Joint Danube Survey

12. August – 29. September 2007

MACROPHYTES

JDS 2 – FINAL REPORT

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Cover picture: *Potamogeton nodosus,* Gabcikovo-Reservoir (© B. Schmidt, 2007)

1 MACROPHYTES

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1.1 INTRODUCTION

The European Water Framework Directive describes “macrophytes” as one of the four obligatory groups of aquatic organisms to survey for the assessment of the ecological status of surface waters. Therefore macrophytes are part of the assessment of water quality of the Danube River. The first survey, JDS 1, was conducted in 2001. Experiences made on necessary resources, sampling sites, methodology, organisation etc were integrated in JDS 2, which was carried out between August 12 and September 28, 2007. The present repetition of this large data collecting activity in different disciplines related to the environment “Danube” produces a scientific knowledge base which allows for describing changes in a Large River. Results on national level and on smaller reaches of the river can support the prediction of future changes. Expert judgement in combination with an analysis of different databases on macrophytes installed by our working group at the Department of Freshwater Ecology enabled us to derive reference conditions and the ecological status for the different reaches of the Danube River.

The Danube ranges as number 40 in the list of the “Large Rivers of the World” and with respect to the numerous data collected over the whole length of the river it is one of the best studied in the world.

The first third of the river length, the “Rhithron” (885 km, from the source to downstream Vienna) is characterised by a high gradient (mean: 0.43 ‰, max. 1.38 ‰) and related high flow velocities. Bank protection and rip-rap stabilise the river course and protect settlements and urban areas. Numerous hydro-electric power plants make use of the steep gradient.

The gradient in the middle reach of the river (861 km, Bratislava to the former Cataracts, river-km 1040 – 941, between Serbia and Romanina) is 0.04 ‰ on average. The reservoirs of the Iron Gate I and II power plants (rkm 1030 – 865) neutralised the cataract reach to facilitate safe river navigation.

The Lower Danube reach is 735 km long, its gradient is 0.04 ‰ all the way to Reni (rkm 130).

The length of the Danube Delta is described by different authors as 100 to 130 km and its gradient is 0,01 ‰ at maximum until the river flows into the Black Sea.

This general division of the river was sub-divided following different opinions:

The division in 9 sections applied in JDS 1 followed a geo-morphological scheme and took some account of the input of anthropogenic discharges. For JDS 2 another sub-division of the river was found: The ICPDR decided on 10 “Section Types”, which follow a top-down / bottom-up approach on benthic invertebrate assemblages, proposing to also reflect climate change effects (WFD Roof Report 2004, *Danube Basin Analysis*).

These new sections differ considerably from the 9 geo-morphological reaches making a direct and straight forward comparison of the two river surveys impossible.

Macrophytes are important units in the aquatic ecosystem: upon occurrence they not only enhance total biodiversity as such, but their plant structures and spatial niches serve as habitat for countless other aquatic and benthic organisms, e.g. for grazing or predating, and influence the water chemistry (e.g. oxygen concentration, nutrients).

The abiotic conditions of a large river like the main channel of the Danube restrict macrophyte growth to areas of decreased flow velocities and water depth usually less than about 2 m, and to side channels and floodplain water systems, where macropyhtes can become the dominant plant group.

The term “macrophytes” comprises the following plant groups:

- Macro algae
- Aquatic mosses only (one liverwort was recorded from one survey site)
- Vascular plants
    - Water ferns
    - Angiosperms

Algae occur on the whole length of the Danube River. The genus Chara (stone worts) prefers the Rhithron section, the upper river reach. The other stonewort genus, Nitellopsis, prefers the lower part of the river, often in greater water depth. Aquatic mosses absolutely prefer the upper reach where rock, large stones or rip-rap dominate the river banks, because these are hardly moved by floods. Therefore the largest almost continuous belt of moss vegetation is found in the German and Austrian reaches. Mosses are practically absent from the middle and lower reach of the river.

Water ferns – two species were found in the Danube – occur in the warmer parts of the Danube. In the tables they are combined with the others in the so called group of “Vascular Plants”.

Macrophytes compete with algae for nutrients and light, easily dominate areas with slower flow and floodplain waters and suppress efficiently algal blooms. Since the macrophytes are determined by the abiotic parameters in their habitats (e.g. water flow, turbidity, light, shade, substrate) they indicate these habitat parameters and “habitat suitability” as well as trophic conditions.

1.1.1 Sampling Sites

The number of sampling sites was about the same in JDS 1 (98 sites) and JDS 2 (96 sites), for the main river channel and the mouth sections of tributaries. In Germany 2 sites, *Deggendorf* und *Niederalteich*, were added and *Upstream Kachlet* was cancelled. In Austria *Upstream Aschach* and *Wallsee* (JDS 1) were exchanged against *Oberloiben* (natural river reach in the constrained valley of the Wachau), site *Schwechat* was cancelled. In Slowakia only 1 site – of 3 in JDS 1 – was sampled in the *Gabcikovo-Reservoir* and *Asvanyraro* oxbow was not sampled any more. Hungary exchanged *Adony/Lorev* for *Tass* site. *Donji Milanovac* and *Iron Gate II* were added the Serbian–Romanian reach. In the Bulgarian–Romanian reach the sample sites were not changed. In Moldova and the Ukraine the number of sites stays the same, but site 96 was moved upstream. In the Delta the *Bystroye-Channel*, and another site were added.

Mouth sections of tributaries were also sampled by the team on the ships.

All samples from upstream sites in tributaries were sampled by national teams and samples and data were brought to the ship by the end of the day.

Despite Standardised Operation Protocols on the survey methodology (SOPs) provided to the national teams this method was usually not followed and especially any data on habitat parameters are missing. Therefore the Austrian team, responsible for the macrophyte results, can not take any responsibility on the accuracy and correctness of data listed as “tributaries”, and these results are completely separated from those collected in the main river channel and in the mouth sections of tributaries by the team on the ship.

Table 1 compares the sampling sites of JDS 1 (blue) and JDS 2 (green) and their relation to the river sections, and the (old) geo-morphological reaches of JDS 1, respectively.

Table 1: Comparison of sampling sites and river-km, JDS 2 and JDS 1

Sections	New sampling location JDS 2	JDS 2 No	rkm JDS 2		rkm JDS 1	JDS 1 No	Sampling location	Country	Geomorph. Reach
1		1	2600	!!	2581	01	Neu-Ulm	DE	1
2		2	2415	!!	2412	02	Kelheim	DE	1
2		3	2354	!!	2358	03	Upstream dam Geisling (Regensburg)	DE	1
					2357	03	Upstream dam Geisling (Regensburg)	DE	1
2	*Deggendorf*	4	2285						
2	*Niederaltteich*	5	2278						
					2233	04	Upstream dam Kachlet (Passau)	DE	1
2		6	2225		2225	05	/Inn0.6 km	DE/AT	1
3		7	2204		2204	06	Jochenstein	DE/AT	2
					2165	07	Upstream dam Aschach	AT	2
3		8	2120		2120	08	Upstream dam Abwinden-Asten	AT	2
					2096	09	Wallsee	AT	2
3		9	2061		2061	10	Upstream dam Ybbs-Persenbeug	AT	2
3	*Oberloiben*	10	2008						
4		11	1950		1950	11	Upstream dam Greifenstein	AT	2
4		12	1942		1942	12	Klosterneuburg	AT	2
					1928	-L	AT		2
					1913	13	/Schwechat 0.1 km	AT	2
4		13	1895		1895	14	Wildungsmauer	AT	2
4		14	1881		1881	15	Upstream Morava(Hainburg)	AT	2
4		15	1880		1880	16	/Morava 0.08 km	AT/SK	2
4		16	1869		1869	17	Bratislava	SK	2
					1865	17	Bratislava	SK	3
					1856	18	Gabcikovo-reservoir-entrance	SK	3
4		17	1852		1852	19	Gabcikovo-reservoir	SK	3
					1846	20	Gabcikovo-reservoir-2	SK	3
					1812	21	Sap-(Outlet-channel)	SK	4
					1812	22	Ásványráró-(old-Danube)	SK/HU	4
4		18	1806		1806	23	Medvedov/Medve	SK/HU	4
4		19	1794		1794	24	/Moson-Danube-0.1-km	HU	4
5		20	1768		1768	25	Komarno/Komarom	SK/HU	4
5		21	1766		1766	26	/Vah-0.8-km	SK	4
5		22	1761		1761	27	Iza/Szony	SK/HU	4
5		23	1719		1719	28	Sturovo/Esztergom	SK/HU	4
5		24	1716		1716	29	/Hron-0.5-km	SK	4
5		25	1708		1708	30	/Ipel/Ipoly-0.7-km	SK/HU	4
5		26	1707		1707	31	Szob	HU	4
5		27	1692		1691	32	Upstream-end-of-Szentendre-Island	HU	4
5		28	1692	!	1691	33	/Upstream-end-of-Szentendre-Island	HU	4
5		29	1659		1659	34	Budapest-upstream	HU	4
5		30	1658	!	1659	35	/Budapest-(old-Danube)-end-of-S-arm	HU	5

Sections	New sampling location JDS 2	JDS 2 No	rkm JDS 2		rkm JDS 1	JDS 1 No	Sampling location	Country	Geomorph. Reach
5		31	1642		1642	36	/Soroksar-Arm-Kvassay-sluice	HU	5
5		32	1632		1632	37	Budapest-downstream	HU	5
5	*Adony/Lorev*	33	1605						
5		34	1586		1586	38	/Soroksar-ArmTass-sluice	HU	5
					1586	39	Tass	HU	5
5		35	1560		1560	40	Dunafoldvar	HU	5
5		36	1533		1533	41	Paks	HU	5
5		37	1497		1497	42	/Sio-1.0-km	HU	5
6		38	1481		1481	43	Baja	HU	5
6		39	1434		1434	44	Hercegszanto	HU	5
6		40	1424		1429	45	Batina	HR/YU	5
6		41	1384		1384	46	Upstream-Drava	HR/YU	5
6		42	1379		1379	47	/Drava-1.4-km	HR	5
6		43	1367		1367	48	Downstream-Drava-(Erdut/Bogojevo)	HR/YU	5
6		44	1355		1355	49	Dalj	HR/YU	5
6		45	1300		1300	50	Ilok-Backa-Palanka	HR/YU	5
6		46	1262	!!	1259	51	Upstream-Novi-Sad	YU	5
6		47	1252		1252	52	Downstream-Novi-Sad	YU	5
6		48	1216		1216	53	Upstream-Tisza-(Stari-Slankamen)	YU	5
6		49	1215		1215	54	/Tisza-1.0-km	YU	5
6		50	1200	!!	1202	55	Downstream-Tisza/Upstream-Sava-(Belegis)	YU	5
6		51	1170		1170	56	/Sava-7-km	YU	6
6		52	1159	!!	1161	57	Upstream-Pancevo/Downstream-Sava	YU	6
6		53	1151		1151	58	Downstream-Pancevo	YU	6
6		54	1132		1132	59	Grocka	YU	6
6		55	1107		1107	60	Upstream-Velika-Morava	YU	6
6		56	1103		1103	61	/Velika-Morava	YU	6
6		57	1097		1097	62	Downstream-Velika-Morava	YU	6
6		58	1077		1077	63	Stara-Palanka-Ram	YU	6
6		59	1071		1071	64	Banatska-Palanka/Bazias	YU/RO	6
7		60	1040		1040	65	Iron-Gate-reservoir-(Golubac/Koronin)	YU/RO	6
7	*Donji Milanovac*	61	991						
7	*Iron Gate I*	62	954	!!	956	66	Iron-Gate-reservoir-(Tekija/Orsova)	YU/RO	6
8		63	926		924	67	Vrbica/Simijan	YU/RO	7
8	*Iron Gate II*	64	865						
8		65	849		849	68	Upstream-Timok-(Rudujevac/Gruia)	YU/RO	7
8		66	845		845	69	/Timok-0.2-km	YU/BU	7
8		67	834		834	70	Pristol/Novo-Selo-Harbour	RO/BG	7
8		68	795		795	71	Calafat	RO/BG	7
8		69	685		685	72	Downstream-Kozloduy	RO/BG	7
8		70	640		640	73	Upstream-Iskar-(Bajkal)	RO/BG	7
8		71	637		637	74	/Iskar-0.3-km	BG	7
8		72	629		629	75	Downstream Iskar	RO/BG	7
8		73	606		606	76	Upstream Olt	RO/BG	7
8		74	605		605	77	/Olt-0.4-km	RO	7
8		75	602		602	78	Downstream Olt	RO/BG	7
8		76	579		579	79	Downstream-Turnu-Magurele/Nikopol	RO/BG	7
8		77	550		550	80	Downstream-Zimnicea/Svishtov	RO/BG	7
8		78	537		537	81	/Jantra-1.0-km	BG	7
8		79	532		532	82	Downstream-Jantra	RO/BG	7

Sections	New sampling location JDS 2	JDS 2 No	rkm JDS 2		rkm JDS 1	JDS 1 No	Sampling location	Country	Geomorph. Reach
8		80	500		500	83	Upstream-Ruse	RO/BG	7
8		81	498		498	84	/Russenski-Lom	BG	7
8		82	488		488	85	Downstream-Ruse/Giurgiu	RO/BG	8
8		83	434		434	86	Upstream-Arges	RO/BG	8
8		84	432		432	87	/Arges	RO	8
8		85	429		429	88	Downstream-Arges,-Oltenita	RO/BG	8
8		86	378		378	89	Chiciu/Silistra	RO/BG	8
9		87	295		295	90	Upstream-Cernavoda	RO	8
9		88	235		235	91	Giurgeni	RO	8
9		89	167		167	92	Braila	RO	8
9		90	154		154	93	/Siret-1.0-km	RO	8
9		91	135		135	94	/Prut-1.0-km-	Ro/md	8
9	*Reni*	92	130		130	95	Reni-Chilia/Kilia-arm	RO/MD	8
10	*Vilkova-Chilia-Arm*	93	18	!!	56	96	Kilia-arm *(Vilkova)*	RO/UA	9
10	*Bystryoe canal*	94	8	!!				UA	
10	*Sulina (Sulina-Arm)*	95	19	!!	12	97	Sulina-arm	RO	9
10	*St. Gheorghe-Arm*	96	7	!!	64	98	St.-George-arm	RO/UA	9

1.2 METHODS

1.2.1 Kohler-Survey (according to EN14184)

The aquatic macrophyte vegetation of the Danube main channel and some mouth sections of important tributaries, was assessed at the preselected sampling sites. Survey units were of 1 km length, covering 3 rkm on each side of the river in the main channel, thus resulting in 6 rkm sampled at each sampling site. Abundance assessment followed European Standard EN 14184, comprising the assessment of individual species and their abundance (Kohler/ Janauer, 1995, Table 2).

Table 2: Five level estimator scale (according to EN 14184)

1	rare
2	occasional
3	frequent
4	abundant
5	very abundant

The advantage of this estimator scale is the easy and quick application in the field and the integrated assessment of the full spatial development of the volume plant stands, which includes the third dimension, too.

The estimator scale follows the function $f(x) = ax^3$, which was posted first by Melzer (1988) and was proved for running waters by Janauer & Heindl, 1998, see Fig 1). Field worker with even little experience are able to assess the plant mass estimates correctly and reproducibly after a very short learning period (Kohler et al., 1971).

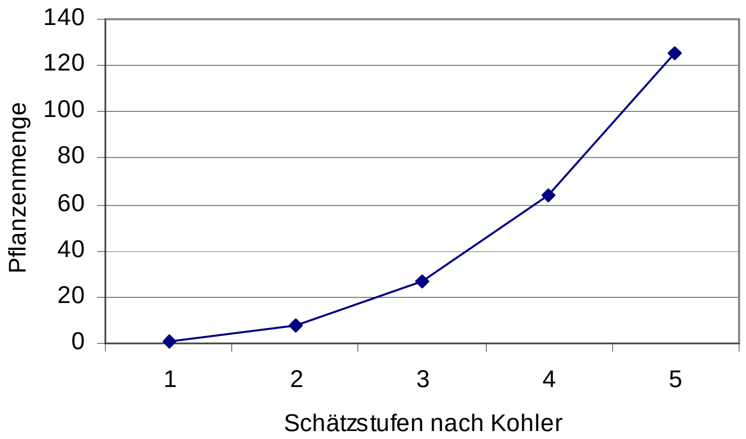

Figure 1: Graph of the Function $f(x) = ax^3$

Criteria for survey unit boundaries are geo-morphological changes in the river bed and banks, and changes in ecological or anthropogenic features in the river, like flow velocity, shading, sewage inflow, bridges, groins and other technical constructions and pronounced changes in aquatic plant species composition and/or abundance (Kohler & Janauer, 1995).

In the JDS 2 (as in JDS 1 and in the MIDCC-project, www.midcc.at) single river-kilometres were selected as appropriate survey units. 3 km were surveyed by boat on each of the two river sides, whereas the surveying person was experienced in this method as a consequence of several surveys in other parts of the Danube River carried out for other projects prior to JDS 2. Helophytes (reed species) were considered of importance to this survey, if growing in the mid-water line directly at the banks. Downriver of the Iron Gate the river was under flood conditions, which resulted in water levels up to 3 m above the mean. This situation receded when reaching the lower-most reaches of the Danube. Aquatic plant assessment became more difficult, yet not impossible, and therefore the survey was focussed on the hydrophyte species in this reach.

1.2.2 Data processing and graphic products

1.2.2.1 Distribution Diagrams

The distribution of all species is shown by Distribution Diagrams (see Figure 2; Software: FDG-Austria; www.midcc.at). Survey unit borders are marked by vertical lines. Survey unit length is proportional to the real length.

The height of the black bars indicates the abundance of each species in each survey unit. For reasons of clarity the 5 levels of the estimator (Kohler, 1978) are reduced to 3 levels (Kohler & Janauer, 1995). Bar heights: Low = levels 1/rare & 2/occasional; Medium = level 3/ frequent; High = levels 4/abundant & 5/very abundant (for more detail: see www.midcc.at).

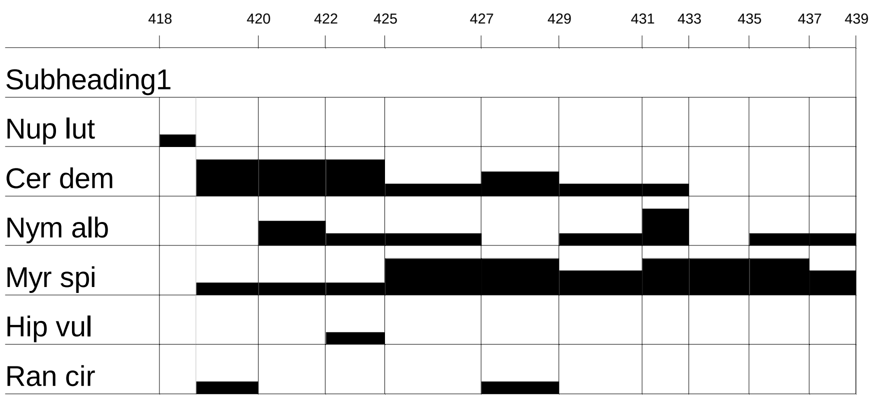

Figure 2: Example of a Distribution Diagram

1.2.2.2 Relative Plant Mass (RPM)

The quantitative relationship of individual plants and how they relate to each other with respect to dominance, as based on the total plant mass in a surveyed river reach, is described by the metric Relative Plant Mass (RPM, Pall& Janauer, 1995, Kohler & Janauer, 1995). All species below 1 % RPM are combined in the „residual", Figure 3). The metric is weighted by the length of the survey units (which may be 1 km as in the JDS assessment, or be of other lengths).

RPM is calculated following Pall & Janauer, 1995:

$$RPM[\%] = \frac{\sum_{i=1}^{n} \left(M_i^3 \bullet L_i \right) \bullet 100}{\sum_{j=1}^{k} \left(\sum_{i=1}^{n} \left(M_{ji}^3 \bullet L_i \right) \right)}$$

RPM = Relative Plant Mass of a species
M_i = Plant Mass Estimate (PME) for the survey unit i of a species
L_i = Length in survey unit i
i, j, k = running indices of different plant species
n = Total number of survey units in the surveyed river section

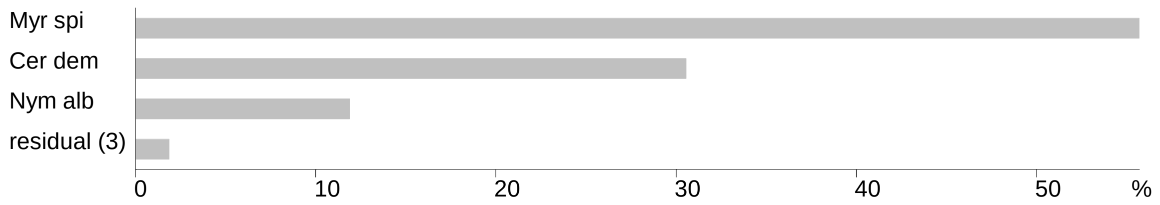

Figure 3: Example of an RPM-Diagram

Since the metric is given on a relative basis („%") other graphics like circular diagrams and summary-bar-charts will be used in this report, too.

1.2.2.3 Habitat Parameters

In each survey unit the predominant substrate around the plant stands was coded (Table 3):

Table 3: Substrate types

Code	Substrate type	Description	Character	Particle size
1	Megalithal, Makrolithal, Mesolithal	fist-, hand-size stones, large boulders, rock face	abiotic	> 6,3 cm
2	Mikrolithal, Akal	large, medium & small gravel, possibly mixed and with some sand fraction	abiotic	2 - 6,3 cm
3	Psammal	sand	abiotic	0,063 - 2 mm
4	Pelal	fine particles, sludge, mud	abiotic	< 0,063 mm
5	Artificial	artificial material like concrete, asphalt, etc.	abiotic	
6	Organic	detritus or other organic material	biotic	

The bank types were categorised as follows (with up to 2 types per rkm)

Table 4: Bank types

Code	Bank type	Description	Character	Particle size
1	Megalithal, Makrolithal, Mesolithal	fist-, hand-size stones, large boulders, rock face	abiotic	> 6,3 cm
2	Mikrolithal, Akal	large, medium & small gravel, possibly mixed and with some sand fraction	abiotic	2 -6,3 cm
3	Psammal	sand	abiotic	0,063 - 2 mm
4	Pelal	feine substrate	abiotic	< 0,063 mm
41	gentle/flat slope/gradient	flat bank, fine substrate	abiotic	
42	vertical/steep slope/gradient	steep bank, fine substrate	abiotic	
5	Artificial	artificial material like concrete, asphalt, etc.)	abiotic	
6	Organic	detritus or other organic material	biotic	

The active water flow velocity was estimated in 4 categories as follows:

Table 5: Water flow velocity classes

Code	Water flow velocity classes	Definition
1	no flow	stagnant
2	low flow	≤ 30 cm /sec
3	medium flow	> 31 < 69 cm /sec
4	high flow	≥ 70 cm /sec

The visibility or Secchi-depth was assessed with a Secchi-plate mounted to an iron rod. The assessment was carried out by the phytoplankton group.

The hydromorphology group assessed several additional morphological features, like type of higher bank, type of inundation area, river width etc.

1.2.3 Differentiation of uniform River Sections

1.2.3.1 Geomorphological River Sections

Lászlóffy's characterisation of the Danube is shown in Table 6. In 1965 the river was hardly impacted by power plant barrages and the river gradient was defined by the natural environmental conditions:

Table 6: Danube Sections (Lászlóffy 1965) based on river gradient

Reach	Distance	Average slope
Mountain Section	river km 2780 - 2497	101 cm/km
Upper Danube	river km 2497 - 1794	40 cm/km
Middle Danube	river km 1794 - 1048	6 cm/km
Cataract-Reach	river km 1040 - 941	28 cm/km
Lower Danube	river km 941 - 80	3.9 cm/km
Danube Delta	river km 80 - 0	few millimetres on each km

In JDS 2 River Section characterisation was based on Lászlóffy's table, but took account of the impoundments of power plants, devoting a special status to the two main impoundments, Gabcikovo (Slovakia, 40 km length) and Iron Gate (Serbia / Romania, 175 km length).

