0.07	1.08	0.06	0.85
Struga Bawol	6.68	6.40	7.00	0.20	3.03	0.42	6.33
Suprasl	6.34	6.42	6.94	0.06	0.89	0.37	5.50
Slina	6.28	5.97	6.31	0.22	3.58	0.24	3.92
Wieprza	5.80	5.75	5.79	0.04	0.61	0.03	0.49
Wolkuszanka	5.92	6.33	-	0.29	4.73	-	-
			Mean	**0.13**	**1.94**	**0.18**	**2.82**
			Minimum	**0.01**	**0.12**	**0.00**	**0.00**
			Maximum	**0.45**	**6.90**	**0.46**	**7.50**

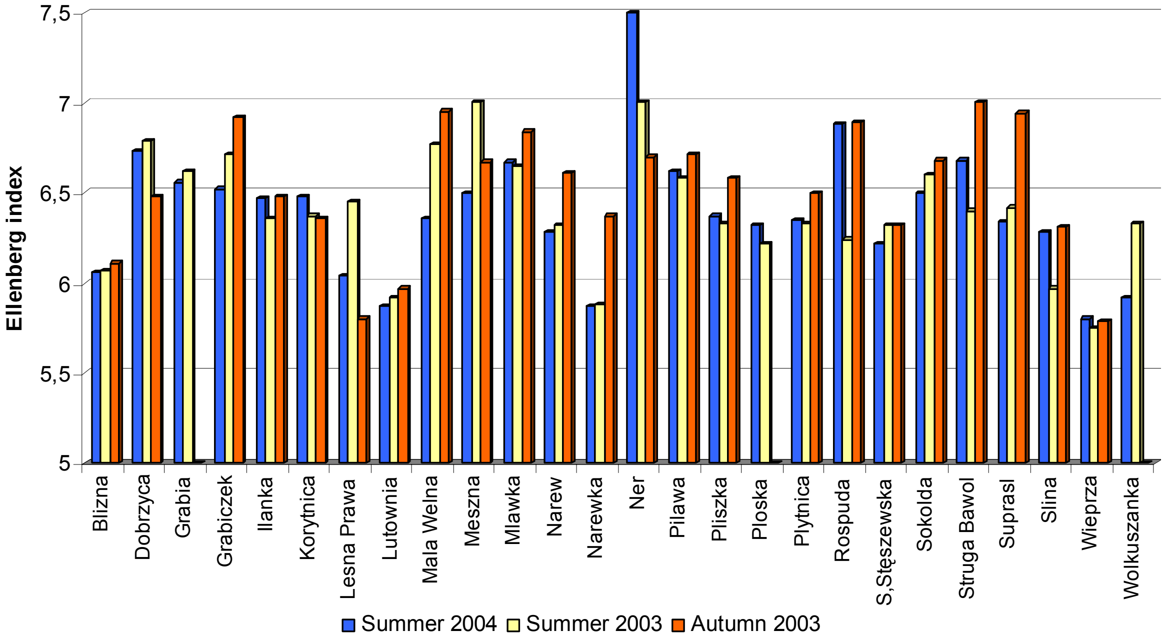


Fig. 11 Temporal variation of Ellenberg index.

Impact of **shade** on the total variance of Ellenberg index was quite important comparing with the total variability (Table 22), although differences between means were not significant (Table 23). The average coefficient of variance was very low (mean CV=2.97) (Table 7, Figure 12).

Table 7 Influence of channel shading on Ellenberg index

Stream Name	Shaded section	Unshaded section	Ellenberg Index SD	Ellenberg Index CV
Dojca	6.10	6.26	0.11	1.83
Miloslawka Trib.	6.70	6.84	0.10	1.46
Flinta I	6.32	6.43	0.08	1.22
Flinta II	6.20	6.63	0.30	4.74
Gluszynka	6.78	6.74	0.03	0.42
Gryzynka	6.09	5.04	0.74	13.34
Kanal Konczak	6.35	5.96	0.28	4.48
Krzycki Row	6.69	6.75	0.04	0.63
Lutynia	6.17	6.24	0.05	0.80
Meszna	6.41	6.94	0.37	5.61
Miala	6.19	6.46	0.19	3.02
Orla	6.77	6.76	0.01	0.10
Ostroroga	6.48	6.07	0.29	4.62
Pilawa	6.55	6.27	0.20	3.09
Pliszka	7.14	6.42	0.51	7.51
Rakowka	6.05	6.01	0.03	0.47
Row Wyskoc	6.79	7.00	0.15	2.15
Ruda	6.36	6.03	0.23	3.77
Sama	6.82	7.06	0.17	2.45
S.Steszewska	6.32	6.22	0.07	1.13
Stopica	6.40	6.35	0.04	0.55
Wolczenica	6.58	6.34	0.17	2.63
Zimna Woda	6.48	6.70	0.16	2.36
		Mean	**0.19**	**2.97**
		Minimum	**0.01**	**0.10**
		Maximum	**0.74**	**13.34**

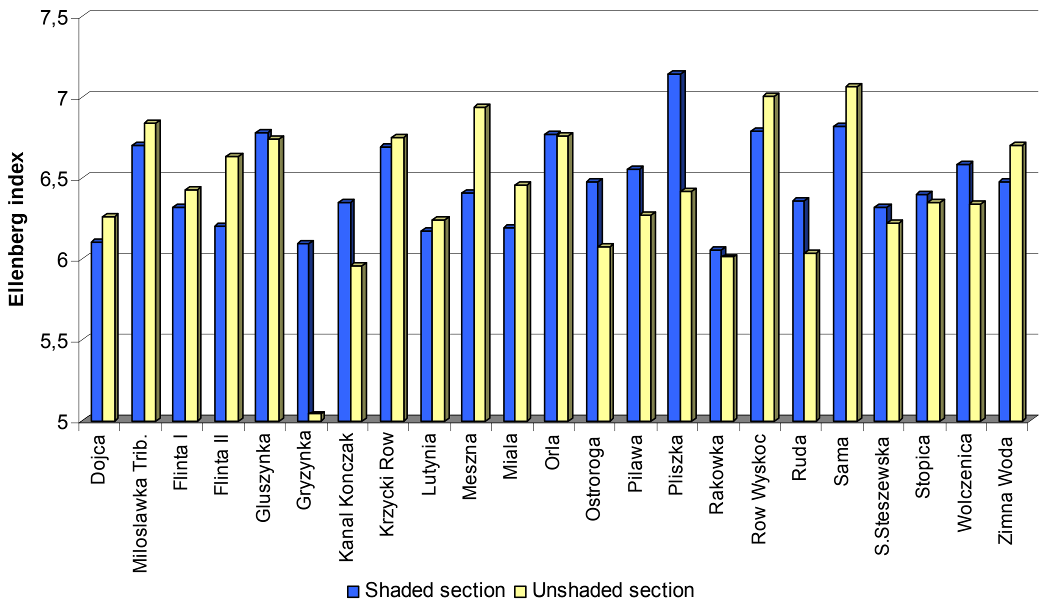


Fig. 12 Influence of channel shading on Ellenberg index.

Habitat modifications appeared as the most important factor influencing total variability of the Ellenberg index (Table 22), although the significant differences between modified and unmodified sections were not statistically confirmed (Table 23). The coefficient of variance was quite uniform among rivers and the average value was quite low (Table 8, Figure 13).

Table 8 Influence of habitat modifications on Ellenberg index

Stream Name	Modified section	Unmodified section	Ellenberg Index SD	Ellenberg Index CV
Dojca	6.26	6.49	0.16	2.55
Flinta	6.15	6.98	0.59	8.94
Grabiczek	7.25	6.52	0.52	7.50
Korytnica	6.18	6.48	0.21	3.35
Mala Welna	6.65	6.54	0.08	1.18
Miala	6.54	6.48	0.04	0.65
Notec	6.97	6.42	0.39	5.81
Ostroroga	6.25	6.59	0.24	3.74
Pilawa	6.76	6.27	0.35	5.32
Pliszka	7.11	7.14	0.02	0.30
Rgilewka	6.60	6.94	0.24	3.55
Row Wyskoc	6.79	6.33	0.33	4.96
Rurzyca	6.50	6.16	0.24	3.80
Struga Bawol I	6.70	6.61	0.06	0.96
Struga Bawol II	6.67	6.97	0.21	3.11
Wirynka	6.42	6.30	0.08	1.33
		Mean	**0.24**	**3.57**
		Minimum	**0.02**	**0.30**
		Maximum	**0.59**	**8.94**

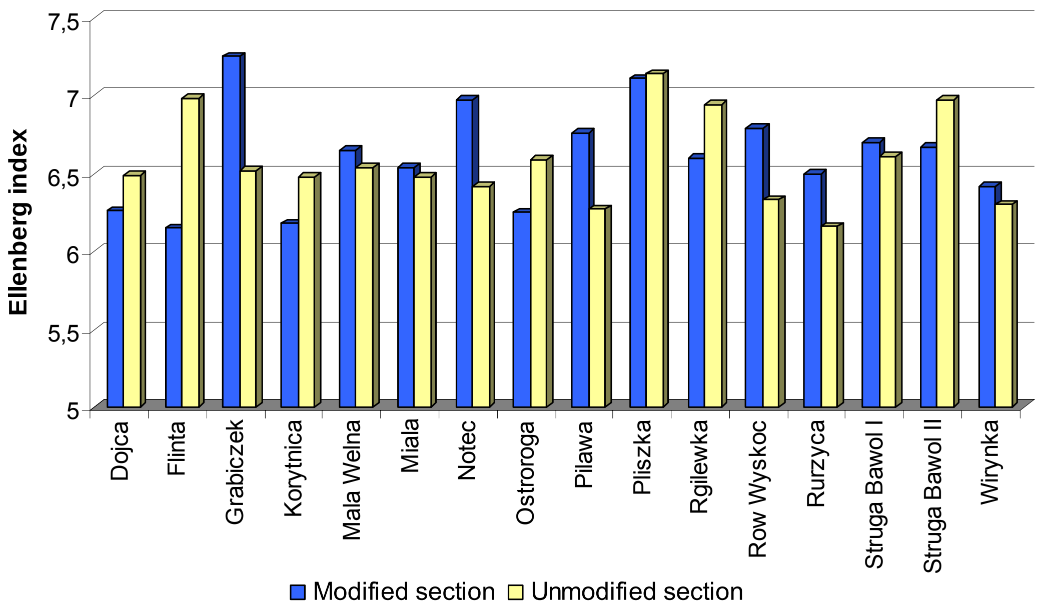


Fig. 13 Influence of habitat modifications on Ellenberg index.

IBMR index

The **inter-surveyor** variation of Macrophyte Biological Index for Rivers - IBMR index plays very small role of the total variability (Table 22). The coefficient of variance calculated for analysed rivers was also very low (CV=3.83) (Table 9, Figure 14). The highest CV was calculated for Ner river where the taxa richness was extremely low and scarce in cover. In that case casual species, could strongly influenced on calculated IBMR index.

Table 9 Variation of IBMR score between surveyors

Stream Name	IBMR score			IBMR SD	IBMR CV
	Surveyor 1	Surveyor 2	Surveyor 3		
Blizna	11.2	11.3	11.5	0.16	1.39
Dobrzyca	10.4	10.6	10.9	0.25	2.38
Grabia	8.9	9.1	9.1	0.13	1.39
Grabiczek	10.0	10.2	10.3	0.17	1.65
Ilanka	11.0	11.1	11.9	0.48	4.24
Korytnica	8.7	9.1	9.7	0.49	5.34
Lutownia	9.8	10.0	10.2	0.21	2.08
Mala Welna	8.2	8.5	8.6	0.23	2.67
Meszna	5.6	6.8	7.3	0.87	13.17
Mlawka	9.6	9.6	9.7	0.09	0.92
Narew	9.8	9.8	10.1	0.16	1.62
Narewka	9.3	9.4	9.9	0.31	3.20
Ner	6.6	8.6	8.7	1.18	14.91
Pilawa	8.6	9.1	9.4	0.37	4.06
Pliszka	10.2	10.9	11.0	0.44	4.13
Ploska	9.7	10.3	10.4	0.37	3.65
Plytnica	10.7	10.8	11.5	0.46	4.14
Rospuda	7.5	7.5	8.1	0.32	4.10
S.Steszewska	9.6	9.7	9.8	0.13	1.36
Skarlanka	10.6	10.8	11.0	0.21	1.95
Sokolda	8.6	9.2	9.5	0.48	5.29
Struga Bawol	7.6	8.6	8.9	0.69	8.18
Suprasl	8.6	8.7	8.8	0.09	1.01
Slina	7.9	8.4	8.5	0.34	4.09
Wieprza	12.0	12.2	-	0.16	1.30
Wolkuszanka	11.0	11.1	11.3	0.17	1.50
			Mean	**0.34**	**3.83**
			Minimum	**0.09**	**0.92**
			Maximum	**1.18**	**14.91**

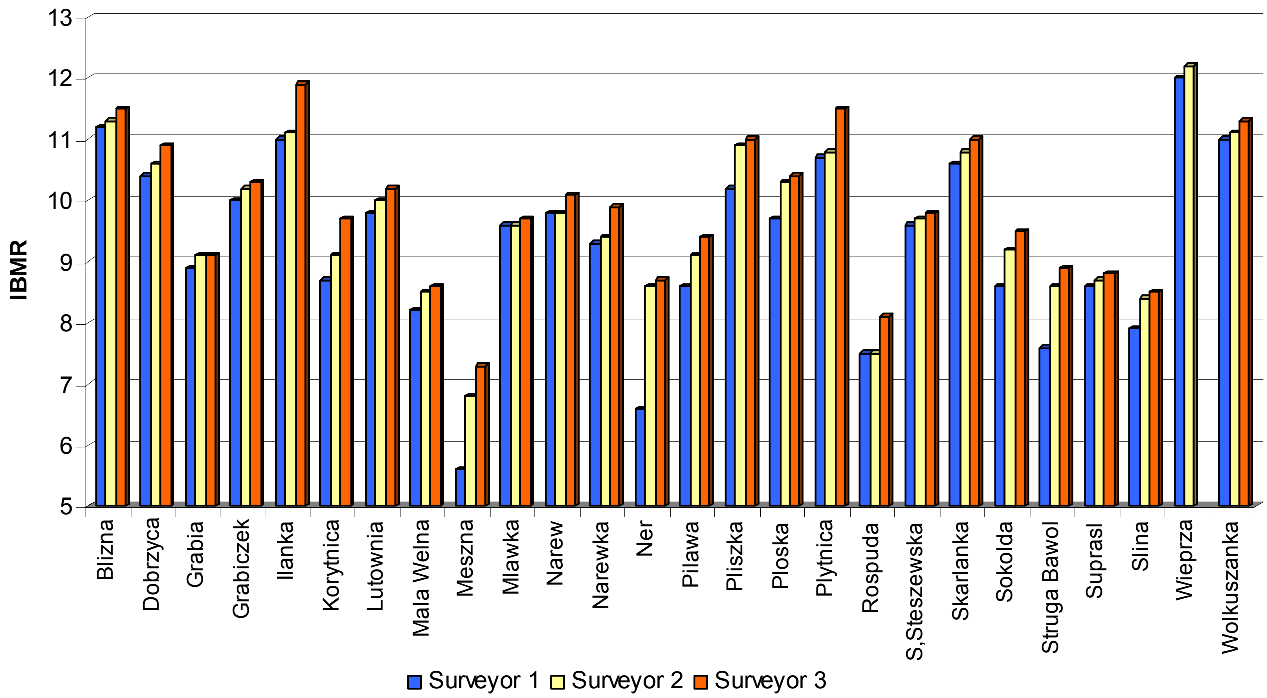


Fig. 14 Variation of IBMR score between surveyors.

Level of **temporal variability** of IBMR for each of the site is presented in the Table 10 and Figure 15. It was generally low considering both two types of temporal variation as differences between years (26 sites) as well as differences between seasons (23 sites). Analysis on influence of temporal sources of IBMR variation on the total variance confirmed its limited level (Table 22). Statistical analysis between means of surveys, carried out in different periods, were not significant (Table 23).

Table 10 Temporal variation of IBMR score

Stream Name	IBMR score			Years		Season	
	Period 1 (Summer 2004)	Period 2 (Summer 2003)	Period 3 (Autumn 2003)	IBMR SD	IBMR CV	IBMR SD	IBMR CV
Blizna	11.1	11.3	11.6	0.16	1.43	0.21	1.85
Dobrzyca	10.8	10.6	10.2	0.12	1.11	0.28	2.69
Grabia	10.3	9.1	-	0.87	8.94	-	-
Grabiczek	10.6	10.3	10.5	0.16	1.56	0.09	0.91
Ilanka	11.1	11.0	10.6	0.06	0.56	0.32	2.94
Korytnica	8.9	9.1	9.4	0.12	1.31	0.22	2.43
Lesna Prawa	10.1	9.5	9.0	0.39	4.02	0.35	3.82
Lutownia	9.9	9.8	9.8	0.04	0.45	0.01	0.10
Mala Welna	10.2	8.5	8.3	1.17	12.44	0.17	2.01
Meszna	8.2	6.8	8.2	1.01	13.46	1.01	13.39
Mlawka	10.4	9.6	8.9	0.56	5.61	0.46	4.97
Narew	10.8	10.1	11.1	0.47	4.47	0.71	6.72
Narewka	9.4	9.4	9.7	0.01	0.13	0.19	1.98
Ner	9.2	8.7	9.4	0.35	3.95	0.49	5.47
Pilawa	9.4	9.1	8.5	0.23	2.53	0.41	4.71
Pliszka	10.3	10.2	9.5	0.09	0.89	0.53	5.39
Ploska	10.6	10.4	-	0.15	1.45	-	-
Plytnica	11.6	11.5	11.2	0.06	0.54	0.23	2.00
Rospuda	7.2	7.5	8.4	0.20	2.72	0.65	8.18
S.Steszewska	9.1	9.6	9.3	0.33	3.56	0.21	2.17
Sokolda	8.5	8.6	8.8	0.06	0.65	0.15	1.67
Struga Bawol	8.6	7.6	7.1	0.71	8.78	0.32	4.33
Suprasl	8.9	8.8	7.9	0.05	0.53	0.60	7.21
Slina	9.5	8.5	8.6	0.73	8.09	0.04	0.45
Wieprza	13.3	12.2	11.8	0.80	6.28	0.26	2.16
Wolkuszanka	12.0	11.3	-	0.48	4.15	-	-
			Mean	**0.36**	**3.83**	**0.34**	**3.81**
			Minimum	**0.01**	**0.13**	**0.01**	**0.10**
			Maximum	**1.17**	**13.46**	**1.01**	**13.39**

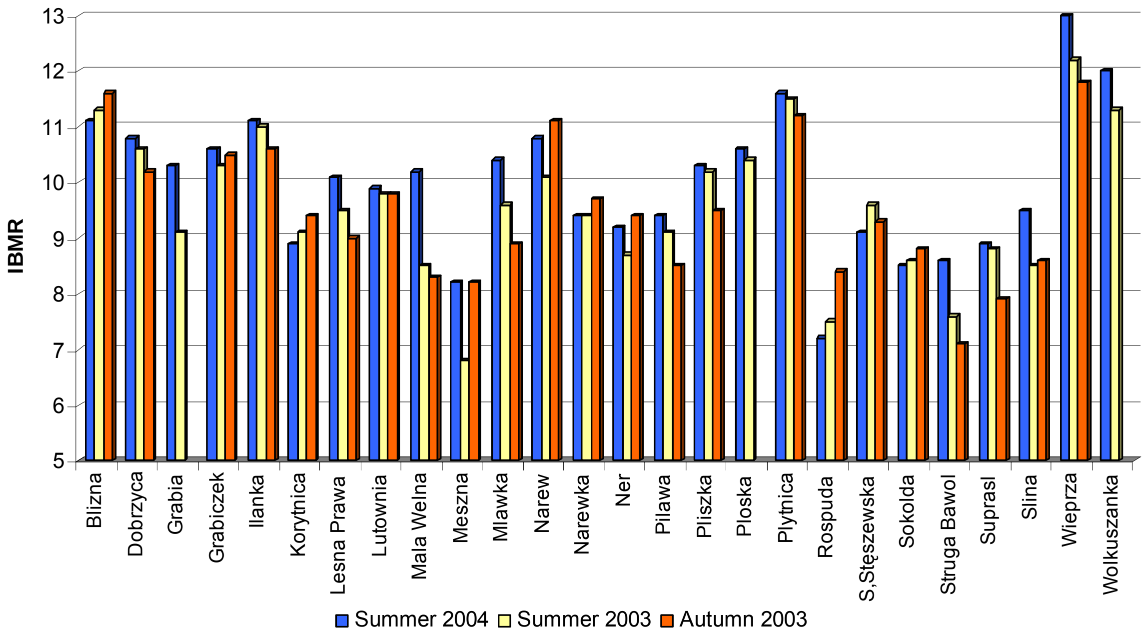


Fig. 15 Temporal variation of IBMR score.

Impact of **shade** on the total variance of IBMR index appeared as a was very important part in the total variability (Table 22), although differences between means of the two sections were not significant (Table 23). The coefficient of variance was rather limited (mean CV=5.04) with a little bit higher values in case of three rivers (Table 11, Figure 16).

Table 11 Influence of channel shading on IBMR score

Stream Name	Shaded section	Unshaded section	IBMR SD	IBMR CV
Dojca	10.2	10.0	0.17	1.66
Miloslawka Trib.	6.7	8.6	1.29	16.86
Flinta I	10.0	9.7	0.21	2.14
Flinta II	9.6	9.7	0.08	0.82
Gluszynka	8.3	8.8	0.37	4.29
Gryzynka	11.1	11.4	0.17	1.55
Kanal Konczak	10.5	10.3	0.17	1.66
Krzycki Row	10.4	10.6	0.16	1.50
Lutynia	7.2	8.9	1.17	14.58
Meszna	6.8	6.2	0.43	6.66
Miala	10.5	10.1	0.28	2.76
Orla	6.3	6.8	0.33	5.03
Ostroroga	8.4	9.3	0.66	7.41
Pilawa	9.2	10.9	1.20	11.87
Pliszka	8.8	9.4	0.41	4.46
Rakowka	10.5	10.7	0.18	1.70
Row Wyskoc	8.5	8.8	0.26	3.00
Ruda	9.0	9.8	0.57	6.03
Sama	8.6	9.6	0.70	7.71
S.Steszewska	9.1	10.1	0.66	6.92
Stopica	11.0	10.3	0.44	4.16
Wolczenica	9.6	9.9	0.22	2.28
Zimna Woda	10.5	10.2	0.18	1.71
		Mean	**0.45**	**5.08**
		Minimum	**0.08**	**0.82**
		Maximum	**1.29**	**16.86**

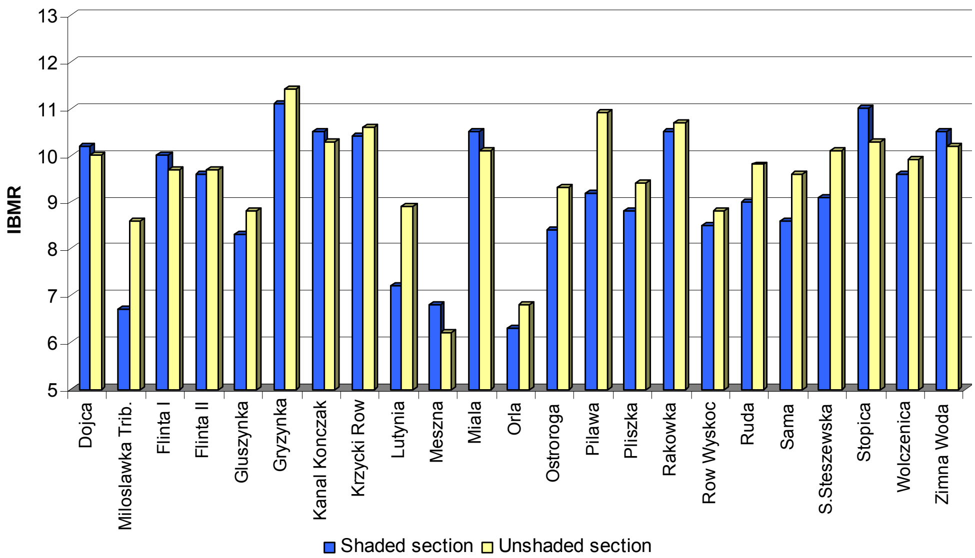


Fig. 16 Influence of channel shading on IBMR score.

Influence of **habitat modification** on the total variation was very large (Table 22) but calculated means according to Willkoxon's test were not significantly different (Table 23). The average coefficient of variance was quite low (CV=5.34) with outlying values in case of two rivers (Pliszka and Korytnica) which represent high status (Table 12, figure 17).

Table 12 Table Influence of channel modifications on IBMR score

Stream Name	Modified section	Unmodified section	IBMR SD	IBMR CV
Dojca	10.2	10.8	0.42	3.99
Flinta	10.4	9.2	0.87	8.91
Grabiczek	9.6	10.6	0.66	6.58
Korytnica	8.1	9.7	1.12	12.61
Mala Welna	8.3	8.4	0.06	0.74
Miala	9.0	8.8	0.16	1.79
Notec	7.3	8.0	0.48	6.27
Ostroroga	8.9	8.9	0.04	0.49
Pilawa	9.6	9.2	0.28	2.95
Pliszka	12.7	8.8	2.70	25.15
Rgilewka	10.1	9.0	0.78	8.14
Row Wyskoc	11.1	11.3	0.13	1.14
Rurzyca	9.1	9.3	0.12	1.30
Struga Bawol I	7.4	7.2	0.10	1.35
Struga Bawol II	8.4	8.9	0.35	4.00
Wirynka	9.3	9.3	0.01	0.06
		Mean	**0.52**	**5.34**
		Minimum	**0.01**	**0.06**
		Maximum	**2.70**	**25.15**

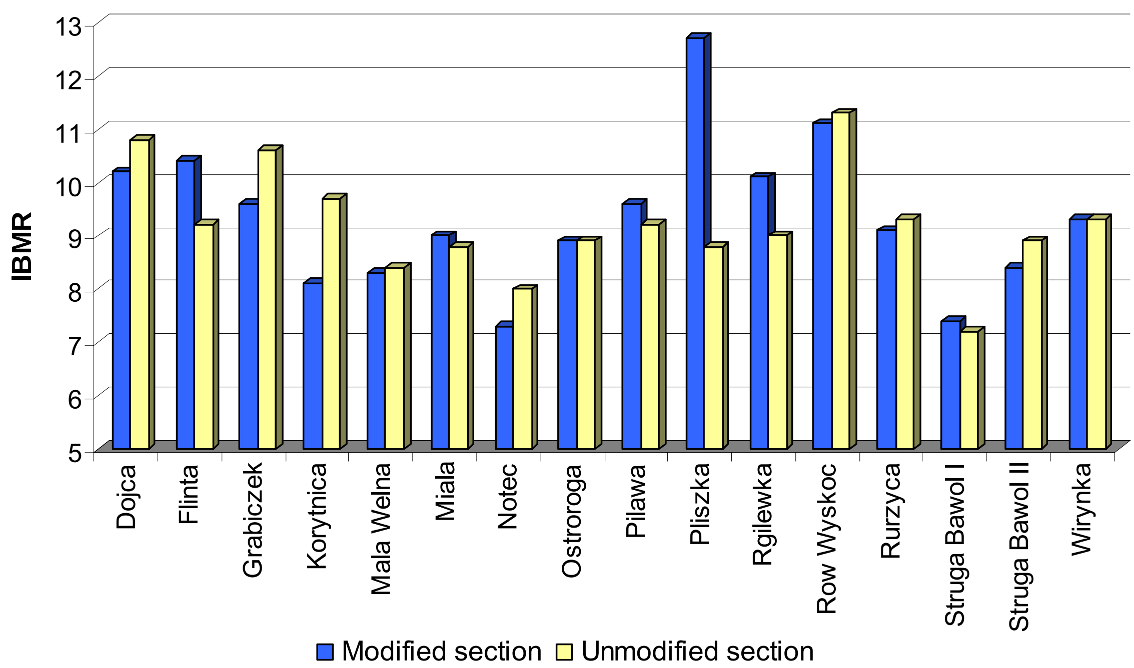


Fig. 17 Table Influence of channel modifications on IBMR score.