Table 7: Danube Sections JDS 1 (Literáthy et al. 2002)

1	Alpine river character; impact by hydroelectric power plants	river km	2581	2225
2	Alpine river character; impact by hydroelectric power plants	river km	2225	1880
3	Impact by the construction of Gabcikovo Dam	river km	1880	1816
4	Change of alpine into lowland river; Danube flows through Hungarian Highlands	river km	1816	1659
5	Danube crosses Hungarian Lowlands; impact by significant emissions of untreated wastewater in Budapest	river km	1659	1202
6	The Sava River/Belgrade - Iron Gate Dam	river km	1202	943
7	Wallachian Lowlands	river km	943	537
8	Lowland river	river km	537	132
9	Danube splits into three main Delta arms	river km	132	12

1.2.3.2 River Sections in JDS 2, 2007

Based on experiences in JDS 1 and a statistical analysis of macro-invertebrate distribution Moog et al. (2006, Table 8) divided the Danube into 10 ecologically uniform reaches. The ICPDR used this classification as a basis for the assessment of water quality in JDS 2, with slight modifications (Table 9).

Table 8: Danube Sections (according to Moog)

Section	Reach	Distance		
1	Upper Course of the Danube	river km	2786	2581
2	Western Alpine Foothills Danube	river km	2581	2225
3	Eastern Alpine Foothills Danube	river km	2225	2001
4	Lower Alpine Foothills Danube	river km	2001	1791/1790
5	Hungarian Danube Bend	river km	1791/1790	1497
6	Pannonian Plain Danube	river km	1497	1071
7	Iron Gate Danube	river km	1071	931
8	Western Pontic Danube	river km	931	378
9	Eastern Wallachian Danube	river km	378	100
10	Danube Delta	river km	100	0

Table 9: Section Types of the Danube for JDS 2 (*WFD Roof Report 2004*, Danube Basin Analysis)

Section	Longitudinal extent of stretch according to JDS points	River km
1	**Upper course of the Danube** Breg- u. Brigach-confluence to Neu Ulm (JDS 1)	2786 2581
2	**Western Alpine Foothills Danube** Neu Ulm to Passau – confluence with Inn River (JDS 2 - 6)	2581 2225
3	**Eastern Alpine Foothills Danube** Passau to Krems (JDS 7 - 10)	2225 2001
4	**Lower Alpine Foothills Danube** Krems to Gönyű / Kli.ská Nemá (JDS 11 - 19)	2001 1789.5
5	**Hungarian Danube Bend** Gönyű / Kli.ská Nemá to Baja (JDS 20 – 37)	1789.5 1497
6	**Pannonian Plain Danube** Baja to Bazias (JDS 38 – 59)	1497 1075
7	**Iron Gate Danube** Bazias to Turnu Severin (JDS 60 – 62)	1075 943
8	**Western Pontic Danube** Turnu Severin to Chiciu/Silistra (JDS 63 – 86)	943 375.5
9	**Eastern Wallachian Danube** Chiciu/Silistra to Isaccea (JDS 87 – 92)	375.5 100
10	**Danube Delta** (rkm 100: Isaccea;. rkm 20 on Chilia arm; rkm 19 on Sulina arm and rkm 7 on Sf. Gheorghe arm (JDS 93 – 96)	100 0

1.2.4 Multivariate DATA ANALYSIS

Multi Response Permutation Procedure (MRPP) was used to test the null hypothesis of no significant differences in the floristic and quantitative composition of survey units among ten previously defined section types. MRPP is the non-parametric analogue of Discriminant Function Analysis but without many of the associated assumptions. Bray-Curtis distance measures and a natural weighting ((n/sum (n)) was used in the MRPP (McCune & Grace 2002).

However, MRPP provides little more than the test statistic, a measure of “effect size” (A-values), and a p-value. Describing the differences among the section types was done through Indicator Species Analysis (ISA, Dufrêne & Legendre 1997). ISA calculates indicator species values by multiplying the relative abundance of each species in a specific section type by the relative frequency of the species occurrence in that section type. A Monte Carlo simulation test with 1000 randomized runs, where survey units are randomly assigned to types, was used to determine the significance ($P \leq 0,05$) of the indicator values (McCune & Grace 2002). MRPP and ISA were conduced with PC-ORD version 5.1 (McCune & Mefford. 2006).

1.2.5 Assessment of the of ecological status

The indication of ecological status assessment complies with the Austrian Directive for Running Waters – Macrophytes (2007). The following calculation method (example out of the "Leitfaden zur Erhebung der biologischen Qualitätselemente, Teil A4 – Makrophyten", p 25) has been used:

Table 10: Calculation of the ecological status

Tabelle 3: Berechnung der Ökologischen Zustandsklasse.

Art	Pflanzenmenge	Klasse 1	Klasse 2	Klasse 3	Klasse 4	Anzahl Klassen
Art 1	PM_1	PM_1				1
Art 2	PM_2	$PM_2 / 3^2$	$PM_2 / 3^2$	$PM_2 / 3^2$		3
Art 3	PM_3	PM_3				1
Art 4	PM_4	$PM_4 / 2^2$	$PM_4 / 2^2$			2
Art 5	PM_5	PM_5 x 0	PM_5 x 0	PM_5 x 0	PM_5 x 0	4

Summe PMxG		$Summe_1$	$Summe_2$	$Summe_3$	$Summe_4$	Quersumme A
Summe PMxGxKL		$Summe_1$ x 1	$Summe_2$ x 2	$Summe_3$ x 3	$Summe_4$ x 4	Quersumme B
Indexwert						Quersumme B / Quersumme A
Ökologische Zustandsklasse (ÖZK)						Indexwert gerundet auf ganze Zahl

PM: abundance of each species
Summe: sum
ÖZK: Index of ecological status (rounded)

Klasse: category
Quersumme: cross sum

The reference conditions were adapted to the conditions of the Danube River in the different Section Types Reaches. However, no sufficient and scientific sound historical quantitative data or modelling approaches are available to produce a solid data base for the macrophyte reference conditions for the whole length of the Danube River. Using various sources like results from side channels, historical maps, saprobiotic maps of the Danube and JDS 1 and JDS 2 data on chemical components as well as data from the whole-length-macrophyte survey in the midcc project potential reference conditions with respect to the ecological characterization of species were used to calculate reference conditions for the assessment of the indication of the ecological status class for the JDS 2 Survey Sites.

The complete data base of reference condition data is not published yet, for further information and scientific cooperation please contact the authors at the University Vienna, Department of Freshwater Ecology.

1.3 RESULTS

1.3.1 Section 1 Upper Course of the Danube, rkm 2786 – 2581

In this Section gorge-like stretches and constrained valleys alternate with alluvial land and riparian lowlands. The gradient is 1.38 – 0.75 ‰.

The first survey site was situated at river kilometer (rkm) 2600 downriver of a small hydro-electric power plant at Leipheim near Neu-Ulm. In this reach the Danube is not navigable and deepest pools reached c. 80 cm depth. The high flow velocity favoured 12 rheophilic species. *Zannichelia palustris* grew in 3 survey units (SUs) in dense swaths and dominated the picture (RPM = 36 %). *Ranunculus fluitans* grew fequently in 4 SUs (RPM = 28 %), *Veronica beccabunga* was present in a few dense swaths in a single SU (RPM = 7 %). A few individuals of *Elodea canadensis*, *Callitriche*, *Lemna minor* and *Spirodela polyrhiza* were found.

Fontinalis antipyretica dominated the five moss species (RPM = 24 %), *Cinclidotus riparius* was detected in 3 SUs (RPM = 2.7 %).

Impatiens glandulifera dominated the helophyte community (9 species) and *Typha latifolia* was found in a single SU.

Steep banks consisting of fine inorganic material prevailed except for locations with bridges.

This reach was surveyed by foot and by car, where approach was possible on tracks across fields. Due to these constraints only 4 rkm could be surveyed in this rather uniform reach.

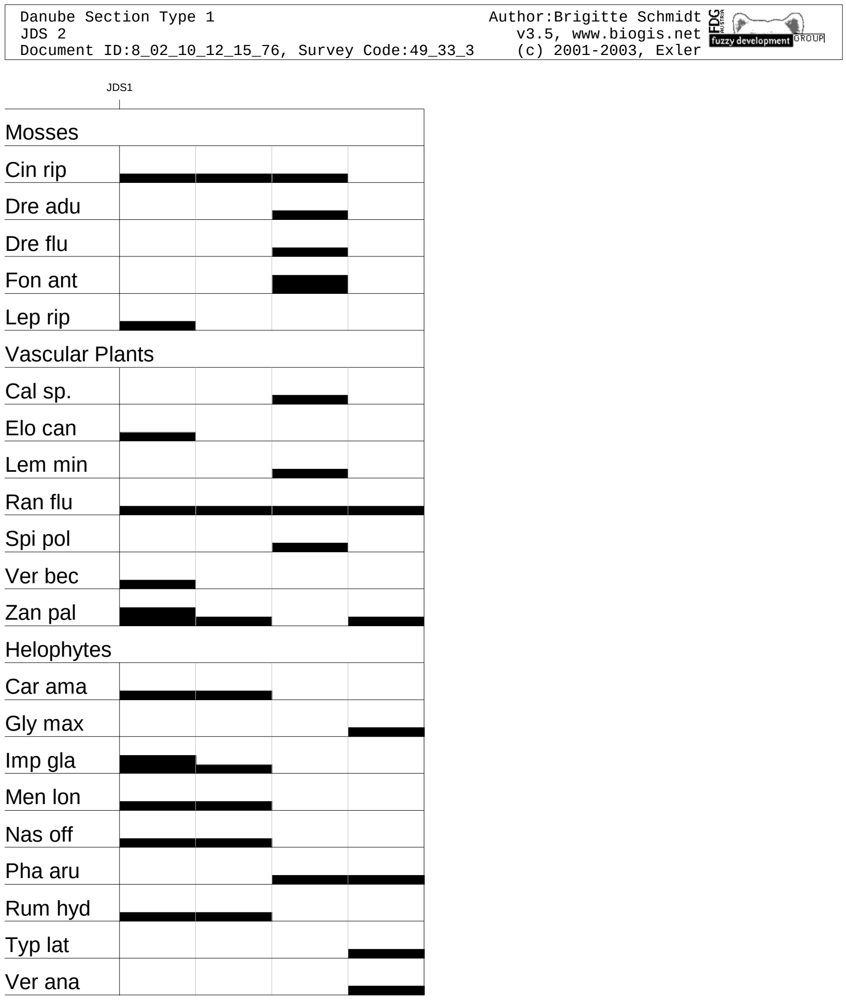

Figure 4: Distribution Diagram Section 1

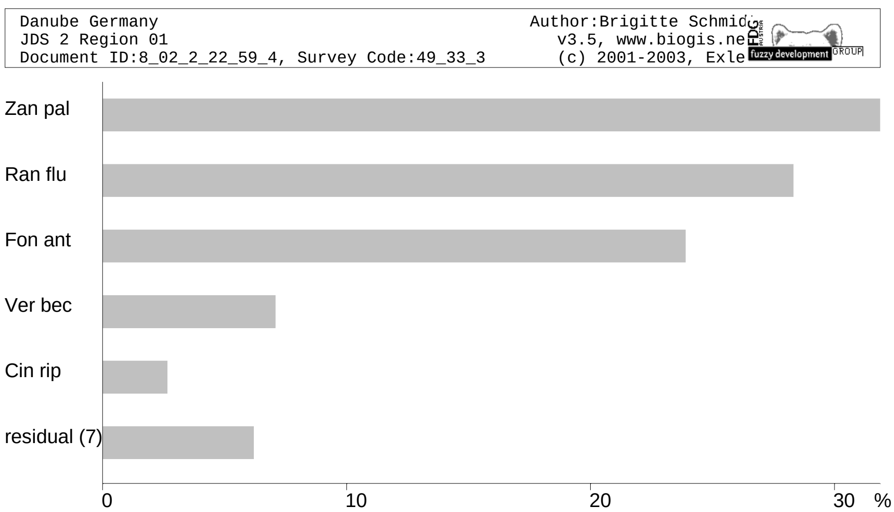

Figure 5: RPM Section 1

1.3.2 Section 2
Western Alpine Foothills Danube, rkm 2581 – 2225

This Section comprises JDS Survey Sites 2 to 6, from Neu-Ulm to the mouth of the Inn River in Passau (356 km length). The Danube flows through wide valleys in a meandering or furcating course, as a result of sideways erosion (gradient 1.1 – 0.3 ‰).

In this Section 28 km were surveyed. Rip-rap (and concrete in some length) was present on 25 km and 3 km were natural. In 15 km length the rip-rap reached so deep that it constituted the substrate for the macrophytes. Gravel was detected in 6 km and sand in 7 km length.

In correspondency with the substrate mosses dominated the aspect of the aquatic vegetation. *Cinclidotus riparius* (21 rkm, RPM = 81 %) dominated the 7 moss species, followed by *Fontinalis antipyretica* (4 km, RPM = 4.2 %) Among the 7 vascular species *Ceratophyllum demersum* (RPM = 2.2 %) and *Potamogeton pectinatus* (RPM = 2 %) were followed by *Callitriche hamulata* and *Potamogeton nodosus* (both species RPM = 1.8 %). Eight helophytes were found on the banks (*Phalaris arundinacea* in 12 km, followed by *Polygonum* and *Rorippa*).

In the mouth section of the Inn River the high suspended solids load (in direct translation the “Milk of the Inn”) only a single survey site was located. *Cinclidotus riparius* was the only macrophyte, growing on an embankment.

The total mass of aquatic vegetation was very low in this Section.

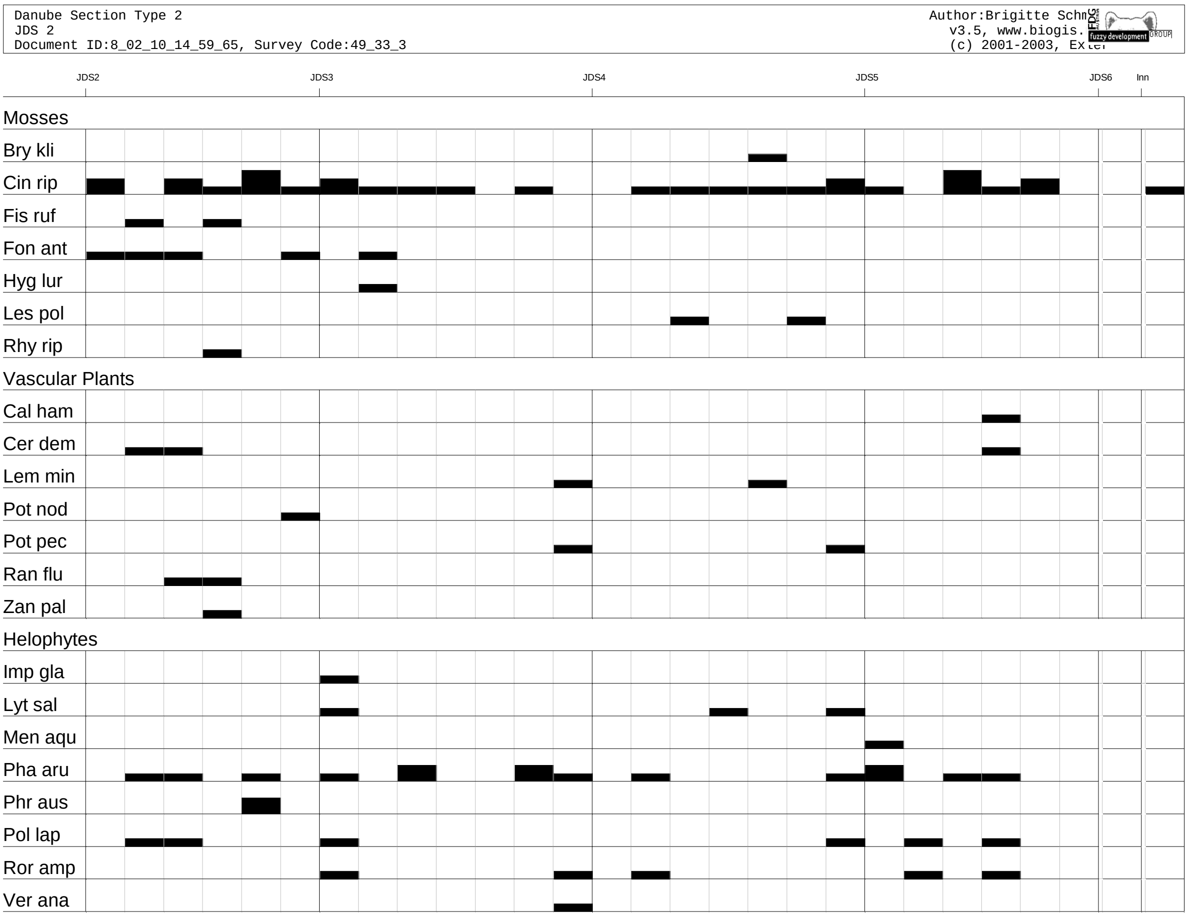

Figure 6: Distribution Diagram Section 2

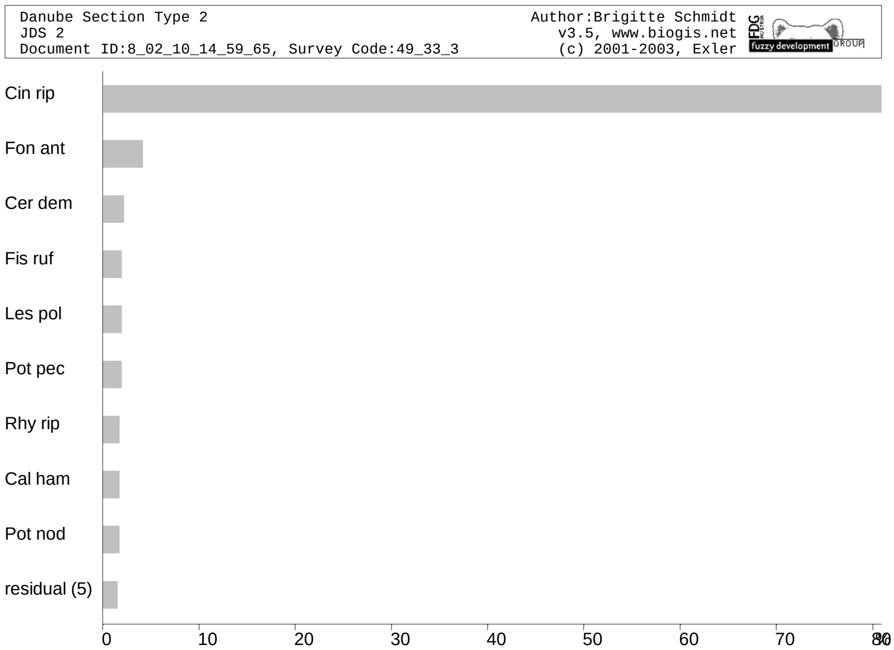

Figure 7: RPM Section 2

1.3.3 Section 3 Eastern Alpine Foothills Danube, rkm 2225 – 2001

Section 3 (Jochenstein to Krems) is 244 km long and comprises the Survey Sites 7 to 10. Four hydro-electric power plants are situated in this Section. The only free flowing reach in a constrained valley, the Wachau Valley, of the Austrian Danube Reach is also located here. The slope is 0.43 ‰ on average and the sediment near the bank consisted of gravel and stones of different size.

Out of 27 rkm surveyed 26 km of protected bank or natural rock were detected, and 1 km bank length consisted of sand. At a length of 14 km rip-rap reached into depth of 2 m and formed the substrate for the macrophytes. Course gravel was found in some places and fine sand was present on 8 km length.

Stony bed conditions and high flow velocities (>70 $cm.sec^{-1}$) in some stretches favoured moss growth (12 species), e.g. *Fontinalis antipyretica* (RPM = 36 %, 16 km). *Potamogeton pectinatus* was dominant (RPM = 37.5 %, 10 km) out of only 5 vascular species. Other mosses were also quite prevalent (*Cinclidotus riparius*, RPM = 8.4 %; *Leskea polycarpa* RPM = 3.2 %; *Fontinalis hypnoides* RPM = 2.7 %). Among the helophytes *Lycopus europaeus* and *Lythrum salicaria* occurred quite regularly.

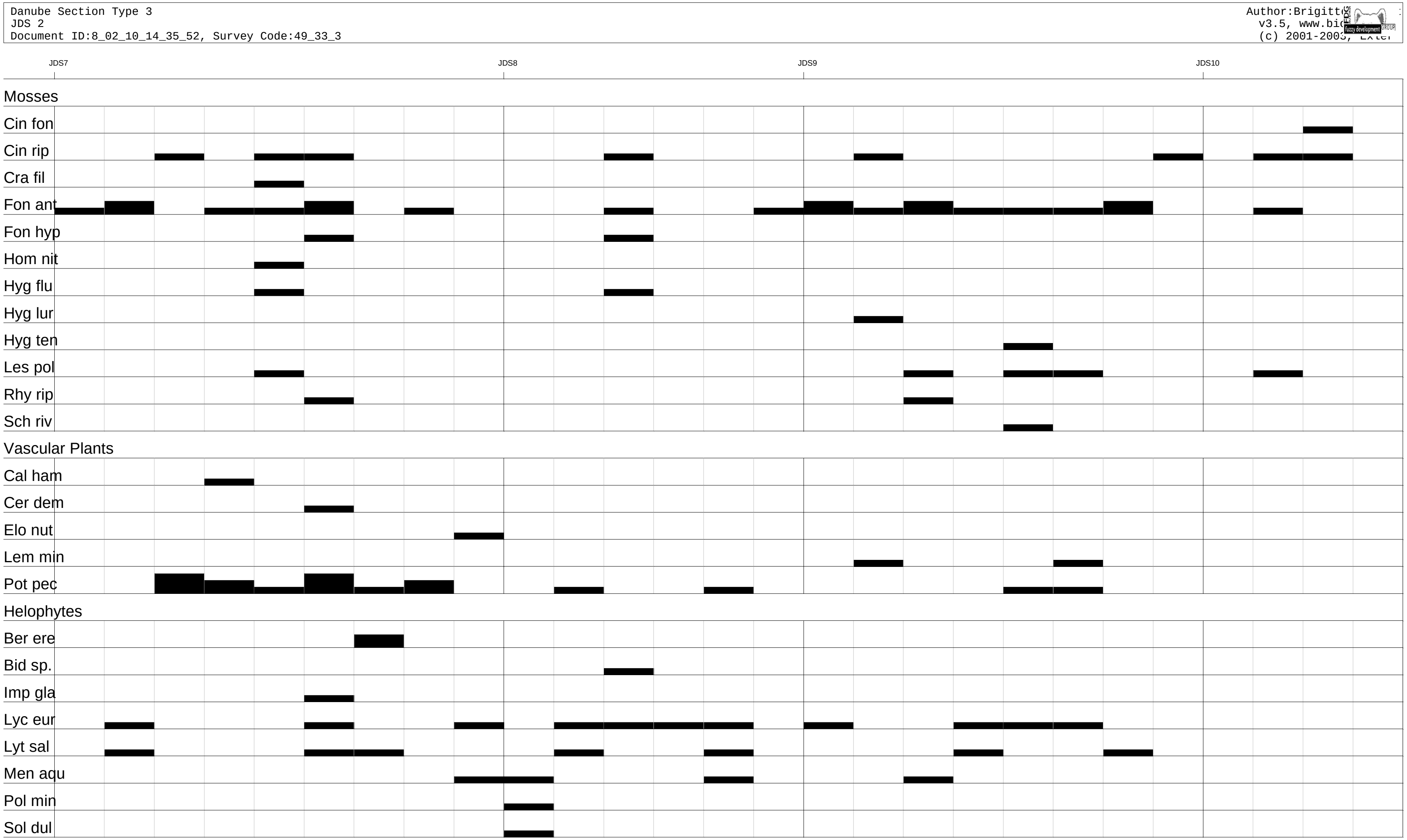

Figure 8: Distribution Diagram Section 3

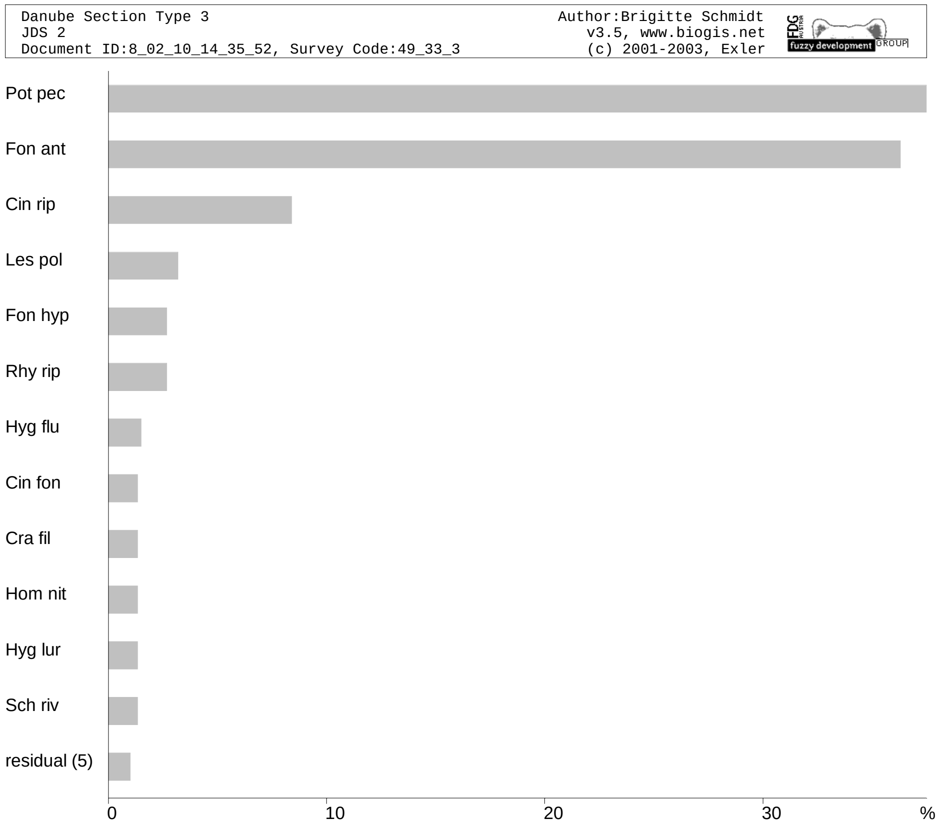

Figure 9: RPM Section 3

1.3.4 Section 4
Lower Alpine Foothills Danube, rkm 2001 – 1789,5

Section 4 is 211 km long and covers the river reach from Krems (Austria) to the Mosoni Duna mouth (Hungary, Gönyű). 9 Survey Sites are located in this reach (JDS 11 to 19).