Number of species

The **inter-surveyor** variation of the species richness assessment was estimated basing on 26 sites placed on different rivers. The coefficient of variance calculated for analysed rivers was quite high (average CV=14.37) (Table 13, Figure 18). Nevertheless, it was found that variance generated by this factor plays very small role in the total variance of the taxa richness matrix (Table 22).

Table 13 Variation of the number of species between surveyors

Stream Name	Number of species			Number of species SD	Number of species CV
	Surveyor 1	Surveyor 2	Surveyor 3		
Blizna	32	35	34	1.53	4.54
Dobrzyca	19	20	22	1.53	7.51
Grabia	17	18	21	2.08	11.15
Grabiczek	11	10	9	1.00	10.00
Ilanka	6	7	7	0.58	8.66
Korytnica	28	32	29	2.08	7.02
Lutownia	21	30	38	8.50	28.67
Mala Wełna	26	30	31	2.65	9.12
Meszna	5	6	5	0.58	10.83
Mlawka	31	36	44	6.56	17.72
Narew	30	27	29	1.53	5.33
Narewka	20	16	16	2.31	13.32
Ner	9	6	4	2.52	39.74
Pilawa	26	28	25	1.53	5.80
Pliszka	24	24	18	3.46	15.75
Ploska	24	20	14	5.03	26.03
Plytnica	8	11	14	3.00	27.27
Rospuda	32	32	25	4.04	13.62
S.Steszewska	21	25	23	2.00	8.70
Skarlanka	27	24	25	1.53	6.03
Sokolda	33	34	40	3.79	10.61
Struga Bawol	20	20	17	1.73	9.12
Suprasl	25	22	27	2.52	10.20
Slina	33	34	31	1.53	4.68
Wieprza	4	8	-	2.83	47.14
Wolkuszanka	23	17	21	3.06	15.02
			Mean	**2.67**	**14.37**
			Minimum	**0.58**	**4.54**
			Maximum	**8.50**	**47.14**

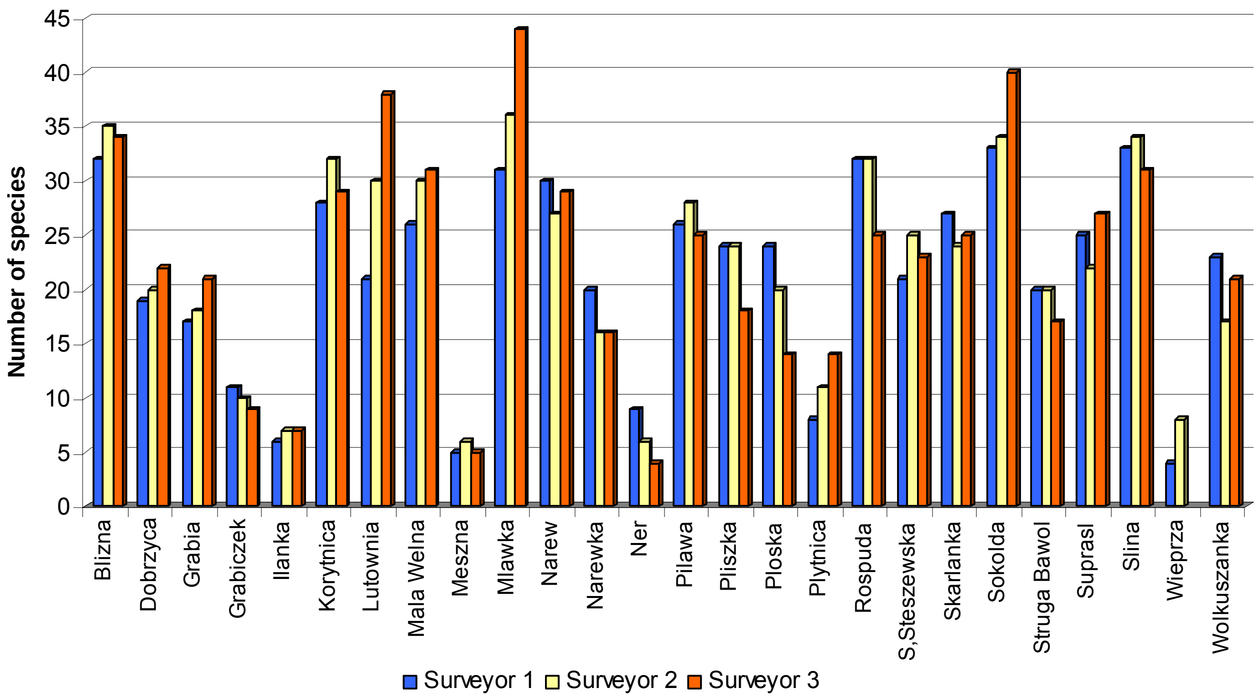


Fig. 18 Variation of the number of species between surveyors.

Many similarities were observed between two types of **temporal variation** as differences between years (26 sites) and differences between seasons (23 sites). The estimated range of the coefficient of variance was relatively large (Table 14, Figure 19). Both types of **temporal source of variation** similarly appeared as very important determinants the total variance (Table 22). Statistical analysis between surveys carried out in different time were not significant (Table 23).

Table 14 Variation of number of species score between periods

Stream Name	Number of species			Years		Season	
	Period 1 (summer 2004)	Period 2 (summer 2003)	Period 3 (autumn 2003)	Number of species SD	Number of species CV	Number of species SD	Number of species CV
Blizna	40	31	30	6.36	17.93	0.71	2.32
Dobrzyca	26	20	26	4.24	18.45	4.24	18.45
Grabia	21	18	-	2.12	10.88	-	-
Grabiczek	12	11	11	0.71	6.15	0.00	0.00
Ilanka	31	6	18	17.68	95.55	8.49	70.71
Korytnica	37	32	35	3.54	10.25	2.12	6.33
Lesna Prawa	24	16	20	5.66	28.28	2.83	15.71
Lutownia	31	21	30	7.07	27.20	6.36	24.96
Mala Wełna	23	26	28	2.12	8.66	1.41	5.24
Meszna	14	5	5	6.36	66.99	0.00	0.00
Mlawka	20	44	39	16.97	53.03	3.54	8.52
Narew	22	30	18	5.66	21.76	8.49	35.36
Narewka	26	20	14	4.24	18.45	4.24	24.96
Ner	6	9	11	2.12	28.28	1.41	14.14
Pilawa	36	26	45	7.07	22.81	13.44	37.85
Pliszka	32	24	28	5.66	20.20	2.83	10.88
Ploska	22	14	-	5.66	31.43	-	-
Plytnica	17	14	14	2.12	13.69	0.00	0.00
Rospuda	30	32	23	1.41	4.56	6.36	23.14
S.Steszewska	26	21	26	3.54	15.04	3.54	15.04
Sokolda	27	40	34	9.19	27.44	4.24	11.47
Struga Bawol	21	20	20	0.71	3.45	0.00	0.00
Suprasl	14	25	12	7.78	39.89	9.19	49.69
Slina	32	34	26	1.41	4.29	5.66	18.86
Wieprza	7	4	17	2.12	38.57	9.19	87.55
Wolkuszanka	22	21	-	0.71	3.29	-	-
			Mean	**5.09**	**24.48**	**4.27**	**20.92**
			Minimum	**0.71**	**3.29**	**0.00**	**0.00**
			Maximum	**17.68**	**95.55**	**13.44**	**87.55**

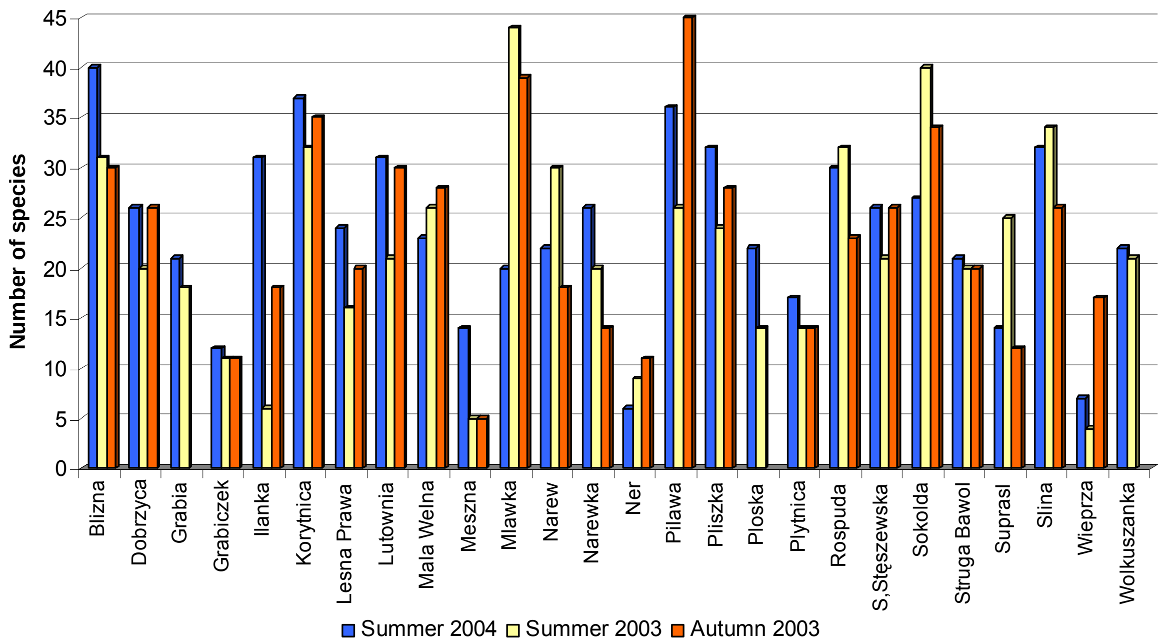


Fig. 19 Variation of number of species score between periods.

Influence of **sunlight exposure** was tested on 23 pairs of sites. It was noticed that shaded and unshaded sections differ in species composition radically. It was also confirmed that it is the most influential factor on the total variance among measured factors (Table 22). Despite that differences between means were not significant (Table 23). The variability between individual sites was extremely differentiated: several sites were not impacted (CV=0 in two cases) whereas several other were highly influenced (CV higher than 70) (Table 15, Figure 20).

Table 15 Influence of channel shading on number of species

Stream Name	Shaded section	Unshaded section	Number of species SD	Number of species CV
Dojca	32	37	3.54	10.25
Miloslawka Trib.	6	12	4.24	47.14
Flinta I	18	29	7.78	33.10
Flinta II	22	22	0.00	0.00
Gluszynka	15	24	6.36	32.64
Gryzynka	26	26	0.00	0.00
Kanal Konczak	23	22	0.71	3.14
Krzycki Row	12	20	5.66	35.36
Lutynia	5	13	5.66	62.85
Meszna	18	8	7.07	54.39
Miala	26	24	1.41	5.66
Orla	23	22	0.71	3.14
Ostroroga	14	16	1.41	9.43
Pilawa	36	41	3.54	9.18
Pliszka	10	31	14.85	72.44
Rakowka	14	28	9.90	47.14
Row Wyskoc	12	17	3.54	24.38
Ruda	25	38	9.19	29.18
Sama	27	20	4.95	21.06
S.Steszewska	19	25	4.24	19.28
Stopica	11	20	6.36	41.06
Wolczenica	21	20	0.71	3.45
Zimna Woda	24	35	7.78	26.37
		Mean	**4.77**	**25.68**
		Minimum	**0.00**	**0.00**
		Maximum	**14.85**	**72.44**

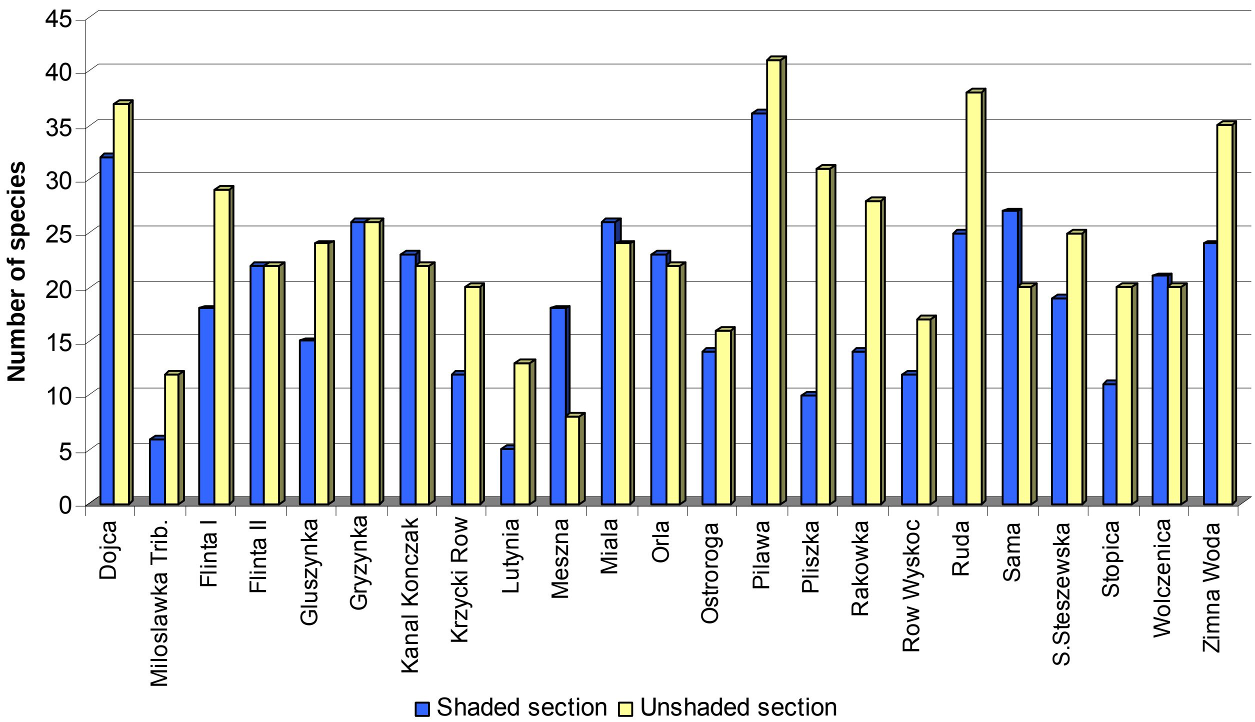


Fig. 20 Influence of channel shading on number of species.

Influence of **habitat modification** on the total variation was rather limited (Table 22) and differences between means for both sections were not significant (Table 23). The variability between 16 individual sites was very differentiated: several sites were not impacted (CV=0) whereas several other sites were highly influenced (CV higher than 70) (Table 16, Figure 21).

Table 16 Influence of channel modifications on number of species

Stream Name	Modified section	Unmodified section	Number of species SD	Number of species CV
Dojca	31	32	0.71	2.24
Flinta	17	52	24.75	71.74
Grabiczek	22	7	10.61	73.15
Korytnica	36	19	12.02	43.71
Mala Wełna	20	18	1.41	7.44
Miala	15	32	12.02	51.15
Noteć	28	24	2.83	10.88
Ostroroga	18	14	2.83	17.68
Pilawa	41	41	0.00	0.00
Pliszka	10	5	3.54	47.14
Rgilewka	11	17	4.24	30.30
Row Wyskoc	11	10	0.71	6.73
Rurzyca	34	24	7.07	24.38
Struga Bawol I	20	21	0.71	3.45
Struga Bawol II	17	20	2.12	11.47
Wirynka	21	16	3.54	19.11
		Mean	**5.57**	**26.29**
		Minimum	**0.00**	**0.00**
		Maximum	**24.75**	**73.15**

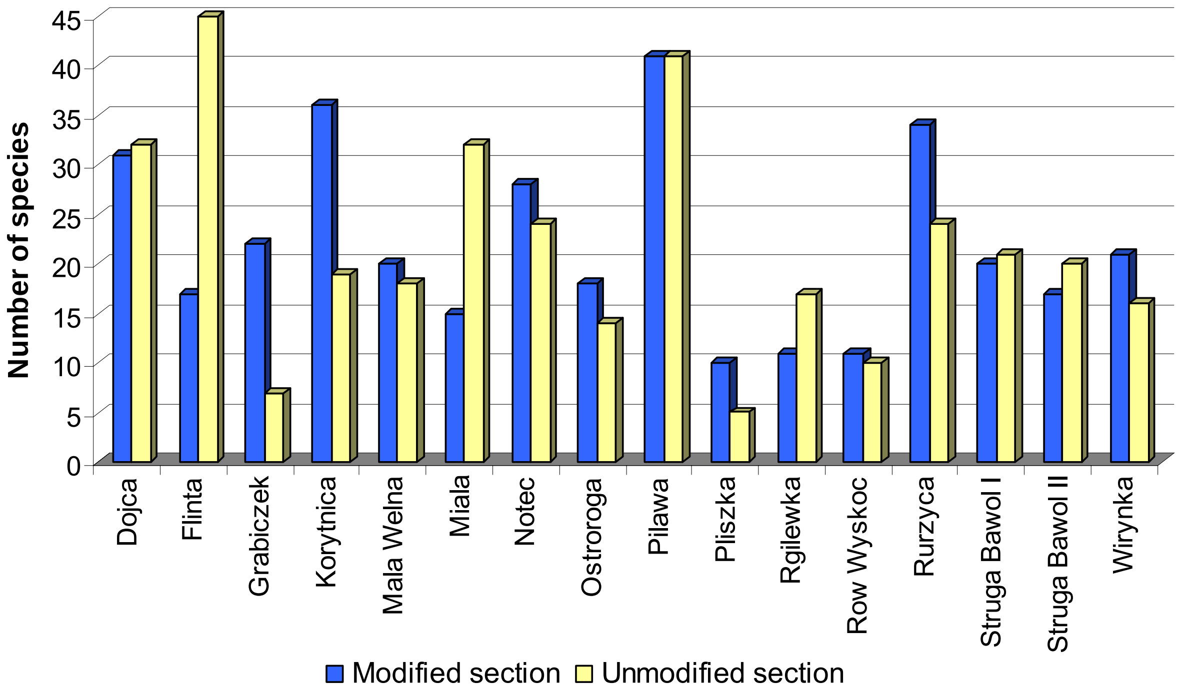


Fig. 21 Influence of channel modifications on number of species.

<u>Shannon's index</u>

The **inter-surveyor** variation was estimated basing on 26 sites placed on different rivers. It was found that the between-surveyors variance was relatively large, indicated for instance, by the high coefficient of variance calculated for analysed sites (average CV=29.23) (Table 17, Figure 22). Comparing with other sources of variation, impact of inter-surveyor variation was quite big but much lower than impact of shade or habitat modification (Table 21). The share of inter-surveyor variation in the total variability was most important in case of Shannon diversity index than in case of other metrics like MTR, IBMR, Ellenberg and taxa richness (Table 22).

Table 17 Variation of Shannon's index between surveyors

Stream Name	Shannon's index			Shannon diversity SD	Shannon diversity CV
	Surveyor 1	Surveyor 2	Surveyor 3		
Blizna	0.83	0.58	0.53	0.16	25.33
Dobrzyca	0.32	0.41	0.29	0.06	18.25
Grabia	0.25	0.19	0.66	0.26	69.27
Grabiczek	0.12	0.07	0.04	0.04	55.89
Ilanka	0.12	0.08	0.07	0.02	26.64
Korytnica	0.33	0.41	0.45	0.06	15.20
Lutownia	0.76	0.70	0.66	0.05	6.44
Mala Wełna	0.47	0.40	0.94	0.29	48.32
Meszna	0.04	0.07	0.09	0.03	39.92
Mlawka	0.84	0.86	0.74	0.07	8.01
Narew	0.33	0.41	0.68	0.19	39.41
Narewka	0.59	0.48	0.84	0.19	29.17
Ner	0.05	0.03	0.07	0.02	37.52
Pilawa	0.49	0.32	0.18	0.15	46.03
Pliszka	0.88	0.47	1.00	0.28	35.85
Ploska	0.26	0.61	0.39	0.18	41.98
Plytnica	0.49	0.33	0.26	0.12	32.50
Rospuda	0.66	0.89	1.02	0.19	21.64
S.Steszewska	0.77	0.68	0.45	0.16	25.79
Skarlanka	0.57	0.80	0.48	0.17	27.04
Sokolda	1.30	1.06	1.06	0.14	12.18
Struga Bawol	0.53	0.48	0.69	0.11	19.46
Suprasl	0.55	0.65	0.80	0.13	18.88
Slina	1.00	0.92	0.97	0.04	4.02
Wieprza	0.03	0.03	-	0.00	11.00
Wolkuszanka	0.33	0.34	0.67	0.20	44.33
			Mean	**0.13**	**29.23**
			Minimum	**0.00**	**4.02**
			Maximum	**0.29**	**69.27**

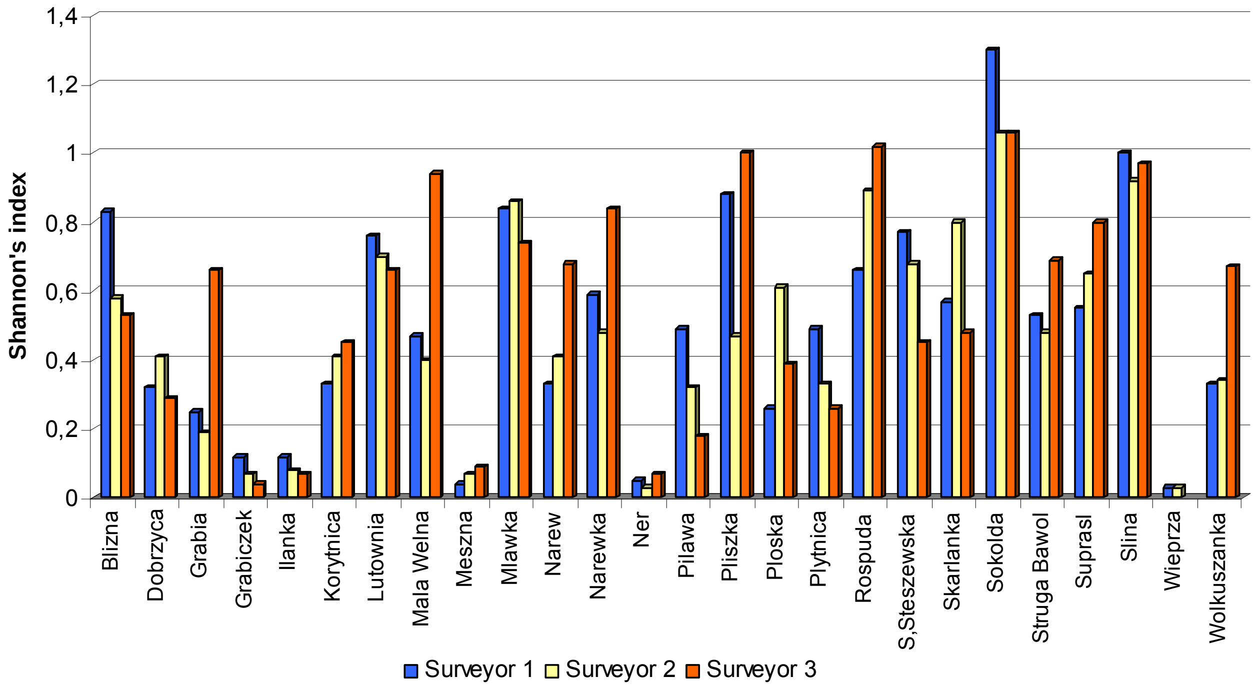


Fig. 22 Variation of Shannon's index between surveyors.

Analysis revealed that **temporal source** of variation influences the total variability in a very limited extent (Table 22). It was proven in case of differences between years as well as differences between seasons. Statistical analysis between surveys carried out in different time were not significant (Table 23). Values of the coefficient of variance for all sites are presented in the Table 18 and Figure 23.

Table 18 Temporal variation of Shannon's index

Stream Name	Shannon's index			Years		Season	
	Period 1 (summer 2004)	Period 2 (summer 2003)	Period 3 (autumn 2003)	Shannon's index SD	Shannon's index CV	Shannon's index SD	Shannon's index CV
Blizna	0.53	0.58	0.56	0.03	5.65	0.01	2.45
Dobrzyca	0.40	0.41	0.54	0.01	1.44	0.09	19.17
Grabia	0.18	0.19	-	0.01	5.09	-	-
Grabiczek	0.01	0.12	0.10	0.08	119.77	0.02	14.71
Ilanka	0.18	0.12	0.21	0.04	27.91	0.06	36.89
Korytnica	0.42	0.41	0.54	0.00	1.01	0.09	18.59
Lesna Prawa	0.80	0.65	0.86	0.11	14.97	0.15	19.61
Lutownia	0.67	0.76	0.76	0.06	8.01	0.00	0.09
Mala Wełna	0.35	0.47	0.76	0.09	20.58	0.20	32.96
Meszna	0.04	0.04	0.09	0.01	12.61	0.04	57.93
Mlawka	0.32	0.74	0.70	0.30	55.71	0.03	4.13
Narew	0.32	0.33	0.19	0.01	1.70	0.10	38.54
Narewka	0.44	0.59	0.70	0.11	21.00	0.08	11.93
Ner	0.02	0.05	0.05	0.02	55.23	0.00	4.78
Pilawa	0.80	0.49	0.48	0.22	34.39	0.01	1.45
Pliszka	0.65	0.47	0.68	0.13	23.18	0.15	25.87
Ploska	0.40	0.39	-	0.01	2.57	-	-
Plytnica	0.25	0.26	0.20	0.01	4.07	0.05	19.76
Rospuda	0.58	0.66	0.99	0.06	9.52	0.23	28.41
S.Steszewska	1.13	0.77	1.23	0.25	26.64	0.32	32.14
Sokolda	0.72	1.06	0.62	0.24	26.82	0.31	36.98
Struga Bawol	0.34	0.53	0.59	0.14	31.69	0.04	7.15
Suprasl	0.41	0.55	0.44	0.10	20.28	0.07	15.10
Slina	0.44	0.92	0.66	0.34	49.98	0.18	23.31
Wieprza	0.05	0.03	0.11	0.02	41.35	0.06	82.85
Wolkuszanka	0.65	0.67	-	0.01	1.92	-	-
			Mean	**0.09**	**23.96**	**0.10**	**23.25**
			Minimum	**0.00**	**1.01**	**0.00**	**0.09**
			Maximum	**0.34**	**119.77**	**0.32**	**82.85**

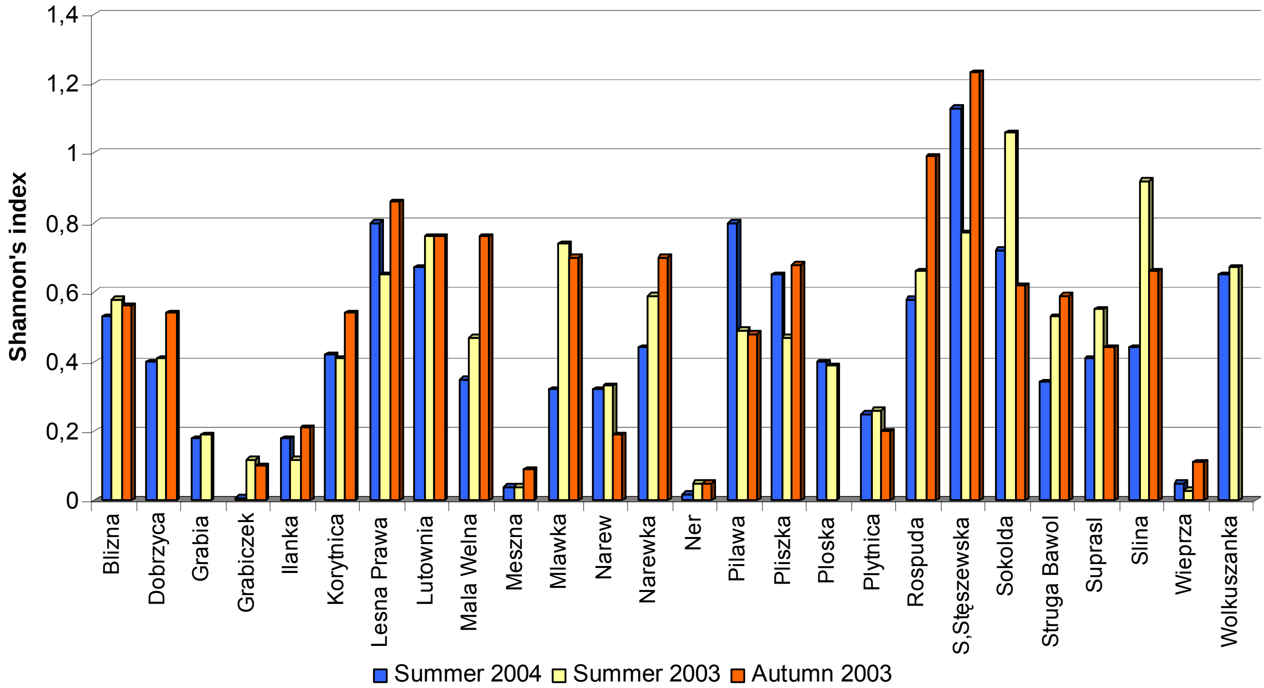


Fig. 23 Temporal variation of Shannon's index.