The slope of the river is c. 0.4 ‰ between Krems and Vienna and gets lower in the Slovak part of Section 4. This effect created the two large islands downriver of Bratislava due to the deposition of finer gravel sizes and the character of the river changes into a more potamal type.

As between Krems and Vienna the whole length of the Danube is part of three successive hydro-power impoundments and from Bratislava to the mouth of the Old Danube river upstream of Gönyü the greatest part of the discharge runs through the Gabcikovo impoundment, this section may realistically look quite uniform as relates to the macro-invertebrate fauna, on which the division of the ten River Sections was originally based. However, at a more detailed scale the slope of the river bed is not totally the same in this Section and even the macrophyte vegetation shows some differences when comparing the species composition upstream and downstream of the mouth of the Morava river.

Among the 55 km of Section 4 45 km were secured by rip-rap and within the areas of shipyards and the cities embankments were detected. Gravel and sand were found on 5 km of the banks, only.

Large stones form the substrate for the macrophytes over 32 km, and gravel and sand were the substrate on 12 km and 3 km, respectively. The remaining length was composed of fine inorganic substrate.

In the distribution diagram the upper part of Section 4 is dominated by an abundance of mosses, over the total length of Section 4 *Potamogeton pectinatus*, a vascular plant, is the most important (RPM = 23,3 %), despite the fact that in SUs 12 – 14, it was the only vascular species except a few single individuals of *Myriophyllum spicatum*.

Downriver of the Morava River mouth (JDS 15) the duckweed *Lemna minor* (RPM = 15.6 %) was second in dominance (additionally *Lemna gibba* and *Spirodela polyrhiza*, both RPM = 2 %), and followed by the moss *Cinclidotus riparius* (RPM = 15 %), *Ceratophyllum demersum* (RPM = 7.5 %), *Potamogeton nodosus* (RPM = 5.4 %) and *Potamogeton perfoliatus* (RPM = 4 %).

In Section 4 the „residuals“ group of species (sum of species with less than 1% RPM) added up to 6%. This means this group comprises many species. Among these species *Riccia fluitans* was found, which is a rare species in duckweed communities.

Phalaris arundinacea and *Phragmites australis* dominated the helophyte group, among many other species of that growth form.

The species richness in Section 4 (12 mosses, 19 aquatic vascular plants, 30 helophytes) was considerably higher than in the Sections upriver. The genus *Polygonum* and *Rorippa* were not determined to species level and were not counted for the total number of species.

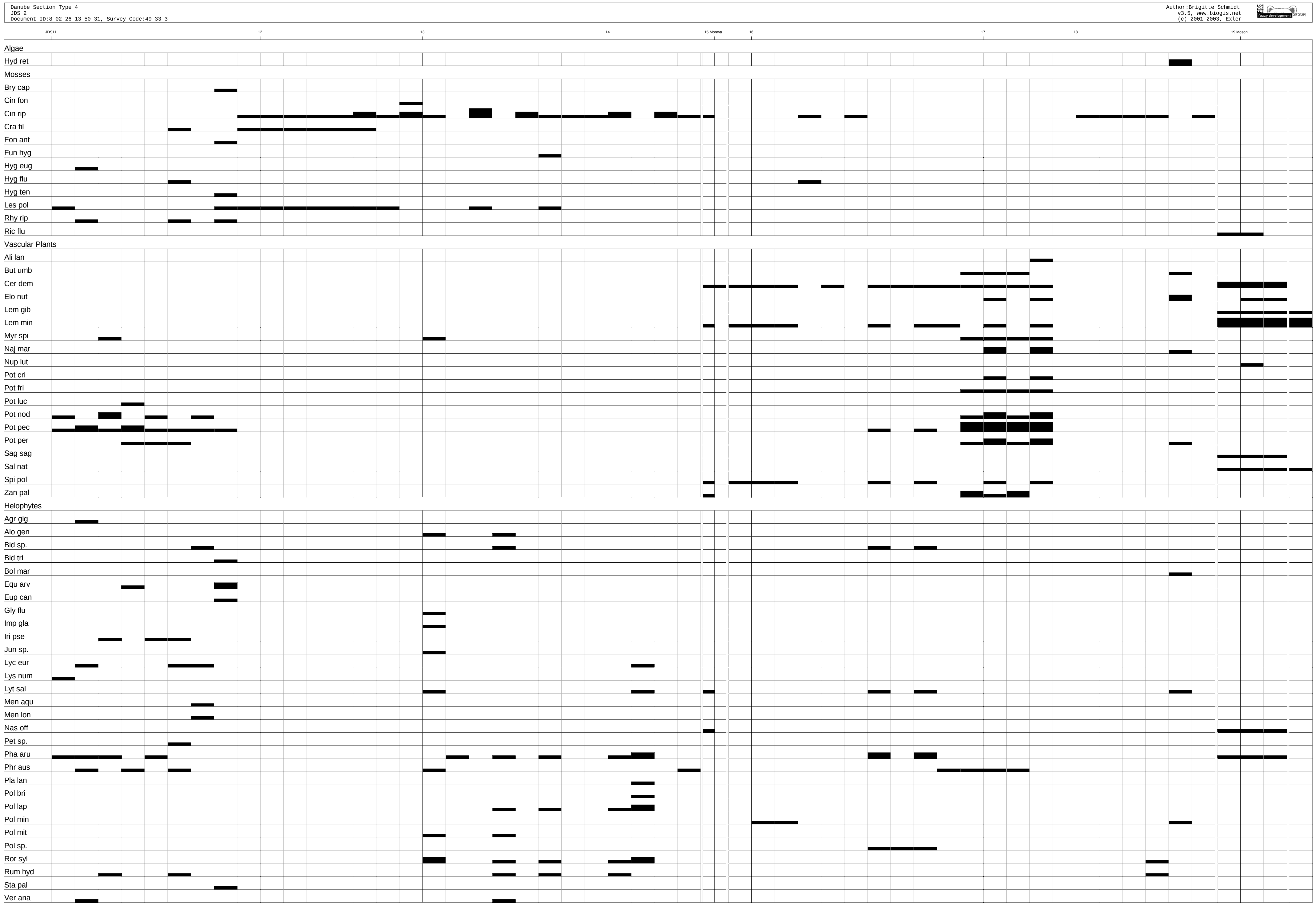

Figure 10: Distribution Diagram Section 4

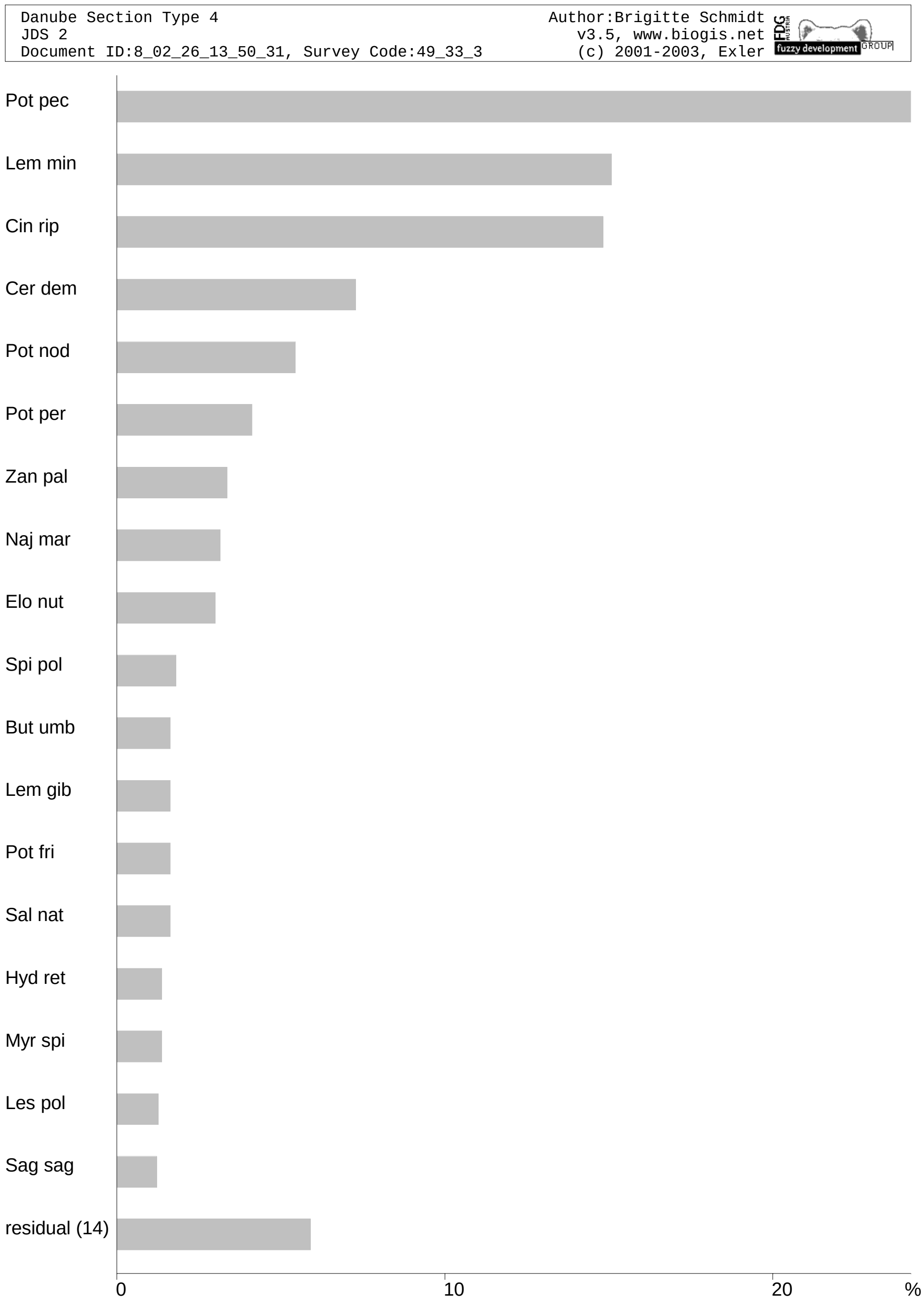

Figure 11: RPM Section 4

1.3.5 Section 5
Hungarian Danube Bend, rkm 1789,5 – 1497

Section 5 comprises survey sites JDS 20 – 37, the reach between Gyönyű/Kližská Nemá and Baja (292 km) in the Hungarian Lowlands till the mouth of the Sio River. Three more important tributaries joined the Danube up from the Sio: Vah, Hron und Ipoly, adding their suspended solids load. At rkm 1690 the Danube turns right in a sharp bend and runs along the island of Szentendre to the South.

In Section 5 more than 94 km were surveyed in the main river channel and in the mouth sections of the four tributaries. Rip-rap was detected in 25 km, 60 km were composed of flat, and 9 km of steep natural banks. The substrate was very variable in stretches of potential macrophyte habitat. Gravel and fine inorganic material were frequent (Figure 38). The mouth sections of the tributaries were shallow and were surveyed with the small boat to a depth limit of 30 cm.

Mosses were restricted to 2 samples and 2 species (*Cinclidotus riparius*, *C. fontinaloides*). *Enteromorpha intestinalis*, a green alga was abundant in the mouth section of the Ipoly River.

23 vascular species were detected. To some surprise two very unlikely species were found: *Utricularia vulgaris*, a species catching small aquatic animals, and the neophyte *Eichhornia crassipes*, which had most probably escaped from a garden pool. It will probably die in the next cold winter and may not cause a neophyte problem.

A most remarkable situation was found over a length of many rkm in 2007: duck weeds formed a loosely-packed carpet, in some places across the whole width of the Danube main river channel (RPM = 35 %; divided into individual species: *Lemna minor* 20 %, *L. gibba* 6 %, *Spirodela polyrhiza* 9 %). It was impossible to detect, if these non-rooted, free-floating plants originated from tributaries or from flow-protected habitats of the river bank. Second and third in RPM were *Ceratophyllum demersum* (RPM = 11 %) und *Myriophyllum spicatum* (RPM = 9 %). Among the pondweeds *Potamogeton pectinatus* (RPM = 8 %, detected over 21 km) and *P. nodosus* (RPM = 4.5 %, 16 km) were important.

The group of helophytes (11 species) was very low in abundance.

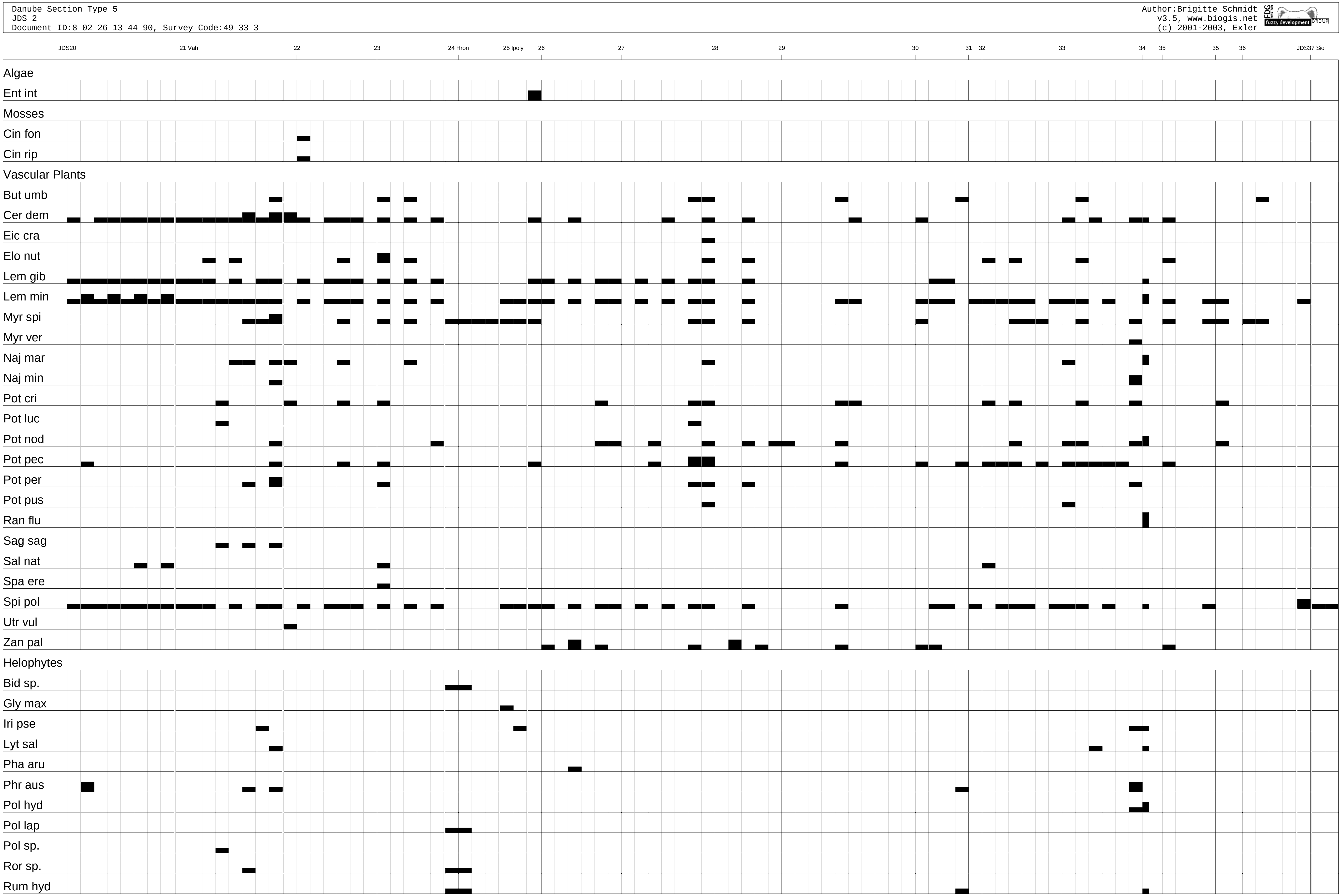

Figure 12: Distribution Diagram Section 5

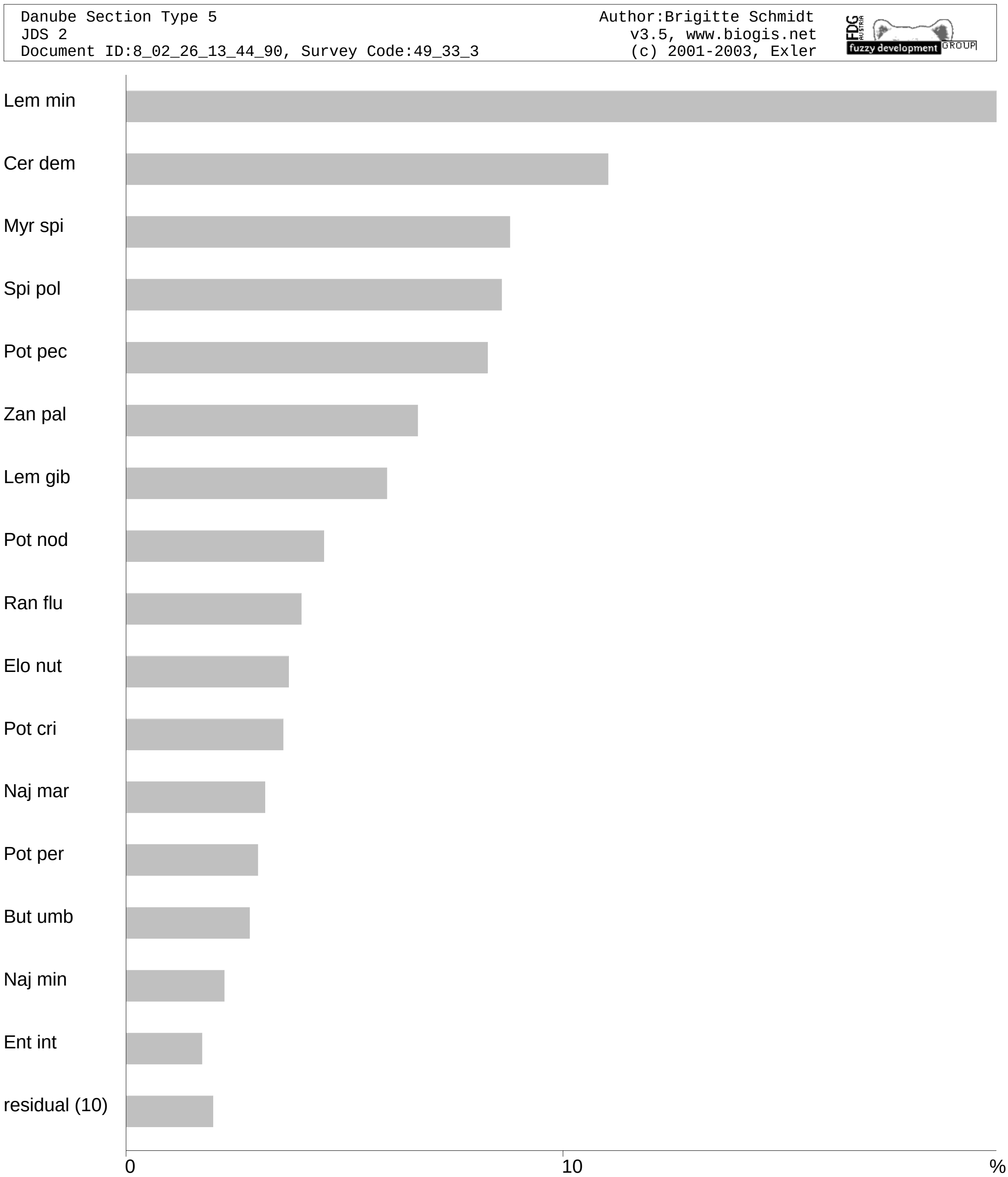

Figure 13: RPM Section 5

1.3.6 Section 6 Pannonian Plain Danube, rkm 1497 – 1071

In Section 6 the Pannonian Plain comprises Survey Sites JDS 38 (Baja) to JDS 58 (Bazias). This Section is over 422 km long and 90 km were surveyed. Due to the river regulation the great number of river bends was converted to meander-oxbows with different type of connectivity. The mouth sections of the large tributaries, Drava, Tisza and Sava, were deeper than the ones in Section 5, and longer stretches could be surveyed.

In proportion reinforced banks (24 km) were second to natural banks (40 km). The remaining bank length consisted of heterogeneous structures. The sediment was dominated by sand (63 km) and fine material with loamy parts (14 km) and larger stones and gravel was detected along 9 km.

Mosses occured in 3 sites and with 3 species where the bank consisted of stones of different size. The macrophytic algae *Hydrodictyon reticulatum*, *Enteromorpha intestinalis* and *Nitellopsis obtusa* were detected. The number of vascular plants increased with reference to Section 5 by 6 species (total: 29 species). 20 species of helophytes grew right down to the water line, but even more so different *Cyperus*- and *Bolboschoenus*- species grew higher up on the islands and higher parts of the banks (of course the vegetation growing at a larger distance to the bank was not integrated in the statistics of abundance). . The appearance of *Chamaesyce glyptosperma* (Euphorbiaceae, originating from USA) around JDS 48 (Upstream Isa) was conspicuous.

Regarding dominance in decreasing order *Ceratophyllum demersum* (RPM = 26.5 %) followed by the water fern *Salvinia natans* (RPM = 10.6 %), the duckweeds *Spirodela polyrhiza* (RPM = 10.2 %) and *Lemna minor* (RPM= 7.2 %).