It was noticed that shaded and unshaded sections differ in species composition radically. It was also confirmed that this is the most influential factor on the total variance among measured factors (Table 26). Influence of **sun light exposure** on the total variability was very strong (Table 23) and differences between shaded and unshaded sections were significant (Table 22). Impact of shading was differentiated among particular sites and several sites were only slightly impacted (CV=1.32) whereas several other were highly influenced (CV reached even 126.09) (Table 19, Figure 24).

Table 19 Influence of channel shading on Shannon's index

Stream Name	Shaded section	Unshaded section	Shannon's index SD	Shannon's index CV
Dojca	0.40	0.85	0.31	49.88
Miloslawka Trib.	0.26	0.66	0.29	62.15
Flinta I	0.21	0.49	0.20	57.39
Flinta II	0.19	0.68	0.35	80.13
Gluszynka	0.12	1.12	0.70	113.37
Gryzynka	0.28	0.48	0.15	38.58
Kanal Konczak	0.72	0.71	0.01	1.32
Krzycki Row	0.11	0.54	0.31	93.62
Lutynia	0.02	0.33	0.22	126.09
Meszna	0.17	0.21	0.03	14.49
Miala	0.25	0.52	0.19	50.45
Orla	0.28	0.48	0.14	37.81
Ostroroga	0.42	0.44	0.01	3.47
Pilawa	0.27	0.41	0.10	29.59
Pliszka	0.13	1.17	0.73	113.14
Rakowka	0.11	1.02	0.65	114.76
Row Wyskoc	0.40	0.74	0.24	42.11
Ruda	0.55	1.07	0.37	45.77
Sama	0.31	0.42	0.07	20.18
S.Steszewska	0.56	0.77	0.15	22.33
Stopica	0.25	0.37	0.09	27.71
Wolczenica	0.26	0.42	0.12	34.21
Zimna Woda	0.31	0.66	0.25	50.66
		Mean	**0.25**	**53.44**
		Minimum	**0.01**	**1.32**
		Maximum	**0.73**	**126.09**

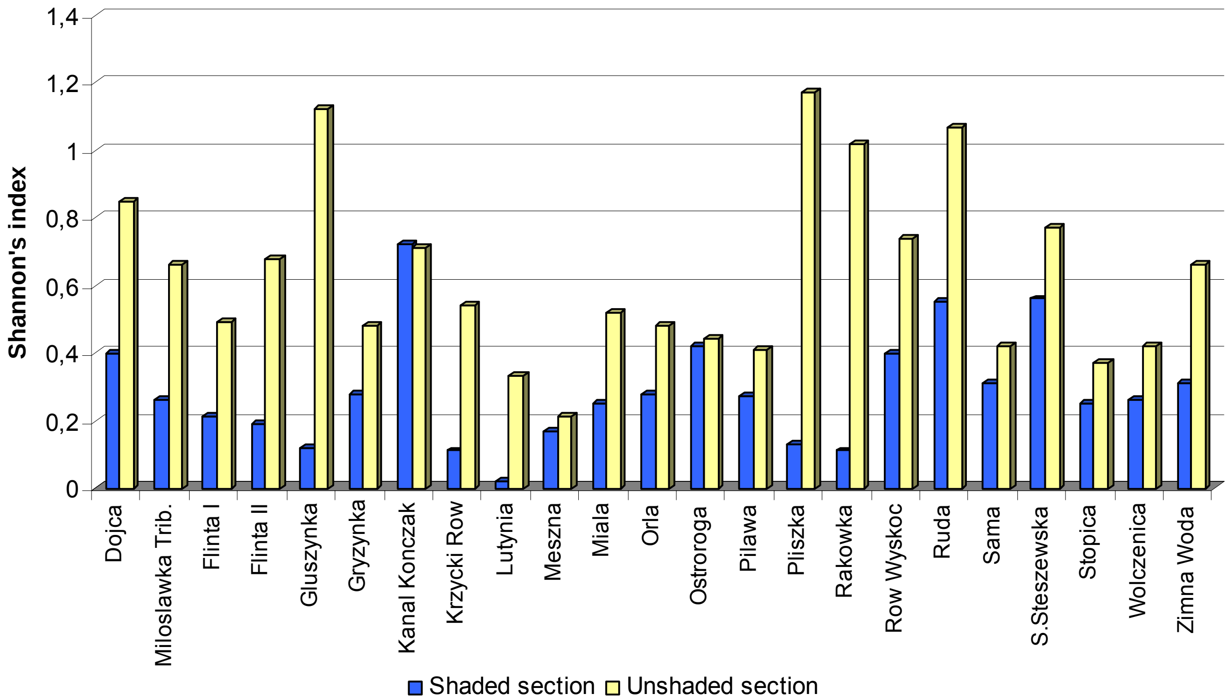


Fig. 24 Influence of channel shading on Shannon's index.

Influence of **habitat modification** on the total variation of Shannon's diversity index was quite large (Table 23) but statistical differences between means of these paired sites were not significant (Table 23). The variability between individual sites were quite differentiated and the coefficient of variances varied between 4.08 and 102.17 (Table 20, Figure 25).

Table 20 Influence of channel modifications on Shannon's index

Stream Name	Modified section	Unmodified section	Shannon's index SD	Shannon's index CV
Dojca	0.40	0.26	0.10	29.59
Flinta	0.68	0.52	0.11	18.19
Grabiczek	0.10	0.27	0.12	64.80
Korytnica	0.11	0.71	0.42	102.17
Mala Wełna	0.68	0.65	0.03	4.08
Miala	0.61	1.08	0.33	39.47
Noteć	0.25	0.92	0.48	81.91
Ostroroga	0.27	0.37	0.07	22.06
Pilawa	0.59	0.41	0.13	25.36
Pliszka	0.06	0.13	0.05	53.11
Rgilewka	0.08	0.13	0.03	30.49
Row Wyskoc	0.07	0.12	0.04	40.27
Rurzyca	0.37	0.48	0.08	18.72
Struga Bawol I	0.78	0.50	0.20	30.55
Struga Bawol II	0.49	0.46	0.02	4.56
Wirynka	0.32	0.97	0.46	72.01
		Mean	**0.17**	**39.84**
		Minimum	**0.02**	**4.08**
		Maximum	**0.48**	**102.17**

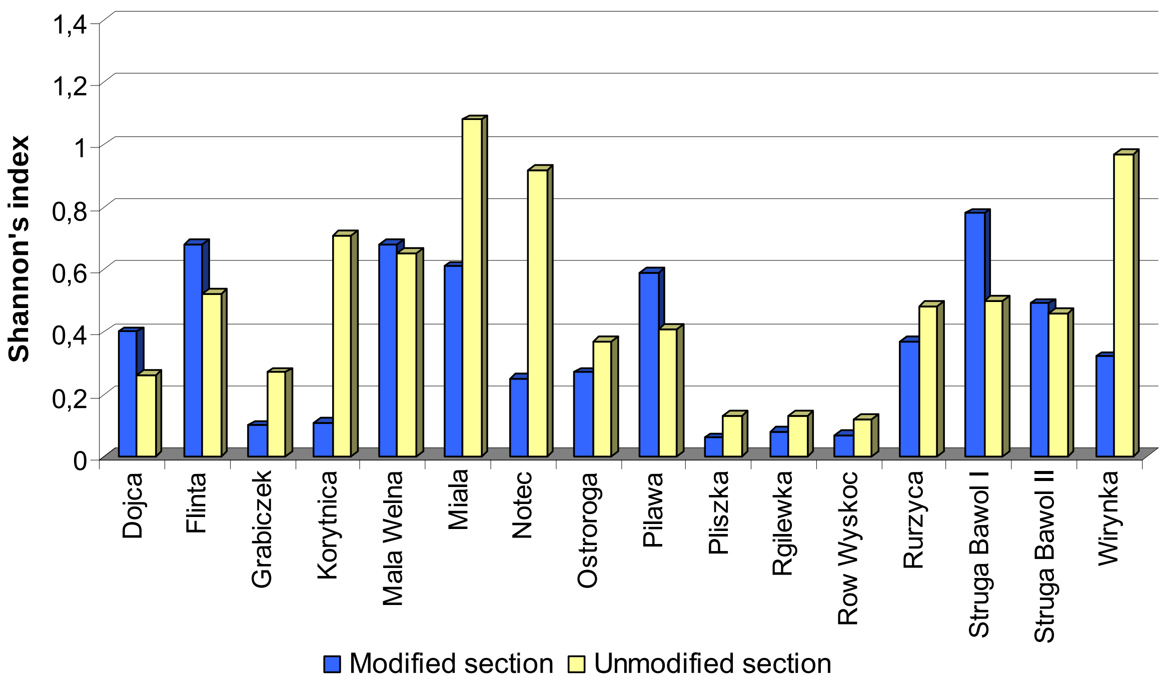


Fig. 25 Influence of channel modifications on Shannon's index.

Results of field experiments for estimation of the influence of temporal and inter-surveyor variation as well as influence of shading conditions and morphological transformations were sumarised in Table 21. The average standard deviations and average standard errors of macrophyte metrics (MTR, Ellenberg index, IBMR, number of species and Shannon's index) from five experiments the were shown. In the case of Ellenberg idex, IBMR and number of species the highest standard deviation was observed for pairs of sites with diferent stage of anthropogenic factor. Shannon index was strongly influenced by shading and highest MTR alteration was found for the surveys carried out in different years. In general, for all indices (except Shannon index) the lowest values of standard deviation were observed in experiment where scores generated by different surveyors were compared.

Table 21 Basic statistics calculated metrics in the series of experiments

	Surveyors	Years	Season	Shading	Modificat.
MTR					
MTR SD mean	1.62	2.47	2.18	1.78	1.95
MTR CV mean	4.75	6.89	6.07	5.20	5.48
Ellenberg index					
Ellenberg index SD mean	0.11	0.13	0.18	0.19	0.24
Ellenberg index CV mean	1.78	1.94	2.82	2.97	3.57
IBMR					
IBMR SD mean	0.34	0.36	0.34	0.45	0.52
IBMR CV mean	3.83	3.83	3.81	5.08	5.34
Number of species					
Number of species SD mean	2.67	5.09	4.27	4.77	5.57
Number of species CV mean	14.37	24.48	20.92	25.68	26.29
Shannon's index					
Shannon's index SD mean	0.13	0.09	0.10	0.25	0.17
Shannon's index CV mean	29.23	23.96	23.25	53.44	39.84

To make comparisons between metrics of the relative size of different sources of variation (inter-surveyor, temporal, shade and habitat modification) the variance (the SD squared) of each metric's values caused by each factor was divided by the total variance amongst all values of that metric. This expresses how much of the total variability in a metric values across all sites of differing types and conditions can attributed to each source of variation. If a very high proportion of total variability is due to say, inter-surveyor differences, then it means that many apparent differences between sites over time could be merely due to fact that different people did the surveys. These relative variance estimates are not strict analysis of variance (ANOVA) estimates which tally because they are based on simply SD derived from different subsets of the dataset (Table 22 and Figure 26).

Table 22 . Estimated percentages of total variance for selected indices due to different factors (total variance excludes 10% of outlier values).

Source of variability	MTR	IBMR	Ellenberg Index	Shannon's index	Number of species
Surveyors	8	5	12	16	6
Years	16	8	15	11	22
Season	19	7	33	10	23
Modifications	8	12	54	36	15
Shading	12	15	23	78	33

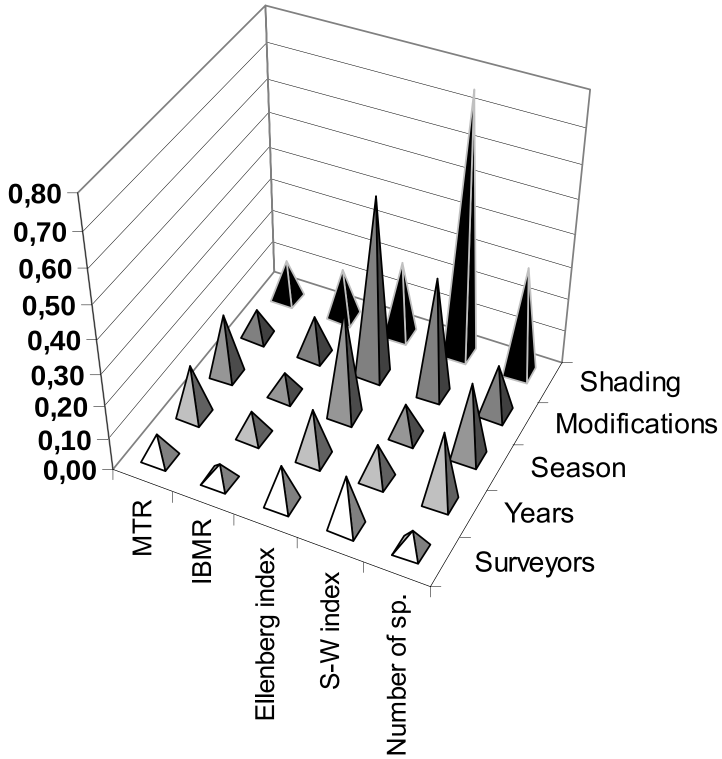


Fig. 26 Ratio of variance effected by different sources against total variance (excluding 10% of outliers).

The detected level of variance was generally the smallest in case of MTR and IBMR. The Ellenberg index was resistant for inter-surveyor variability and was repeatable between years but it was strongly disturbed by habitat modification. Changes in vegetation between seasons also influence its score very much. The diversity metrics are strongly influenced by shading, especially Shanon's index, which was also very sensitive on habitat modifications.

Analysis showed that different metrics react in the variable way under variety of tested factors and the significance of observed trends was tested (Wilkoxon's test) (Table 23). In case of MTR all differences were not significant. The temporal factor as season of the year influenced Ellenberg index and IBMR. Shading influenced IBMR and very strongly both diversity metrics.

The detected level of variance in case of **MTR** and **IBMR** was always low and it can be assumed that they are predictable trophy metrics. The **Ellenberg** index which was originally calibrated on nitrogen level detection was resistant for inter-surveyor variability and was repeatable between years but it was strongly disturbed by habitat modification. Changes in vegetation between seasons also influence its score very much. Ellenberg nitrogen index as well as diversity metrics seems not to be predicable tools in the river classification and theirs applications requires further development.

Table 23 Results of Wilkoxon's test

Parameter	Factors combination	p level
MTR	Summer 2003 vs. Summer 2004	#
	Summer 2003 vs. Autumn 2003	#
	Modified vs. Unmodified	#
	Shaded vs. Unshaded	#
Ellenberg's index	Summer 2003 vs. Summer 2004	#
	Summer 2003 vs. Autumn 2003	*
	Modified vs. Unmodified	#
	Shaded vs. Unshaded	#
IBMR	**Summer 2003 vs. Summer 2004**	**
	Summer 2003 vs. Autumn 2003	#
	Modified vs. Unmodified	#
	Shaded vs. Unshaded	*
Number of species	Summer 2003 vs. Summer 2004	#
	Summer 2003 vs. Autumn 2003	#
	Modified vs. Unmodified	#
	Shaded vs. Unshaded	**
Shannon's index	Summer 2003 vs. Summer 2004	#
	Summer 2003 vs. Autumn 2003	#
	Modified vs. Unmodified	#
	Shaded vs. Unshaded	***

- p > 0,05; * - p < 0,05; ** - p < 0,01; *** - p < 0,001

The estimated range of variations was calculated as probability of misgrading a site with a use of STARBUGS program. The eutrophication as a strongest gradient was considered with the three metrics (MTR, IBMR and Ellenberg). Software STARBUGS (**Clarke** 2004) was used to test the effect of class boundaries on obtained status without assessment of uncertainty. The ecological status class assessment for individual metrics is evaluated as normalised Ecological Quality Ratios (EQRs) involving the ratio of the observed metric values (O) to the Reference Condition values (E_1) of the metric.

$$EQR = \frac{O - E_0}{E_1 - E_0}$$

where:

O – observed value,

E_1 – value of metric for which EQR = 1, (Reference Condition value)

E_0 – value of metric for which EQR = 0.

By setting the E_0 values to zero, and the E_1 values to the model expected value under Reference Conditions, the EQR values become O/E ratios of the observed (O) to expected (E) values of metrics (**Clarke** *et al.* 1996, **Clarke** *et al.* 2002, **Wright** *et al* 2000).

The effect of inter-surveyor variation was tested first (Fig. 27). The probability of misgrading the site based on plant species is much higher when the Ellenberg index is used than in case of MTR and IBMR methods (which gives a very similar results).

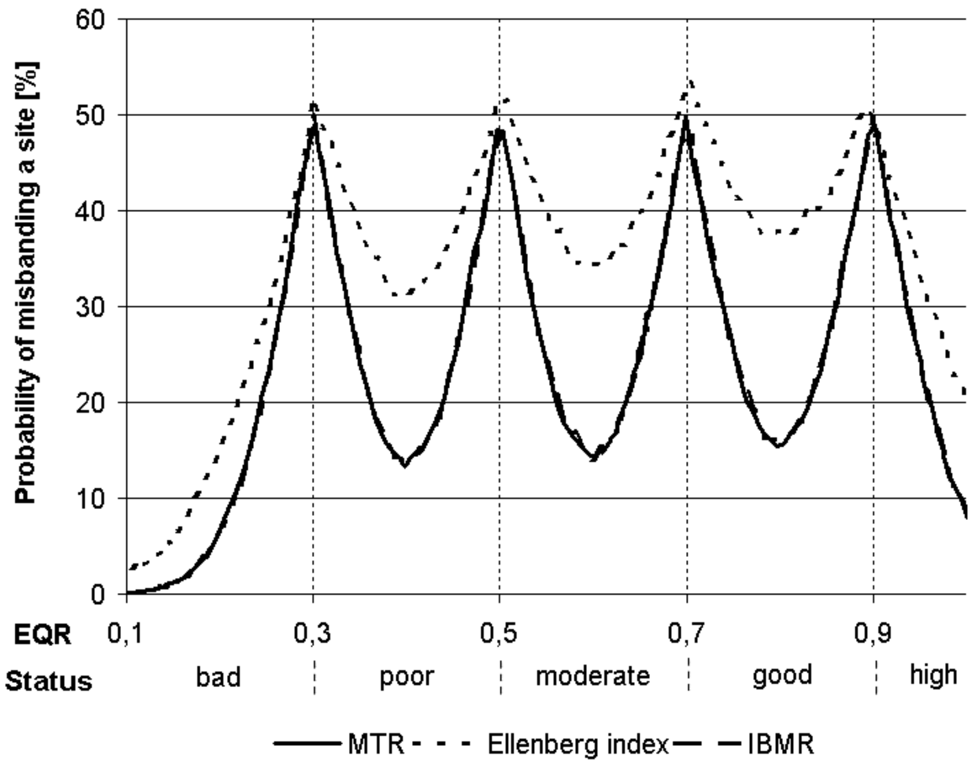


Fig. 27 Plots of the probability of misgrading a site for a macrophyte metrics detecting eutrophication – sampling variation estimated for the inter-surveyor effect.

The effect of temporal variation was tested regarding differences between yeas (Fig. 28) and differences between two season in the same year (Fig. 29). The probability of misgrading the site based on plant species in both cases was the highest for the Ellenberg index and the lowest in case of IBMR.

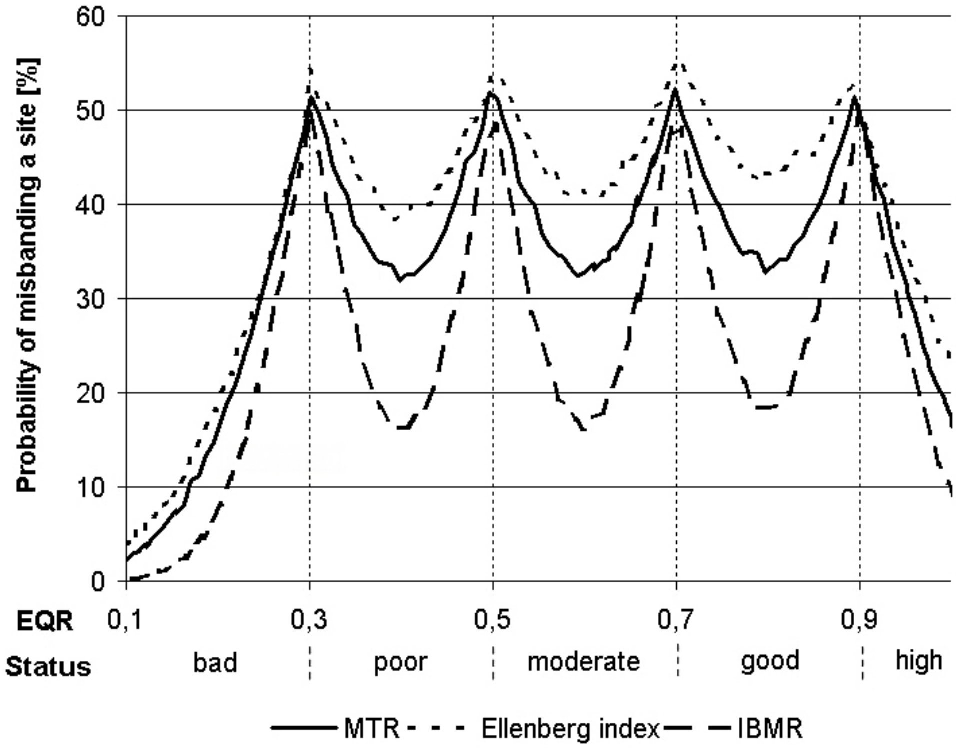


Fig. 28 Plots of the probability of misgrading a site for a macrophyte metrics detecting eutrophication – sampling variation estimated for the temporal range of variation (different years).

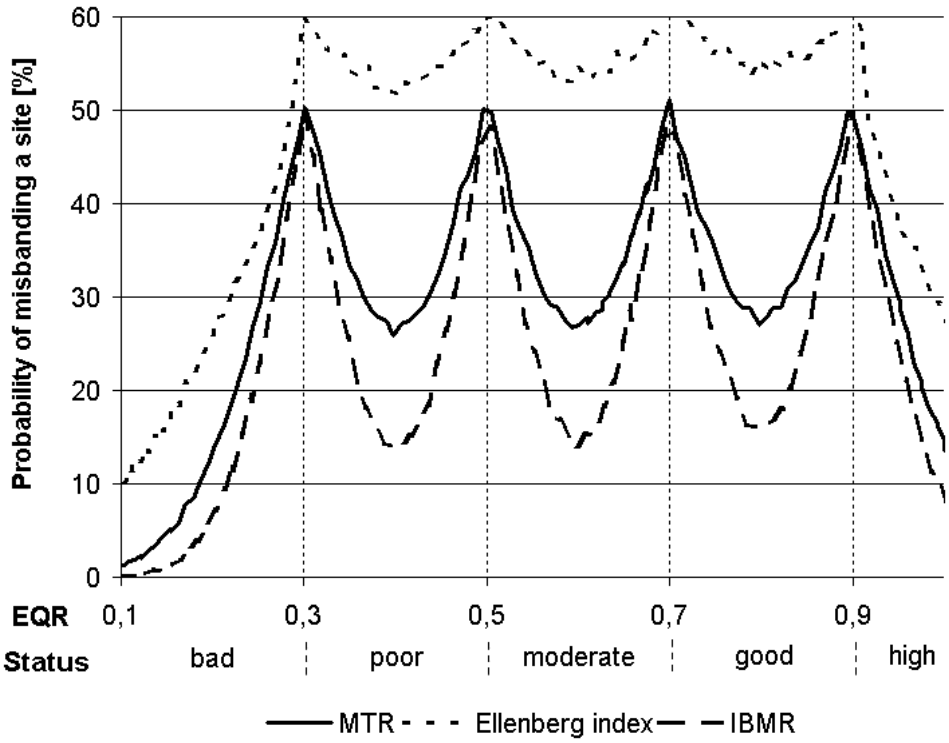


Fig. 29 Plots of the probability of misgrading a site for a macrophyte metrics detecting eutrophication – sampling variation estimated for the temporal range of variation (different parts of the years).

The probability of misgrading the site based on the variation effected by different shading (Fig. 30) showed that MTR is the most resistant method followed by IBMR.