The pondweeds were represented by *Potamogeton nodosus* (RPM = 8.9 %), *P. pectinatus* (RPM = 5.9 %), *P. gramineus* (RPM = 5.1%) and *P. perfoliatus* (RPM = 4.1%).

A special species was *Azolla filiculoides* (a water fern, RPM = 1.5 %) occurring in habitats close to the bank, with the water trickling over the sediment. A thermophilic element, *Valisneria spiralis*, was detected in larger swathes. The smallest flowering plant, *Wolffia arrhiza*, was detected among duckweeds and is a very rare species with respect to the Danube main river channel.

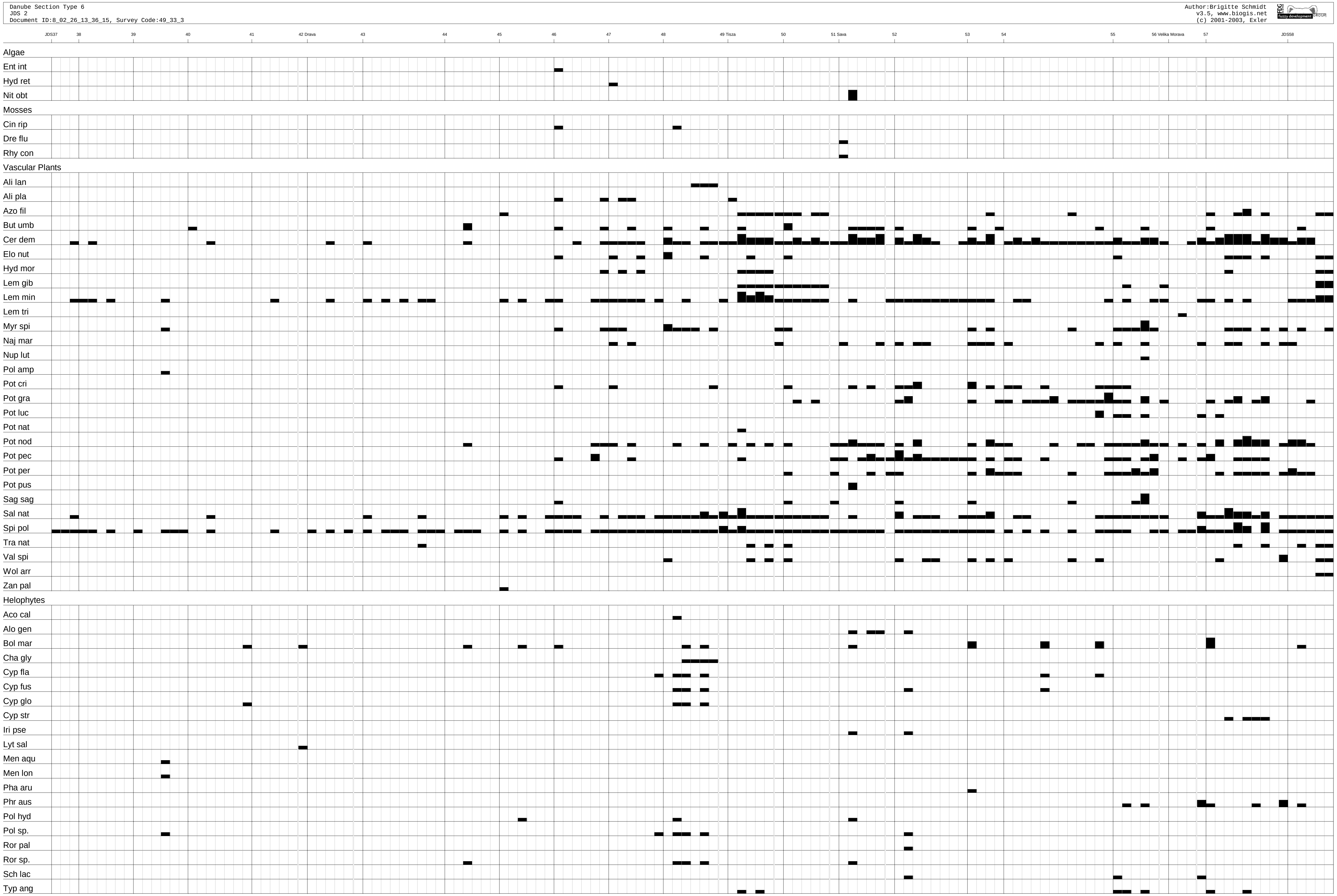

Figure 14: Distribution Diagram Section 6

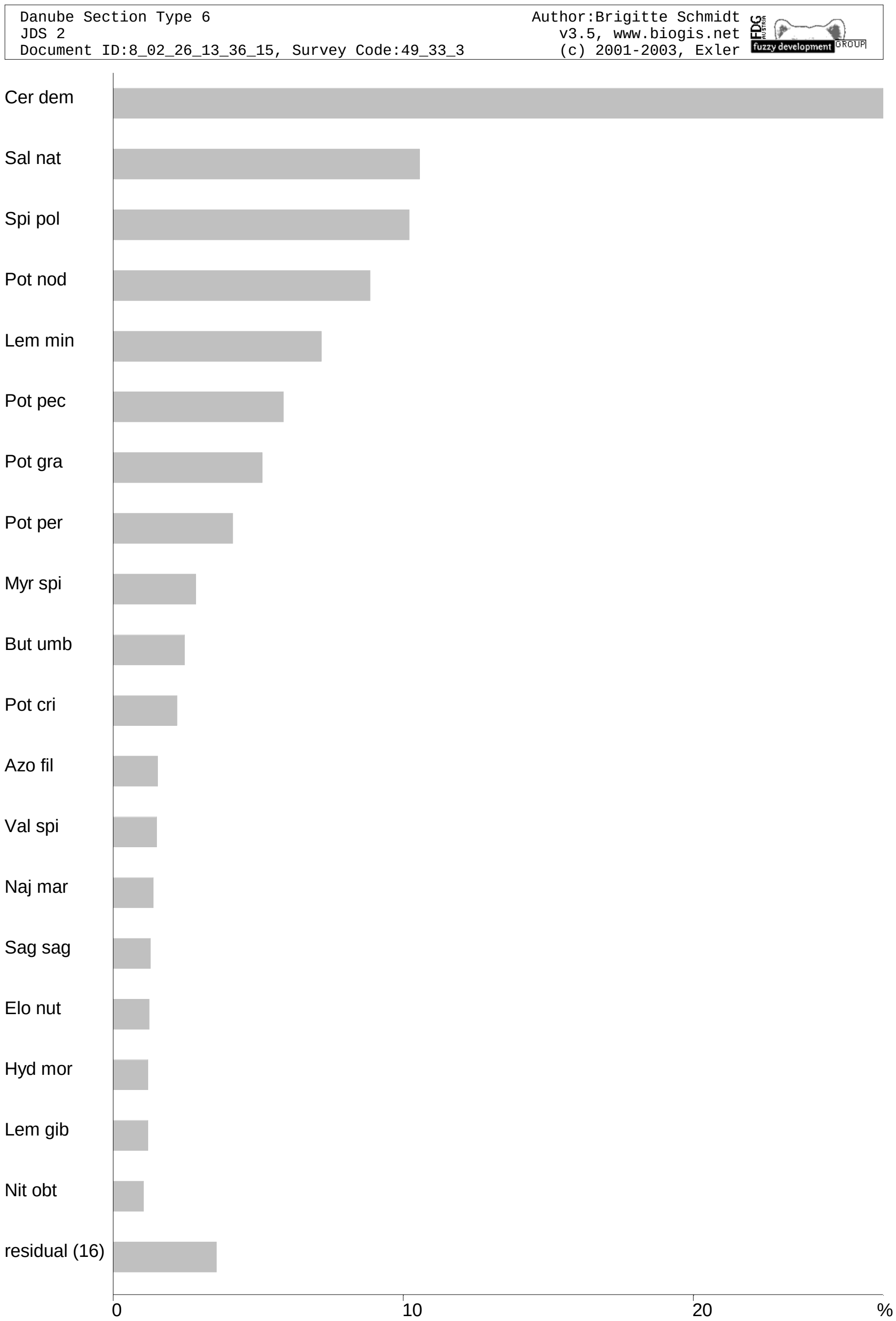

Figure 15: RPM Section 6

1.3.7 Section 7
Iron Gate Danube, rkm 1071 – 943

Section 7 reaches from Bazias to Turnu Severin (128 km) in the Iron Gate reach. 26 km were surveyed. This series of gorges, the former reach of cataracts, was impounded for two hydro-electric power plants. Between the gorge passages today the Danube is up to 750 m wide and islands in the middle as well as decayed trees extend over the water surface, and *plauri*, floating reed islands, form on their rim. Rocky hills flank the wider parts of the gorge reach.

Due to these conditions two thirds of the banks consist of rock (20 km), 6 km are formed by steep grassy banks. As a consequence of the impoundment the flow velocity is slow and fine inorganic sediment (14 km) and sand (7 km) dominate.

On the rocks and stones three moss species were detected. The stonewort *Nitellopsis obtusa* grew in dense stands (RPM = 2.4 %) in the lake-like wider reaches of the impoundment. In this relatively short section 23 vascular plants were found. *Ceratophyllum demersum* dominated (RPM = 27.7 %) over *Potamogeton nodosus* (RPM = 17.9 %) and *Myriophyllum spicatum* (RPM = 10 %). *Potamogeton zizii*, the pondweed hybrid *Potamogeton lucens* x *gramineus*, was identified by anatomical stem cross sections. In these slow flowing waters the duckweeds reached RPM = 12 %.

Helophytes were scarce on the rocky and steep banks

Figure 16: Distribution Diagram Section 7

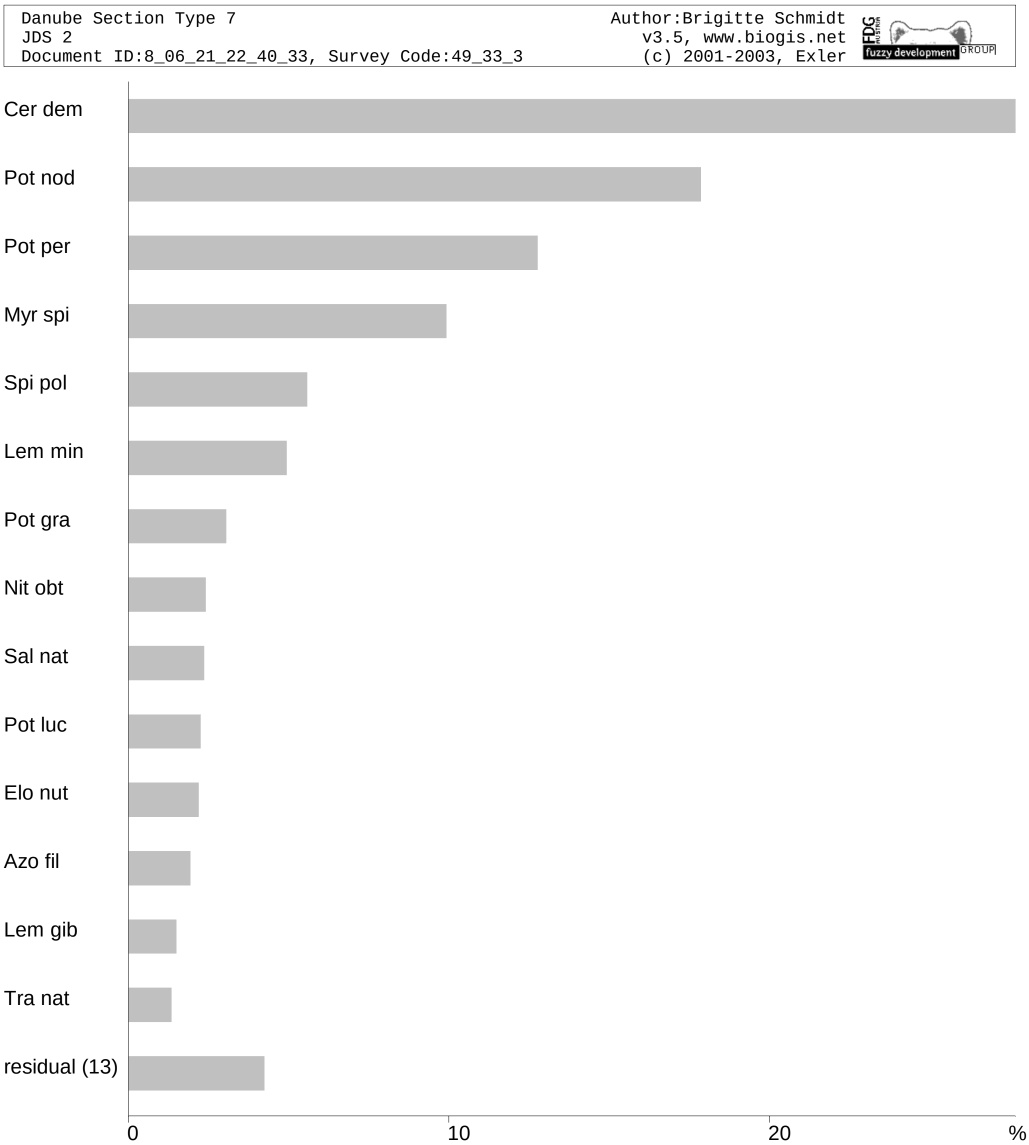

Figure 17: RPM Section 7

1.3.8 Section 8, Western Pontic Danube, rkm 943 – 375,5

Section 8 is the longest reach determined by ICPDR (567.5 km, 23 Survey Sites, JDS 63 – 86), which begins downriver of the Iron Gates power plant near Turnu Severin (Vrbica/Simijan) and ends at Chiciu/Silistra. With slight bends the course of the Danube is flanked by riparian landscape with terraces and quite uniform deciduous forests. Several islands modify the picture of the river, while being subject to change in case of floods. With the right bank often steep and limiting the run of the river, the left bank leads softly over to extensive wetlands. The general slope is c. 0,04 ‰

In this Section 135 km were surveyed, including the mouth sections of the rivers Timok, Iskar, Olt, Jantra and Arges. Flat banks composed of sand covered more than half of the reach (80 km). Steep banks (c. 31 km) were found in the remaining lengths, mainly in embankments in cities and ship moles. Sand was the substrate in c. 100 km length.

No mosses were found in this Section, but three algae species were quite abundant.

26 vascular species were recorded. *Ceratophyllum demersum* (RPM = 37 %) was dominant in over 100 km length. *Vallisneria spiralis* (RPM = 9.8 %) occurred only down to the confluence with the Iskar. *Myriophyllum spicatum* (RPM = 6.8 %), *Lemna minor* and *Spirodela polyrhiza* (RPM = 6.4 % each) wer present in almost all SUs. *Potamogeton perfoliatus*, *P. crispus* and *Elodea nuttallii* follwed in decreasing order. When adding all duckweed species their contribution to dominance would be RPM = 13.4 %.

27 helophytes usually grew in a short distance inland leaving some part of the bank without plant growth, or grew above from the steep banks on the right river side. The abundance of helophytes growing close to the water line was very low.

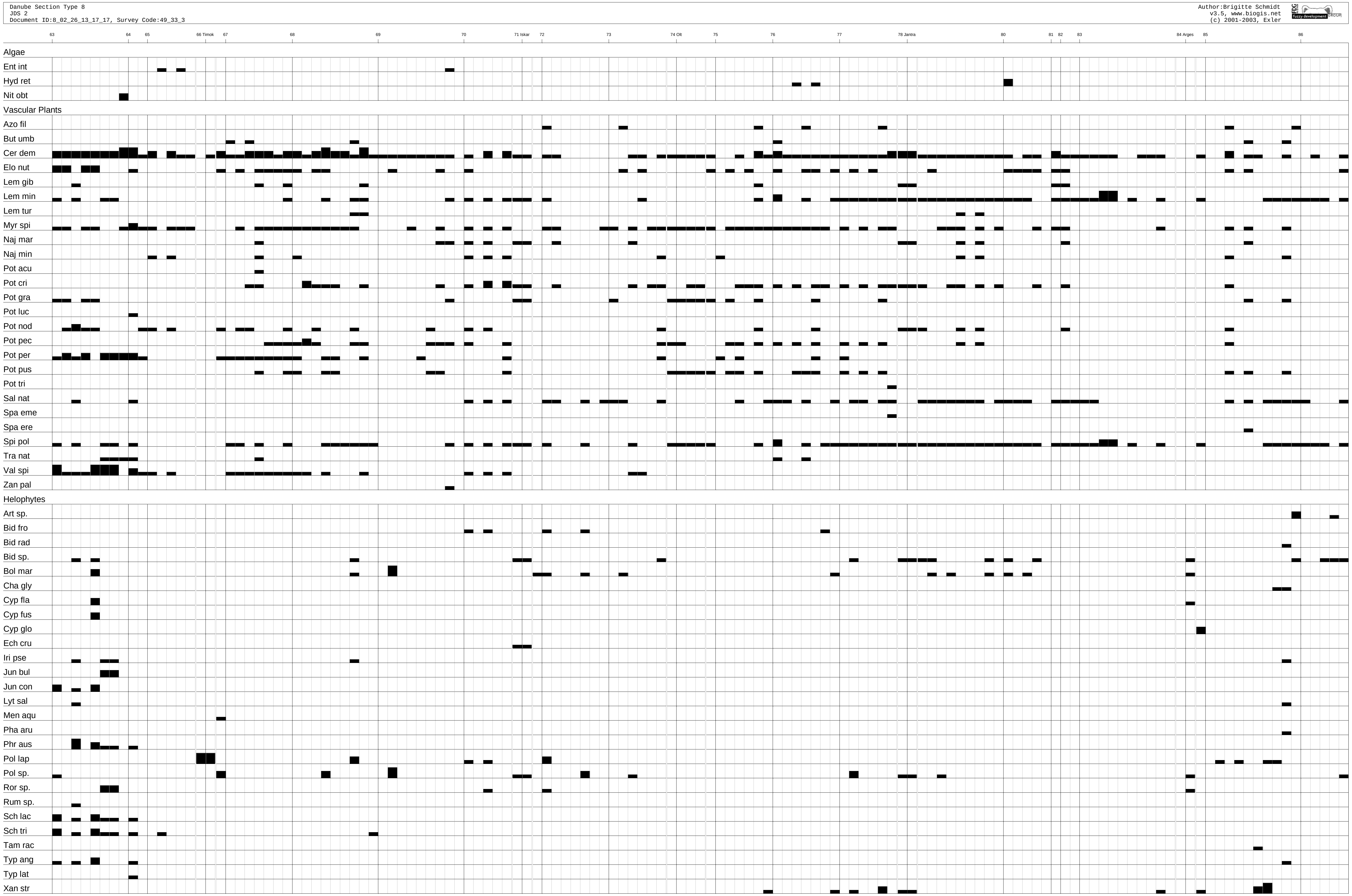

Figure 18: Distribution Diagram Section 8

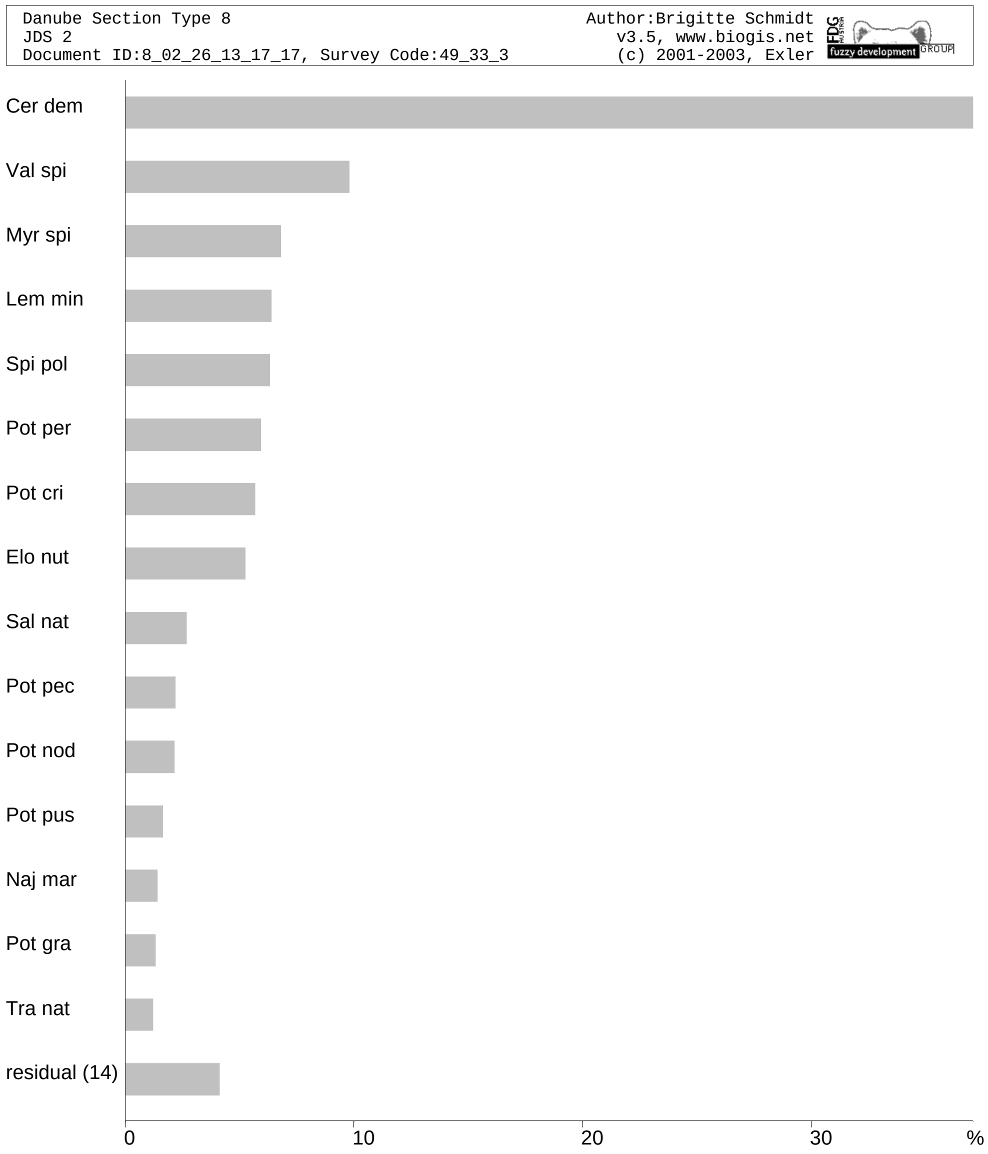

Figure 19: RPM Section 8

1.3.9 Section 9 Eastern Wallachian Danube, rkm 375,5 – 100

Only 5 Survey Sites were located in Section 9 (275 km, JDS 87 to 91) between Chiciu/Silistra and Isaccea. The Danube flows north towards the Black Sea. In this very wide and flat valley the river is up to 650 m wide. The slope is only 0.04 ‰. The river erodes the sandy banks and in the extensive floodplains large wetlands and many floodplain lakes and other waterbodies exist.

27 km were surveyed. Most river banks (23 km) consisted of sand, 2 km were composed of steep fine inorganic material and 2 km were reinforced for navigational purposes.

The sediment, too, consisted of sand (24 km), and fine material mixed with loam was found in 2 km. Municipal sewer outflow resulted in an increase of organic material and respective deposits (all together a stretches of c. 1 km). Due to these conditions the turbidity of the water increased considerably (Secchi – Transparency < 40 cm). Light can be considered the limiting factor for aquatic macrophyte growth in this Section.

Algae and mosses did not exist in this section. Vascular plants were reduced to 12 species. Helophytes (17 species) were under strong competition by *Xanthium strumarium*, a burdock species on the sandy banks. In the riparian forests the typical *Tamarix ramosissima* was found in a few places.

Ceratophyllum demersum (RPM = 44.8 %) dominated *Butomus umbellatus* (RPM = 12 %), an amphiphyte, growing here in the submerged state, and *Najas marina* (RPM = 3 %). Duckweeds were not disturbed by the high turbidity as they float on the water surface (*Lemna minor* RPM = 13.4 %; *Spirodela polyrhiza* RPM = 12.2 %, *Lemna gibba* and *L. trisulca* RPM = 1.5 % each).

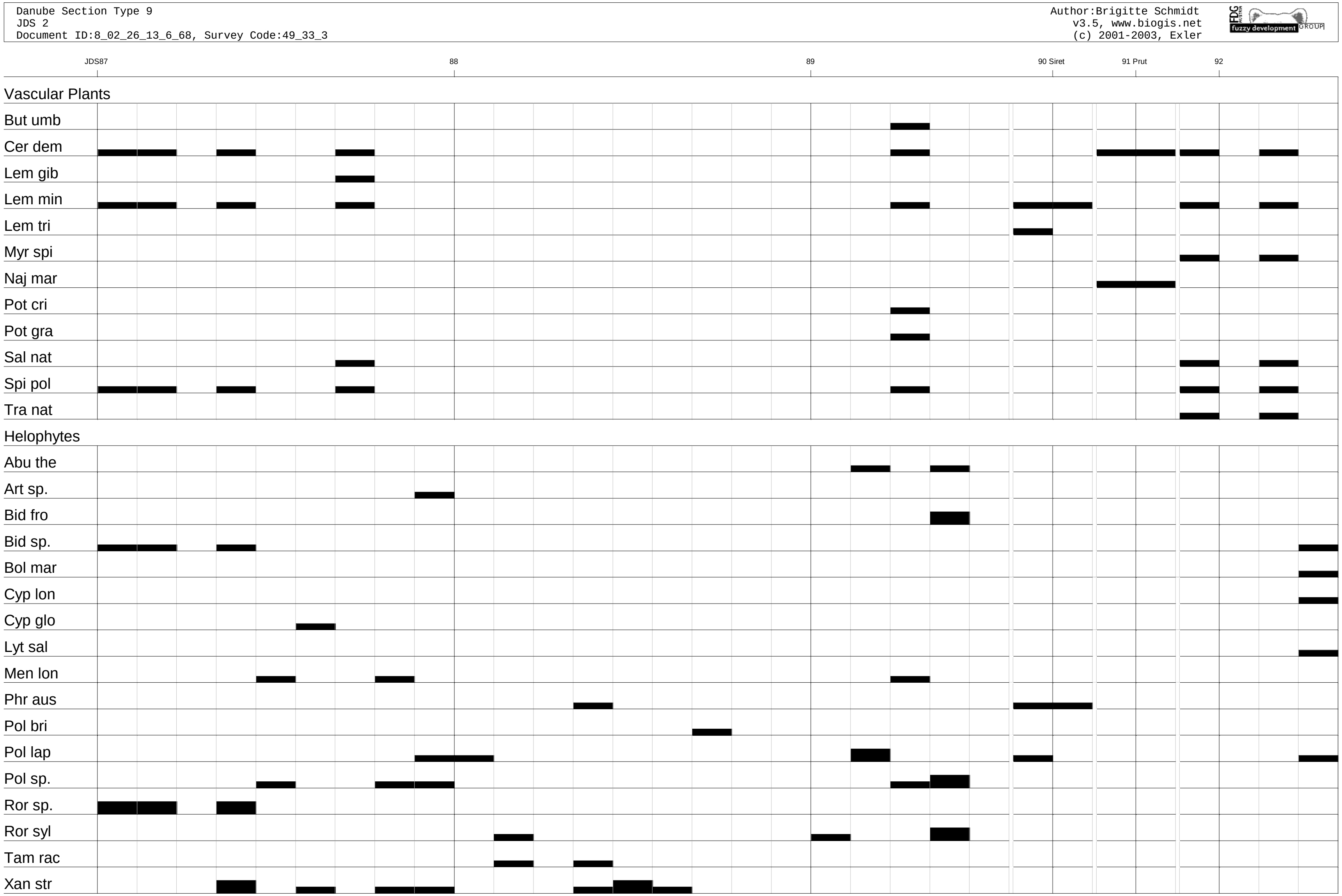

Figure 20: Distribution Diagram Section 9

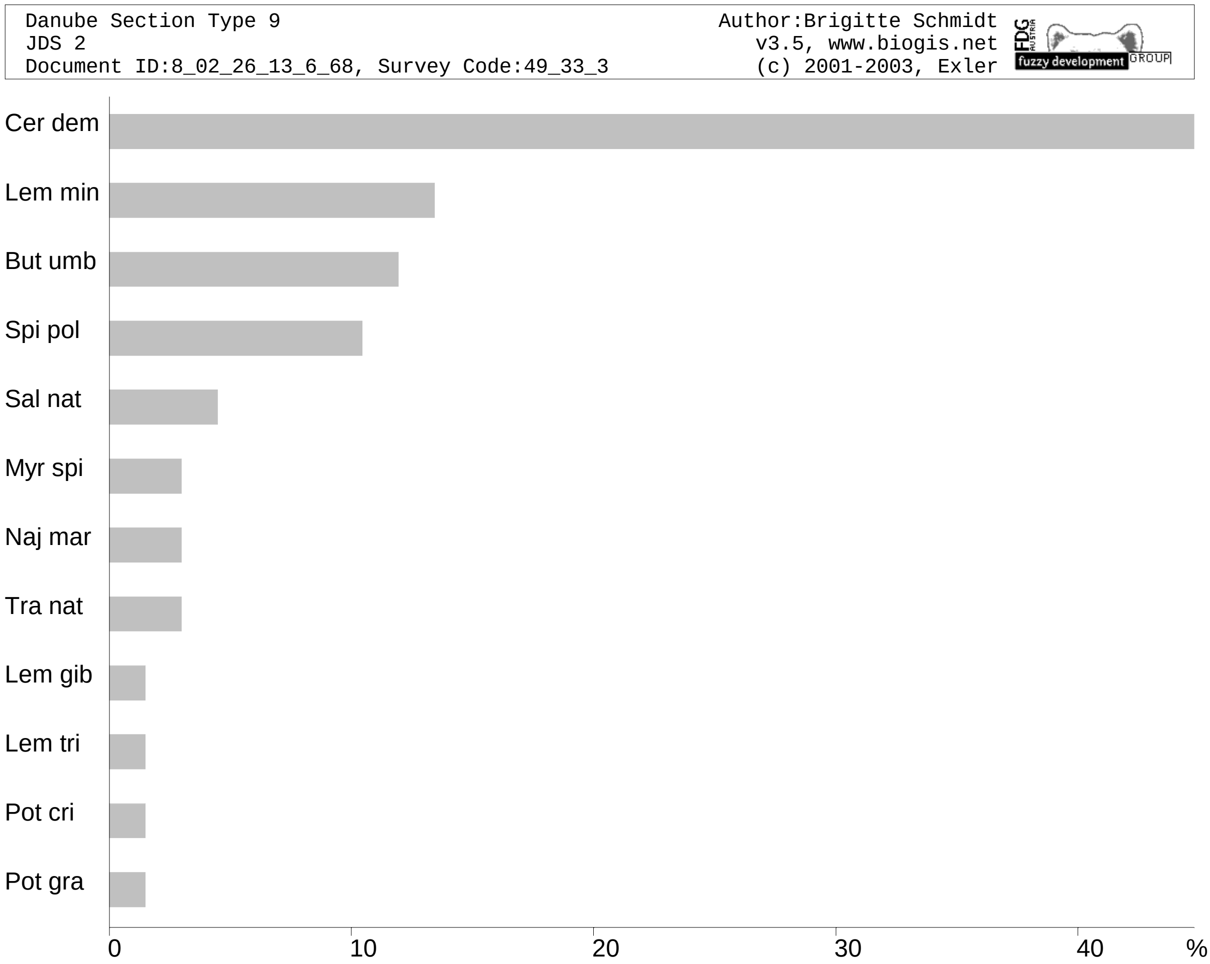

Figure 21: RPM Section 9

1.3.10 Section 10 Danube Delta rkm 100 – 0

Section 10 comprises the Danube Delta. Three large canals, navigable by ocean-going ships, and numerous smaller Danube side channels add up to much over 100 km length. Floating *plauri* (freely floating reed islands) are rarely noticed as such, as they are sometimes of enormous size. Reed dominates by all means the lower half of the canals. The slope varies between 0.04 ‰ und 0.001 ‰.

In this Section 17 km of Survey Sites were investigated (JDS 93 to 96, Vilkova-Chilia-Channel, Bystroye-Channel, Sulina-Channel, St. Gheorghe-Channel).

All banks in the surveyed river length were flat except 2 km of embankments and 2 km with steeper banks. The sediment consisted of silt or mud. Sand was detected in only a few rkm.

Despite the fact that only a few rkm were surveyed in this Section it was rich in species (16 vascular plants and 20 helophytes), but abundances were low. Mosses and macrophytic algae were not detected. The order of dominance: *Ceratophyllum demersum* (RPM = 39.8 %), *Potamogeton nodosus* (RPM = 9.7 %), *P. pectinatus* and *P. perfoliatus*

(RPM = 7.4 %), *Salvinia natans* and *Myriophyllum spicatum* (RPM = 6.8 %). Duckweeds were not abundant (RPM = 7 %). A rare species was *Stratiotes aloides*, which was detected between the reeds, but it was close to the state of hibernating.

The list of helophytes presented here (20 species) could be extended when surveying in a smaller scale, but the focus was laid on aquatic macrophytes in this survey.

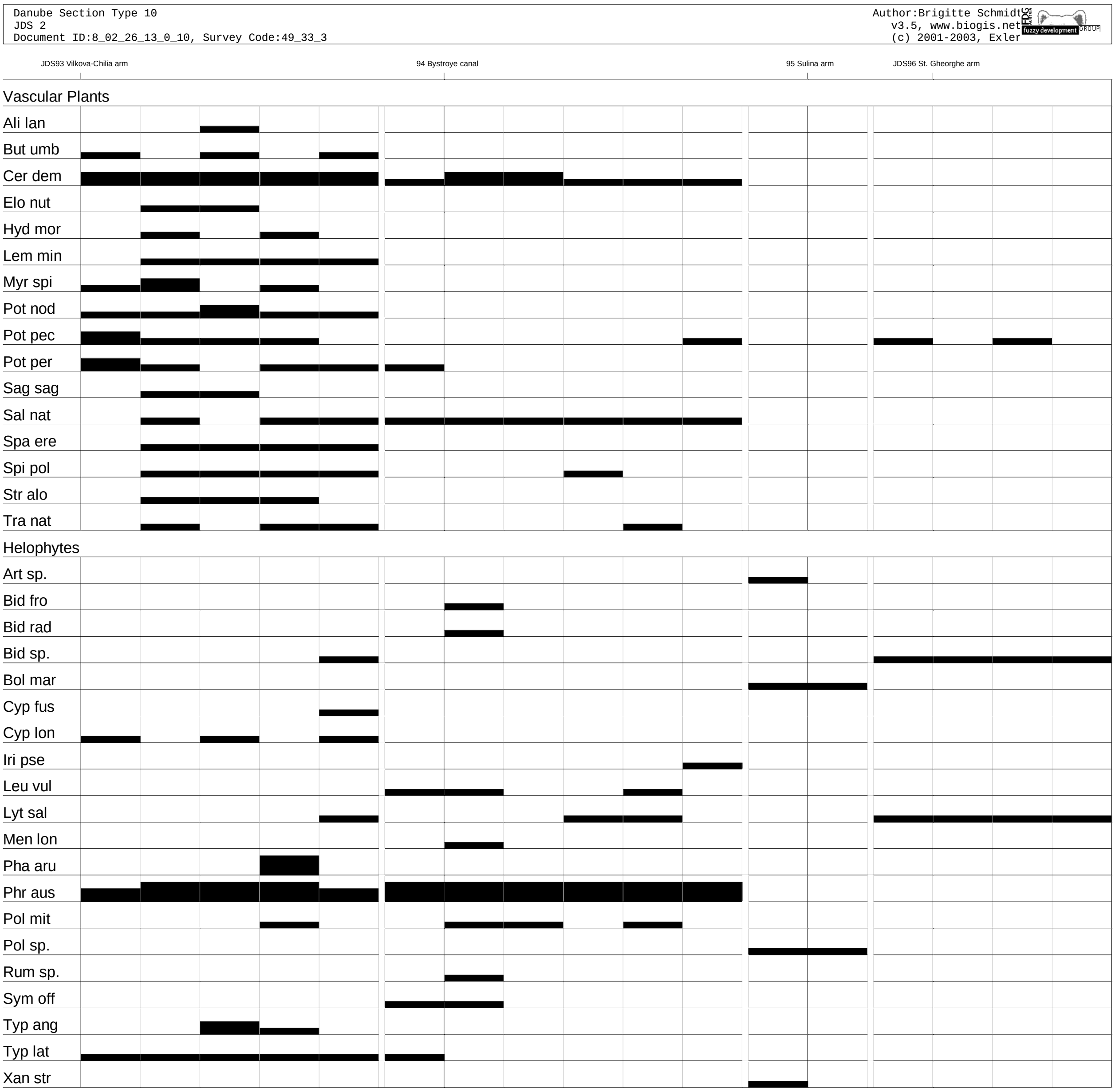

Figure 22: Distribution Diagram Section 10

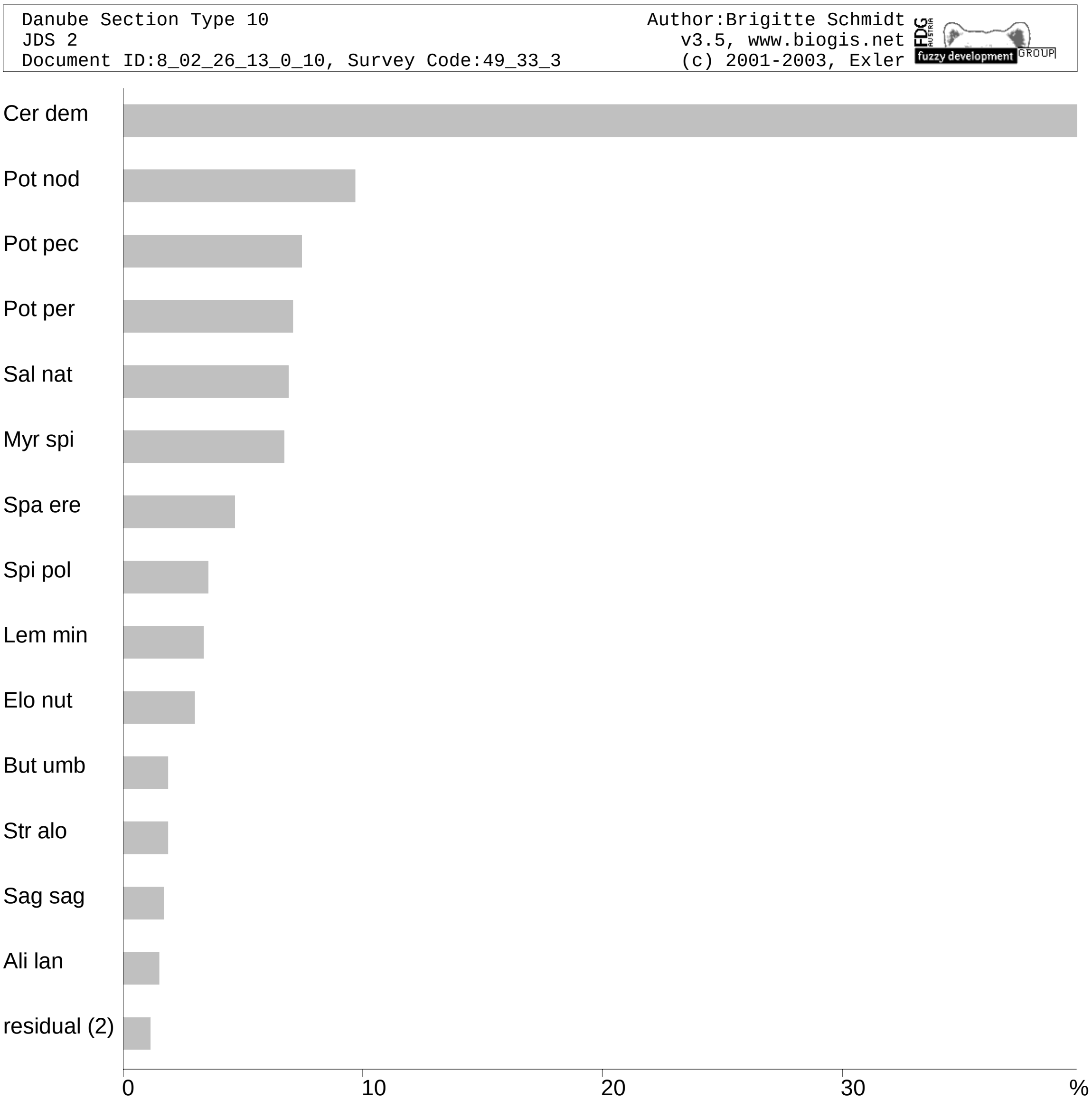

Figure 23: RPM Section 10

1.3.11 Overview on the whole Danube River

1.3.11.1 Relative Plant Mass of plant groups

The development of macrophyte families and some higher taxa as a mirror of species group behaviour along the course of the Danube is a possibility to see changes on a greater scale. RPM values accumulated for such higher taxa in each river section, and the total number of species recorded in the same reach, are presented in Figure 24. Comments on some of the taxa or species groups follow below (categories relating to Figure 24 are printed in *italics* in the text):

Bryophytes (aquatic mosses and liverworts) prefer large stones and running water, where CO_2 is easily available. This group is dominant in the uppermost three sections of the Danube.

The aquatic *ferns Salvinia natans* and *Azolla filiculoides* show their greatest abundance in Section 6. This part of the Danube is characterised by the confluence with the three largest tributaries, the Drava, Tisza und Sava. This section is also marked out by the highest species richness – a total of 32 species – recorded in the main river channel.

Many Ranunculaceae species are limited to fast flowing reaches of rivers. *Ranunculus fluitans* was recorded in Section 5 in the outlet of the Rackeve-Soroksar side channel, where high flow velocities and clear cool water were present, possibly influenced by groundwater welling up.

Lemnidae were exceptionally abundant over the whole Danube in 2007. To some surprise peak abundances of these free floating species were recorded in survey units with faster flow than would be expected, as their occurrence in almost still waters like the Iron Gate or the Danube Delta sparse.

Potamogetonaceae were rather evenly distributed across Sections 3 to 10. This is mainly due to the wide ecological amplitude of the species *P. pectinatus*, which is tolerant to a wide range of habitat parameter properties, e.g. nutrient load, flow velocity, covering by "Aufwuchs".

Ceratophyllaceae and *Halorhagaceae*, predominantly represented by *Ceratophyllum demersum* und *Myriophyllum spicatum*, occur almost everywhere in the Danube, as is appropriate for so called "ubiquistic" species. It should be stated here that C. demersum is a rootless species and its wide spread in the river is of no small surprise, but has been recorded several times before by the authors of this report. Despite the fact that some experts claim that ubiquists are of no importance in describing the aquatic vegetation with respect to classifications (e.g. respective to the WFD), those species play an important role in the dominance relationships of aquatic plant species and should not be neglected, as they increase in importance when going downriver.

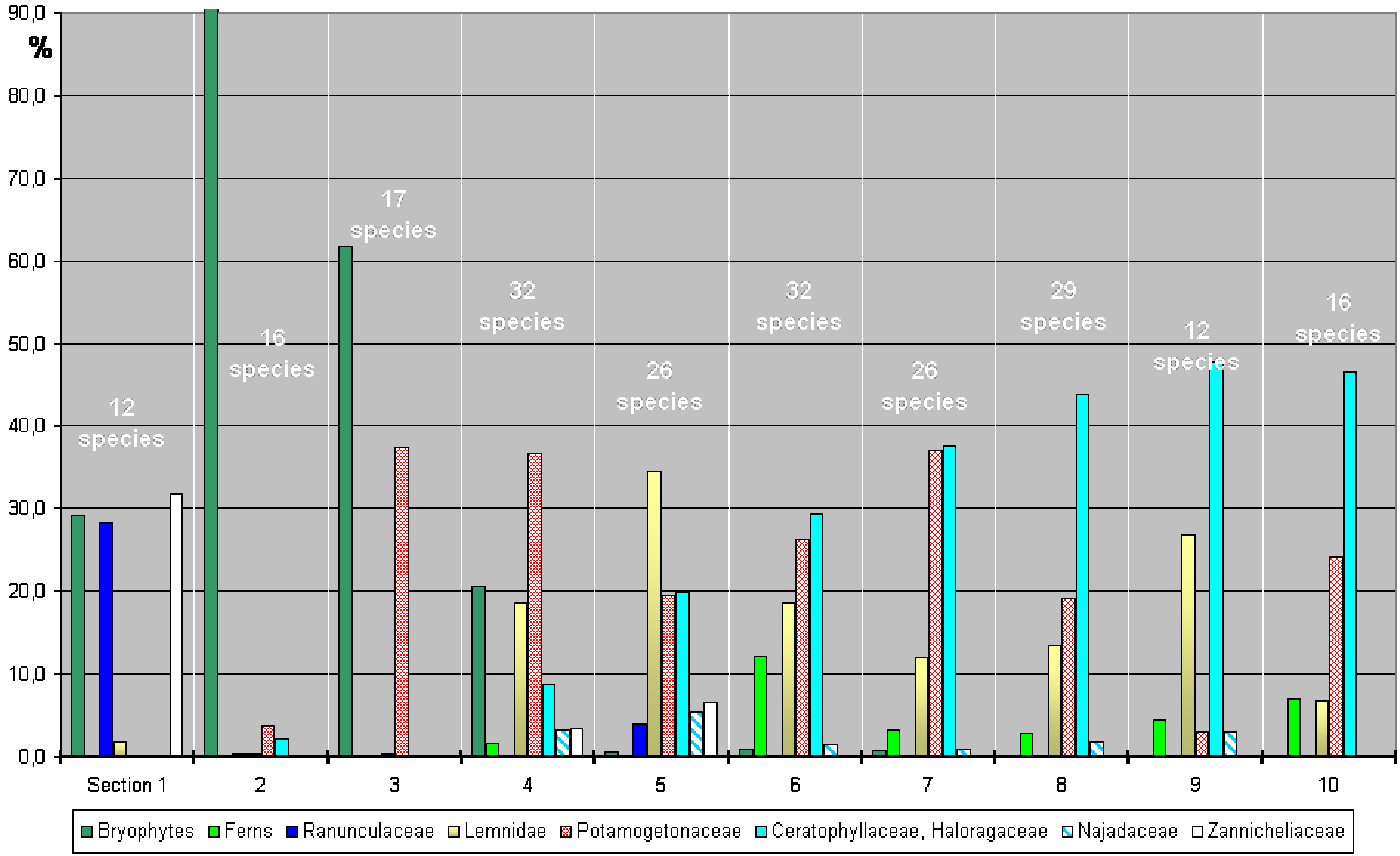

Figure 24: Development of RPM of different plant groups

1.3.11.2 Upstream - downstream comparison of selected Sampling Sites

The comparison of upstream / downstream sampling sites of larger cities or confluence regions of tributaries produced interesting results with respect to averaged plant mass and species richness: in 8 out of 11 situations an increase of plant mass and species number was recorded (red arrows in Figure 25). These clear changes point to an enhancement of nutrients at the downriver site. Negative impacts of very poor water quality or other adverse influences should be absent from the downstream sites.

Downstream of Belgrade and at the confluences of the rivers Iskar and Jantra species number and abundance decreased (black arrows). Causes for this result can be shown after consulting the results of other JDS 2 Core Team member groups, as the impact of anthropogenic substances of physical parameters (bank type, sediment type, suspended solids) could have caused this effect.