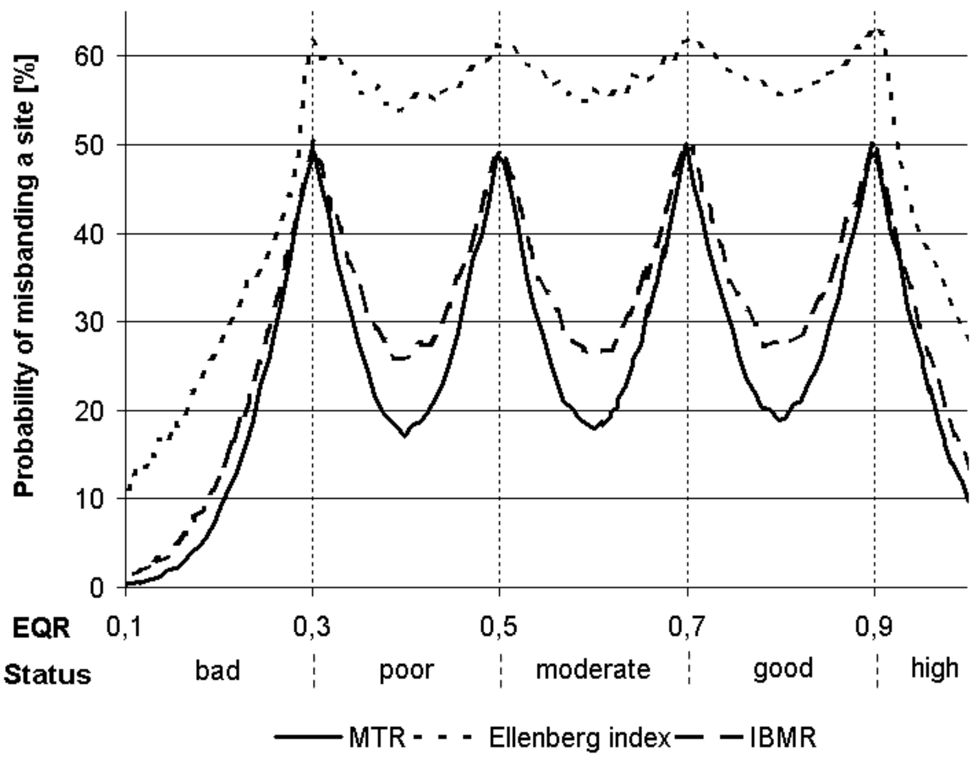


Fig. 30 Plots of the probability of misgrading a site for a macrophyte metrics detecting eutrophication – sampling variation estimated for the effect of shading

Analysis showed that some of macrophyte based methods can be utilised for estimating ecological status of rivers according to WFD. They can be also utilised as a tools of estimating the trophic degradation and the level of variance enables for applying the 5 point scale of ecological quality.

Conclusions

- Obtained results showed, that several methods based on indicative values of plant species can be utilised for estimating of ecological status of rivers.
- Among analysed metrics MTR, IBMR and Ellenberg index can be used for organic pollution assessment whereas the diversity metrics as number of species and Shannon‘s index in is not corresponding with ecological status of rivers.
- The rate of variance showed, that sources of uncertainty is relatively low comparing with the total variance enabling for the application five levels of ecological status approach.. The estimated probability of misgrading a site for the mid-class value varied from 15% (MTR and IBMR) to 50% in case of Ellenberg index.
- Among the estimated sources of variance the smallest role was indicated by inter-surveyor factor. Slightly stronger was influence of temporal variation (years and seasons) as shading. The impact of habitat modification was the most important.
- Obtained results based on the data from Polish rivers shows the major sources of variation and assess their impact on the final score. It facilitates evaluation of the limitation of confidence in assessment based on aquatic plants, providing hints applicable in designing of future field surveys.
- Analysis showed the some of macrophyte based methods can be utilised as a tools of estimating the trophic degradation and the level of variance enables for applying the 5 point scale of ecological quality.
- The probability of misgrading the site based on plant species is the lowest in case of MTR and IBMR methods.
- Analysis showed the some of macrophyte based methods can be utilised for estimating ecological status of rivers according to WFD.

4 RIVER MORPHOLOGY

4.1 Methodological principles

Studies of hydromorphological survey variability based on replicate sampling experiments undertaken on Polish lowland rivers during 2003 and 2004. The field survey was carried out according to STAR hydromorphological protocol (Buffani & Erba 2002). It is based on River Habitat Survey (RHS), which was developed in Britain (Environmental Agency 1997). Assessment of variability of hydromorphological method was focused on variability of RHS numerical scores (Raven et al 1998):

- Habitat Modification Score (HMS) based on the extent and type of artificial features and modifications,
- Habitat Quality Assessment (HQA) based on the extent and variety natural features recorded.

4.2 Assessment of variation of the RHS numerical scores

The possible **inter-surveyor variation** of RHS numerical scores (HMS an HQA) was tested in Summer 2003 in the experiment when three fully trained surveyors carried out independent survey on 26 river locations (matrix n=3 x 26). To avoid effect of spatial differences between these surveys, starting point (first spot-check) was coordinated with GPS, maps and detailed drawn plans. Field examination was taken during the same visit although surveyors did it independently with a difference of about an hour.

A series of experiments enabled **natural background variation** to be assessed. Studies of differences **between years** were based on 26 river locations surveyed in the same phases ofJune/July 2003 and 2004 (n=26 x 2). Impact of **seasonal change** during the one year was estimated by survey carried in two different terms of the year. It was tested in the year 2003 where vegetation in the early Summer (June/July) was compared with Autumn growth (September) (n=24 x 2).

For all the attributes recorded in RHS system the agreement between surveys carried out by different surveyors and between different periods was investigated. Every group of attributes was analysed individually to estimate rate of agreement and to indicate sources of differences.

Inter-surveyor variation

Results of the inter-surveyor replicate sampling for HQA are presented in the Table 24 and for HMS in Table 25. The range of both metrics is very large and for the HQA it was 24.7 -

61.7 and for HMS it was even larger varying from 0 to 73. The average variability between surveyors was relatively high (CV=11.36 for HQA and CV=43.00 for HMS). The total variation was also very high. To estimate the influence of the inter-surveyor variation in the total variation mean variance between three surveyors was divided by the total variance. This ratio was equal to 0.06 for HMS and to 0.11 for HQA (Table 101).

Table 24 Variation of HQA score between surveyors

Stream Name	HQA score			HQA SD	HQA CV
	Surveyor 1	Surveyor 2	Surveyor 3		
Blizna	25.0	20.0	36.0	8.19	30.32
Dobrzyca	56.0	61.0	53.0	4.04	7.13
Grabia	48.0	45.0	50.0	2.52	5.28
Grabiczek	48.0	57.0	66.0	9.00	15.79
Ilanka	64.0	56.0	64.0	4.62	7.53
Korytnica	60.0	59.0	55.0	2.65	4.56
Lutownia	-	65.0	55.0	7.07	11.79
Mala Welna	36.0	29.0	39.0	5.13	14.80
Meszna	32.0	32.0	33.0	0.58	1.79
Mlawka	33.0	45.0	42.0	6.24	15.61
Narew	34.0	34.0	43.0	5.20	14.04
Narewka	34.0	39.0	40.0	3.21	8.53
Ner	50.0	43.0	45.0	3.61	7.84
Pilawa	58.0	67.0	60.0	4.73	7.66
Pliszka	56.0	61.0	54.0	3.61	6.33
Ploska	35.0	32.0	39.0	3.51	9.94
Plytnica	57.0	54.0	51.0	3.00	5.56
Rospuda	54.0	50.0	67.0	8.89	15.59
S.Steszewska	30.0	24.0	20.0	5.03	20.40
Skarlanka	61.0	60.0	59.0	1.00	1.67
Sokolda	29.0	38.0	44.0	7.55	20.40
Struga Bawol	37.0	33.0	38.0	2.65	7.35
Suprasl	26.0	24.0	32.0	4.16	15.23
Slina	26.0	29.0	33.0	3.51	11.97
Wieprza	53.0	59.0	56.0	3.00	5.36
Wolkuszanka	27.0	20.0	32.0	6.03	22.89
			Mean	**4.57**	**11.36**
			Minimum	**0.58**	**1.67**
			Maximum	**9.00**	**30.32**

Table 25 Variation of HMS score between surveyors, data from 26 river sites, Summer 2003

Stream Name	HMS score			HMS SD	HMS CV
	Surveyor 1	Surveyor 2	Surveyor 3		
Blizna	44.0	28.0	36.0	8.00	22.22
Dobrzyca	0.0	0.0	0.0	0.00	0.00
Grabia	0.0	1.0	2.0	1.00	100.00
Grabiczek	14.0	13.0	17.0	2.08	14.19
Ilanka	0.0	0.0	0.0	0.00	0.00
Korytnica	0.0	0.0	0.0	0.00	0.00
Lutownia		1.0	13.0	8.49	121.22
Mala Welna	26.0	18.0	32.0	7.02	27.73
Meszna	67.0	78.0	74.0	5.57	7.63
Mlawka	41.0	21.0	44.0	12.50	35.39
Narew	2.0	0.0	12.0	6.43	137.77
Narewka	64.0	52.0	42.0	11.02	20.91
Ner	10.0	12.0	9.0	1.53	14.78
Pilawa	4.0	0.0	0.0	2.31	173.21
Pliszka	0.0	0.0	0.0	0.00	0.00
Ploska	62.0	12.0	32.0	25.17	71.22
Plytnica	4.0	0.0	0.0	2.31	173.21
Rospuda	0.0	0.0	0.0	0.00	0.00
S.Steszewska	52.0	56.0	46.0	5.03	9.80
Skarlanka	0.0	0.0	0.0	0.00	0.00
Sokolda	41.0	15.0	58.0	21.66	56.99
Struga Bawol	13.0	3.0	18.0	7.64	67.39
Suprasl	24.0	22.0	23.0	1.00	4.35
Slina	65.0	42.0	73.0	16.09	26.82
Wieprza	0.0	0.0	0.0	0.00	0.00
Wolkuszanka	15.0	29.0	20.0	7.09	33.26
			Mean	**5.84**	**43.00**
			Minimum	**0.00**	**0.00**
			Maximum	**25.17**	**173.21**

The corresponding responses from three surveyors at each spot-check on each site were compared. Percentage of agreement achieved between surveyors is presented in the last column of the tables. Responses to all of the attributes were considered comparing spot-check records as *Flow type* (Table 26, Fig 31), *Bed material* (Table 27, Fig. 32), *Bank top structure* (Table 28, Fig. 33), *Bank face structure* (Table 29), *Submerged linear-leaved vegetation* (Table 30), *Submerged fine-leaved channel vegetation* (Table 31), *Algae channel vegetation* (Table 32), *Submerged broad-leaved* (Table 33), *Amphibious channel vegetation* (Table 34), *Free floating channel vegetation* (Table 35), *Floating leaved channel vegetation* (Table 36), *Emergent reeds channel vegetation* (Table 37), *Emergent broad leaved* (Table 38), *Liverworts channel vegetation* (Table 39), *None or not visible channel vegetation* (Table 40).

Attributes recorded at the sweep-up part were also concerned about and comparison of the corresponding responses from three surveyors were completed for: *Land-use within 50 m of* *banktop* (Table 41), *Extent of bank trees* (Table 42), *Shading of channel* (Table 43), *Overhanging boughs* (Table 44), *Exposed bankside roots* (Table 45), *Underwater tree roots* (Table 46), *Fallen trees* (Table 47) and *Coarse woody debris* (Table 48).

Table 26 Between-surveyor variation on recording flow type at spot-checks.

First surveyor	Others surveyors							Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Free fall	Chaotic flow	Unbroken standing waves	Rippled flow	Upwelling	Smooth	Not perceptible		
Free fall	50	0	0	50	0	0	0	1	50
Chaotic flow	0	0	0	100	0	0	0	3	0
Rippled	0	2	4	64	4	21	5	56	64
Upwelling	0	0	10	80	10	0	0	5	10
Smooth	0	0	0	11	2	57	29	91	57
Not perceptible	0	0	0	13	0	88	0	4	0

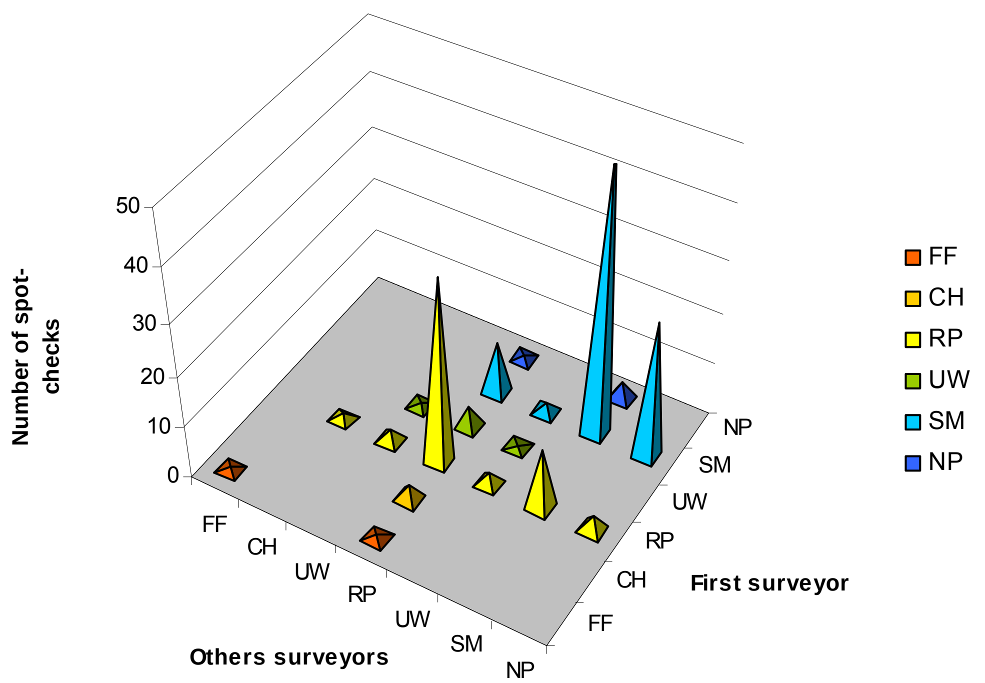


Fig. 31 Between-surveyor variation on recording flow type at spot-checks

Table 27 Between-surveyor variation on recording bed material at spot-checks

First surveyor	Others surveyors									Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Not visible	Boulders	Cobbles	Gravel/pebble	Sand	Silt	Clay	Peat	Artificial		
Not visible	40	0	0	0	30	30	0	0	0	10	40
Cobbles	0	0	50	0	50	0	0	0	0	1	50
Gravel/ pebble	3	0	1	62	30	3	0	0	0	47	62
Sand	6	0	0	9	75	8	0	2	0	135	75
Silt	3	0	1	3	25	59	0	10	0	38	59
Clay	0	0	0	0	0	0	50	50	0	3	50
Peat	0	0	0	0	29	32	0	39	0	14	39
Artificial	0	25	0	0	50	0	0	0	25	2	25

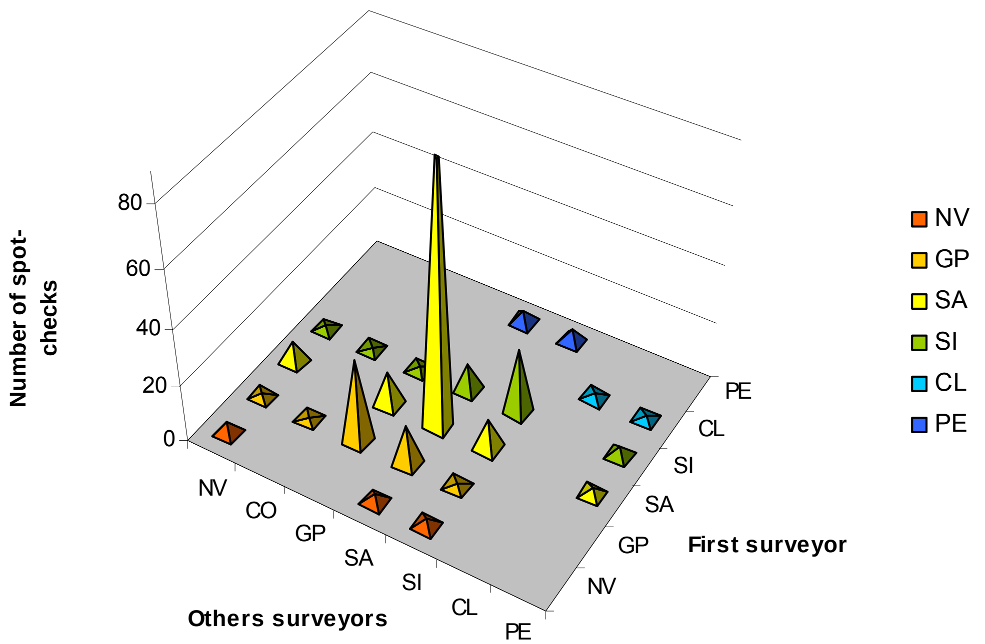


Fig. 32 Between-surveyor variation on recording bed material at spot-checks

Concerning channel attributes as **flow type** (Table 26, Figure 31) and **bed material** (Table 27, Figure 32) the range of equal identification by all surveyors was between 57 % and 75 % (for most frequent attributes - more than 15 spot-checks). The highest rate of disagreement was in case of *smooth flow* (misidentified with *not perceptible* or *rippled*). A very high disagreement was also in case of *peat* (although the sample was very small - 14 spot-checks) which was misidentified with *silt* or *sand*. Further studies (Section 4.3) revealed that these attributes can influence strongly HQA, therefore detected uncertainties should be focused during the training process to assure the value of RHS survey.

Table 28 Between-surveyor variation on recording bank top (left and right) structure at spot-checks

First surveyor	Others surveyors				Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Uniform	Simple	Complex	Not visible		
Uniform	82	18	0	0	249	81.7
Simple	35	58	5	2	160	58.4
Complex	10	52	36	2	90	35.6
Not visible	0	100	0	0	1	0.0

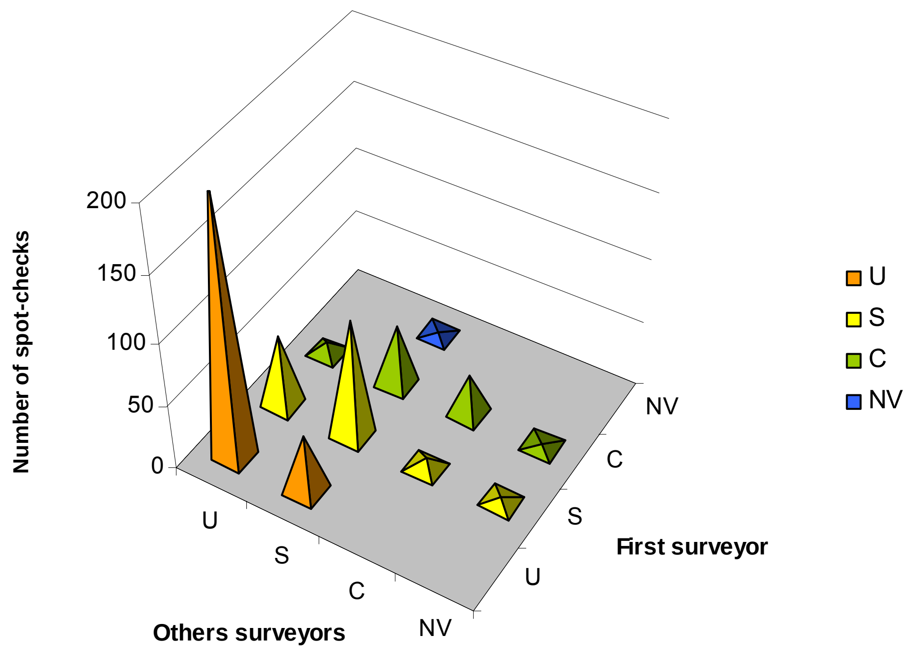


Fig. 33 Between-surveyor variation on recording bank top (left and right) structure at spot-checks

Table 29 Between-surveyor variation on recording bank face (left and right) structure at spot-checks

First surveyor	Others surveyors					Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Bare	Uniform	Simple	Complex	Not visible		
Bare	50	50	0	0	0	4	50.0
Uniform	2	82	15	0	0	252	82.1
Simple	2	44	50	4	0	165	50.0
Complex	0	19	56	23	2	79	22.7

Comparing records undertaken by three surveyors assessing **bank top** and **bank-face vegetation structure** (Table 28 and 29) the percentage agreement was varied from 22 % and 82 %. The highest rate of disagreement was between *Simple* and *Complex* structure. The vegetation structure is an important part of HQA score estimating habitat quality value although both of these attributes are equally treated and the improper identification does not influence the total score. The relatively frequent disagreement between *Uniform* and *Simple* was recorded and this kind of misjudgement influence the total score. The differences between these two categories of vegetation structure should be underlined during RHS training.

Table 30 Between-surveyor variation on recording Submerged linear-leaved channel vegetation at spot-checks

First surveyor	Others surveyors			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	64	11	24	191	64.4
Extensive	54	46	0	12	45.8
Not recorded	36	2	63	28	62.5

Table 31 Between-surveyor variation on recording Submerged fine-leaved for channel vegetation at spot-checks

First surveyor	Others surveyors			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	28	0	72	38	27.6
Extensive	0	0	100	2	0.0

Not recorded	20	7	73	103	72.8

Table 32 Between-surveyor variation on recording Algae for channel vegetation at spot-checks

First surveyor	Others surveyors			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	27	23	50	26	26.9
Extensive	60	15	25	10	15,0
Not recorded	34	6	60	151	59.9

Table 33 Between-surveyor variation on recording Submerged broad-leaved for vegetation channel vegetation at spot-checks

First surveyor	Others surveyors			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	69	14	17	164	69.4
Extensive	63	36	1	40	36.3
Not recorded	37	16	47	49	46.9

Table 34 Between-surveyor variation on recording Amphibious for channel vegetation at spot-checks

First surveyor	Others surveyors		Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Not recorded		
Present	35	65	51	35.3
Not recorded	20	80	92	80.4

Table 35 Between-surveyor variation on recording Free floating for channel vegetation at spot-checks

First surveyor	Others surveyors			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	63	26	10	117	63.2
Extensive	57	43	0	7	42.9
Not recorded	49	3	48	118	47.9

Table 36 Between-surveyor variation on recording Floating leaved for channel vegetation at spot-checks

First surveyor	Others surveyors			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	49	20	31	70	48.6
Extensive	50	17	33	12	16.7
Not recorded	24	4	72	94	71.8

Table 37 Between-surveyor variation on recording Emergent reeds for channel vegetation at spot-checks

First surveyor	Others surveyors			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	85	4	11	219	85.2
Extensive	84	13	3	16	12.5
Not recorded	36	0	64	40	63.8

Table 38 Between-surveyor variation on recording Emergent broad leaved for channel vegetation at spot-checks

First surveyor	Others surveyors			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	75	0	25	212	74.8
Extensive	100	0	0	3	0.0
Not recorded	34	0	66	60	65.8

Table 39 Between-surveyor variation on recording Liverworts channel vegetation at spot-checks

First surveyor	Others surveyors		Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Not recorded		
Present	24	76	52	24.0
Not recorded	9	91	113	90.7

Table 40 Between-surveyor variation on recording none or not visible for channel vegetation at spot-checks

First surveyor	Others surveyors			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	None	Not visible	Not recorded		
None	90	0	10	5	90.0
Not visible	25	0	75	8	0.0
Not recorded	19	11	69	31	69.4

For the most frequent channel **vegetation groups** (more than 15 spot-checks) the percentage of agreement between surveyors was between 24.0 and 90.7 % (Table 30-40). The highest rate of disagreement was in case of *Liverworts, Algae, Submerged fine-leaved* and *Free-floating* channel vegetation. In most of these situations plants recorded by one surveyor were omitted by another one. In case of *Algae* and *Bryophytes* it was probably undetection of these inconspicuous groups of plants. In case of *Free-floating* plants the presence of these species were certainly noticed but the disagreement between surveyors based on the 1% cover condition in recording (only macrophytes covering more than 1% can be recorded). The *Amphibious plants* were often included into the *Emergent broad-leafed* category because surveyors found the definition of *Amphibious plants* as not precise enough.

Table 41 Between-surveyor variation on recording Land-use within 50 m of banktop (left and right) at sweep-up

First surveyor	Others surveyors										Number of records	Percentage agreement
	Broadleaved/mixed woodland	Coniferous woodland	Coniferous plantation	Scrub & shrubs	Wetland	Rough/unimproved grassland/pasture	Improved/semi-improved grassland	Tall herb	Suburban/urban development	Tilled land		
Broadleaved/mixed woodland	69	6	1	1	13	3	0	6	0	0	158	69.4
Coniferous woodland	50	38	0	0	0	0	0	13	0	0	3	37.5
Scrub & shrubs	17	0	0	24	37	0	0	21	0	0	14	24.5
Wetland	8	0	0	1	70	2	2	17	0	0	102	69.9
grassland/ pasture	0	0	0	4	11	29	32	18	5	1	53	28.7
Improved grassland	3	0	0	6	11	19	49	10	2	0	100	48.7

Tall herb	4	0	0	5	6	18	2	62	3	0	56	61.7
Suburban/ urban development	0	0	0	0	0	0	0	100	0	0	1	0.0
Tilled land	0	0	0	13	0	9	3	15	13	49	13	48.5

For the most frequent **land-use within 50 m of banktop** (more than 15 spot-checks) the percentage agreement between surveyors was between 28.7 and 69.9 %. *Rough pasture* was often mistaken with *Improved grassland* or/and *Tall herbs.* It is suggested to develop more precise definition for these categories.

Table 42 Between-surveyor variation on recording Extent of bank trees (left and right) at sweep-up

First surveyor	Others surveyors							Number of records	Percentage agreement
	Not recorded	None	Isolated/scattered	Regularly spaced, single	Occasional clumps	Semi-continuous	Continuous		
Not recorded	0	25	50	0	25	0	0	2	0,0
None	0	83	18	0	0	0	0	9	82,5
Isolated	0	30	60	0	6	4	0	15	60,3
Occasional clumps	0	0	8	33	33	17	8	6	33,3
Semi-continuous	0	0	0	0	0	80	20	5	80,0
Continuous	0	0	0	0	8	19	73	13	73,2

Table 43 Between-surveyor variation on recording shading of channel at sweep-up

First surveyor	Others surveyors				Number of records	Percentage agreement
	Not recorded	None	Present	Extensive		
Not recorded	0	17	50	33	3	0.0
None	0	81	19	0	8	81.3
Present	0	0	100	0	5	100.0
Extensive	0	0	12	88	9	88.2

Table 44 Between-surveyor variation on recording overhanging boughs at sweep-up

First surveyor	Others surveyors				Number of records	Percentage agreement
	Not recorded	None	Present	Extensive		

Not recorded	0	50	50	0	3	0.0
None	0	80	20	0	13	80.0
Present	0	0	86	14	7	85.7
Extensive	0	0	75	25	2	25.0

Table 45 Between-surveyor variation on recording Exposed bankside roots at sweep-up

First surveyor	Others surveyors				Number of records	Percentage agreement
	Not recorded	None	Present	Extensive		
Not recorded	0	67	17	17	3	0.0
None	0	80	20	0	13	80.0
Present	0	0	94	6	0	93.8
Extensive	0	0	100	0	1	0.0

Table 46 Between-surveyor variation on recording underwater tree roots at sweep-up

First surveyor	Others surveyors				Number of records	Percentage agreement
	Not recorded	None	Present	Extensive		
Not recorded	0	67	17	17	3	0.0
None	0	89	11	0	14	88.9
Present	0	14	86	0	7	85.7
Extensive	0	0	100	0	1	0.0

Table 47 Between-surveyor variation on recording fallen trees at sweep-up

First surveyor	Others surveyors				Number of records	Percentage agreement
	Not recorded	None	Present	Extensive		
Not recorded	0	33	67	0	3	0.0
None	0	88	12	0	9	88.2
Present	0	21	71	8	12	70.8
Extensive	0	0	100	0	1	0.0

Table 48 Between-surveyor variation on recording coarse woody debris at sweep-up

First surveyor	Others surveyors				Number of records	Percentage agreement
	Not recorded	None	Present	Extensive		

Not recorded	0	33	50	17	3	0.0
None	0	84	16	0	13	84.0
Present	0	6	81	13	8	81.3
Extensive	0	0	100	0	1	0.0

The **sweep-up attributes** were recorded with a high level of agreement between surveyors. More inconsistency was found in assessing the *Extent of bank trees* especially in situation when trees are scarcely developed and when forming small and bushy form.

Temporal variation – years

Results of experiment were the same surveyor visited same site in 2003 and 2004 are presented Table 49 (impact on HQA) and Table 50 (impact on HMS). The average variability between-years was relatively high (CV=9.46 for HQA and CV=17.53 for HMS) although the total variation was also very high. The significance test for differences between seasons failed (Table 100). To estimate influence of between-years variation in the total variation mean variance between surveyed seasons of the year was divided by the total variance. The outlying values were excluded and the ratio was equal to 0.01 for HMS and 0.05 for HQA (Table 101).

Table 49 Variation of HQA score between years

Stream Name	HQA score		Years		
	Period 1 (Summer 2004)	Period 2 (Summer 2003)	HQA mean	HQA SD	HQA CV
Blizna	34.0	36.0	35.0	1.41	4.04
Dobrzyca	70.0	61.0	65.5	6.36	9.72
Grabia	52.0	50.0	51.0	1.41	2.77
Grabiczek	70.0	66.0	68.0	2.83	4.16
Ilanka	64.0	64.0	64.0	0.00	0.00
Korytnica	65.0	60.0	62.5	3.54	5.66
Lesna Prawa	49.0	47.0	48.0	1.41	2.95
Lutownia	70.0	65.0	67.5	3.54	5.24
Mala Welna	25.0	36.0	30.5	7.78	25.50
Meszna	38.0	32.0	35.0	4.24	12.12
Mlawka	30.0	33.0	31.5	2.12	6.73
Narew	41.0	43.0	42.0	1.41	3.37
Narewka	43.0	34.0	38.5	6.36	16.53
Ner	35.0	43.0	39.0	5.66	14.50
Pilawa	66.0	67.0	66.5	0.71	1.06
Pliszka	52.0	56.0	54.0	2.83	5.24
Ploska	34.0	35.0	34.5	0.71	2.05
Plytnica	50.0	51.0	50.5	0.71	1.40
Rospuda	66.0	67.0	66.5	0.71	1.06
S.Steszewska	19.0	30.0	24.5	7.78	31.75

Sokolda	38.0	44.0	41.0	4.24	10.35
Struga Bawol	25.0	37.0	31.0	8.49	27.37
Suprasl	26.0	32.0	29.0	4.24	14.63
Slina	29.0	33.0	31.0	2.83	9.12
Wieprza	77.0	56.0	66.5	14.85	22.33
Wolkuszanka	35.0	32.0	33.5	2.12	6.33
		Mean	**46.4**	**3.78**	**9.46**
		Minimum	**24.5**	**0.00**	**0.00**
		Maximum	**68.0**	**14.85**	**31.75**

Table 50 Variation of HMS score between years

Stream Name	HMS score		Years		
	Period 1 (Summer 2004)	Period 2 (Summer 2003)	HMS mean	HMS SD	HMS CV
Blizna	37.0	36.0	36.5	0.71	1.94
Dobrzyca	0.0	0.0	0.0	0.00	0.00
Grabia	0.0	2.0	1.0	1.41	141.42
Grabiczek	11.0	17.0	14.0	4.24	30.30
Ilanka	0.0	0.0	0.0	0.00	0.00
Korytnica	0.0	0.0	0.0	0.00	0.00
Lesna Prawa	16.0	16.0	16.0	0.00	0.00
Lutownia	0.0	1.0	0.5	0.71	141.42
Mala Welna	38.0	26.0	32.0	8.49	26.52
Meszna	83.0	67.0	75.0	11.31	15.08
Mlawka	41.0	41.0	41.0	0.00	0.00
Narew	12.0	12.0	12.0	0.00	0.00
Narewka	70.0	64.0	67.0	4.24	6.33
Ner	11.0	12.0	11.5	0.71	6.15
Pilawa	0.0	0.0	0.0	0.00	0.00
Pliszka	0.0	0.0	0.0	0.00	0.00
Ploska	70.0	62.0	66.0	5.66	8.57
Plytnica	0.0	0.0	0.0	0.00	0.00
Rospuda	0.0	0.0	0.0	0.00	0.00
S.Steszewska	54.0	52.0	53.0	1.41	2.67
Sokolda	15.0	18.0	16.5	2.12	12.86
Struga Bawol	26.0	24.0	25.0	1.41	5.66
Suprasl	71.0	73.0	72.0	1.41	1.96
Slina	52.0	58.0	55.0	4.24	7.71
Wieprza	0.0	0.0	0.0	0.00	0.00
Wolkuszanka	10.0	20.0	15.0	7.07	47.14
		Mean	**23.4**	**2.12**	**17.53**
		Minimum	**0.0**	**0.00**	**0.00**
		Maximum	**75.0**	**11.31**	**141.42**

The corresponding responses from the surveys carried out in 2003 and 2004 were tested at each spot-check of 27 sites. Percentage of agreement between different years are presented in the last column of the tables. Responses to all of the attributes were considered, by comparing records on **spot-check** attributes as *Flow type* (Table 51), *Bed material* (Table 52), *Bank top structure* (Table 53), *Bank face structure* (Table 54), *Submerged linear-leaved channel* *vegetation* (Table 55), *Submerged fine-leaved channel vegetation* (Table 56), *Algae channel vegetation* (Table 57), *Submerged broad-leaved* (Table 58), *Amphibious channel vegetation* (Table 59), *Free floating channel vegetation* (Table 60), *Floating-leaved channel vegetation* (Table 61), *Emergent reeds channel vegetation* (Table 62), *Emergent broad-leaved* (Table 63), *Liverworts channel vegetation* (Table 64), None or not visible channel vegetation (Table 65).

Attributes recorded at the **sweep-up** part of the RHS survey were also compared for the between-year effect regarding: *Land-use within 50 m of banktop* (Table 66), *Extent of bank trees* (Table 67), *Shading of channel* (Table 68), *Overhanging boughs* (Table 69), *Exposed bankside roots* (Table 70), *Underwater tree roots* (Table 71), *Fallen trees* (Table 72) and *Coarse woody debris* (Table 73).

Table 51 Between-year variation on recording flow type at spot checks

2003	2004							Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Free fall	Chaotic flow	Unbroken standing waves	Rippled	Upwelling	Smooth	Not perceptible		
Free fall	100	0	0	0	0	0	0	1	100
Chaotic flow	0	0	0	100	0	0	0	3	0
Rippled	0	2	9	64	4	18	4	56	64
Upwelling	0	0	20	60	20	0	0	5	20
Smooth	0	0	0	12	1	64	23	91	64
Not perceptible	0	0	0	25	0	75	0	4	0

Table 52 Between-year variation on recording bed material at spot checks

2003	2004									Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Not visible	Boulders	Cobbles	Gravel/pebble	Sand	Silt	Clay	Peat	Artificial		
Not visible	40	0	0	0	30	30	0	0	0	10	40
Cobbles	0	0	100	0	0	0	0	0	0	1	100

Gravel/pebble	2	0	0	72	19	6	0	0	0	47	72
Sand	1	0	0	7	86	5	0	0	0	135	86
Silt	0	0	0	5	18	66	0	11	0	38	66
Clay	0	0	0	0	0	0	100	0	0	3	100
Peat	0	0	0	0	14	50	0	36	0	14	36
Artificial	0	0	0	0	50	0	0	0	50	2	50

For the channel attributes as *Flow type* (Table 51) and *Substrate* (Table 52) the percentage agreement between surveyors was between 64 and 86 % (when attribute was recorded at least 15 spot-checks). The highest rate of disagreement was in case of *Smooth* flow type (misidentified mostly with *Not perceptible* and *Rippled*) and *Rippled* (misidentified mostly with *Smooth*).

Table 53 Between-year variation on recording Bank top (left and right) structure at spot-checks

2003	2004					Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Bare	Uniform	Simple	Complex	Not visible		
Uniform	1	78	21	0	0	249	78.4
Simple	0	38	53	6	3	160	53.0
Complex	0	15	48	33	4	90	32.9
Not visible	0	0	100	0	0	1	0.0

Table 54 Between-year variation on recording Bank face (left and right) structure at spot-checks

2003	2004					Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Bare	Uniform	Simple	Complex	Not visible		
Bare	50	50	0	0	0	4	50.0
Uniform	4	81	15	0	1	252	80.9
Simple	2	47	49	2	1	165	48.8
Complex	0	24	48	23	5	79	22.6

Analysing differences between years the in the **Bank-top** and **Bank-face vegetation structure** it was found that) the percentage agreement ranged from 22.6 % to 80.9 % (Table 53 and 54) (for samples larger attributes than 15 spot-checks). The highest rate of disagreement was detected for *Complex* type of vegetation, which were recorded as *Simple* in the following year.

Table 55 Between-year variation on recording Submerged linear-leaved for channel vegetation at spot-checks

2003	2004			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	66	8	26	191	66.0
Extensive	25	75	0	12	75.0
Not recorded	32	0	68	28	67.9

Table 56 Between-year variation on recording Submerged fine-leaved for channel vegetation at spot-checks

2003	2004			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	32	0	68	38	31.6
Extensive	0	0	100	2	0.0
Not recorded	21	13	66	103	66.0

Table 57 Between-year variation on recording Algae for channel vegetation at spot-checks

2003	2004			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	23	8	69	26	23.1
Extensive	60	30	10	10	30.0
Not recorded	32	3	66	151	65.6

Table 58 Between-year variation on recording Submerged broad-leaved for channel vegetation at spot-checks

2003	2004			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	66	15	19	164	65.9
Extensive	70	30	0	40	30.0
Not recorded	33	10	57	49	57.1

Table 59 Between-year variation on recording Amphibious for channel vegetation at spot-checks

2003	2004		Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Not recorded		
Present	25	75	51	25.5
Not recorded	16	84	92	83.7

Table 60 Between-year variation on recording Free floating for channel vegetation at spot-checks

2003	2004			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	58	25	17	117	58.1
Extensive	86	14	0	7	14.3
Not recorded	42	3	56	118	55.9

Table 61 Between-year variation on recording Floating leaved for channel vegetation at spot-checks

2003	2004			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	53	27	20	70	52.9
Extensive	58	33	8	12	33.3
Not recorded	34	7	59	94	58.5

Table 62 Between-year variation on recording Emergent reeds for channel vegetation at spot-checks

2003	2004			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	84	3	12	219	84.5
Extensive	81	13	6	16	12.5
Not recorded	28	0	73	40	72.5

Table 63 Between-year variation on recording Emergent broad leaved for channel vegetation at spot-checks

2003	2004			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	71	0	29	212	70.8
Extensive	100	0	0	3	0.0
Not recorded	18	0	82	60	81.7

Table 64 Between-year variation on recording Liverworts for channel vegetation at spot-checks

2003	2004		Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Not recorded		
Present	21	79	52	21.2
Not recorded	10	90	113	90.3

Table 65 Between-year variation on recording None or Not Visible for channel vegetation at spot-checks

2003	2004			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	None	Not visible	Not recorded		
None	100	0	0	5	100.0
Not visible	38	0	63	8	0.0
Not recorded	26	23	52	31	51.6

For the most frequent **vegetation groups** growing in the channel (recorded at least at 15 spot-checks) the percentage agreement between years varied from 12.5 to 90.3 % (Tables 55-65).

The highest rate of disagreement was in case of *Emergent reeds, Liverworts, Algae* and *Amphibious* channel vegetation. The major reason of differences in records was different extent of vegetation development in 2004 and 2003. The development of *Algae* and *Bryophytes* was very limited in 2004 comparing with 2003. *Emergent reeds* were also less developed in 2004.

Table 66 Between-year variation on recording land-use within 50 m of banktop (left and right) at sweep-up

2003	2004										Number of records	Percentage agreement
	Broad leaved/mixed woodland	Coniferous woodland	Coniferous plantation	Scrub & Shrubs	Wetland	Rough/unimproved grassland/pasture	Improved/semi-improved grassland	Tall herb	Suburban/urban development	Tilled land		
Broad leaved/mixed woodland	70	2	2	0	16	3	0	7	1	0	158	69.7
Coniferous woodland	100	0	0	0	0	0	0	0	0	0	3	0.0
Scrub & Shrubs	29	0	0	21	29	0	0	21	0	0	14	21.4
Wetland	11	0	0	1	73	2	2	10	0	0	102	73.1
Grassland/ pasture	0	0	0	4	5	35	28	20	7	3	53	34.7
Improved/ semi-improved grassland	5	0	0	5	7	24	45	11	3	0	100	44.7
Tall herb	5	0	0	5	6	18	2	61	3	0	56	61.3
Suburban/urban development	0	0	0	0	0	0	0	100	0	0	1	0.0
Tilled land	0	0	0	13	0	17	0	6	13	53	13	52.8

For the most frequent **Land-use within 50 m of banktop** (more than 15 spot-checks) the percentage agreement between year was between 34.7 and 73.1% (Table 66). The source of the difference was the difficulty to categorise *Rough pasture, Improved grassland* and *Tall herbs.* The same surveyor categorised the land use differently during the different visits. Difficulties with these categories were also discovered during the inter-surveyor experiment.

Table 67 Between-year variation on recording extent of bank trees (left and right) at sweep-up

2003	2004							Number of records	Percentage agreement
	Not recorded	None	Isolated/ scattered	Regularly spaced/single	Occasional clumps	Semi-continuous	Continuous		
Not recorded	0	0	100	0	0	0	0	2	0.0
None	0	78	23	0	0	0	0	9	77.5
Isolated	0	27	60	0	6	7	0	15	59.8
Occasional clumps	0	0	17	33	33	17	0	6	33.3
Semi-continuous	0	0	0	0	0	83	17	5	83.3
Continuous	0	0	0	0	0	38	62	13	61.9

Table 68 Between-year variation on recording shading of channel at sweep-up

2003	2004				Number of records	Percentage agreement
	Not recorded	None	Present	Extensive		
Not recorded	0	33	33	33	3	0.0
None	0	88	13	0	8	87.5
Present	0	0	100	0	5	100.0
Extensive	0	0	11	89	9	88.9

Table 69 Between-year variation on recording overhanging boughs at sweep-up

2003	2004				Number of records	Percentage agreement
	Not recorded	None	Present	Extensive		
Not recorded	0	67	33	0	3	0.0
None	0	77	23	0	13	76.9
Present	0	0	100	0	7	100.0
Extensive	0	0	100	0	2	0.0

Table 70 Between-year variation on recording exposed bankside roots at sweep-up

2003	2004				Number of records	Percentage agreement
	Not recorded	None	Present	Extensive		
Not recorded	0	67	0	33	3	0.0
None	0	77	23	0	13	76.9
Present	0	0	88	13	0	87.5
Extensive	0	0	100	0	1	0.0

Table 71 Between-year variation on recording underwater tree roots at sweep-up

2003	2004				Number of records	Percentage agreement
	Not recorded	None	Present	Extensive		
Not recorded	0	67	0	33	3	0.0
None	0	93	7	0	14	92.9
Present	0	29	71	0	7	71.4
Extensive	0	0	100	0	1	0.0

Table 72 Between-year variation on recording fallen trees at sweep-up

First season	Second season				Number of records	Percentage agreement
	Not recorded	None	Present	Extensive		
Not recorded	0	33	67	0	3	0.0
None	0	89	11	0	9	88.9
Present	0	25	67	8	12	66.7
Extensive	0	0	100	0	1	0.0

Table 73 Between-year variation on recording coarse woody debris at sweep-up

First season	Second season				Number of records	Percentage agreement
	Not recorded	None	Present	Extensive		
Not recorded	0	33	33	33	3	0.0
None	0	85	15	0	13	84.6
Present	0	13	75	13	8	75.0
Extensive	0	0	100	0	1	0.0

The S**weep-up** attributes were recorded with a high level of agreement between years. More attention should be paid for categorising the scarcely developed trees when small/bushy.

Temporal variation – seasons

Results of the between-seasons replicate sampling experiment for HQA are presented in the Table 74 and for HMS in Table 75. The average variability was lower in case of HQA (CV=8.72) and higher for HMS (CV=19.12), which is impacted by several outliers. Due to variance the significance test for differences between seasons failed (Table 100). To estimateinfluence of between-season variation on the total variation mean variance between surveyed seasons of year was divided by the total variance. The outlying values were excluded and the ratio was equal to 0.01 for HMS and 0.07 for HQA (Table 101).

Table 74 Variation of HQA score between seasons

Stream Name	HQA score		Season		
	Period 2 (Summer 2003)	Period 3 (Autumn 2003)	HQA mean	HQA SD	HQA CV
Blizna	36.0	39.0	37.5	2.12	5.66
Dobrzyca	61.0	62.0	61.5	0.71	1.15
Grabia	50.0	47.0	48.5	2.12	4.37
Grabiczek	66.0	53.0	59.5	9.19	15.45
Ilanka	64.0	65.0	64.5	0.71	1.10
Korytnica	60.0	56.0	58.0	2.83	4.88
Lesna Prawa	47.0	48.0	47.5	0.71	1.49
Lutownia	65.0	48.0	56.5	12.02	21.28
Mala Welna	36.0	37.0	36.5	0.71	1.94
Meszna	32.0	35.0	33.5	2.12	6.33
Mlawka	33.0	40.0	36.5	4.95	13.56
Narew	43.0	45.0	44.0	1.41	3.21
Narewka	34.0	48.0	41.0	9.90	24.15
Ner	43.0	47.0	45.0	2.83	6.29
Pilawa	67.0	66.0	66.5	0.71	1.06
Pliszka	56.0	62.0	59.0	4.24	7.19
Ploska	35.0	27.0	31.0	5.66	18.25
Plytnica	51.0	52.0	51.5	0.71	1.37
Rospuda	67.0	61.0	64.0	4.24	6.63
S.Steszewska	30.0	24.0	27.0	4.24	15.71
Sokolda	44.0	35.0	39.5	6.36	16.11
Struga Bawol	37.0	42.0	39.5	3.54	8.95
Suprasl	32.0	32.0	32.0	0.00	0.00
Slina	33.0	26.0	29.5	4.95	16.78
Wieprza	56.0	59.0	57.5	2.12	3.69
Wolkuszanka	32.0	24.0	28.0	5.66	20.20
		Mean	**46.0**	**3.64**	**8.72**
		Minimum	**27.0**	**0.00**	**0.00**
		Maximum	**66.5**	**12.02**	**24.15**

Table 75 Variation of HMS score between season

Stream Name	HMS score		Season		
	Period 2 (Summer 2003)	Period 3 (Autumn 2003)	HMS mean	HMS SD	HMS CV
Blizna	36.0	40.0	38.0	2.83	7.44
Dobrzyca	0.0	0.0	0.0	0.00	0.00
Grabia	2.0	0.0	1.0	1.41	141.42
Grabiczek	17.0	21.0	19.0	2.83	14.89
Ilanka	0.0	0.0	0.0	0.00	0.00
Korytnica	0.0	0.0	0.0	0.00	0.00
Lesna Prawa	16.0	16.0	16.0	0.00	0.00
Lutownia	1.0	0.0	0.5	0.71	141.42
Mala Welna	26.0	27.0	26.5	0.71	2.67
Meszna	67.0	79.0	73.0	8.49	11.62
Mlawka	41.0	38.0	39.5	2.12	5.37
Narew	12.0	14.0	13.0	1.41	10.88
Narewka	64.0	71.0	67.5	4.95	7.33
Ner	12.0	12.0	12.0	0.00	0.00
Pilawa	0.0	0.0	0.0	0.00	0.00
Pliszka	0.0	0.0	0.0	0.00	0.00
Ploska	62.0	62.0	62.0	0.00	0.00
Plytnica	0.0	0.0	0.0	0.00	0.00
Rospuda	0.0	0.0	0.0	0.00	0.00
S.Steszewska	52.0	37.0	44.5	10.61	23.84
Sokolda	18.0	10.0	14.0	5.66	40.41
Struga Bawol	24.0	27.0	25.5	2.12	8.32
Suprasl	73.0	68.0	70.5	3.54	5.01
Slina	58.0	38.0	48.0	14.14	29.46
Wieprza	0.0	0.0	0.0	0.00	0.00
Wolkuszanka	20.0	10.0	15.0	7.07	47.14
		Mean	**22.5**	**2.64**	**19.12**
		Minimum	**0.0**	**0.00**	**0.00**
		Maximum	**73.0**	**14.14**	**141.42**

The corresponding responses from two seasons was tested in the year 2003 and the early Summer records (June/July) were compared with the September survey at each spot-check on each site. Percentage of agreement between seasons achieved are presented in the last column of the tables. Responses to all the attributes were considered comparing **Spot-check** records as *Flow type* (Table 76), *Bed material* (Table 77), *Bank-top structure* (Table 78), *Bank-face channel vegetation* (Table 79), *Submerged linear-leaved channel vegetation* (Table 80), *Submerged fine-leaved channel vegetation* (Table 81), *Algae channel vegetation* (Table 82), *Submerged broad-leaved* (Table 83), *Amphibious channel vegetation* (Table 84), *Free-floating channel vegetation* (Table 85), *Floating-leaved channel vegetation* (Table 86), *Emergent reeds channel vegetation* (Table 87), *Emergent broad leaved* (Table 88), *Liverworts channel vegetation* (Table 89), *None or not visible channel vegetation* (Table 90).

Attributes recorded at **Sweep-up** part were also considered and comparison of recorded *Land-use within 50 m of banktop* (Table 91), *Extent of bank trees* (Table 92), *Shading of channel* (Table 93), *Overhanging boughs* (Table 94), *Exposed bankside roots* (Table 95), *Underwater tree roots* (Table 96), *Fallen trees* (Table 97) and *Coarse woody debris* (Table 98).

Table 76 Between-season variation on recording Flow type at spot-check

First season	Second season							Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Free fall	Unbroken Standing waves	Chaotic flow	Rippled	Upwelling	Smooth	Not perceptible		
Free fall	0	0	0	100	0	0	0	1	0.0
Unbroken standing waves	0	0	0	100	0	0	0	6	0.0
Chaotic flow	0	0	0	100	0	0	0	1	0.0
Rippled	0	0	2	68	6	25	0	54	67.9
Upwelling	0	0	0	50	25	0	25	4	25.0
Smooth	0	0	0	11	1	63	24	71	63.4
Not perceptible	0	0	0	0	0	22	78	23	78.3

Table 77 Between-season variation on recording bed material at spot-checks

Firs season	Second season									Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Artificial	Clay	Cobbles	Gravel/ pebble	Not visible	Peat	Sand	Silt	Boulders		
Artificial	0	0	0	0	0	0	0	0	100	1	0
Clay	0	0	0	0	0	100	0	0	0	3	0
Cobbles	0	0	0	0	0	0	100	0	0	1	0
Gravel/Pebble	0	0	5	47	5	0	42	2	0	46	47
Not visible	0	0	0	0	0	0	43	57	0	7	0
Peat	0	0	0	0	0	22	44	33	0	9	22
Sand	0	0	0	11	10	2	66	10	1	138	66
Silt	0	0	0	3	13	24	21	39	0	45	39

For the most frequent channel attributes as **Flow type** (Table 76) and **Substrate** (Table 77) (more than 15 spot-checks) the percentage agreement between seasons was between 39 and 78.3 %. The highest rate of disagreement was in case of *Silt* (misidentified mostly with *Peat* and *Sand*).

Table 78 Between-season variation on recording Bank top (left and right) structure at spot-checks

First season	Second season					Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Bare	Uniform	Simple	Complex	Not visible		
Bare	0	100	0	0	0	2	0.0
Uniform	0	81	18	1	0	269	81.4
Simple	0	25	68	7	0	181	68.2
Complex	0	0	37	63	0	39	63.2
Not visible	0	35	55	10	0	9	0.0

Table 79 Between-season variation on recording Bank face (left and right) structure at spot-checks

First season	Second season					Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Bare	Uniform	Simple	Complex	Not visible		
Bare	31	52	17	0	0	14	31.0
Uniform	0	79	19	2	0	302	78.6
Simple	1	27	62	11	0	156	61.6
Complex	0	0	68	32	0	21	31.9
Not visible	0	58	42	0	0	7	0.0

For the most frequent **Bank-top** and **Bank-face vegetation structure** attributes (more than 15 spot-checks) the percentage agreement between seasons was between 31.9 % and 81.4 % (Table 78 and 79). The highest rate of disagreement was in case of judgment between *Complex* and *Simple*. Differences in the vegetation development between Summer and Autumn are the suspected sources of variability.

Table 80 Between-season variation on recording Submerged linear-leaved for channel vegetation at spot-checks

First season	Second season			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	63	12	25	138	63.0
Extensive	68	32	0	25	32.0
Not recorded	54	9	37	68	36.8

Table 81 Between-season variation on recording Submerged fine-leaved for channel vegetation at spot-checks

First season	Second season			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	29	3	68	34	29.4
Extensive	0	8	92	13	7.7
Not recorded	19	0	81	96	81.3

Table 82 Between-season variation on recording Algae for channel vegetation at spot-checks

First season	Second season			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	53	3	43	60	53,3
Extensive	67	33	0	9	33,3
Not recorded	26	16	58	118	57,6

Table 83 Between-season variation on recording Submerged broad-leaved for channel vegetation at spot-checks

First season	Second season			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	73	14	13	152	73.0
Extensive	37	59	5	42	58.5
Not recorded	59	7	34	59	33.9

Table 84 Between-season variation on recording Amphibious for channel vegetation at spot-checks

First season	Second season		Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Not recorded		
Present	71	29	28	71.4
Not recorded	21	79	115	79.1

Table 85 Between-season variation on recording Free floating for channel vegetation at spot-checks

First season	Second season			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	76	14	11	123	75.6
Extensive	42	58	0	33	57.6
Not recorded	48	8	44	86	44.2

Table 86 Between-season variation on recording Floating leaved for channel vegetation at spot-checks

First season	Second season			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	23	11	66	76	22.8
Extensive	27	3	70	30	3.3
Not recorded	23	11	66	70	65.8

Table 87 Between-season variation on recording Emergent reeds for channel vegetation at spot-checks

First season	Second season			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	89	6	5	209	88.9
Extensive	78	22	0	9	22.2
Not recorded	46	0	54	57	54.4

Table 88 Between-season variation on recording Emergent broad leaved for channel vegetation at spot-checks

First season	Second season			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Extensive	Not recorded		
Present	84	1	16	164	83.5
Extensive	100	0	0	1	0.0
Not recorded	56	0	44	110	43.6

Table 89 Between-season variation on recording Liverworts for channel vegetation at spot-checks

First season	Second season		Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	Present	Not recorded		
Present	55	45	22	54.5
Not recorded	8	92	143	91.6

Table 90 Between-season variation on recording None or not visible for channel vegetation at spot-checks

First season	Second season			Number of spot-checks (sample>15 in red)	Percentage agreement (sample>15 in red)
	No	Not visible	Not Recorded		
No	44	0	56	16	56.3
Not visible	0	0	100	7	0.0
Not recorded	10	0	90	21	90.5

For the most frequent channel vegetation groups (more than 15 spot-checks) the percentage agreement between seasons was between 3.3 and 91.6 % (Table 80-90). The highest rate of disagreement was in case of *Floating-leaved, Submerged fine-leaved, Submerged linear-leaved* and *Submerged broad-leaved* channel vegetation. The seasonal changes in vegetation were most visible for these plants.