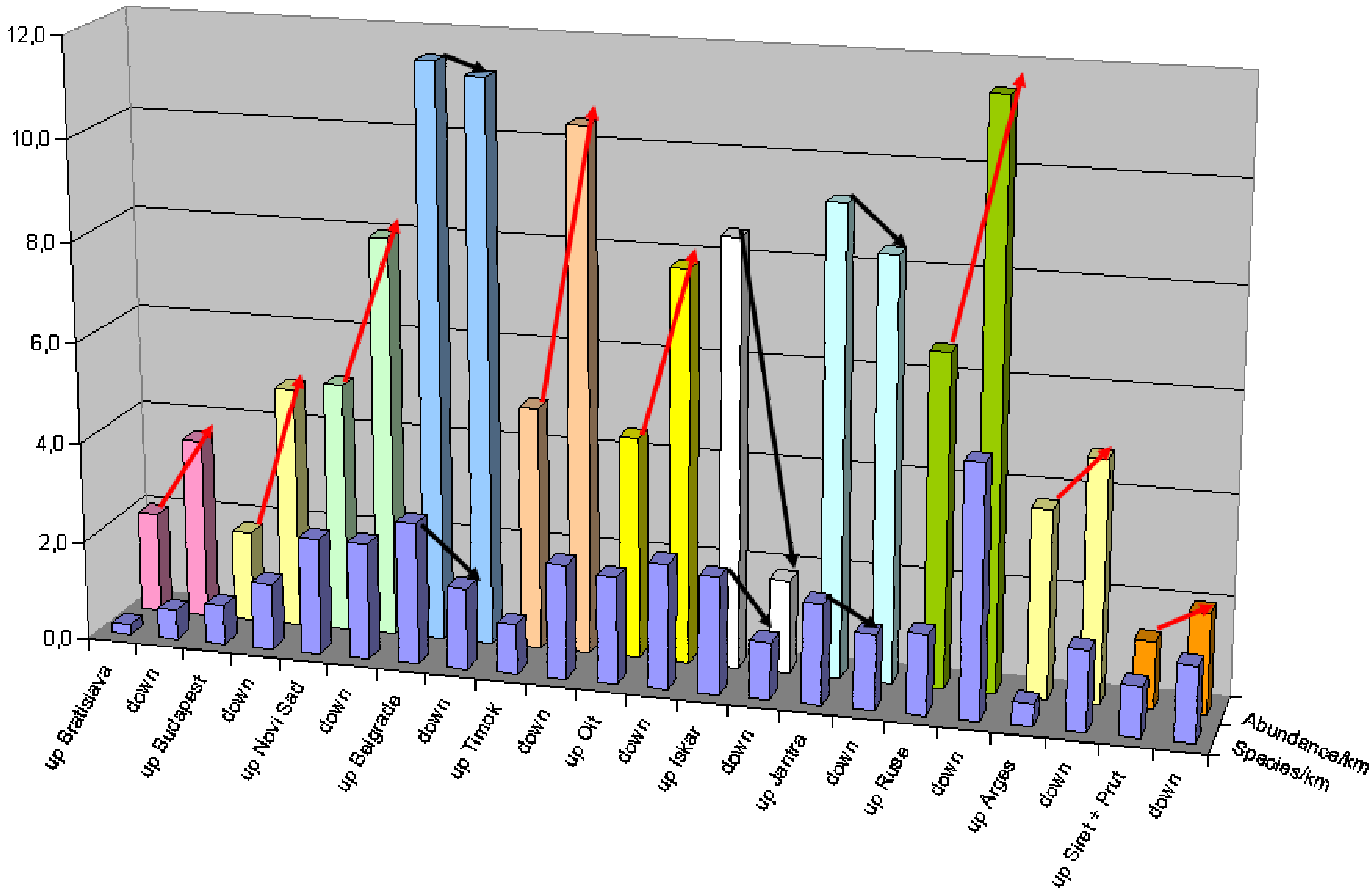

Figure 25: Upstream–downstream of selected sampling sites

1.3.11.3 Similarity of River Sections

For assessing the similarity of river sections the results were analysed with multivariate statistical methods. Each section was compared with the other sections and results show that each individual section is significantly different from the others and is characterised by its own indicator species.

Table 11: Multivariate Statistics

A-Values of the Multi Response Permutation Procedure (MRPP) between the Sections (**significante A-values** are in **bold,** P ≤ 0,001).

SECTION	ST-1	ST-2	ST-3	ST-4	ST-5	ST-6	ST-7	ST-8	ST-9	ST-10
ST-1	-									
ST-2	**0,0978**	-								
ST-3	**0,0888**	**0,1340**	-							
ST-4	**0,0300**	**0,0379**	**0,0633**	-						
ST-5	**0,0396**	**0,1500**	**0,1185**	**0,0781**	-					
ST-6	**0,0296**	**0,1234**	**0,1000**	**0,0743**	**0,0376**	-				
ST-7	**0,1688**	**0,2816**	**0,2377**	**0,1121**	**0,0849**	**0,0424**	-			
ST-8	**0,0269**	**0,1109**	**0,0919**	**0,0676**	**0,0429**	**0,0315**	**0,0399**	-		
ST-9	**0,0718**	**0,1482**	**0,1161**	**0,0467**	**0,0479**	**0,0413**	**0,1385**	**0,0282**	-	
ST-10	**0,1311**	**0,1944**	**0,1364**	**0,0598**	**0,0741**	**0,0434**	**0,1455**	**0,0351**	**0,0671**	-

Except for Section 4 all other sections had at least one specific indicator species (Table 12). Section 4 is located between Greifenstein (A) and the mouth of the Mosoni Duna (HU): the statistical analysis seem to indicate that this reach is a kind of an “ecotone”, a boundary reach, between two different sections. Later analyses based on the macrophytes could reveal, where the exact point of separation of these sections could be. In Sections 9 and 10 helophyte species were the indicator species, in all other sections indicators were among the aquatic macrophytes.

Table 12: Indicator species per section

Section 1	Section 2	Section 3	Section 4	Section 5
Ranunculus fluitans	Cinclidotus riparius	Fontinalis antipyretica		Lemna gibba
Zannichelia palustris	Phalaris arundinacea	Lycopus europaeus		

Section 6	Section 7	Section 8	Section 9	Section 10
Spirodela polyrhiza	Potamogeton perfoliatus	Potamogeton pusillus	Xanthium strumarium	Phragmithes australis
Salvinia natans	Potamogeton nodosus			Lythrum salicaria
	Ceratophyllum demersum			Typha latifolia

1.3.12 Tributaries

National teams co-operating with the JDS 2 crew collected macrophyte data from sampling sites in the upper reaches of some tributaries. Field protocols and some plant samples were brought to the ship for data processing. As some national teams followed their own interpretation of the standardised methodology the ViennaTeam does not take responsibility for the results based on the national data sets.

1.3.12.1 Morava und Dyje (SK, CZ)

In the Morava three sampling sites were surveyed:

Morava:	JDS 15	at Devin (mouth section)	
	MO2	at Lanzhot (SK)	rkm 79
Dyje:	MO1	at Pohansku (CZ)	rkm 17

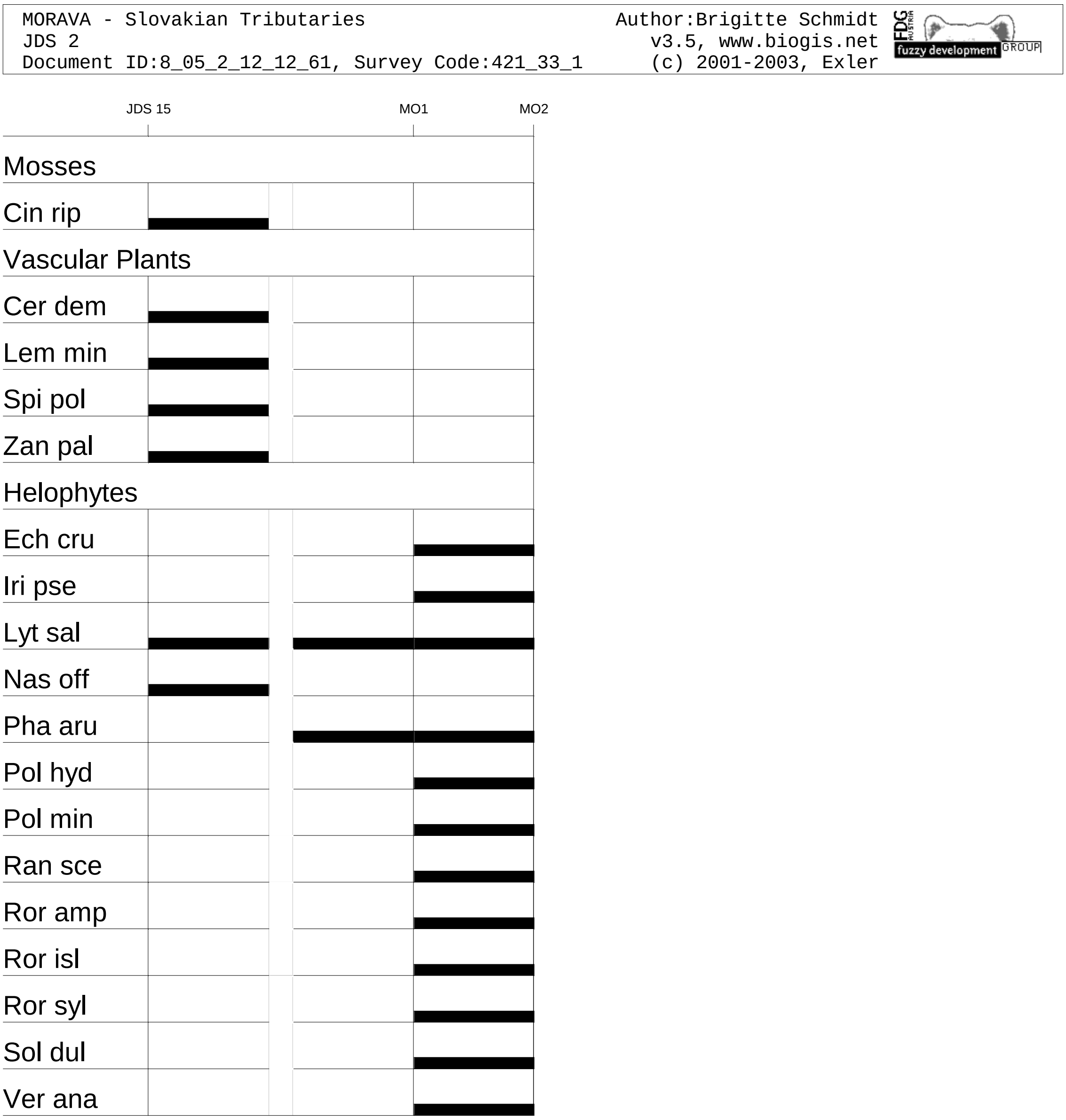

Figure 26: Distribution Diagram River Morava and Dyje

Real aquatic macrophytes were detected only in the mouth section (Devin) and the RPM was quite similar to that processed by the JDS Core Team on the ship. At the sampling sites upriver only helophytes were found on the river banks.

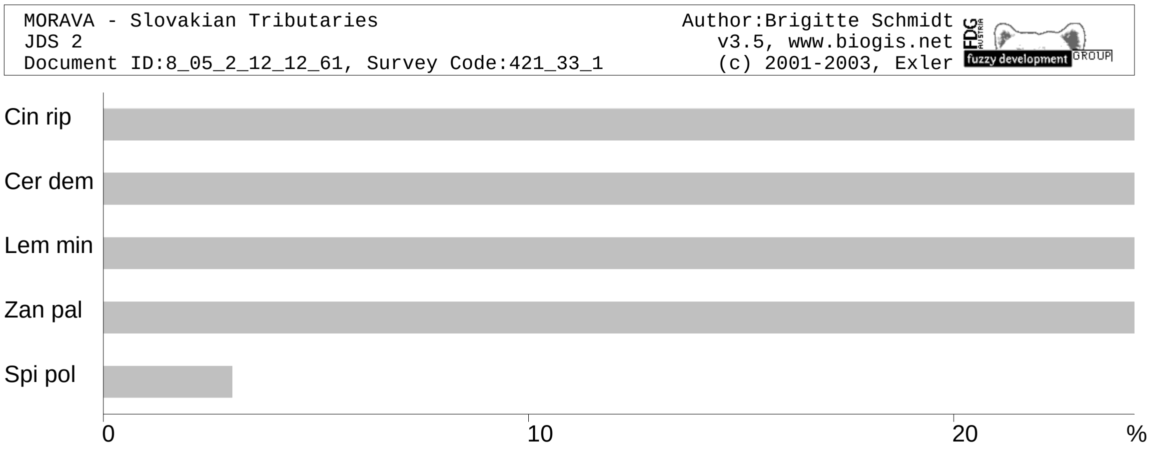

Figure 27: RPM River Morava

1.3.12.2 Sava (RS)

The Sava was surveyed at Novi Belgrade (rkm 6 – 8) by the Core Team. Four upstream sampling sites of 500 m length were surveyed by the national team:

SA4	Usce	rkm 62
SA3	Sremska Mitrovica	rkm 136
SA2	Jamena	rkm 195
SA1	Zupanja	rkm 254

Ceratophyllum demersum grew in 9 of 10 survey units (RPM = 39.9 %), and *Potamogeton nodosus* was detected in seven survey units (RPM = 13.5 %). *Nitellopsis obtusa* occurred only in a single river kilometer at Novi Belgrade, but the plant stands were large (RPM = 12.8 %).

In comparison the Sava was rich in aquatic species (18). Based on the list of delivered data it seems that helophytes had not been assessed by the national team.

Figure 28: Distribution Diagram River Sava

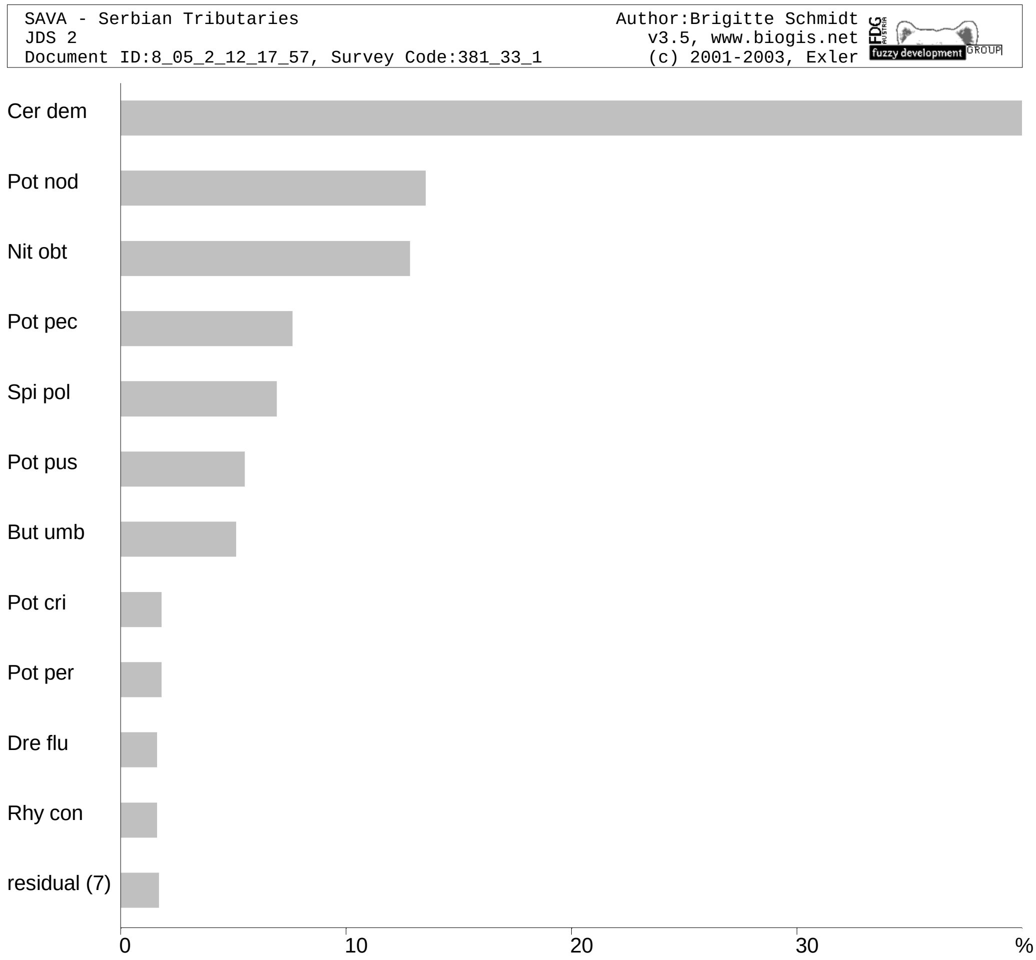

Figure 29: RPM River Sava

1.3.12.3 Arges (RO, BG)

The Romanian national team surveyed 500 m length upstream as well as downstream of the settelments at two sampling sites. The survey units scaled 100 m. At the mouth of Arges the ViennaTeam took survey units of 1000 m routinely.

JDS-AR2	Upstream/downstream Bucharest	rkm 121
JDS-AR1	Upstream/downstream Pitesti	rkm 234

In the mouth no macrophytes could be detected, in JDS-AR2 *Ceratophyllum demersum* and *Salvinia natans* were found upstream, as 10 species of macrophytes and 4 species of helophytes were recorded in one 100 m stretch downstream (Figure 30). In JDS-AR1 only 3 macrophytes and 3 helophytes could be detected.

Spirodela polyrhiza shows the highest RPM = 25 % followed by *Salvinia natans* (RPM = 22,2 %), *Cladophora glomerata* (RPM = 16,7 %) and *Ceratophyllum demersum* (RPM = 11,1 %).

Figure 30: Distribution Diagram River Arges

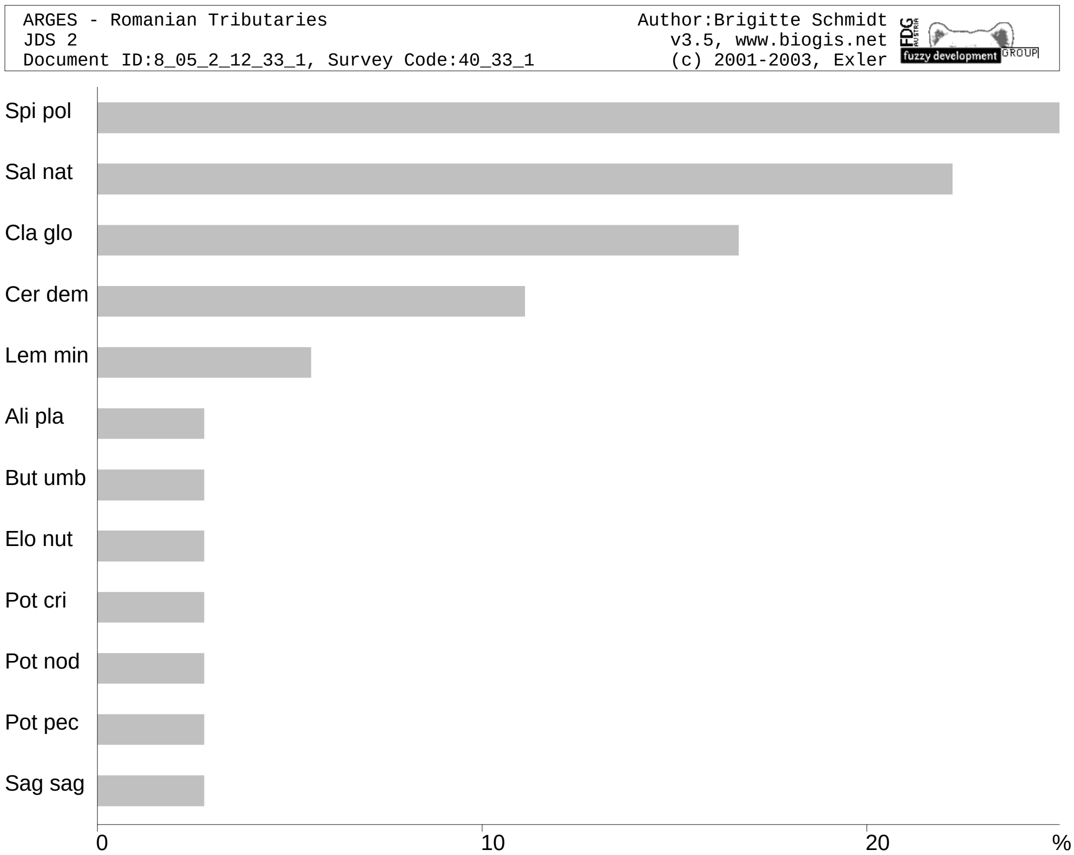

Figure 31: RPM River Arges

1.3.12.4 Olt (RO)

The national team sampled at two sites in the River Olt:

JDS-OL2	Upstream/downstream Slatina	rkm 61
JDS-OL1	Upstream/downstream Rm Valcea	rkm 163

In the mouth of the River Olt the ViennaTeam found 7 macrophytes in nearly all 4 survey units (4 km) but no helophytes, so the RPM for the whole river is dominated by the plants of this stretch. At JDS-OL2 only three macrophytes but 14 helophytes were surveyed, at JDS-OL1: 9 macrophytes and 7 helophytes. Regarding dominance in decreasing order *Myriophyllum spicatum*, *Potamogeton gramineus* and *Spirodela polyrhiza* (each RPM = 16.7 %) were followed by *Ceratophyllum demersum* and *Potamogeton pusillus* (each RPM = 14.5 %), *Potamogeton pectinatus* (RPM = 9.4 %) and *Potamogeton crispus* (RPM = 8.3 %).