Table 91 Between-season variation on recording land-use within 50 m of banktop (left and right) at sweep-up

First season	Second season										Number of records	Percentage agreement
	Broadleaved /mixed woodland	Coniferous woodland	Coniferous plantation	Scrub & shrubs	Wetland	Rough/unimproved grassland /pasture	Improved/semi-improved grassland	Tall herb	Suburban/urban development	Tilled land		
Broadleaved /mixed woodland	75	12	1	1	8	0	0	3	0	1	136	75.4
Coniferous woodland	25	50	0	0	25	0	0	0	0	0	3	50.0
Coniferous plantation	75	0	0	0	0	0	0	25	0	0	3	0.0
Scrub & shrubs	0	0	0	94	0	0	0	6	0	0	15	93.8
Wetland	12	1	0	1	63	3	1	19	0	0	116	62.8
Unimproved grassland /pasture	0	0	0	1	21	27	36	13	2	0	63	27.2
Improved/semi-improved grassland	0	0	0	2	5	14	73	7	0	0	63	72.6
Tall herb	4	4	0	4	17	11	3	58	0	0	83	57.6
Suburban/urban development	17	0	0	0	8	8	8	33	25	0	12	25.0
Tilled land	0	0	0	0	0	38	0	0	0	63	6	62.5

Table 92 Between-season variation on recording Extent of bank trees (left and right) at sweep-up

First season	Second season							Number of records	Percentage agreement
	Not recorded	None	Isolated/scattered	Regularly spaced. single	Occasional clumps	Semi-continuous	Continuous		
None	0	100	0	0	0	0	0	11	100.0
Isolated/scattered	0	14	64	0	14	7	0	14	64.3
Regularly spaced. single	0	0	0	100	0	0	0	2	100.0
Occasional clumps	0	0	25	0	75	0	0	3	75.0
Semi-continuous	0	0	13	0	23	23	43	11	22.5
Continuous	0	0	0	0	0	0	100	9	100.0

Table 93 Between-season variation on recording Shading of channel at sweep-up

First season	Second season			Number of records	Percentage agreement
	None	Present	Extensive		
None	75	25	0	8	75.0
Present	0	88	13	8	87.5
Extensive	0	13	88	9	87.5

Table 94 Between-season variation on recording overhanging boughs at sweep-up

First season	Second season			Number of records	Percentage agreement
	None	Present	Extensive		
None	83	17	0	12	83.3
Present	8	67	25	13	66.7

Table 95 Between-season variation on recording Exposed bankside roots at sweep-up

First season	Second season			Number of records	Percentage agreement
	None	Present	Extensive		
None	92	8	0	12	91.7
Present	10	90	0	11	90.0
Extensive	0	100	0	2	0.0

Table 96 Between-season variation on recording Underwater tree roots at sweep-up

First season	Second season			Number of records	Percentage agreement
	None	Present	Extensive		
None	81	19	0	17	81.3
Present	0	100	0	7	100.0
Extensive	0	100	0	1	0.0

Table 97 Between-season variation on recording Fallen trees at sweep-up

First season	Second season			Number of records	Percentage agreement
	None	Present	Extensive		
None	82	18	0	12	81.8
Present	8	83	8	12	83.3
Extensive	0	100	0	1	0.0

Table 98 Between-season variation on recording Coarse woody debris at sweep-up

First season	Second season			Number of records	Percentage agreement
	None	Present	Extensive		
None	83	17	0	13	83.3
Present	10	80	10	10	80.0
Extensive	0	100	0	2	0.0

Sweep-up attributes were recorded with a high level of agreement between periods of vegetation season (Table 91-98). More attention should be delivered for categorising trees because *Semi-continuous* category was misinterpreted with *Continuous* or *Occasional clumps*.

Discussion and Conclusions

Undertaken analysis showed the problems related with variation associated with hydromorphological assessment of rivers impacted by inter-surveyor and temporal factor. The hydromorphological variation was identified as change of the RHS numerical score variation. The variation of paricularr RHS attributes was estimated considering the rate of agreement between surveys impacted by different sources of variation.

The comparision of the rate of agrement of surveys impacted by different sources of variation was presented in Table 99. Comparing records, carried out by different surveyors and records gathered in different time, it was possible to estimate percentage of disagreement under different source of variability. The level of disagreement was very differentiated regarding attribute and factor measured. The level of disagreement was comparable to several other studies carried out in UK (Fox et al. 1998).

Table 99. Comparision of the rate of agrement of surveys impacted by different sources of variation. The range of presented attributes limited to large populations – more than 15 samples).

Attributes	Surveyors		Years		Season	
	% agreement (>75 in red)	Number of spot-checks	% agreement (>75 in red)	Number of spot-checks	% agreement (>75 in red)	Number of spot-checks
Flow type at spot-checks						
Free fall (FF)	50	1	100	1	0.0	1
Unbroken standing waves (UW)	0	0	0	0	0.0	6
Chaotic flow (CH)	0	3	0	3	0.0	1
Rippled (RP)	64	56	64	56	67.9	54
Upwelling (UP)	10	5	20	5	25.0	4
Smooth (SM)	57	91	64	91	63.4	71

Not perceptible (NP)	0	4	0	4	78.3	23
Channel substrate at spot-checks						
Not visible (NV)	40	10	40	10	0	1
Cobbles (CO)	50	1	100	1	0	3
Gravel/pebble (GP)	62	47	72	47	0	1
Sand (SA)	75	135	86	135	47	46
Silt (SI)	59	38	66	38	0	7
Clay (CL)	50	3	100	3	22	9
Peat (PE)	39	14	36	14	66	138
Artificial (AR)	25	2	50	2	39	45
BANKTOP (LEFT AND RIGHT) VEGETATION STRUCTURE AT SPOT CHECKS						
Bank top structure						
Bare (B)	0.0	0	0.0	0	0.0	2
Uniform (U)	81.7	249	78.4	249	81.4	269
Simple (S)	58.4	160	53.0	160	68.2	181
Complex (C)	35.6	90	32.9	90	63.2	39
Not visible (NV)	0.0	1	0.0	1	0.0	9
Bank face structure						
Bare (B)	50.0	4	50.0	4	31.0	14
Uniform (U)	82.1	252	80.9	252	78.6	302
Simple (S)	50.0	165	48.8	165	61.6	156
Complex (C)	22.7	79	22.6	79	31.9	21
Not visible (NV)	0.0	0.0	0.0	0.0	0.0	7
CHANEL VEGETATION TYPES AT SPOT CHECKS						
None or not visible						
Present (P)	90.0	5	100.0	5	56.3	16
Extensive (E)	0.0	8	0.0	8	0.0	7
Not recorded	69.4	31	51.6	31	90.5	21
Liverworts / mosses						
Present (P)	24.0	52	21.2	52	54.5	22
Not recorded	90.7	113	90.3	113	91.6	143
Emergent broad leaved herbs						
Present (P)	74.8	212	70.8	212	83.5	164
Extensive (E)	0.0	3	0.0	3	0.0	1
Not recorded	65.8	60	81.7	60	43.6	110
Emergent reeds / sedges / rushes / grasses / horsetails						
Present (P)	85.2	219	84.5	219	88.9	209
Extensive (E)	12.5	16	12.5	16	22.2	9
Not recorded	63.8	40	72.5	40	54.4	57
Floating leaved (rooted)						
Present (P)	48.6	70	52.9	70	22.8	76
Extensive (E)	16.7	12	33.3	12	3.3	30
Not recorded	71.8	94	58.5	94	65.8	70
Free floating						
Present (P)	63.2	117	58.1	117	75.6	123
Extensive (E)	42.9	7	14.3	7	57.6	33
Not recorded	47.9	118	55.9	118	44.2	86
Amphibious						
Present (P)	35.3	51	25.5	51	71.4	28
Not recorded	80.4	92	83.7	92	79.1	115
Submerged broad-leaved						
Present (P)	69.4	164	65.9	164	73.0	152
Extensive (E)	36.3	40	30.0	40	58.5	42
Not recorded	46.9	49	57.1	49	33.9	59
Submerged linear-leaved						
Present (P)	64.4	191	66.0	191	63.0	138
Extensive (E)	45.8	12	75.0	12	32.0	25
Not recorded	62.5	28	67.9	28	36.8	68
Submerged fine-leaved						
Present (P)	27.6	38	31.6	38	29.4	34
Extensive (E)	0.0	2	0.0	2	7.7	13
Not recorded	72.8	103	66.0	103	81.3	96

Filamentous algae						
Present (P)	26.9	26	23.1	26	53.3	60
Extensive (E)	15.0	10	30.0	10	33.3	9
Not recorded	59.9	151	65.6	151	57.6	118
LAND-USE WITHIN 50 M OF BANKTOP (LEFT AND RIGHT)						
Broadleaved / mixed woodland (semi-natural) (BL)	69.4	158	69.7	158	75.4	136
Coniferous woodland (semi-natural) (CW)	37.5	3	0.0	3	50.0	3
Coniferous plantation (CP)	0.0	0	0.0	0	0.0	3
Scrub & shrubs (SH)	24.5	14	21.4	14	93.8	15
Wetland (e.g. bog, marsh, fen) (WL)	69.9	102	73.1	102	62.8	116
Rough / unimproved grassland / pasture (RP)	28.7	53	34.7	53	27.2	63
Improved / semi-improved grassland (IG)	48.7	100	44.7	100	72.6	63
Tall herb / rank vegetation (TH)	61.7	56	61.3	56	57.6	83
Suburban / urban development (SU)	0.0	1	0.0	1	25.0	12
Tilled land (TL)	48.5	13	52.8	13	62.5	6
EXENT OF TREES AND ASSOCIATED FEATURES AT SWEEP-UP						
Extent of bank trees (left and right)						
Not recorded	0.0	2	0.0	2	0.0	0
None	82.5	9	77.5	9	100.0	11
Isolated/scattered	60.3	15	59.8	15	64.3	14
Regularly spaced, single	0.0	0	0.0	0	100.0	2
Occasional clumps	33.3	6	33.3	6	75.0	3
Semi-continuous	80.0	5	83.3	5	22.5	11
Continuous	73.2	13	61.9	13	100.0	9
Shading of channel						
Not recorded	0.0	3	0.0	3	0.0	0
None	81.3	8	87.5	8	75.0	8
Present (P)	100.0	5	100.0	5	87.5	8
Extensive (E)	88.2	9	88.9	9	87.5	9
Overhanging boughs						
Not recorded	0.0	3	0.0	3	0.0	0
None	80.0	13	76.9	13	83.3	12
Present (P)	85.7	7	100.0	7	66.7	13
Extensive (E)	25.0	2	0.0	2	0.0	0
Exposed bankside roots						
Not recorded	0.0	3	0.0	3	0.0	0
None	80.0	13	76.9	13	91.7	12
Present (P)	93.8	0	87.5	0	90.0	11
Extensive (E)	0.0	1	0.0	1	0.0	2
Underwater tree roots						
Not recorded	0.0	3	0.0	3	0.0	0
None	88.9	14	92.9	14	81.3	17
Present (P)	85.7	7	71.4	7	100.0	7
Extensive (E)	0.0	1	0.0	1	0.0	1
Fallen trees						
Not recorded	0.0	3	0.0	3	0.0	0
None	88.2	9	88.9	9	81.8	12
Present (P)	70.8	12	66.7	12	83.3	12
Extensive (E)	0.0	1	0.0	1	0.0	1
Large woody debris						
Not recorded	0.0	3	0.0	3	0.0	0
None	84.0	13	84.6	13	83.3	13
Present (P)	81.3	8	75.0	8	80.0	10
Extensive (E)	0.0	1	0.0	1	0.0	2

The variation associated with hydromorphological assessment of rivers was determined by evaluation of changes of River Habitat Survey numerical scores. The statistical test (*Willkoxon's tesr*) revealed that HQA and HMS variation influenced by temporal factor (both years and seasons) was not significant (Table 100).

Table 100 Results of Wilkoxon's test

Parameter	Factors combination	p level
HQA	summer 2004 vs. summer 2003	#
	summer 2003 vs. autumn 2003	#
HMS	summer 2004 vs. summer 2003	#
	summer 2003 vs. autumn 2003	#

- p > 0,05; * - p < 0,05; ** - p < 0,01; *** - p < 0,001

To estimate influence of different sources of variation (inter-surveyor and temporal) the variance calculated for particular source of error was divided by total variance (Table 101). The inter-surveyor source of variability was more important than temporal one.

Table 101 Ratio of variance effected by different sources against total variance (excluding 10% of outliers)

Source of variability	HMS	HQA
Surveyors	0.06	0.11
Years	0.01	0.05
Seasons	0.01	0.07

Analysis showed that hydromorphological assessment can be utilised for estimating ecological status of rivers according to WFD (European Parliament... 2000). Analysed method - River Habitat Survey delivers two numerical quality scores as HQA and HMS which are relatively resistant to most important sources of variability. The detected level of variance can be utilised to estimate potential sampling variation and to estimate probability of misgrading a site (Error module). More studies on the wider range of river types with class boundaries established.

4.3 Criteria and procedures for quality control/Software for quality control

Background

To develop criteria and procedures for computer program controlling quality of the RHS databases, STAR hydromorphological database was analysed. Analysis enabled for revealing pan-European pattern of hydromorphological attributes. They are supplemented by criteria developed for main geographical regions in Europe. Established multilevel set of criteria can already support the quality control process and it is approachable for further developments based on other datasets.

RHS sensitivity in different regions in Europe

To reveal hydromorphological pattern, in the first step, the frequency of individual RHS attributes (number of features per attribute recorded) was estimated among main geographical regions in Europe. Analysis were undertaken in four geographical regions of Europe, categorisated presented according to Hering, Strackbein 2002:

1. Alpine:
   - *Small-sized crystalline streams of the ridges of the central Alps,*
   - *Small-sized, streams in the southern calcareous Alps.*

   Rivers of Alpine mountains with the catchment area between 10 and 100 km^2; high altitudes (200 – 800 m); typical for siliceous ore calcareous geology. The Alpine streams are present in Ecoregion 9 (Alps).
2. Lowlands:
   - *Medium-sized lowland streams*
   - *Medium-sized streams on calcareous soils*
   - *Medium-sized, lowland calcareous streams (RIVPACS group 20)*
   - *Medium-sized, lowland streams*
   - *Medium-sized, lowland streams (Eco Region 14)*
   - *Medium-sized, lowland streams (Eco Region 16)*
   - *Small-sized, lowland calcareous streams (RIVPACS group 32)*

   Rivers of lowland regions, generally in Western and Central Europe; catchment area between 100 and 1000 km^2; low altitudes (below 200 m.a.s.l.). Typical for Ecoregion 13 (Western Lowlands), 14 (Middle Lowlands),15 (Baltic Region),16 (Eastern Lowlands) and 18 (Great Britain).
3. South European:
   - *Small-sized, calcareous mountain streams in Western, Central and Southern Greece*

- *Small-sized, calcareous streams in the Central Apennines*
- *Medium-sized in the lower mountainous areas of Southern Portugal*
- *Small-sized, siliceous streams on Aegean Islands*

Broad range of catchment area (between 10 and 1000 km^2), present in very diversified altitudes (from lowland regions to 800 m.a.s.l.); typical for siliceous ore calcareous geology. South European rivers are present in Ecoregion 1 (Iberian and Macronesian Region), 3 (Italy, Corsica and Malta), 5 (Western Dinarian Balkans) and 6 (Western Greek Balkans).

4. Mountains:
   - *Small-sized Buntsandstein streams*
   - *Small-sized calcareous mountain streams in the Eastern Carpathians*
   - *Small-sized shallow mountain streams*
   - *Small-sized siliceous mountain streams in the Western Carpathians*
   - *Small-sized streams in the Central, sub-alpine mountains*
   - *Small-sized, shallow headwater streams in Eastern France*
   - *Small-sized, shallow mountain streams*
   - *Small-sized, siliceous mountain streams in Northern Greece*

Small catchments (between 10 and 100 km^2); rather high altitudes (between 200 and 500 m.a.s.l.); siliceous geology is predominant. Mountain streams are present in Ecoregion 8 (Western Plateau), 9 (Central Plateau) and 10 (Carpathians).

Attributes influencing RHS numerical scores (HMS, HQA) were extracted for each of the geographical group (Table 102 and 103). The share of individual attributes in the total HQA/HMS score was estimated. Dividing HQA/HMS score points (share) with the number of records per feature the "impact" of every feature was be estimated and differences between attributes could be observed. In this way the sensitive parts of RHS habitat assessment were indicated enabling for further quality improvements.

Habitat Quality Assessment score in different regions in Europe. Table 100 presents RHS attributes influencing Habitat Quality Assessment score according to geographical regions described above. Uniform patterns were found among the analysed regions that individual attributes never deliver more than 14% of the HQA score and there is a group of dominating seven attributes where each delivers around 10% of the total score what makes about 75% of the total score. The common feature for all analysed region is large role of bank vegetation – such attributes as *Vegetation structure* on the *Bank face* as well and as *Bank top* and *Bank Trees* always delivers about 10% of total HQA score. Large importance among all regions was also shown by *Substrate in spot-checks* and *Flow types in spot-checks* although the individual score was more variable (10.3-13.7 %).

Substantial importance of *In-stream plant vegetation* was revealed in case of lowland rivers. This attribute delivered in average 13.7% of the total HQA score and it was proven to be the very influential attribute as delivering 963 points from only 759 records. This attribute played smaller role in other regions. The most important attribute for HQA score in case of Mountain geographical group was *Bank features recorded in spot-checks* delivering 13.2% of the total score. This attribute was also important for South European rivers (10.72 %). More differences between regions can be observed by analysing low scoring attributes.

To analyse impact of different attributes on HQA score share of HQA score points was divided by number of recorded features. The big differences between attributes were identified and this ratio was varying from 0.1 to 2.7. This ratio was especially low in case of: *Channel features only found in sweep-up, Flow types only found in sweep-up, Bank features only found in sweep-up.* Wrong identification of these attributes does not strongly influence total HQA score. On the other hand, misidentification of high ratio attributes impacts the final score very strongly. These are: *Flow types in spot-checks, Channel substrate type in spot-checks, Channel types of vegetation, Features of special interest* (Lowland and Alpine rivers only).

To improve survey quality it is recommend to define more precisely underlined high scoring attributes and to focus on these problems during training courses. Other studies of this WP (see Section 4.2), have proven that misidentifications among the most important attributes is quite frequent. Much attention to the underlined elements is recommended for quality improvement of procedures. Results were utilised in QA software.

Table 102 RHS survey attributes influencing Habitat Quality Assessment (HQA) in different regions in Europe

Geographical region	Attributes influencing HQA	Number of features	Share of attribute in number of features [%]	HQA score points	Share of attribute in HQA score [%]	Attribute impact on HQA score
Lowlands	Flow type(s) (spot-checks)	300	3.82	724	10.29	2.7
	Flow types only found in sweep up	739	9.42	225	3.20	0.3
	Channel substrate (spot-checks)	369	4.70	770	10.94	2.3
	Channel feature(s) (spot-checks)	199	2.54	90	1.28	0.5
	Channel features only found in sweep-up	297	3.79	102	1.45	0.4
	Marginal & Bank features (spot-checks)	556	7.09	427	6.07	0.9
	Bank features only found in sweep up	349	4.45	122	1.73	0.4
	Vegetation structure (Bank-face)	634	8.08	713	10.13	1.3
	Vegetation structure (Bank-top)	578	7.37	736	10.46	1.4
	Point bars	108	1.38	50	0.71	0.5
	Channel vegetation types	759	9.67	963	13.69	1.4
	Land-use within 50 m of banktop (Sweep-up)	1067	13.60	461	6.55	0.5
	Extent of trees (Sweep-up)	1010	12.87	698	9.92	0.8
	Associated features	638	8.13	610	8.67	1.1
	Features of special interest	242	3.08	345	4.90	1.6
	Total	**7845**	**100.00**	**7036**	**100.00**	
Mountines	Flow type(s) (spot-checks)	343	5.84	652	12.83	2.2
	Flow types only found in sweep up	442	7.53	236	4.64	0.6
	Channel substrate (spot-checks)	320	5.45	561	11.04	2.0
	Channel feature(s) (spot-checks)	176	3.00	140	2.76	0.9
	Channel features only found in sweep-up	305	5.20	63	1.24	0.2
	Marginal & Bank features (spot-checks)	591	10.07	668	13.15	1.3
	Bank features only found in sweep up	236	4.02	39	0.77	0.2
	Vegetation structure (Bank-face)	569	9.69	540	10.63	1.1
	Vegetation structure (Bank-top)	511	8.70	499	9.82	1.1
	Point bars	70	1.19	33	0.65	0.5
	Channel vegetation types	137	2.33	171	3.37	1.4
	Land-use within 50 m of banktop (Sweep-up)	754	12.84	314	6.18	0.5
	Extent of trees (Sweep-up)	729	12.42	512	10.08	0.8
	Associated features	471	8.02	443	8.72	1.1
	Features of special interest	217	3.70	210	4.13	1.1
	Total	**5871**	**100.00**	**5081**	**100.00**	
South European	Flow type(s) (spot-checks)	189	6.97	279	12.06	1.7
	Flow types only found in sweep up	138	5.09	93	4.02	0.8
	Channel substrate (spot-checks)	175	6.45	270	11.67	1.8
	Channel feature(s) (spot-checks)	90	3.32	88	3.80	1.1
	Channel features only found in sweep-up	81	2.99	23	0.99	0.3
	Marginal & Bank features (spot-checks)	196	7.22	248	10.72	1.5
	Bank features only found in sweep up	175	6.45	44	1.90	0.3
	Vegetation structure (Bank-face)	210	7.74	221	9.55	1.2
	Vegetation structure (Bank-top)	185	6.82	240	10.38	1.5
	Point bars	62	2.29	33	1.43	0.6
	Channel vegetation types	93	3.43	109	4.71	1.4
	Land-use within 50 m of banktop (Sweep-up)	420	15.48	167	7.22	0.5
	Extent of trees (Sweep-up)	299	11.02	203	8.78	0.8
	Associated features	193	7.11	160	6.92	1.0
	Features of special interest	207	7.63	135	5.84	0.8
	Total	**2713**	**100.00**	**2313**	**100.00**	
Alpine	Flow type(s) (spot-checks)	99	6.60	183	13.65	2.1
	Flow types only found in sweep up	110	7.33	55	4.10	0.6
	Channel substrate (spot-checks)	99	6.60	158	11.78	1.8
	Channel feature(s) (spot-checks)	65	4.33	80	5.97	1.4
	Channel features only found in sweep-up	58	3.87	7	0.52	0.1
	Marginal & Bank features (spot-checks)	113	7.53	99	7.38	1.0
	Bank features only found in sweep up	39	2.60	10	0.75	0.3
	Vegetation structure (Bank-face)	146	9.73	154	11.48	1.2
	Vegetation structure (Bank-top)	139	9.27	134	9.99	1.1
	Point bars	11	0.73	8	0.60	0.8
	Channel vegetation types	29	1.93	49	3.65	1.9
	Land-use within 50 m of banktop (Sweep-up)	194	12.93	84	6.26	0.5
	Extent of trees (Sweep-up)	229	15.27	151	11.26	0.7
	Associated features	124	8.27	99	7.38	0.9
	Features of special interest	45	3.00	70	5.22	1.7
	Total	**1500**	**100.00**	**1341**	**100.00**	

Habitat Modification Score in different regions in Europe. Table 103 presents RHS attributes influencing Habitat Modification Score (HMS) in the four geographical regions. The structure of this metric is very different from HQA index. The main difference is large disproportion of input into the total score between different attributes. A single attribute: *Modifications at spot-checks* delivers majority of points: between 62 and 78 % of the HMS score. Another difference is that this category aggregates two groups of features separately recorded as *Channel modifications* and *Bank modifications.*

Large importance of *Modifications at spot-checks* attribute was observed among all European groups. It was specially important for Alpine rivers where this feature delivered in average 78.53 % of the total score. Another evidence of importance of this attribute is its input of 1.4 point per each feature recorded. Revealed dominance of one attribute suggests that proper identification of this attribute is crucial for the quality of data. Other studies of this WP (see Section 4.2), have proven much disagreement between surveyors during the field recording. More detail definition, extensive explanations and attention to the training courses is recommended to be focused on the high scoring attributes. Much attention to the underlined elements is recommended for the **quality improvement** procedures. Results were utilised in QA software (Section 4.4)

Table 103 RHS survey attributes influencing Habitat Modification Score (HMS) in different regions in Europe

Geographical region	Attributes influencing HMS	Number of features	Share of attribute in number of features [%]	HMS score points	Share of attribute in HMS score [%]	Attribute impact on HMS score
Lowlands	Modifications at spot checks	622	65.27	1176	72.15	1.1
	Modifications only found in sweep-up	247	25.92	168	10.31	0.4
	Artificial features	84	8.81	286	17.55	2.0
	Suma / Sum	**953**	**100.00**	**1630**	**100.00**	
Mountines	Modifications at spot checks	506	56.41	1174	62.78	1.1
	Modifications only found in sweep-up	249	27.76	331	17.70	0.6
	Artificial features	142	15.83	365	19.52	1.2
	Suma / Sum	**897**	**100.00**	**1870**	**100.00**	
South European	Modifications at spot checks	169	63.77	137	60.62	1.0
	Modifications only found in sweep-up	65	24.53	81	35.84	1.5
	Artificial features	31	11.70	8	3.54	0.3
	Suma / Sum	**265**	**100.00**	**226**	**100.00**	
Alpine	Modifications at spot checks	166	57.44	684	78.53	1.4
	Modifications only found in sweep-up	82	28.37	48	5.51	0.2
	Artificial features	41	14.19	139	15.96	1.1
	Suma / Sum	**289**	**100.00**	**871**	**100.00**	

Conclusions. It was found that only a part of RHS attributes influences quality numerical score and the role of each of them was quantified. Analysis enabled the extraction of attributes crucial for HMS and HQA variability. Results of the Section 4.2 also inform about possible problems related with them. To improve the quality of RHS data, high scoring attributes should be more precisely defined. Also more explanations and attention on the training courses is recommended.

Criteria and procedures for quality control/Software for quality control

Background. Basing on multilevel analysis of the hydromorphological database the set of criteria and procedures for quality control of data collection was developed. Although the survey is carried out by trained surveyors increasing number of collected data within River Habitat Survey (RHS) requires advanced quality assessment/quality control (QA/QC) procedures. The QA/QC procedures recommended here for RHS are analogous to those already applied to meteorological data QA/QC procedures (Meek and Hatfield 1994). During the procedure of RHS data entering the information that does not meet pre-defined QC criteria is flagged out for further quality inspection. The computer program module based on these criteria was established to support quality control.

Development of QA/QC procedures for RHS. QC procedures were developed for STAR European RHS database with four types of macroregions: Lowlands, Alpine, Mountains and South European as defined above in this Section (RHS sensitivity in different regions in Europe). The analysis carried out on three different levels provide criteria for quality control procedures:

- Criteria of absent feature – all absent (or very rare) features identified in existing databases representing particular geographical region;
- Criteria of features combination within one attribute – unique combination of two features of the same attribute in one RHS section;
- Criteria of features combination between different attributes – unique combination of two features of different attributes in RHS section.