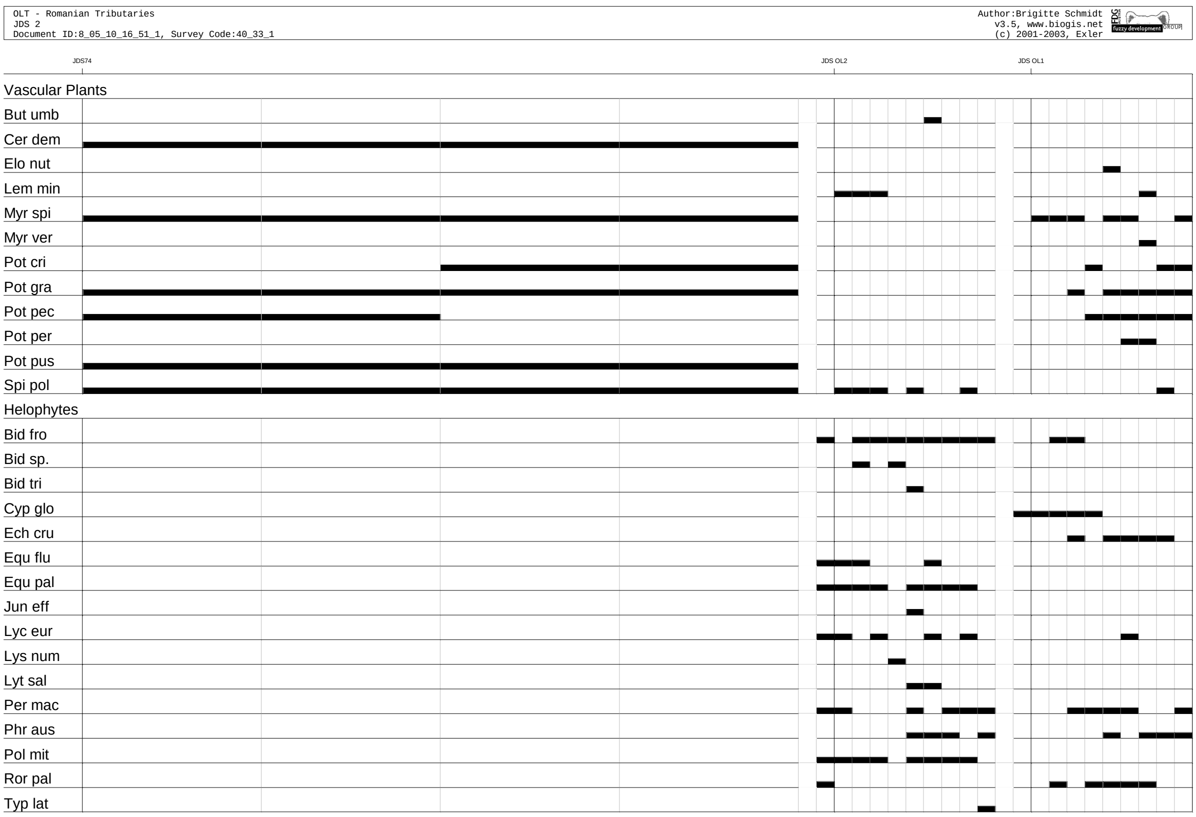

Figure 32: Distribution Diagram River Olt

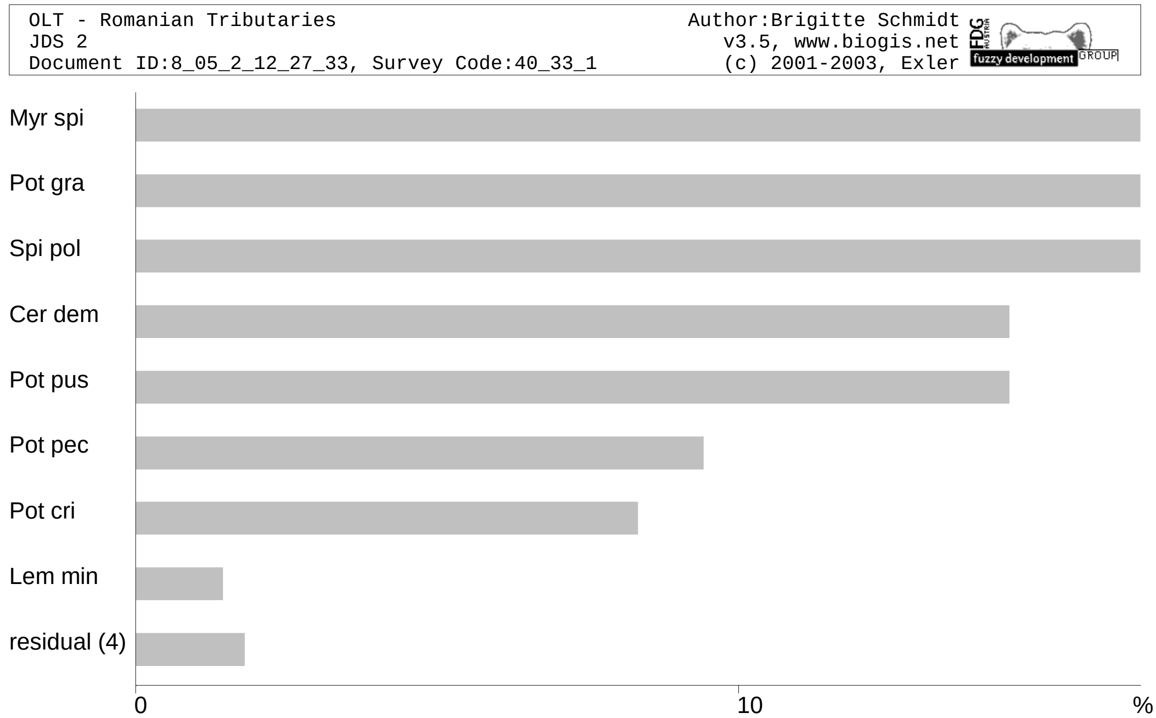

Figure 33: RPM River Olt

1.3.12.5 Prut (RO)

In the River Prut two sampling sites were investigated by the national team:

JDS-PR2	Upstream/downstream Bumbata-Leova	rkm 220
JDS-PR1	Upstream/downstream Ungheni	rkm 404

Macrophytes were only recorded in the mouth, *Ceratophyllum demersum* and *Najas marina*, so they split up the RPM among each other. The national team surveyed 9 helophytes.

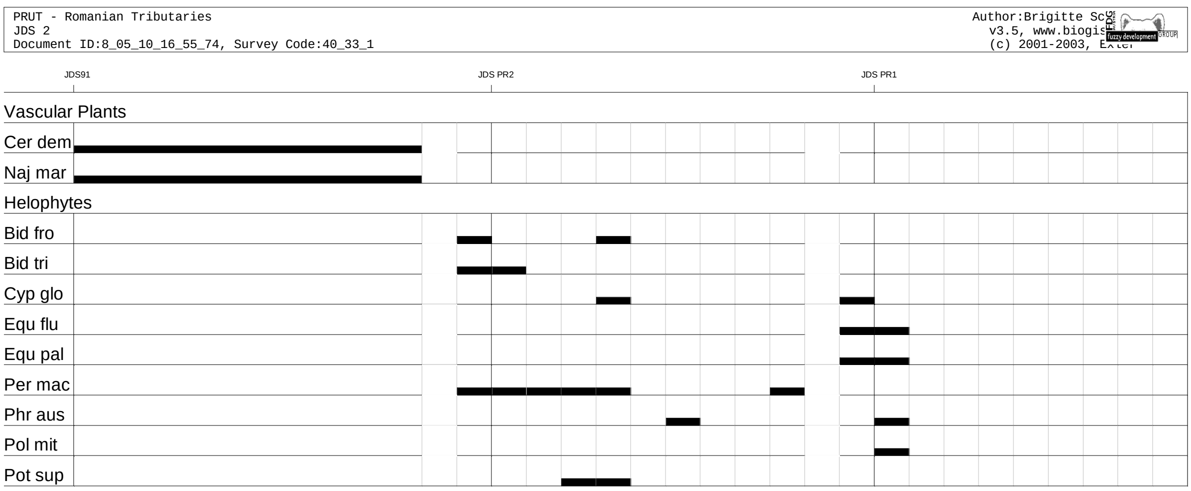

Figure 34: Distribution Diagram River Prut

1.3.12.6 Other Tributaries

In all other rivers the national teams had not detected macrophytes. In two cases samples were brought to the Core Team, but these samples did not contain any macrophytes, neither full plants nor parts of it.

1.3.13 Habitat Parameters

1.3.13.1 Secchi- Transparency

Secchi transparency was measured by the Phytplankton Group. In the diagram below (Figure 35) the lower transparencies are characterised by the darker shade in the background and symbolise the lower visibility. The retentive effect of hydro-power reservoirs on suspended solids is clearly noticed by enhanced transparencies in the reach downriver of the barrier. Following the river course the water again gets less transparent as tributaries, but also autochthonous plankton algae growth increasingly limit visibility.

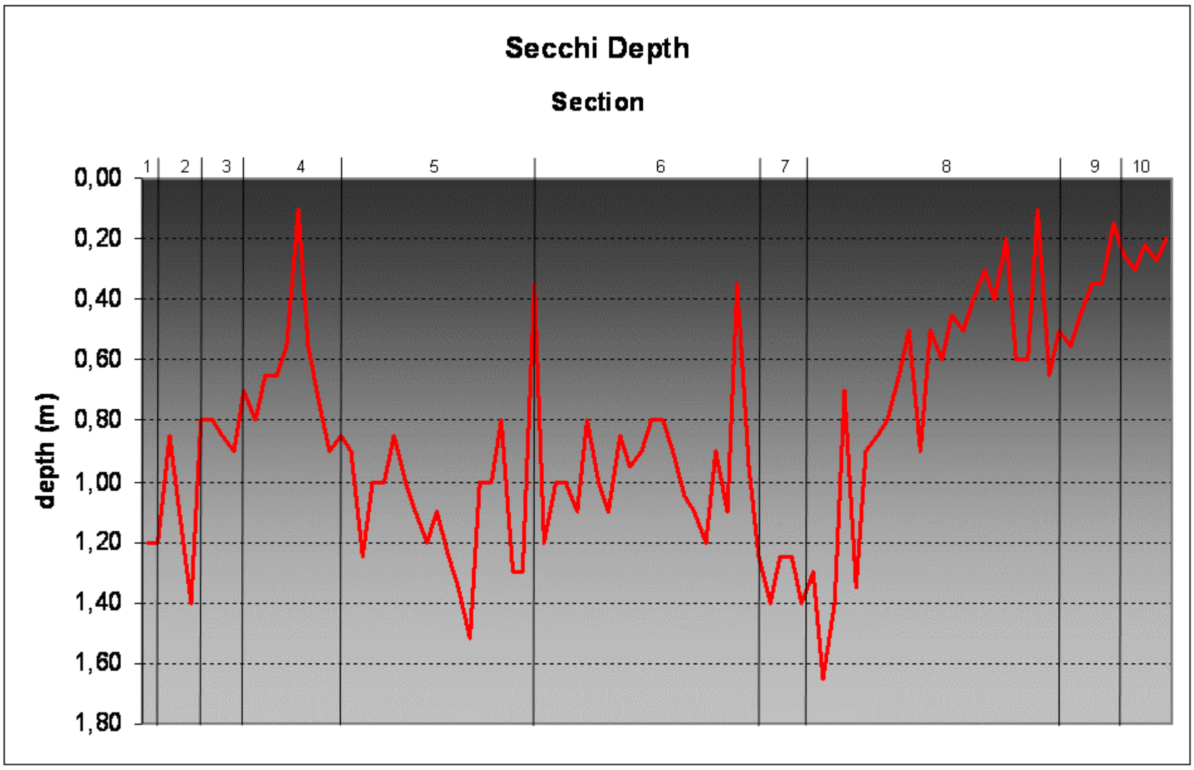

Figure 35: Secchi - Transparency

1.3.13.2 Water Flow Class

The Upper Reach of the Danube is characterised by a high vertical gradient and accordingly high flow velocities were recorded („medium“, 31 - 69 $cm.sec^{-1}$ to „high“, ≥70 $cm.sec^{-1}$) in the first two River Sections. Lower flow velocities („no flow“ and „low“, 0>v≤30 $cm.sec^{-1}$) in River Section 3 is caused by the large reservoirs of the hydro-electric power plants in Austria. In this country only in the Wachau Valley, and downriver of Vienna, the flow velocities correspond to the gradient of this certainly regulated, but not impounded reach. In the power plant impoundments the flow velocities depend in part on the management situation: during flooding periods the sluice and flood gates are opened and in the lower part of the impoundment the flow velocities are considerably enhanced.

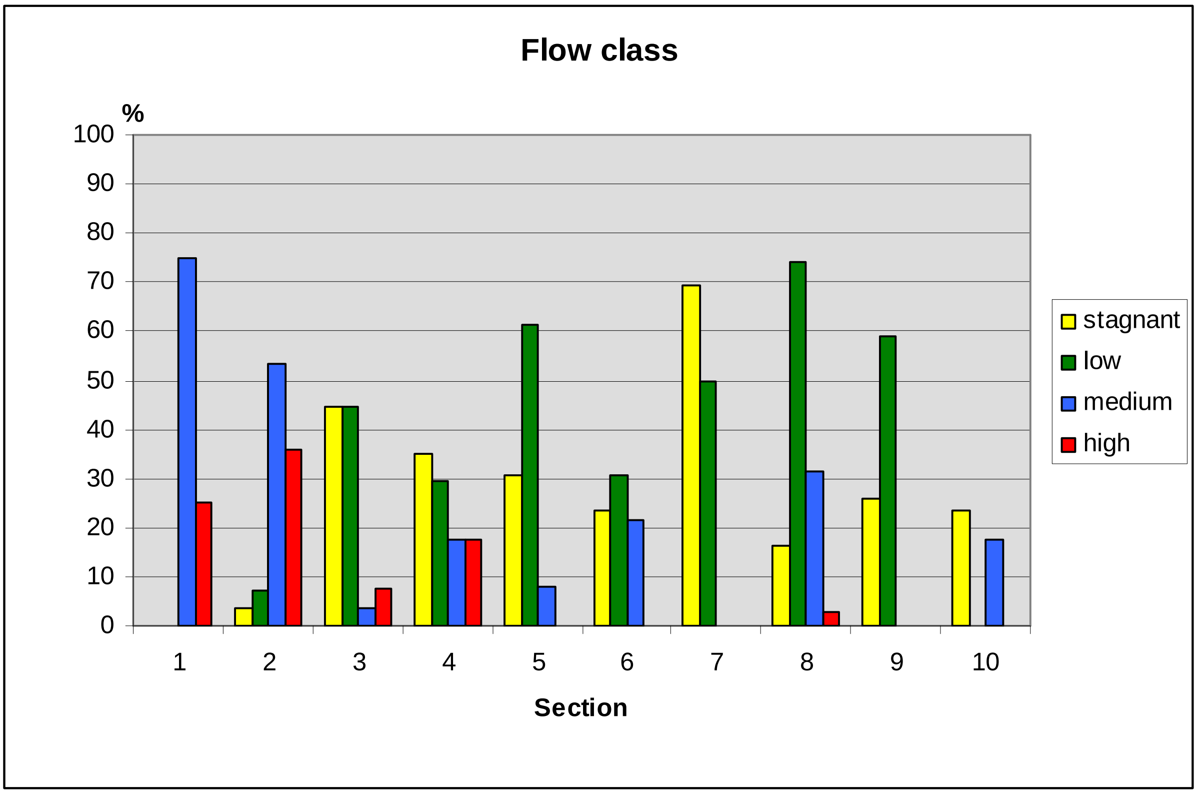

Figure 36: Water Flow Velocities per River Section

1.3.13.3 Bank Structure

In Section 1 the banks of the Danube are in nearly natural conditions, except the mean water line, where rip-rap and steep banks with grass lead to meadows, fields and riparian forests. In Sections 2 to 4 high flow velocities prevail and rip-rap dominates the banks. In the Iron Gate reservoirs native rock is the main substrate on the river banks. The other Sections are characterised by banks consisting of fine inorganic substrate with steeper or softer slope gradient. Artificial bank material like embankments, is present in Section 8 and 10 to some extent and serves navigational purposes.

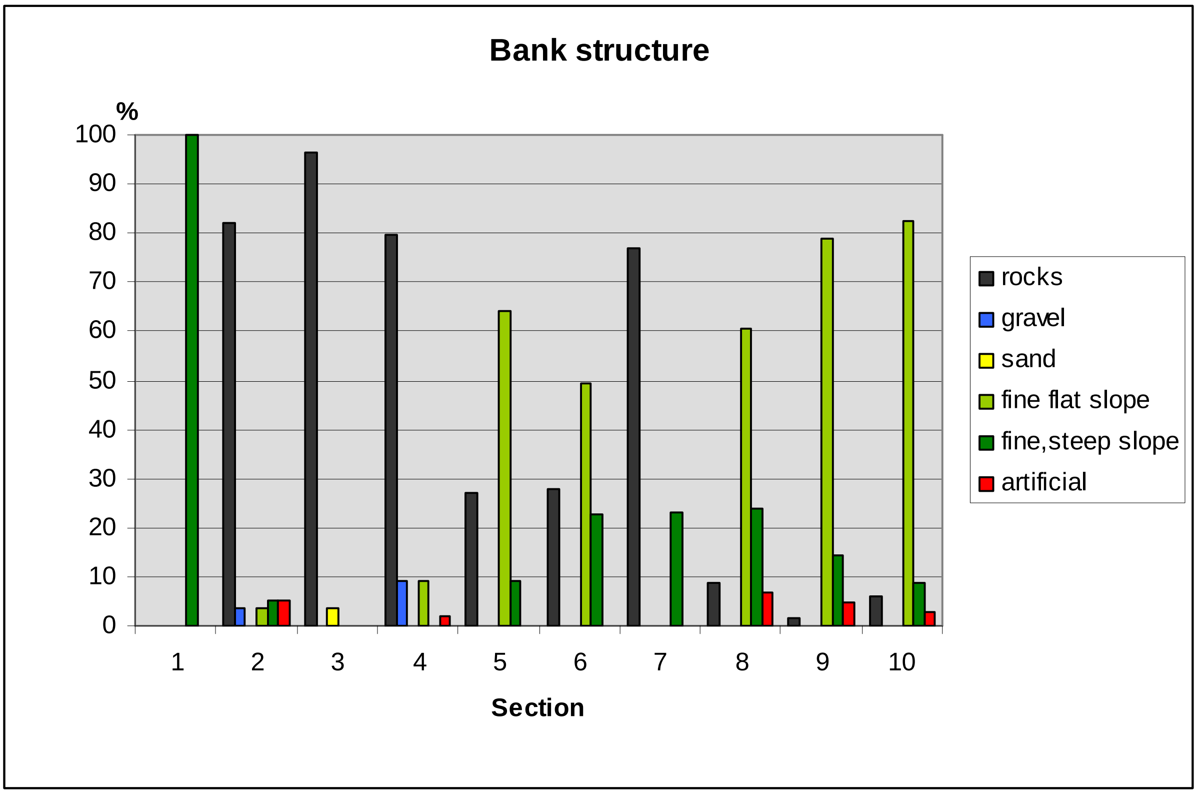

Figure 37: Bank Structure per Section

1.3.13.4 Sediment

In the Upper Danube the sediment is dominated by gravel, in accordance with the predominant flow conditions in river reaches without power plant impoundments. In Sections 2 to 4 rip-rap and submerged berms made of large stones, with the spaces between often filled with finer grain sizes, form the substrate for the macrophytes. Due to low transparency (an effect of the alpine-born tributaries) macrophytes lack light in depths greater than c. 1.5 m. From Section 5 onwards the portion of sand increases and only from Section 10 downriver sands are replaced by silty material and mud.

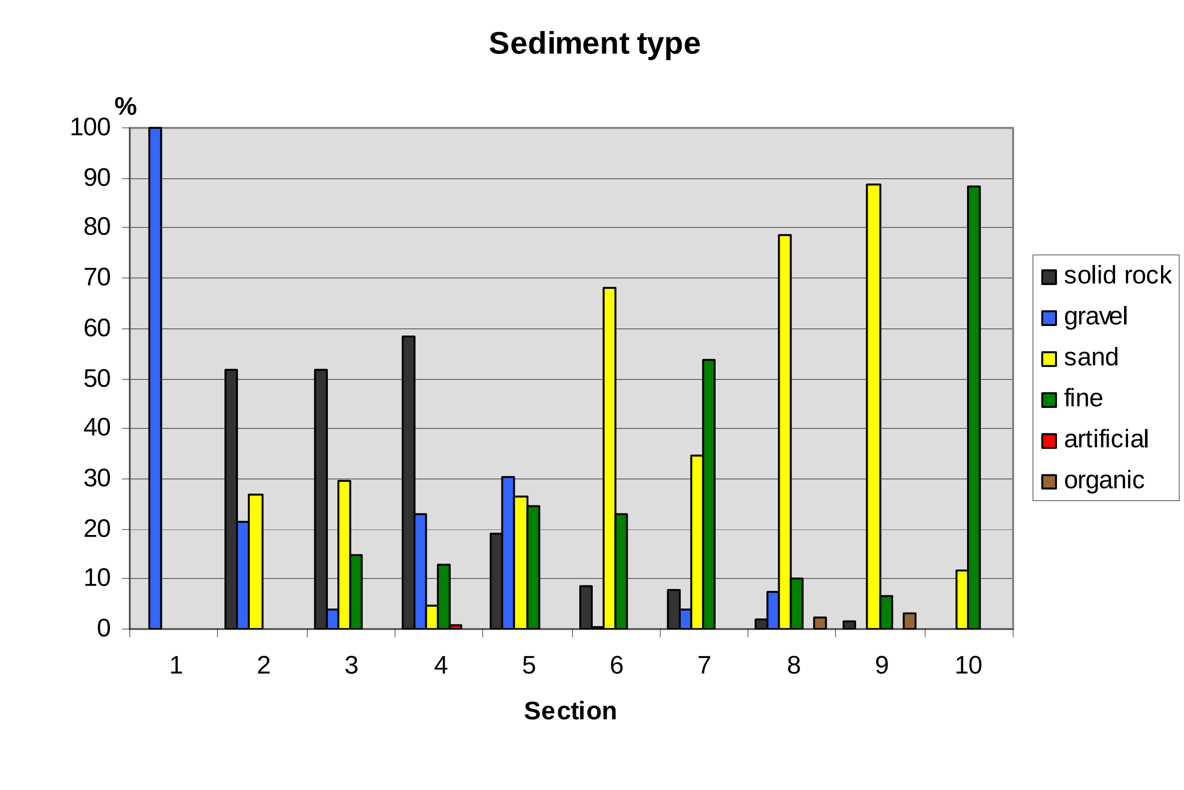

Figure 38: Substrates per Section

1.3.13.5 Landuse

The “Landuse-Type” was surveyed from the ship in the landscape at the Survey Sites and adjacent to the river course. The protocol allowed for two types per survey unit. Figure 39 shows the relative proportion of landuse-types per Section.

In the Upper Danube agricultural areas and fruit cultivation (Code 24, light brown) are close to the river. Floods reach these areas only for a few days per year and cause little damage. Different greens in the figure represent woody vegetation along the Danube, which are of natural or anthropogenic origin. Carrying out the survey from the ship it was not always possible to clearly differentiate between “broad leaved deciduous forest” and natural riparian woodlands (“wetlands with tall woody vegetation”). Red bars indicate for settlements, towns and cities, but survey sites were then always closely situated to the built-up areas. This influences – and even distort – the results in Section 7, where landuse-type “settlements and other built-up areas” dominated the survey sites to more than 50%.

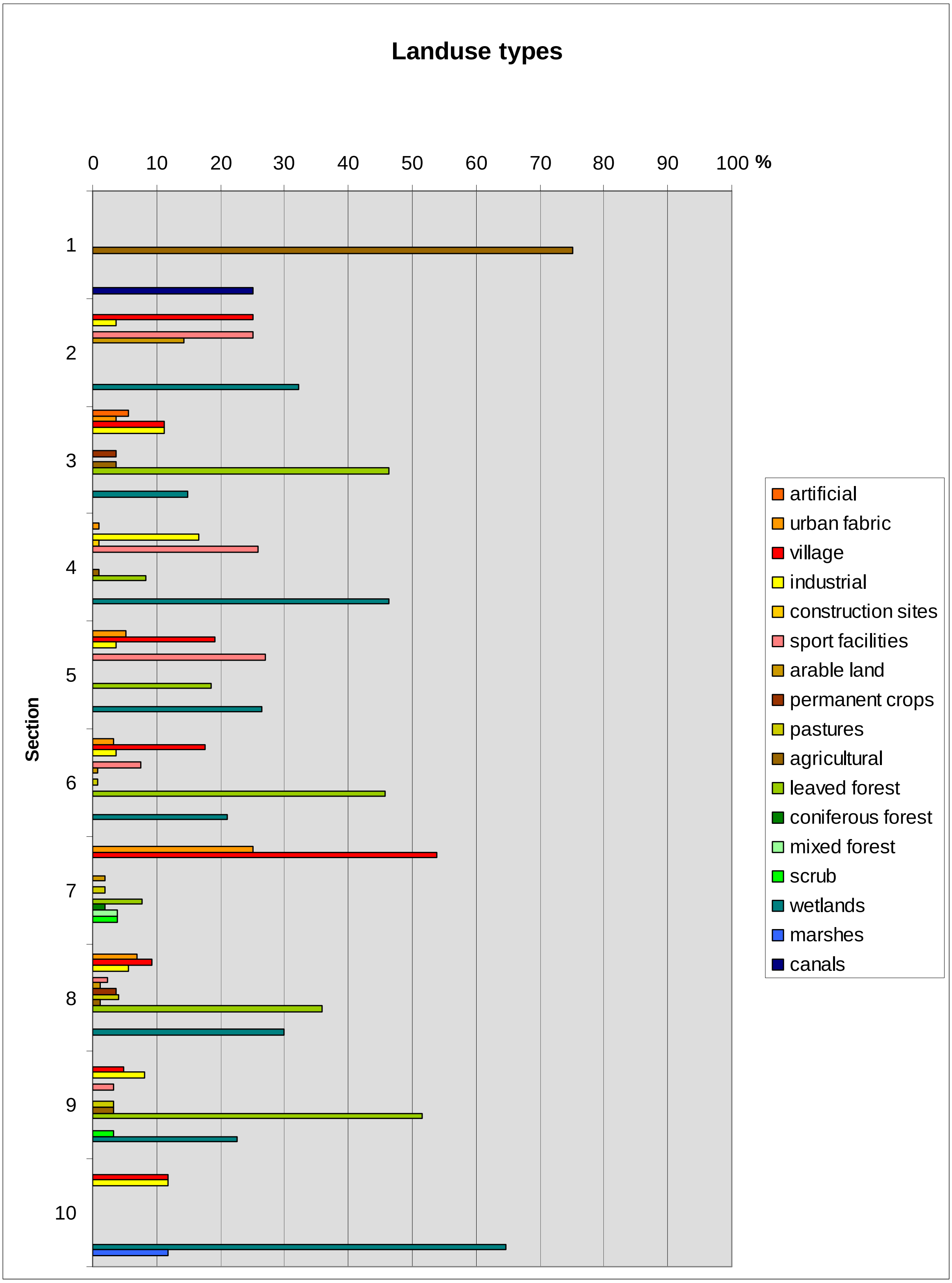

Figure 39: Landuse Types per Section

1.3.14 Comparison of Species JDS 1 und JDS 2

1.3.14.1 Species List of Macrophytes (Algae, Mosses, Vascular Plants)

In JDS 2 (2007) 69 macrophyte species were detected, whereas in JDS 1 (2001) only 44 species were found. This may be due, in part, to the shorter length of survey in JDS 1.