Extent of combination utilized for each criterion is very wide and the special attention was paid to attributes influencing strongly on HQA and HMS score (see Section 4.3 RHS sensitivity in different regions in Europe). The developed module was integrated with RHS database prepared in Microsoft Access®.

First level of criteria of data input is based on selection of features which do not fulfil condition of appearance abundance:

$$L_{Ă} \geq 5\% \ L_S$$

where:
$L_{Ă}$: number of occurrences of attribute on all RHS research sites,
L_S: number of RHS research sites

Survey sites which do not fulfil the condition above (what means that identified feature is present on less then 5% of RHS sites) are detected. This level of criteria includes attributes which are identified on spot-checks:

- *Flow type*,
- *Channel substrate*,
- *Channel modification(s)*,
- *Channel feature(s)*,
- *Material**,
- *Bank modification(s)**,
- *Marginal&bank features**,
- *Land – use within 5 m of banktop**,
- *Bankface structure**,
- *Banktop structure**,
- *Vegetation types***.

* - for attributes, which are identified for left and right bank and when there was possibility to mark more than one attribute in the RHS form, their abundance was summed in the way as it is presented below:

Sample Number	bankface structure (left bank)					bankface structure (right bank)					bankface structure (all)				
	B	U	S	C	NV	B	U	S	C	NV	B	U	S	C	NV
O0208942	0	6	4	0	0	0	10	0	0	0	0	16	4	0	0
O0208962	0	7	3	0	0	0	7	3	0	0	0	14	6	0	0
O0209002	0	10	0	0	0	0	10	0	0	0	0	20	0	0	0
O0209012	0	9	1	0	0	0	8	2	0	0	0	17	3	0	0
O0209022	0	10	0	0	0	0	10	0	0	0	0	20	0	0	0
O0209042	0	6	2	2	0	0	4	3	3	0	0	10	5	5	0

** - for attributes identified in three-steps scale (*none, present, extent*) the scale was converted to two steps (*none, present*, where *present* means also *extent*)

Attributes recorded in the sweep – up were also analysed:

- *Extent of channel and bank features*,
- *Extent of trees and associated features*,
- *Bank profiles*,

- *Land – use within 50 m of banktop,*
- *Riffles, pools, point bars.*

Basing on European scale analysis attributes recorded on less than 5% of RHS survey sites (spot-check part as well as sweep-up) were selected to be flagged out. For these records verification is suggested. The flagging procedure was programmed in Visual Basic modules which automatically identify surveys selected according to this criterion.

Procedures utilised for the first level criteria are summarised in Appendix 5. During the analyses frequency of features in four geographical regions was calculated. In further analyses percentage share for every feature in the four regions was calculated. Features, that did not meet requirement of 5% share in overall number of records per regions, were marked red in the table. During this analysis 68 features were underlined. In addition, 60 other features were identified as Pan-European with percentage share higher than 5% per each region.

Second level of criteria is based on determination of connections between features of the same river attribute. For this purpose the matrix was built where pairs of features were analysed:

	NV	FF	CH	BW	UW	RP	SM	NP	UP	CF	DR
NV	0	0	0	0	0	0	0	0	0	0	0
FF	0	3	0	0	0	3	3	0	2	0	0
CH	0	0	0	0	0	0	0	0	0	0	0
BW	0	0	0	0	0	0	0	0	0	0	0
UW	0	0	0	0	7	7	2	0	2	1	0
RP	0	3	0	0	7	53	35	2	7	3	0
SM	0	3	0	0	2	35	71	19	7	2	0
NP	0	0	0	0	0	2	19	28	0	0	0
UP	0	2	0	0	2	7	7	0	8	2	0
CF	0	0	0	0	1	3	2	0	2	3	0
DR	0	0	0	0	0	0	0	0	0	0	0

Matrix above contains features of *Flow type* category. It was used to determine presence of pairs of features. For example *UW* (*upwelling*) was identified 7 times in connection with *RP* (*rippled*). Similar matrixes were developed for all groups of attributes analysed in I stage of marking the RHS sites. Red colour shows attributes which were marked according to first criterion.

The matrix above was converted to matrix containing presence of pairs of attributes which were identified in more than 5% of research sites. The following condition was stated:

$$(AA \geq 5\%) = 1$$

$$(AA < 5\%) = 0$$

where:
AA: pair of attribute,

	NV	FF	CH	BW	UW	RP	SM	NP	UP	CF	DR
NV	0	0	0	0	0	0	0	0	0	0	0
FF	0	0	0	0	0	0	0	0	0	0	0
CH	0	0	0	0	0	0	0	0	0	0	0
BW	0	0	0	0	0	0	0	0	0	0	0
UW	0	0	0	0	1	**1**	0	0	0	0	0
RP	0	0	0	0	**1**	1	**1**	0	**1**	0	0
SM	0	0	0	0	0	**1**	1	**1**	**1**	0	0
NP	0	0	0	0	0	0	**1**	1	0	0	0
UP	0	0	0	0	0	**1**	**1**	0	1	0	0
CF	0	0	0	0	0	0	0	0	0	0	0
DR	0	0	0	0	0	0	0	0	0	0	0

Pairs of features which has „0" mark, were identified as „suspected" pairs, and were used to flag the research sites. The matrix above was integrated with RHS database for purpose of developing automatic module which verifies data implemented to the database.

Third level of criteria is based on determination of connections between different attributes. For this purpose similar matrixes were built as in the second level, but they contain features combination between different attributes – unique combination of two features of different attributes in one observation set. Three matrixes were built:

1st matrix contains following attributes:

- *Riffles, pools, point bars*,
- *Vegetation types*,
- *Marginal&bank features**,
- *Channel substrate*,
- *Flow type*,
- *Extent of channel and bank features*,
- *Channel feature(s).*

2nd matrix contains following attributes:

- *Bank modification(s)**,
- *Channel modification(s)*,
- *Land – use within 50 m of banktop*,
- *Land – use within 5 m of banktop**,
- *Bank profiles*,

- *Material*.*

3rd matrix contains following groups of attributes:

- *Extent of trees and associated features,*
- *Bankface structure*,*
- *Banktop structure*,*
- *Vegetation types**,*
- *Land – use within 50 m of banktop,*
- *Land – use within 5 m of banktop*.*

In some cases attributes are present in more than one matrix (*Vegetation types, Land – use within 50 m of banktop*). It was a part of control procedure for verification of several connections between these attributes. Example of such matrix is presented below:

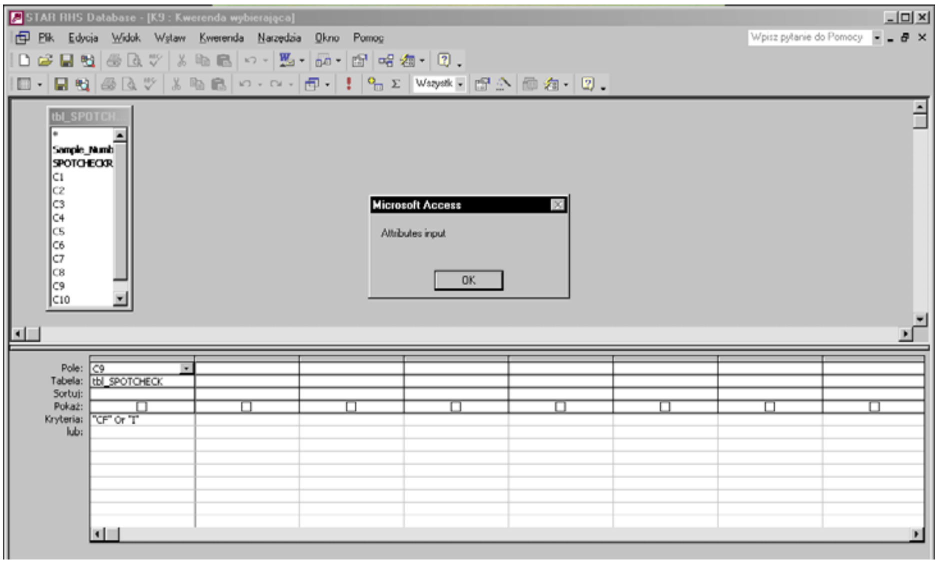
		Trees and other associated features											
		None	Isol/sc att	Regula r	Occasio nal	Semi-con	Contin ous	Shadi ng	overhangi ng boughts	banksi de roots	under roots	fallen trees	large woody debris
banktop structure 5 m	B	0	3	0	0	1	0	1	0	0	0	1	0
	U	5	27	5	12	13	18	62	43	46	35	47	43
	S	2	23	5	10	14	22	64	46	49	38	50	46
	C	0	2	2	6	9	12	31	28	28	24	28	24
	N V	0	0	1	0	2	1	4	2	2	1	3	3

As in the first and second stage, the matrix of with presence of attributes was built. It determines pairs of attributes according to the 5 % of research sites condition:

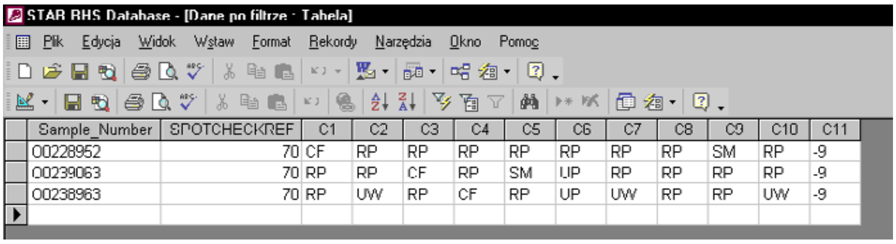
		Trees and other associated features											
		No ne	Isol/sc att	Regul ar	Occasio nal	Semi-con	Contin ous	Shadi ng	overhangi ng boughts	banksi de roots	under roots	fallen trees	large woody debris
banktop structure 5 m	B	0	0	0	0	0	0	0	0	0	0	0	0
	U	1	1	1	1	1	1	1	1	1	1	1	1
	S	0	1	1	1	1	1	1	1	1	1	1	1
	C	0	0	0	1	1	1	1	1	1	1	1	1
	N V	0	0	0	0	0	0	0	0	0	0	0	0

The matrixes presented above were implemented to RHS database as a new table and query objects. In the table above pairs of features with the „0” category are those selected for marking.

The QC procedure for RHS survey may be conducted in two ways, according to requirements. It is possible to analyse whole database to detect particular attribute or set of attributes. In this case module requiring input of the searched variable is used:



In the example above required attribute is extracted by the module procedure according to ten-spot-check filtrating system. The information extracted from the database is presented in further stages of the analysis as presented in the table below. The QC procedure for the whole survey site is undertaken by alternative module. The final effect of work is a table which present marked attributes or their pairs:



Sample_Number	SPOTCHECKREF	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
00228952	70	CF	RP	RP	RP	RP	RP	RP	RP	SM	RP	-9
00239063	70	RP	RP	CF	RP	SM	UP	RP	RP	RP	RP	-9
00238963	70	RP	UW	RP	CF	RP	UP	UW	RP	RP	UW	-9

Modules presented above were developed using Microsoft Visual Basic 6.0. for Access. The QC procedure is fully combined with RHS database. It bases on standard objects of the STAR hyromorphological databases (Queries, Tables and Formulas). Several of existing objects were modified to make it more effective in cooperation with new modules (some new records were added to existing tables, eg. tbl_SPOTCHECK, tbl_SITES).

Conclusions

It was found that only a part of RHS attributes influence quality numerical score and the role of each of them was quantified. Analysis enabled for extracting attributes, which are crucial for the HMS and HQA variability. Results of the Section 4.2 inform about possible problems related with them. To improve the quality of RHS data, more attention should be paid for high scoring attributes in terms of precise definitions, descriptions and attention on training courses.

The created module supports the existing format of the RHS database in the data quality procedures. Developed criteria base still on a small amount of data and more extensive studies across a wider range of river types throughout Europe is required. The created module is accessible for modifications and further development will be undertaken in purpose of optimisation according to requirements.

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Deliverable N4

Appendices

Workpackage number 19:

Errors and variation associated with field protocols for the collection and application of macrophyte and hydro-morphological data

Appendix 1 Staff list

No.	Name	Charakter of work
1.	Krzysztof Szoszkiewicz	coordination, field work (macrophytes, RHS, hydrology), chemistry, analysis
2.	Janina Zbierska	coordination, analysis
3.	Ryszard Staniszewski	coordination, field work (macrophytes, RHS, hydrology), analysis
4.	Dominik Mendyk	macrophytes, field work (macrophytes, RHS, hydrology), data entry, analysis
5.	Jerzy Kupiec	field work (macrophytes, RHS, hydrology), data entry, analysis
6.	Szymon Jusik	field work (macrophytes, RHS, hydrology), data entry, analysis
7.	Tomasz Zgola	field work (macrophytes, RHS, hydrology), analysis
8.	Artur Golis	field work (RHS, hydrology), data entry, analysis
9.	Justyna Urbaniak	chemistry
10.	Sadzide Murat-Blazejewska	analysis (hydrology)
11.	Jolanta Kujawa	analysis (hydrology)
12.	Mariusz Sojka	analysis (hydrology)
13.	Jacek Lesny	field work (hydrology), analysis
14.	Bogdan Chojnicki	analysis
15.	Barbara Bis	STAR coordination in Poland, project design
16.	Joanna Zelazna-Wieczorek	algae identification

Appendix 2 WP survey sites

No	Site Number	River Name	Site Name	Stream system	Eco-region	Region	GPS		WP7
							Latitude	Longitude	
1.	917	Blizna	Szczerba	Szczeberka - Rospuda - Biebrza - Narew - Wisla	16	podlaskie	N 53^{O} 54.456`	E 22^{O} 58.794`	Yes
2.	895	Dobrzyca	Czaple	Gwda - Notec - Warta - Odra	14	zachodniopomorskie	N 53^{O} 16.596`	E 16^{O} 34.125`	Yes
3.	1042	Dojca	Ruchocki Mlym	Obra - Warta - Odra	14	wielkopolskie	N 52^{O} 08.992`	E 16^{O} 07.130`	No
4.	1127	Miloslawka Trib.	Mlodzikowo	Miloslawka – Maskawa – Warta - Odra	14	wielkopolskie	N 52^{O} 08.213`	E 17^{O} 15.256`	No
5.	1045	Flinta	Skrzetusz	Welna - Warta - Odra	14	wielkopolskie	N 52^{O} 51.086`	E 16^{O} 47.861`	No
6.	1125	Gluszynka	Daszewice	Warta - Odra	14	wielkopolskie	N 52^{O} 18.348`	E 16^{O} 57.362`	No
7.	904	Grabia	Jambork	Ner - Warta -Odra	14	lodzkie	N 51^{O} 34.161`	E 19^{O} 15.579`	Yes
8.	1048	Grabiczek	Durlag	Drweca-Wisla	16	warminsko - mazurskie	N 53^{O} 37.591`	E 20^{O} 02.436`	No
9.	1049	Gryzynka	Szklarka Radnicka	Odra	14	lubuskie	N 52^{O} 05.957`	E 15^{O} 16.826`	No
10.	899	Ilanka	Maczkow	Odra	14	lubuskie	N 53^{O} 16.295`	E 14^{O} 45.548`	Yes
11.	1051	Kanal Konczak	Podlesie	Konczak-Warta-Odra	14	wielkopolskie	N 52^{O} 45.029`	E 16^{O} 40.136`	No
12.	898	Korytnica	Jazwiny	Drawa - Notec - Warta - Odra	14	zachodniopomorskie	N 53^{O} 10.012`	E 15^{O} 54.964`	Yes
13.	1053	Krzycki Row	Krzekotowo	Odra	14	dolnoslaskie	N 52^{O} 46.525`	E 17^{O} 59.197`	No
14.	915	Lesna Prawa	Stopily	Bug - Narew - Wisla	16	podlaskie	N 52^{O} 38.849`	E 23^{O} 40.402`	Yes
15.	1139	Lutynia	Jarocin	Warta - Odra	14	wielkopolskie	N 51^{O} 58.418`	E 17^{O} 29.643`	No
16.	913	Lutownia	Stara Bialowieza	Narewka - Narew -Wisla	16	podlaskie	N 52^{O} 44.030`	E 23^{O} 47.117`	Yes
17.	905	Mala Welna	Kiszkowo	Warta - Odra	14	wielkopolskie	N 52^{O} 35.392`	E 17^{O} 16.034`	Yes
18.	902	Meszna	Dziedzice	Wartsa - Odra	14	wielkopolskie	N 52^{O} 14.580`	E 17^{O} 50.638`	Yes
19.	1063	Miala	Pilka	Notec-Warta-Odra	14	wielkopolskie	N 52^{O} 47.402`	E 16^{O} 03.311`	No
20.	908	Mlawka	Szrensk	Wkra - Narew - Wisla	16	mazowieckie	N 53^{O} 00.507`	E 20^{O} 07.668`	Yes
21.	912	Narew	Babia Gora	Wisla	16	podlaskie	N 52^{O} 54.141`	E 23^{O} 53.635`	Yes
22.	914	Narewka	Podolany	Narew - Wisla	16	podlaskie	N 52^{O} 41.358`	E 23^{O} 52.900`	Yes
23.	903	Ner	Lutomiersk	Warta - Odra	14	lodzkie	N 51^{O} 45.286`	E 19^{O} 14.630`	Yes
24.	1068	Notec	Kolonia Mchowek	Warta-Odra	14	wielkopolskie	N 52^{O} 25.547`	E 18^{O} 40.795`	No
25.	1070	Orla	Kuklinow	Barycz - Odra	14	wielkopolskie	N 53^{O} 20.785`	E 18^{O} 03.356`	No
26.	1129	Ostroroga	Biezdrowo	Warta - Odra	14	wielkopolskie	N 52^{O} 41.074`	E 16^{O} 17.507`	No

	Site Number	River Name	Site Name	Stream system	Eco-region	Region	GPS		WP7
27.	894	Pilawa	Szwecja	Gwda - Notec - Warta - Odra	14	wielkopolskie	N 53^{O} 21.261`	E 16^{O} 33.072`	Yes
28.	897	Pliszka	Drzewce	Odra	14	lubuskie	N 52^{O} 13.857`	E 15^{O} 05.857`	Yes
29.	910	Ploska	Krolowy Most	Suprasl - Narew - Wisla	16	podlaskie	N 53^{O} 08.110`	E 23^{O} 28.080`	Yes
30.	896	Plytnica	Plytnica	Gwda - Notec - Warta - Odra	14	wielkopolskie	N 53^{O}20.125`	E16^{O} 45.805`	Yes
31.	1074	Rakowka	Nowy Sumin	Stazka-Brda-Wisla	14	kujawsko - pomorskie	N 53^{O} 35.339`	E 17^{O} 58.357`	No
32.	1076	Rgilewka	Grzegorzew	Warta - Odra	14	wielkopolskie	N 52^{O} 12.084`	E 18^{O} 43.527`	No
33.	916	Rozpuda	Jozefowo	Biebrza - Narew	16	podlaskie	N 53^{O} 56.299`	E 22^{O} 54.231`	Yes
34.	1135	Row Wyskoc	Wyskoc	Warta - Odra	14	wielkopolskie	N 52^{O} 04.143`	E 16^{O} 47.285`	No
35.	1080	Ruda	Rudzki Mlyn	Brda-Wisla	14	kujawsko - pomorskie	N 53^{O} 33.093`	E 17^{O} 54.212`	No
36.	1082	Rurzyca	Krepsko	Rurzyca - Gwda - Notec - Warta - Odra	14	wielkopolskie	N 52^{O} 20.276`	E 16^{O} 48.053`	No
37.	1084	Sama	Obrzycko	Warta-Odra	14	wielkopolskie	N 52^{O} 41.963`	E 16^{O} 32.640`	No
38.	900	S.Steszewska	Kraplewo	Warta - Odra	14	wielkopolskie	N 52^{O} 17.419`	E 16^{O} 41.127`	Yes
39.	501	Skarlanka	Otreba	Drweca-Wisla	16	kujawsko - pomorskie	N 53^{O} 25.435`	E 19^{O} 24.461`	No
40.	909	Sokolda	Podkamionka	Suprasl - Narew - Narew	16	podlaskie	N 53^{O} 19.989`	E 23^{O} 23.162`	Yes
41.	1088	Stopica	Huta Szklana	Stopica - Drawa - Notec - Warta - Odra	14	wielkopolskie	N 52^{O} 53.501`	E 15^{O} 59.558`	No
42.	901	Struga Bawol	Katy	Warta - Odra	14	wielkopolskie	N 52^{O} 14.385`	E 17^{O} 49.913`	Yes
43.	911	Suprasl	Walily Stacja	Narew - Wisla	16	podlaskie	N 53^{O} 06.503`	E 23^{O} 40.480`	Yes
44.	907	Slina	Zawady	Narew - Wisla	16	podlaskie	N 53^{O} 09.240`	E 22^{O} 40.312`	Yes
45.	906	Wieprza	Gradki Dolne	Morze Baltyckie	14	pomorskie	N 54^{O} 08.574`	E 17^{O} 02.478`	Yes
46.	1133	Wirynka	Komorniki	Warta - Odra	14	wielkopolskie	N 52^{O} 20.270`	E 16^{O} 48.083`	No
47.	1096	Wolczenica	Swietoszkowo	Dzwina	14	zachodniopomorskie	N 53^{O} 45.625`	E 14^{O} 54.469`	No
48.	918	Wolkuszanka	Wolkusz	Czarna Hancza - Niemen	16	podlaskie	N 53^{O} 48.405`	E 23^{O} 30.824`	Yes
49.	1098	Zimna Woda		Odra	14	lubuskie	N 52^{O} 01,484`	E 15^{O} 31,185`	No

Appendix 3 WP19 sites – list of rivers with the extent of work undertaken

No	Site Number	River Name	Site Name	RHS, MTR & Chemistry				Additional hydrology
				Inter-surveyor sampling	Temporal variability sampling	Modifications impact	Shade impact	
1.	917	Blizna	Szczerba	1	1	0	0	1
2.	895	Dobrzyca	Czaple	1	1	0	0	1
3.	1042	Dojca	Ruchocki Mlym	0	0	1	1	0
4.	1127	Miloslawka Trib.	Mlodzikowo	0	0	0	1	0
5.	1045	Flinta	Skrzetusz	0	0	1	2	0
6.	1125	Gluszynka	Daszewice	0	0	0	1	0
7.	904	Grabia	Jambork	1	1	0	0	1
8.	1048	Grabiczek	Durlag	1	1	1	0	0
9.	1049	Gryzynka	Szklarka Radnicka	0	0	0	1	0
10.	899	Ilanka	Maczkow	1	1	0	0	1
11.	1051	Kan.Konczak	Podlesie	0	0	0	1	0
12.	898	Korytnica	Jazwiny	1	1	1	0	1
13.	1053	Krzycki Row	Krzekotowo	0	0	0	1	0
14.	915	Lesna Prawa	Stopily	0	1	0	0	0
15.	1139	Lutynia	Jarocin	0	0	0	1	0
16.	913	Lutownia	Stara Bialowieza	1	1	0	0	1
17.	905	Mala Welna	Kiszkowo	1	1	1	0	1
18.	902	Meszna	Dziedzice	1	1	0	1	1
19.	1063	Miala	Pilka	0	0	1	1	0
20.	908	Mlawka	Szrensk	1	1	0	0	1
21.	912	Narew	Babia Gora	1	1	0	0	1
22.	914	Narewka	Podolany	1	1	0	0	1
23.	903	Ner	Lutomiersk	1	1	0	0	1
24.	1068	Notec	Kolonia Mchowek	0	0	1	0	0
25.	1070	Orla	Kuklinow	0	0	0	1	0
26.	1129	Ostroroga	Biezdrowo	0	0	1	1	0
27.	894	Pilawa	Szwecja	1	1	1	1	0
28.	897	Pliszka	Drzewce	1	1	1	1	0
29.	910	Ploska	Krolowy Most	1	1	0	0	1
30.	896	Plytnica	Plytnica	1	1	0	0	1
31.	1074	Rakowka	Nowy Sumin	0	0	0	1	1
32.	1076	Rgilewka	Grzegorzew	0	0	1	0	0
33.	916	Rozpuda	Jozefowo	1	1	0	0	0
34.	1135	Row Wyskoc	Wyskoc	0	0	1	1	0
35.	1080	Ruda	Rudzki Mlyn	0	0	0	1	1
36.	1082	Rurzyca		0	0	1	0	0
37.	1084	Sama	Obrzycko	0	0	0	1	0
38.	900	S.Steszewska	Kraplewo	1	1	0	1	1
39.	501	Skarlanka	Otreba	1	0	0	0	0
40.	909	Sokolda	Podkamionka	1	1	0	0	1
41.	1088	Stopica	Huta Szklana	0	0	0	1	0
42.	901	Struga Bawol	Katy	1	1	2	0	1
43.	911	Suprasl	Walily Stacja	1	1	0	0	1
44.	907	Slina	Zawady	1	1	0	0	1
45.	906	Wieprza	Gradki Dolne	1	1	0	0	0
46.	1133	Wirynka	Komorniki	0	0	1	0	0
47.	1096	Wolczenica	Swietoszkowo	0	0	0	1	0
48.	918	Wolkuszanka	Wolkusz	1	1	0	0	0
49.	1098	Zimna Woda		0	0	0	1	0
			Σ	**26**	**26**	**16**	**23**	**21**

Appendix 4 Survey sites – description of catchments area and the floodplain

A) Catchment area

Stream name	Catchment area	Geology/ dominant	Geology in the catchment [%]					Land use in the catchment [%]								
			Peat	Alluvial	Terrestial (sander)	Terrestial (moraines)	Loess	Native forest conif.	Native forest decid.	Native forest mixed	Non-native forest	Wet-lands	Crop land arable	Pas-teure	Urban sites and other	Standing waters
Blizna	116.7	siliceous	0.5	2.3	57.9	39.3	0.0	10.7	40.6	5.7	25.0	1.2	12.3	0.7	0.8	3.0
Dobrzyca	882.5	siliceous	3.0	1.4	63.1	28.5	0.0	9.7	5.0	3.4	27.0	0.5	42.0	1.4	7.0	4.0
Grabia	328.8	siliceous	1.0	12.3	13.4	73.0	0.0	0.0	0.0	2.3	14.9	0.1	79.1	2.0	1.3	0.3
Grabiczek	112.0	siliceous	4.5	0.0	21.1	74.4	0.0	0.0	1.0	2.0	14.0	0.7	75	1.0	5.3	1.0
Gryzynka	74.5	siliceous	5.3	0.4	78.7	15.6	0.0	0.0	0.0	2.0	78.0	0.4	5	10.0	3.8	0.8
Ilanka	357.3	siliceous	3.9	9.0	68.8	17.2	0.0	2.9	25.0	0.5	40.0	0.9	21.4	2.0	6.2	1.1
Kanal Konczak	182.8	siliceous	13.5	10.2	35.5	30.8	0.0	0.0	0.0	0.0	25.0	0.3	60	7.0	7.7	0.0
Korytnica	212.0	siliceous	4.0	3.3	52.7	38.2	0.0	1.5	27.0	0.1	50.5	0.4	7.8	4.3	6.6	1.8
Lesna Prawa	222.4	organic/ siliceous	4.9	11.6	15.0	68.5	0.0	29.3	5.0	12.1	5.0	7.6	29.9	4.9	5.2	1.0
Lutownia	119.5	organic	1.5	8.5	23.8	66.2	0.0	63.1	2.5	23.6	5.0	0.0	4.3	0.7	0.8	0.0
Mala Welna	342.0	siliceous	6.4	2.4	26.9	62.0	0.0	0.0	0.0	0.4	5.6	0.8	75.9	7.2	7.8	2.3
Meszna	248.1	siliceous	5.2	5.2	77.7	6.2	0.0	2.2	0.0	0.8	13.4	0.4	64.7	2.8	10.1	5.6
Miala	182.2	siliceous	2.2	2.2	95.6	0.0	0.0	0.0	2.0	2.0	86.0	0.3	5	1.0	2.0	1.7
Mlawka	622.0	siliceous	16.2	4.4	62.3	16.6	0.0	0.0	0.0	2.0	14.1	1.5	53	15.1	14.9	0.4
Narew	608.0	organic	35.0	17.0	24.0	24.0	0.0	27.3	3.1	3.8	7.1	6.3	25	27.4	0.0	0.0
Narewka	230.6	organic	15.0	0.0	85.0	0.0	0.0	28.7	46.9	5.5	5.0	0.8	10	2.7	0.4	0.0
Ner	459.3	siliceous	8.7	3.8	15.5	71.9	0.0	0.0	0.0	0.0	7.7	0.0	14.7	1.8	75.7	0.1
Notec	174.9	siliceous	5.3	3.8	30.1	60.8	0.0	0.0	0.0	0.0	10.0	2.0	70	0.0	16.0	2.0
Pilawa	392.3	siliceous	5.3	3.2	32.9	53.3	0.0	1.6	20.0	2.9	45.2	5.0	13.7	2.0	4.3	5.3

Stream name	Catchment area	Geology/ dominant	Geology in the catchment [%]					Land use in the catchment [%]								
			Peat	Alluvial	Terrestial (sander)	Terrestial (moraines)	Loess	Native forest conif.	Native forest decid.	Native forest mixed	Non-native forest	Wet-lands	Crop land arable	Pas-teure	Urban sites and other	Standing waters
Pliszka	241.8	siliceous	1.4	3.7	77.0	16.3	0.0	7.3	20.0	1.0	48.0	1.0	14.2	2.6	4.3	1.6
Ploska	189.2	organic	2.0	9.4	55.4	33.2	0.0	16.5	25.7	0.0	30.0	0.2	16.4	8.1	2.6	0.1
Plytnica	277.4	siliceous	3.9	4.5	57.6	32.0	0.0	5.0	20.3	1.0	41.0	1.4	18.6	4.4	6.3	2.0
Rakowka	53.8	siliceous	1.5	3.0	88.9	6.7	0.0	2.0	0.0	2.0	70.0	0.4	15.0	5.0	4.6	1.0
Rospuda	353.5	organic	5.0	8.4	11.6	75.0	0.0	3.9	10.2	1.3	6.6	0.7	71.1	2.5	1.1	2.6
Ruda	101.2	siliceous	2.4	4.0	86.9	6.7	0.0	5.0	2.0	4.0	69.0	0.7	10.0	3.0	5.3	1.0
Sama	446.8	siliceous	8.8	16.3	19.1	55.8	0.0	0.0	0.0	0.0	13.0	0.0	75.0	2.0	9.0	1.0
S.Steszewska	108.54	siliceous	8.1	1.5	30.8	56.7	0.0	2.3	0.0	0.7	9.3	0.9	68.7	5.4	9.8	2.9
Skarlanka	50.3	siliceous	3.6	0.0	27.0	69.4	0.0	0.0	0.0	3.2	30.0	0.0	52.0	0.0	2.5	5.2
Sokolda	205.9	organic	11.2	9.6	26.3	52.9	0.0	17.6	3.6	0.9	10.7	0.5	49.6	13.8	3.1	0.2
Struga Bawol	424.4	siliceous	3.0	6.0	49.8	41.2	0.0	0.7	0.0	0.5	4.5	0.0	80.8	3.7	9.8	0.1
Suprasl	222.1	organic	39.0	1.4	42.4	17.2	0.0	2.8	20.0	0.0	23.1	1.5	16.3	32.7	3.5	0.0
Slina	306.9	organic	1.4	13.3	8.0	77.3	0.0	2.0	7.3	4.0	13.7	0.5	66.6	3.5	2.3	0.0
Wieprza	125.0	siliceous	0.0	12.9	69.5	15.0	0.0	6.0	0.0	1.0	27.2	0.8	51.3	4.0	7.1	2.6
Wolczenica	184.9	siliceous	11.2	4.8	28.1	55.9	0.0	0.0	0.0	3.0	35.0	1.6	45.0	9.0	5.7	0.7
Wolkuszanka	105.2	organic/ siliceous	21.4	0.0	56.3	22.3	0.0	22.4	33.0	7.0	7.2	5.2	17.5	7.1	0.6	0.0

B) Floodplain and hydrology

Stream name	Altitude of sampling site	Slope of valey floor RHS [%]	Land use in floodplain [%]							Strahler system	Distance to source	Mean annual discharge [MQ l/s]	Presence of lakes upstream
			Forets	Pasture	Wetlands	Scrub and herbs	Crop land	Standing water	Urban sites and other				
Blizna	140	0.05	5	95	0	0	0	0	0	3	14.2	460	yes
Dobrzyca	100	0.10	78	0	22	0	0	0	0	4	51.1	5145	yes
Grabia	175	0.07	8	73	20	0	0	0	0	4	37.5	2150	no
Grabiczek	112	0.10	10	80	0	0	7	0	5	4	19.0	980	yes
Gryzynka	45	0.20	83	0	5	0	5	5	2	2	10.5	410	yes
Ilanka	40	0.05	100	0	0	0	0	0	0	3	40.6	1797	no
Kanal Konczak	62	0.08	86	15	0	0	0	0	0	4	15.5	440	no
Korytnica	80	0.12	75	0	25	0	0	0	0	3	31.5	954	yes
Lesna Prawa	160	0.02	40	0	60	0	0	0	0	3	19.0	1390	no
Lutownia	165	0.03	75	0	25	0	0	0	0	2	16.0	720	no
Mala Welna	115	0.04	0	64	0	8	22	2	4	3	44.7	739	yes
Meszna	85	0.10	0	70	0	30	0	0	0	4	33.0	749	yes
Miala	41	0.05	0	85	0	15	0	0	0	2	36.5	850	yes
Mlawka	110	0.04	8	86	0	5	0	0	1	3	34.8	3650	yes
Narew	155	0.06	0	100	0	0	0	0	0	3	40.3	3170	yes
Narewka	150	0.04	0	100	0	0	0	0	0	3	23.3	1380	no
Ner	180	0.09	0	81	0	2	15	0	2	4	34.5	2310	yes
Notec	99	0.05	0	40	40	0	18	2	0	3	33.0	530	yes
Pilawa	110	0.13	70	0	20	10	10	0	0	4	47.5	3268	yes
Pliszka	90	0.20	60	0	0	0	0	0	0	3	14.6	684	yes
Ploska	145	0.08	4	96	0	0	0	0	0	2	20.0	945	no
Plytnica	88	0.17	70	0	15	15	0	0	0	4	53.5	1401	no
Rakowka	101	0.05	50	50	0	0	0	0	0	2	13.0	400	yes

Stream name	Altitude of sampling site	Slope of valey floor RHS [%]	Land use in floodplain [%]							Strahler system	Distance to source	Mean annual discharge [MQ l/s]	Presence of lakes upstream
			Forets	Pasture	Wetlands	Scrub and herbs	Crop land	Standing water	Urban sites and other				
Rospuda	140	0.15	82	0	18	0	0	0	0	3	48.0	3220	yes
Ruda	87	0.10	1	97	0	0	0	0	2	2	17.0	610	yes
Sama	47	0.16	40	30	0	30	0	0	0	4	41.9	1150	yes
S.Steszewska	85	0.03	0	99	0	0	0	0	1	2	23.4	344	yes
Skarlanka	84	0.25	100	0	0	0	0	0	0	2	12.0	310	yes
Sokolda	180	0.07	0	100	0	0	0	0	0	3	25.0	1060	no
Struga Bawol	85	0.10	0	48	0	17	35	0	0	4	32.5	654	no
Suprasl	155	0.04	18	83	0	0	0	0	0	2	26.5	1160	no
Slina	115	0.08	0	100	0	0	0	0	0	3	29.5	1290	no
Wieprza	73	0.50	96	2	0	2	0	0	0	3	18.5	485	yes
Wolczenica	185	0.10	8	6	0	0	60	12	14	2	16.5	610	no
Wolkuszanka	120	0.09	3	98	0	0	0	0	0	4	15.5	1090	no

Appendix 5 First level of criteria for RHS quality control procedures

(Description and explanation: Section 4.4.)

Attribute	Feature	Number of records per features in the regions				Number of records per region				Share of feature [%]				Features absent in all regions	Features present in all regions
		Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alnpie		
Flow type	NV	1	6	0	2					0.33	1.75	0.00	2.02	X	
	FF	0	4	5	3					0.00	1.17	2.65	3.03	X	
	CH	3	19	21	15					1.00	5.54	11.11	15.15		
	BW	7	30	16	15					2.33	8.75	8.47	15.15		
	UW	27	62	21	19					9.00	18.08	11.11	19.19		X
	RP	111	94	44	25	300	343	189	99	37.00	27.41	23.28	25.25		X
	SM	120	84	39	7					40.00	24.49	20.63	7.07		X
	NP	29	18	42	2					9.67	5.25	22.22	2.02		
	UP	2	8	0	3					0.67	2.33	0.00	3.03	X	
	CF	0	18	1	8					0.00	5.25	0.53	8.08		
	DR	0	0	0	0					0.00	0.00	0.00	0.00	X	
Channel substrate	AR	26	21	6	4					7.05	6.56	3.19	4.04		
	NV	8	12	18	7					2.17	3.75	9.57	7.07		
	BE	26	36	29	19					7.05	11.25	15.43	19.19		X
	BO	61	76	49	23					16.53	23.75	26.06	23.23		X
	CO	40	64	34	19					10.84	20.00	18.09	19.19		X
	GP(P)	45	42	13	15	369	320	188	99	12.20	13.13	6.91	15.15		X
	GP(G)	99	33	21	3					26.83	10.31	11.17	3.03		
	SA	41	21	5	1					11.11	6.56	2.66	1.01		
	SI	17	3	1	0					4.61	0.94	0.53	0.00	X	
	CL	3	2	9	0					0.81	0.63	4.79	0.00	X	
	PE	0	0	0	0					0.00	0.00	0.00	0.00	X	
	EA	3	10	3	8					0.81	3.13	1.60	8.08		
Channel modifications	NK	11	5	1	3					6.08	3.45	1.79	6.38		
	NO	128	92	48	22					70.72	63.45	85.71	46.81		X
	CV	0	0	0	2					0.00	0.00	0.00	4.26	X	
	RS	25	24	1	7	181	145	56	47	13.81	16.55	1.79	14.89		
	RI	8	21	4	6					4.42	14.48	7.14	12.77		
	DA	9	3	2	7					4.97	2.07	3.57	14.89		
	FO	0	0	0	0					0.00	0.00	0.00	0.00	X	

Attribute	Feature	Number of records per features in the regions				Number of records per region				Share of feature [%]				Features absent in all regions	Features present in all regions
		Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alnpie		
Channel features	NV	2	4	0	2					1.05	2.61	0.00	3.92	X	
	NO	148	102	45	24					77.49	66.67	53.57	47.06		X
	EB	2	4	4	11					1.05	2.61	4.76	21.57		
	RO	0	1	9	0					0.00	0.65	10.71	0.00		
	VR	0	0	0	0	191	153	84	51	0.00	0.00	0.00	0.00	X	
	MB	9	20	5	8					4.71	13.07	5.95	15.69		
	VB	15	14	15	6					7.85	9.15	17.86	11.76		X
	MI	13	8	4	0					6.81	5.23	4.76	0.00		
	TR	2	0	2	0					1.05	0.00	2.38	0.00	X	
Channel material	NV	12	29	2	5					2.63	5.69	0.70	2.76		
	BE	12	26	34	14					2.63	5.10	11.97	7.73		
	BO	38	60	41	37					8.33	11.76	14.44	20.44		X
	CO	22	50	58	18					4.82	9.80	20.42	9.94		
	GS	39	56	38	16					8.55	10.98	13.38	8.84		X
	EA	276	185	80	32					60.53	36.27	28.17	17.68		X
	PE	24	9	11	0					5.26	1.76	3.87	0.00		
	CL	5	12	1	0					1.10	2.35	0.35	0.00	X	
	CC	11	31	7	14	456	510	284	181	2.41	6.08	2.46	7.73		
	SP	0	1	0	2					0.00	0.20	0.00	1.10	X	
	WP	0	5	0	4					0.00	0.98	0.00	2.21	X	
	GA	0	2	2	0					0.00	0.39	0.70	0.00	X	
	BR	14	37	9	22					3.07	7.25	3.17	12.15		
	RR	3	7	1	17					0.66	1.37	0.35	9.39		
	TD	0	0	0	0					0.00	0.00	0.00	0.00	X	
	FA	0	0	0	0					0.00	0.00	0.00	0.00	X	
	BL	0	0	0	0					0.00	0.00	0.00	0.00	X	
Bank modifications	NK	19	18	0	5					4.10	4.96	0.00	4.07	X	
	NO	252	176	80	39					54.43	48.48	68.97	31.71		X
	RS	75	45	9	29					16.20	12.40	7.76	23.58		X
	RI	76	93	16	43	463	363	116	123	16.41	25.62	13.79	34.96		X
	PC	27	9	6	4					5.83	2.48	5.17	3.25		
	BM	2	0	4	0					0.43	0.00	3.45	0.00	X	
	EM	12	22	1	3					2.59	6.06	0.86	2.44		

Attribute	Feature	Number of records per features in the regions				Number of records per region				Share of feature [%]				Features absent in all regions	Features present in all regions
		Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alnpie		
Margianl and bank features	NV	7	15	1	4					1.24	2.45	0.41	3.54	X	
	NO	295	191	80	56					52.30	31.26	33.20	49.56		X
	EC	55	100	27	6					9.75	16.37	11.20	5.31		X
	S.C.	52	69	26	7					9.22	11.29	10.79	6.19		X
	PB	36	36	19	8	564	611	241	113	6.38	5.89	7.88	7.08		X
	VP	14	28	20	1					2.48	4.58	8.30	0.88		
	SB	59	115	34	25					10.46	18.82	14.11	22.12		X
	VS	37	57	34	6					6.56	9.33	14.11	5.31		X
	NB	9	0	0	0					1.60	0.00	0.00	0.00	X	
Land use (5 m)	BL	0	2	20	0					0.00	0.63	16.67	0.00		
	BP	0	0	0	0					0.00	0.00	0.00	0.00	X	
	CW	0	0	0	0					0.00	0.00	0.00	0.00	X	
	CP	0	0	0	0					0.00	0.00	0.00	0.00	X	
	SH	0	0	0	0					0.00	0.00	0.00	0.00	X	
	OR	1	8	6	0					0.23	2.52	5.00	0.00		
	WL	40	3	2	2					9.20	0.94	1.67	2.44		
	MH	5	9	4	0					1.15	2.83	3.33	0.00	X	
	AW	0	0	0	0					0.00	0.00	0.00	0.00	X	
	OW	0	0	0	0	435	318	120	82	0.00	0.00	0.00	0.00	X	
	RP	73	18	10	6					16.78	5.66	8.33	7.32		X
	IG	93	81	6	19					21.38	25.47	5.00	23.17		X
	TH	141	77	44	4					32.41	24.21	36.67	4.88		
	RD	0	0	0	0					0.00	0.00	0.00	0.00	X	
	SU	45	87	22	38					10.34	27.36	18.33	46.34		X
	TL	27	26	6	4					6.21	8.18	5.00	4.88		
	IL	0	1	0	0					0.00	0.31	0.00	0.00	X	
	PG	10	6	0	9					2.30	1.89	0.00	10.98		
	NV	0	0	0	0					0.00	0.00	0.00	0.00	X	
Banktop structure	B	89	125	30	25					14.04	22.05	15.31	17.12		X
	U	218	162	53	34					34.38	28.57	27.04	23.29		X
	S	250	189	72	51	634	567	196	146	39.43	33.33	36.73	34.93		X
	C	72	80	41	36					11.36	14.11	20.92	24.66		X
	NV	5	11	0	0					0.79	1.94	0.00	0.00	X	

Attribute	Feature	Number of records per features in the regions				Number of records per region				Share of feature [%]				Features absent in all regions	Features present in all regions
		Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alnpie		
Bankface structure	B	89	125	40	25	634	569	210	146	14.04	21.97	19.05	17.12		X
	U	218	163	54	34					34.38	28.65	25.71	23.29		X
	S	250	190	74	51					39.43	33.39	35.24	34.93		X
	C	72	80	42	36					11.36	14.06	20.00	24.66		X
	NV	5	11	0	0					0.79	1.93	0.00	0.00	X	
Vegetation	Amphibious	90	15	3	0	858	242	94	66	10.49	6.20	3.19	0.00		
	Emergent broad lived	86	10	5	1					10.02	4.13	5.32	1.52		
	Emergent reeds	119	6	12	3					13.87	2.48	12.77	4.55		
	Filamentous algae	73	50	22	17					8.51	20.66	23.40	25.76		X
	Floating leaved	58	1	2	0					6.76	0.41	2.13	0.00		
	Free floating	54	1	2	0					6.29	0.41	2.13	0.00		
	Liveworts	81	64	15	25					9.44	26.45	15.96	37.88		X
	None	58	72	24	20					6.76	29.75	25.53	30.30		X
	Submerged broad leaved	85	10	2	0					9.91	4.13	2.13	0.00		
	Submerged fine leaved	60	6	7	0					6.99	2.48	7.45	0.00		
	Submerged linear lived	94	7	0	0					10.96	2.89	0.00	0.00		
Trees and other associated features	None	11	3	1	0	787	574	229	152	1.40	0.52	0.44	0.00	X	
	Isol/scatt	19	10	5	2					2.41	1.74	2.18	1.32	X	
	Regular	4	6	2	2					0.51	1.05	0.87	1.32	X	
	Occasional	17	21	5	1					2.16	3.66	2.18	0.66	X	
	Semi-con	49	29	11	13					6.23	5.05	4.80	8.55		
	Continous	49	34	17	10					6.23	5.92	7.42	6.58		X
	Shading	129	98	34	26					16.39	17.07	14.85	17.11		X
	overhanging boughts	111	83	28	24					14.10	14.46	12.23	15.79		X
	bankside roots	104	83	34	22					13.21	14.46	14.85	14.47		X
	under roots	100	79	37	17					12.71	13.76	16.16	11.18		X
	fallen trees	94	66	27	15					11.94	11.50	11.79	9.87		X
	large woody debris	100	62	28	20					12.71	10.80	12.23	13.16		X

Attribute	Feature	Number of records per features in the regions				Number of records per region				Share of feature [%]				Features absent in all regions	Features present in all regions
		Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alnpie		
Land-use 50 m (sweep-up)	Broadleaf/mixed woodland (97 form)	42	70	0	17	1067	754	416	194	3.94	9.28	0.00	8.76		
	Broadleaf/mixed woodland (seminatural)	165	92	73	28					15.46	12.20	17.55	14.43		X
	Broadleaf/mixed plantation	17	7	5	6					1.59	0.93	1.20	3.09	X	
	Coniferous woodland (semi-natural)	31	3	9	0					2.91	0.40	2.16	0.00	X	
	Coniferous plantation	32	35	5	4					3.00	4.64	1.20	2.06	X	
	Scrub & Shrub	132	90	68	21					12.37	11.94	16.35	10.82		X
	Orchard	8	9	12	0					0.75	1.19	2.88	0.00	X	
	Wetland (eg bog. marsh. fen)	60	9	2	2					5.62	1.19	0.48	1.03		
	Moorland/heath	8	20	33	0					0.75	2.65	7.93	0.00		
	Open water	5	14	0	7					0.47	1.86	0.00	3.61	X	
	Artificial open water	7	2	0	0					0.66	0.27	0.00	0.00	X	
	Natural open water	8	2	6	0					0.75	0.27	1.44	0.00	X	
	Rough/unimproved grassland/pasture	104	32	39	10					9.75	4.24	9.38	5.15		
	Improved/semi-improved grass	118	88	26	14					11.06	11.67	6.25	7.22		X
	Tall herbs/rank vegetation	194	122	68	19					18.18	16.18	16.35	9.79		X
	Rock. scree & sand dunes	8	14	12	10					0.75	1.86	2.88	5.15		
	Suburban/urban development	51	92	35	37					4.78	12.20	8.41	19.07		
	Tilled land	49	31	23	4					4.59	4.11	5.53	2.06		
	Irrigated land	8	5	0	0					0.75	0.66	0.00	0.00	X	
	Parkland & Gardens	20	8	0	13					1.87	1.06	0.00	6.70		
	Not visible	0	9	0	2					0.00	1.19	0.00	1.03	X	

Attribute	Feature	Number of records per features in the regions				Number of records per region				Share of feature [%]				Features absent in all regions	Features present in all regions
		Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alnpie		
Bank profiles (sweep-up)	Vertical/undercut	201	151	63	41					21.68	21.00	20.66	20.92		X
	Vertical plus toe	123	80	51	15					13.27	11.13	16.72	7.65		X
	Steep (>45)	214	125	51	24					23.09	17.39	16.72	12.24		X
	Gentle	108	82	37	21					11.65	11.40	12.13	10.71		X
	Composite	23	26	26	13					2.48	3.62	8.52	6.63		
	Natural berm	11	6	12	0					1.19	0.83	3.93	0.00	X	
	Resectioned (reprofiled)	79	43	8	23					8.52	5.98	2.62	11.73		
	Reinforced - whole bank	52	70	30	40	927	719	305	196	5.61	9.74	9.84	20.41		X
	Reinforced - top only	2	11	4	2					0.22	1.53	1.31	1.02	X	
	Reinforced - toe only	52	48	4	10					5.61	6.68	1.31	5.10		
	Artificial two-stage	1	1	4	0					0.11	0.14	1.31	0.00	X	
	Poached	46	24	10	0					4.96	3.34	3.28	0.00	X	
	Embanked	12	27	0	6					1.29	3.76	0.00	3.06	X	
	Set-back embankments	3	25	5	1					0.32	3.48	1.64	0.51	X	
Extent of channel and bank features	Free fall flow (waterfalls)	5	14	8	6	1130	1016	554	258	0.44	1.38	1.44	2.33	X	
	Chute flow (cascades)	17	46	21	20					1.50	4.53	3.79	7.75		
	Broken standing waves (rapids)	20	55	22	25					1.77	5.41	3.97	9.69		
	Unbroken standing waves (riffles)	62	89	36	24					5.49	8.76	6.50	9.30		X
	Rippled flow (runs)	118	94	37	27					10.44	9.25	6.68	10.47		X
	Upwelling(boils)	23	33	5	11					2.04	3.25	0.90	4.26	X	
	Smooth flow (glides)	130	90	38	15					11.50	8.86	6.86	5.81		X
	No perceptible flow (pools)	61	59	35	3					5.40	5.81	6.32	1.16		
	Ponded reach(es)	2	3	0	0					0.18	0.30	0.00	0.00	X	
	No flow (dry)	5	1	11	0					0.44	0.10	1.99	0.00	X	
	Marginal deadwater	66	50	29	7					5.84	4.92	5.23	2.71		
	Eroding cliff	55	34	25	4					4.87	3.35	4.51	1.55	X	
	Stable cliff	42	23	26	2					3.72	2.26	4.69	0.78	X	

Attribute	Feature	Number of records per features in the regions				Number of records per region				Share of feature [%]				Features absent in all regions	Features present in all regions
		Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alpine	Lowland	Mountine	South-European	Alnpie		
Extent of channel and bank features	Vegetated bedrock/boulders	20	10	16	0					1.77	0.98	2.89	0.00	X	
	Exposed boulders	66	69	37	26					5.84	6.79	6.68	10.08		X
	Exposed bedrock	18	25	24	12					1.59	2.46	4.33	4.65	X	
	Unvegetated mid-channel bar(s)	37	34	8	10					3.27	3.35	1.44	3.88	X	
	Vegetated mid-channel bar(s)	33	23	15	5					2.92	2.26	2.71	1.94	X	
	Mature island(s)	23	11	5	1					2.04	1.08	0.90	0.39	X	
	Unvegetated side bar(s)	73	74	30	20	1130	1016	554	258	6.46	7.28	5.42	7.75		X
	Vegetated side bar(s)	64	48	28	8					5.66	4.72	5.05	3.10		
	Unvegetated point bar(s)	58	27	32	4					5.13	2.66	5.78	1.55		
	Vegetated point bar(s)	34	19	26	0					3.01	1.87	4.69	0.00	X	
	Unvegetated silt deposit(s)	25	38	13	9					2.21	3.74	2.35	3.49		
	Discrete unvegetated sand deposit(s)	50	42	27	11					4.42	4.13	4.87	4.26	X	
	Discrete unvegetated gravel deposit(s)	23	5	0	8					2.04	0.49	0.00	3.10	X	
Riffles. pools. point bars	Riffles	348	808	229	464					37.99	56.27	35.34	76.95		X
	Pools	272	437	191	91	916	1436	648	603	29.69	30.43	29.48	15.09		X
	Unvegetated p b	189	112	119	40					20.63	7.80	18.36	6.63		X
	Vegetated p b	107	79	109	8					11.68	5.50	16.82	1.33		

Appendix 6 Training Workshop

Title: River morphology assessment (RHS) and macrophytes as bioindicators (MTR)

Date: 31st of May – 9th of June 2003

Organisers:

1. August Cieszkowski Agricultural University in Poznan (ACAU)
2. University of Lodz

Program:

The aim of workshop was to ensure high quality of river habitat and macrophyte surveys in Poland and other countries. Theoretical and practical aspects of both surveys were presented by the following experts:

Lecturers:

Nigel Holmes - Alconbury Environmental Consultants. UK (MTR)
Paul Raven - Environment Agency. UK (introduction to RHS)
Peter Scarlett - CEH. UK (RHS)
Duncan Hornby - CEH. UK (RHS)

List of participants

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1.	Janina Zbierska	Agricultural University in Poznan. Poland
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4.	Jerzy Kupiec	Agricultural University in Poznan. Poland
5.	Dominik Mendyk	Agricultural University in Poznan. Poland
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7.	Tomasz Zgola	Agricultural University in Poznan. Poland
8.	Klaudia Borowiak	Agricultural University in Poznan. Poland
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10.	Maria Golis	Agricultural University in Poznan. Poland
11.	Barbara Bis	University of Lodz. Poland
12.	Marek Jakubowski	University of Lodz. Poland
13.	Patrycja Jozefowicz	University of Lodz. Poland
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17.	Joanna Zurawska	Wojewodzki Inspektorat Ochrony Srodowiska. Szczecin. Poland
18.	Artur Golis	University of Gdansk Dep. of Plant Taxonomy and Nature Conservation. Poland
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24.	Peter Chynoradsky	Slovak Institute of Hydrometeorology. Slovakia
25.	Agrita Briede	University of Latvia. Riga. Latvia
26.	Andris Urtans	University of Latvia. Riga. Latvia