Abbreviation	Genus name	Species name	Author	present at JDS 2	present at JDS 1
Ali gra	Alisma	gramineum	LEJEUNE		x
Ali lan	Alisma	lanceolatum	With.	x	
Ali pla	Alisma	plantago-aquatica	L.	x	
Amb var	Amblystegium	varium	(Hedw.) Lindb.		x
Azz fil	Azolla	filiculoides	Lamarck	x	
Bra riv	Brachythecium	rivulare	Schimp.		x
Bry cap	Bryum	capillare	Hedw.	x	
Bry kli	Bryum	klinggraeffii	Schimp.	x	
Bry pal	Bryum	pallescens	Schleich. ex Schwägr.		x
But umb	Butomus	umbellatus	L.	x	
Cal ham	Callitriche	hamulata	Kütz. ex W. D. J. Koch	x	
Cal sp.	Callitriche	sp.	no Author	x	
Cer dem	Ceratophyllum	demersum	L.	x	x
Cin fon	Cinclidotus	fontinaloides	(Hedw.) P. Beauv.	x	
Cin rip	Cinclidotus	riparius	(Host ex Brid.) Arnott	x	x
Cra fil	Cratoneuron	filicinum	(Hedw.) Spruce	x	x
Did top	Didymodon	tophaceus	(Brid.) Lisa		x
Dre adu	Drepanocladus	aduncus	(Hedw.) Warnst.	x	
Dre flu	Drepanocladus	fluitans	(Hedw.) Warnst.	x	
Eic cra	Eichhornia	crassipes	(Mart.) Solms	x	
Elo can	Elodea	canadensis	Michx.	x	x
Elo nut	Elodea	nuttallii	(Planch.) H.St.John	x	x
Ent int	Enteromorpha	intestinalis	(L.) Link	x	
Eur cra	Eurhynchium	crassinervium	(WILS.) SCHIMP.		x
Fiss ruf	Fissidens	rufulus	B.S.G.	x	x
Fon ant	Fontinalis	antipyretica	Hedw.	x	x
Fun hyg	Funaria	hygrometrica	Hedw.	x	
Hom nit	Homalothecium	nitens	(Hedw.) Robins	x	
Hyd mor	Hydrocharis	morsus-ranae	L.	x	x
Hyd ret	Hydrodictyon	reticulatum	(L.)	x	
Hyg eug	Hygrohypnum	eugyrium	(Schimp.) Broth.	x	
Hyg flu	Hygroamblystegium	fluviatile	(Hedw.) Loeske	x	
Hyg lur	Hygrohypnum	luridum	(Hedw.) Jenn.	x	x
Hyg ten	Hygroamblystegium	tenax	(Hedw.) Jenn.	x	
Lem gib	Lemna	gibba	L.	x	
Lem min	Lemna	minor	L.	x	x
Lem tri	Lemna	trisulca	L.	x	
Lem tur	Lemna	turionifera	Landolt	x	
Lep rip	Leptodictyum	riparium	(Hedw.) Warnst.	x	x
Les pol	Leskea	polycarpa	Hedw.	x	x
Lim aqu	Limosella	aquatica	L.		x

Myr spi	Myriophyllum	spicatum	L.		
Myr ver	Myriophyllum	verticillatum	L.		
Naj mar	Najas	marina	L.		
Naj min	Najas	minor	All.		
Nit obt	Nitellopsis	obtusa	(Desv. in Loisel.) J.Groves		
Nup lut	Nuphar	lutea	(L.) Sibth. & Sm.		
Nym alb	Nymphea	alba	L.		
Pol amp	Polygonum	amphibium	L.		
Pot acu	Potamogeton	acutifolius	Link		
Pot alp	Potamogeton	alpinus	BALB.		
Pot cri	Potamogeton	crispus	L.		
Pot fri	Potamogeton	friesii	Rupr.		
Pot gra	Potamogeton	gramineus	L.		
Pot luc	Potamogeton	lucens	L.		
Pot nat	Potamogeton	natans	L.		
Pot nod	Potamogeton	nodosus	Poir.		
Pot pec	Potamogeton	pectinatus	L.		
Pot per	Potamogeton	perfoliatus	L.		
Pot pra	Potamogeton	praelongus	WULF.		
Pot pus	Potamogeton	pusillus	L.		
Pot tri	Potamogeton	trichoides	Cham. & Schltdl.		
Pot ziz	Potamogeton	x zizii	Koch ex Roth		
Ran flu	Ranunculus	fluitans	Lam.		
Rhy con	Rhynchostegium	confertum	(Dicks.) B.S.G.		
Rhy rip	Rhynchostegium	riparioides	(Hedw.) Cardot		
Ric flu	Riccia	fluitans	L. emend Lorb.		
Sag sag	Sagittaria	sagittifolia	L.		
Sal nat	Salvinia	natans	(L.) All.		
Sch apo	Schistidium	apocarpum	(Hedw.) B.S.G. em. Poelt		
Sch riv	Schistidium	rivulare	(Brid.) Podp.		
Spa eme	Sparganium	emersum	Rehmann		
Spa ere	Sparganium	erectum	L.		
Spi pol	Spirodela	polyrhiza	(L.) Schleid.		
Str alo	Stratiotes	aloides	L.		
Tra nat	Trapa	natans	L.		
Utr vul	Utricularia	vulgaris	L.		
Val spi	Vallisneria	spiralis	L.		
Ver bec	Veronica	beccabunga	L.		
Wol arr	Wolffia	arrhiza	(L.) Horkel ex Wimm.		
Zan pal	Zannichellia	palustris	L.		

1.3.14.2 Species List of Helophytes

In JDS 1 only three – dominant – helophyte species were introduced to the field protocols, as in JDS 2 due to the much longer survey lengths 60 helophyte species were mapped (not counting the specimens for which a determination to species level was not possible due to the less advanced development of the individual plants. Some helophyte species may gain importance under climate change conditions. The development of neophytic species should be carefully monitored, as with the occurrence of the Euphorbiaceae *Chamaesyce glyptosperma*.

Abbreviation	Genus name	Species name	Author	present at JDS 2	JDS 1
Abu the	Abutilon	theophrasti	MEDIK.		
Aco cal	Acorus	calamus	L.		
Agr gig	Agrostis	gigantea	Roth		
Alo gen	Alopecurus	geniculatus	L.		
Art sp.	Artemisia	sp.	no Author		
Ber ere	Berula	erecta	(Hudson) Coville		
Bid fro	Bidens	frondosa	L.		
Bid rad	Bidens	radiata	THUILL.		
Bid sp.	Bidens	sp.	no Author		
Bid tri	Bidens	tripartita	L.		
Bol mar	Bolboschoenus	maritimus	(L.) Palla		
Car ama	Cardamine	amara	L.		
Cha gly	Chamaesyce	glyptosperma	(Engelm.) Small		
Cyp fla	Cyperus	flavescens	L.		
Cyp fus	Cyperus	fuscus	L.		
Cyp glo	Cyperus	glomeratus	L.		
Cyp lon	Cyperus	longus	L.		
Cyp str	Cyperus	strigosus	L.		
Dic mic	Dichostylis	micheliana	(L.) RCHB.		
Ech cru	Echinochloa	crus-galli	(L.) P. Beauv.		
Eci cru	Echinochloa	crus-galli	(L.) P. Beauv.		
Equ arv	Equisetum	arvense	L.		
Eup can	Eupatorium	cannabinum	L.		
Fon hyp	Fontinalis	hypnoides	Hartm.		
Gly flu	Glyceria	fluitans	(L.) R.Br.		
Gly max	Glyceria	maxima	(Hartm.) Holmb.		
Imp gla	Impatiens	glandulifera	Royle		
Iri pse	Iris	pseudacorus	L.		
Jun bul	Juncus	bulbosus	L.		
Jun con	Juncus	conglomeratus	L.		
Jun sp.	Juncus	sp.	no author		
Leu vul	Leucanthemum	vulgaris sensu latu	LAM.		
Lyc eur	Lycopus	europaeus	L.		
Lys num	Lysimachia	nummularia	L.		
Lyt sal	Lythrum	salicaria	L.		
Men aqu	Mentha	aquatica	L.		
Men lon	Mentha	longifolia	(L.) Huds.		
Nas off	Nasturtium	officinale	R.Br.		
Pet sp.	Petasites	sp.	no Author		
Pha aru	Phalaris	arundinacea	L.		
Phr aus	Phragmites	australis	(Cav.) Trin. ex Steud.		
Pla lan	Plantago	lanceolata	L.		
Pol bri	Polygonum	brittingeri	(OPIZ) OPIZ		
Pol hyd	Polygonum	hydropiper	L.		
Pol lap	Polygonum	lapathifolium	L.		
Pol min	Polygonum	minus	Huds.		
Pol mit	Polygonum	mite	Schrank		
Pol sp.	Polygonum	sp.	no author		
Ran sce	Ranunculus	sceleratus	L.		

Ror amp	Rorippa	amphibia	(L.) Besser		
Ror isl	Rorippa	islandica	(Oeder ex Murray) Borbás		
Ror pal	Rorippa	palustris	(L.) Besser		
Ror sp.	Rorippa	sp.	no author		
Ror syl	Rorippa	sylvestris	(L.) Besser		
Ror syl	Rorippa	sylvestris	(L.) Besser		
Rum hyd	Rumex	hydrolapathum	Huds.		
Rum sp.	Rumex	sp.	no author		
Sch lac	Schoenoplectus	lacustris	(L.) Palla		
Sch tri	Schoenoplectus	triqueter	(L.) Palla		
Sol dul	Solanum	dulcamara	L.		
Sta pal	Stachys	palustris	L.		
Sym off	Symphytum	officinale	L.		
Tam rac	Tamarix	ramosissima	Karel. Ex Boiss		
Typ ang	Typha	angustifolia	L.		
Typ lat	Typha	latifolia	L.		
Ver ana	Veronica	anagallis-aquatica	L.		
Xan str	Xanthium	strumarium	L.		

1.3.15 Aspects regarding the ecological status

The Danube is not only the most international River in Europe as regards the number of national states located in its catchment, it is also a river of its own character as no other flowing water equals its length, its size and catchment area in Western and Central Europe. Therefore expert judgement had to be used to construct reference conditions; no good enough historical quantitative data or modelling approaches are available to produce a solid data base for the macrophyte reference conditions for the whole length of the Danube River.

Special attention was given to the following determining aspects of river conditions (I) Occurrence of mosses in contrained reaches and gorges were considered close to natural conditions; (II) the indicative relevance of mosses in hydro-power reservoirs located in wide valleys or geological basins was considered much less natural as these plants prefer the artificial riprap along the river banks as a habitat; (III) The indicative relevance of vascular species in hydro-power reservoirs was adapted according to the historical river channel system; (IV) In regulated river reaches vascular species were weighted with regard to the original undisturbed historical river conditions; (V) In the lower reach river reaches without direct human impact were considered to be rather close to natural conditions as the size of the catchment determines the natural load of carbon and plant nutrients, favouring species adapted to such conditions. Using various sources like results from side channels historical maps, saprobiotic maps of the Danube and JDS 1 and JDS 2 data on chemical components as well as data from the whole-length-macrophyte survey in the midcc project potential reference conditions with respect to the ecological characterization of species were used to calculate the proposed ecological status for the JDS 2 Survey Sites.

The following results have to be taken as first outcome of extensive calculations.

For the Survey Sites located in hydro-electric power plant reservoirs it is quite evident that for most of them data reported most probably fail to meet the conditions of the good ecological status In the so called "free flowing" stretches, which are regulated for either navigation and/or flood protection purposes but not impounded, the conditions are different and many Survey Sites are considered to meet the conditions for indicating good ecological status. In some cases they may be very close to natural conditions. However, some tributary mouth stretches in the lower reaches of the Danube River alter this general situation considerably, as is the case for Sio, Timok, Russenski Lom, Arges, Siret and Prut. The missing or very low number of macrophytes reflects the indication of poor ecological status. This is to be noted as the downriver sampling sites in the main channel indicate good status, as they are situated in considerable distance to the merging with these tributaries (e.g. downstream Russenski Lom: 10 km, Timok, Drava, Morava, Sio >11 km, Arges: 3 km; Braila: 13 km). The mixing of water from the tributaries with the great discharge of the main river channel causes the dilatation of the respective load of nutrients and pollutants.

Downriver of such impacts on water quality the respective side of the main river channel is directly influenced and can fail to meet the indication of good status, while the other side of the river stays in the indication of the good status (e.g. Braila).

When following strictly the rules of the calculations of ecological status so far applied to the data of the JDS 2 survey limiting conditions are specified in the different methodological approaches which state that a too low number of species or of their abundance bans the calculation of the ecological status. Following this recommendation several Survey Sites in the Lower Danube River reach cannot be classified. Yet, this recommendation was not strictly followed as especially in the Middle and Lower Danube conditions are completely different from the Upper Reach. A "supplement" calculation was performed, and the results are indicated in the respective table by "*numbers in italics*".

However, if no macrophytes are present at all other authors regard the ecological status in those rare cases as "bad". Yet, these authors also mention that macrophyte absence may not always be caused by human impact. In such a situation the reasons for macropyhte absence must be sought

Table 13: Proposal for the ecological status of each Sampling Site

JDS2 Code	Country	Station	Danube type	rkm	Macropyhtes ecological status	*Species no. <4*	course of Danube
JDS1	DE	Upstream Iller	1	2600	2		Upper Danube
JDS2	DE	Kelheim – gauging station	2	2415	2		
JDS3	DE	Geisling power plant	2	2354	3		
JDS4	DE	Deggendorf	2	2285	2		
JDS5	DE	Niederalteich	2	2278	2		
JDS6	DE, AT	/Inn, rkm 4.2	Tributary	2225	0	*4 (if basin)*	
JDS7	DE, AT	Jochenstein	3	2204	2		
JDS8	AT	Upstream dam Abwinden-Asten	3	2120	3		
JDS9	AT	Upstream dam Ybbs-Persenbeug	3	2061	1		
JDS10	AT	Oberloiben	3	2008	0	*1*	
JDS11	AT	Upstream dam Greifenstein	4	1950	3		
JDS12	AT	Klosterneuburg	4	1942	0	*4*	
JDS13	AT	Wildungsmauer	4	1895	3		
JDS14	AT	Upstream Morava (Hainburg)	4	1881	0	*2*	
JDS15	AT, SK	/Morava (rkm 0.08)	Tributary	1880	2		
JDS16	SK	Bratislava	4	1869	3		
JDS17	SK, HU	Gabcikovo reservoir	4	1852	3		
JDS18	SK, HU	Medvedov/Medve	4	1806	2		Middle Danube
JDS19	HU	/Moson Danube Arm – end (rkm 0.1)	4	1794	2		
JDS20	SK, HU	Komarno/Komarom	5	1768	2		
JDS21	SK	/Vah (rkm 0.8)	Tributary	1766	2		
JDS22	SK, HU	Iza/Szony	5	1761	3		
JDS23	SK, HU	Sturovo/Esztergom	5	1719	2		
JDS24	SK	/Hron (rkm 0.5)	Tributary	1716	0	*2*	
JDS25	SK, HU	/Ipoly (rkm 0.7)	Tributary	1708	0	*2*	
JDS26	HU	Szob	5	1707	2		
JDS27	HU	Upstream end of Szentendre Island	5	1692	2		
JDS28	HU	/Upstream end of Szentendre Island (arm)	5	1692	2		
JDS29	HU	Budapest upstream	5	1659	2		
JDS30	HU	/Budapest (old Danube) end of S.arm	5	1658	2		
JDS31	HU	/Rackeve-Soroksar Danube Arm - start	5	1642	0	*2*	
JDS32	HU	Budapest downstream	5	1632	2		
JDS33	HU	Adony/Lórév	5	1605?	2		
JDS34	HU	/Rackeve-Soroksar Danube Arm end		1586	2		
JDS35	HU	Dunafoldvar	5	1560	2		
JDS36	HU	Paks	5	1533	0	*2*	
JDS37	HU	/Sio (rkm 1.0)	Tributary	1497	0	*no calculation*	
JDS38	HU	Baja	6	1481	2		
JDS39	HU	Hercegszanto	6	1434	2		
JDS40	HR, RS	Batina	6	1424	2		
JDS41	HR, RS	Upstream Drava	6	1384	0	*no calculation*	
JDS42	HR	/Drava (rkm 1.4)	Tributary	1379	0	*no calculation*	
JDS43	HR, RS	Downstream Drava (Erdut/Bogojevo)	6	1367	0	*no calculation*	

JDS2 Code	Country	Station	Danube type	rkm	Macropyhtes ecological status	*Species no. <4*	course of Danube
JDS44	HR, RS	Dalj	6	1355	2		Middle Danube
JDS45	HR, RS	Ilok/Backa Palanka	6	1300	2		
JDS46	RS	Upstream Novi-Sad	6	1262	2		
JDS47	RS	Downstream Novi-Sad	6	1252	2		
JDS48	RS	Upstream Tisa (Stari Slankamen)	6	1216	2		
JDS49	RS	/Tisa (rkm 1.0)	Tributary	1215	2		
JDS50	RS	Downstream Tisa/Upstream Sava (Belegis)	6	1200	2		
JDS51	RS	/Sava (rkm 7.0)	Tributary	1170	2		
JDS52	RS	Upstream Pancevo/Downstream Sava	6	1159	2		
JDS53	RS	Downstream Pancevo	6	1151	2		
JDS54	RS	Grocka	6	1132	2		
JDS55	RS	Upstream Velika Morava	6	1107	2		
JDS56	RS	/Velika Morava	Tributary	1103	2		
JDS57	RS	Downstream Velika Morava	6	1097	2		
JDS58	RS	Starapalanka – Ram	6	1077	2		
JDS59	RS, RO	Banatska Palanka/Bazias	7	1071	2		
JDS60	RS, RO	Irongate reservoir (Golubac/Koronin)	7	1040	2		
JDS61	RS, RO	Donji Milanovac	7	991	2		
JDS62	RS, RO	Irongate reservoir (Tekija/Orsova)	7	954	2		
JDS63	RS, RO	Vrbica/Simijan	8	926	2		Lower Danube
JDS64	RS, RO	Iron Gate II	8	865	2		
JDS65	RS, RO	Upstream Timok (Rudujevac/Gruia)	8	849	2		
JDS66	RS, BG	/Timok (rkm 0.2)	Tributary	845	0	*no calculation*	
JDS67	RO, BG	Pristol/Novo Selo Harbour	8	834	2		
JDS68	RO, BG	Calafat	8	795	2		
JDS69	BG, RO	Downstream Kozloduy	8	685	2		
JDS70	BG, RO	Upstream Iskar (Bajkal)	8	640	2		
JDS71	BG	/Iskar (rkm 0.3)	Tributary	637	2		
JDS72	BG, RO	Downstream Iskar	8	629	2		
JDS73	RO, BG	Upstream Olt	8	606	2		
JDS74	RO	/Olt (rkm 0.4)	Tributary	605	2		
JDS75	RO, BG	Downstream Olt	8	602	2		
JDS76	RO, BG	Downstream Turnu-Magurele/Nikopol	8	579	2		
JDS77	RO, BG	Downstream Zimnicea/Svishtov	8	550	2		
JDS78	BG	/Jantra (rkm 1.0)	Tributary	537	2		
JDS79	RO, BG	Downstream Jantra	8	532	2		
JDS80	BG, RO	Upstream Ruse	8	500	2		
JDS81	BG	/Russenski Lom		498	0	*no calculation*	
JDS82	BG, RO	Downstream Ruse/Giurgiu	8	488	2		

JDS2 Code	Country	Station	Danube type	rkm	Macropyhtes ecological status	*Species no. <4*	course of Danube
JDS83	RO, BG	Upstream Arges	8	434	2		Lower Danube
JDS84	RO	/Arges	Tributary	432	0	*(5)no calculation*	
JDS85	RO, BG	Downstream Arges, Oltenita	8	429	2		
JDS86	RO, BG	Chiciu/Silistra	8	378	2		
JDS87	RO	Upstream Cernavoda	9	295	2		
JDS88	RO	Giurgeni	9	235	0	*3 (at right side only)*	
JDS89	RO	Braila	9	167	0	*2 (at right side only)*	
JDS90	RO	/Siret (rkm 1.0)	Tributary	154	0	*3*	
JDS91	RO, MD	/Prut (rkm 1.0)	Tributary	135	0	*no calculation*	
JDS92	RO, UA	Reni	9	130	2		Delta
JDS93	RO, UA	Vilkova - Chilia arm/Kilia arm	10	18	2		
JDS94	UA	/Bystroe canal	10	8	3		
JDS95	RO	Sulina - Sulina arm	10	0	0	*no calculation*	
JDS96	RO	Sf.Gheorghe - Sf.Gheorghe arm	10	0	0	*no calculation*	

Explanatory notes:

At JDS 10, Oberloiben, macrophytes were hardly found in the last free flowing stretch of the Danube in Austria due to the high flow velocity. As it is rocky there and as the high flow gradient allows the transportation of coarser and higher volume weight material on which mosses grow naturally the calculation with the three moss species found shows a ‘high status’ (1).

At JDS 12, Klosterneuburg, the sampling site was situated in front of the lido of Kritzendorf and three species of mosses were found on the boulders of groynes and embankment. One of them, *Cinclidotus riparius,* is classified as an’ ubiquist’, this is a plant which could grow in all stretches of the Danube. Under the rules of the Austrian guideline it is not allowed to calculate an ecological status though the high flow velocity hardly lets grow a higher species number. As it is a basin the mosses were classified as nonnatural and the calculation results in a ‘poor status’ (4).

At JDS 84, Arges, no macrophytes could be found, the taken pictures show the excrements floating in the confluence, this legitimates a ‘bad status’ (5).

At JDS 88, Giurgeni, it was not obvious why scarcely any macrophytes could be found. The two big shipwrecks ran ashore in the middle of the Danube cannot be held responsible for it.. A few individuals of *Lemna, Spirodela* and *Typha* on the right side cause a ‘moderate status’ (3) while the left side may deserve a ‘bad status’.

At JDS 89, Braila, the left side was also found without any macrophytes and the pictures show a small tributary with excrements on the left side. Calculating only for the right side the output results even in a ‘good status’.

1.4 DISCUSSION AND SUMMARY

In JDS 2 96 Sites were sampled. Their accumulated length was 556.5 km and covered aquatic macrophytes as well as bank-side helophytes (reeds). The sampled length was c. three times as along as that during the JDS 1 survey in 2001 (180 sampling sites à 1 km). This expansion of sampled river length followed a concept worked out through statistical analysis, and proposed, by ViennaTeam prior to the JDS 2 survey. Results show that this expansion was a minimum requirement for collecting sufficient data for a survey of rivers the size of the Danube, and the lower reaches of its larger tributaries. In JDS 1 such an expansion would have been totally impossible with respect to infrastructure (number of available small boats) and the general schedule at sampling sites. Thus the sampling strategy chosen for JDS 2 should be seen as the optimum between the time-limited approach of JDS 1 and an even better methodological adaptation, which would need sampling length expanded for c. another 50 % (c. 5 rkm each side of the channel)

69 species of macropyhtes and 60 species of helophytes were detected in 485 survey sites (87% of all sampled river-kilometers). Among species were found which are rare in large rivers: *Wolffia arrhiza, Lemna turionifera, Riccia fluitans, Azolla filiculoides* and *Utricularia vulgaris*, *Trapa natans* and *Stratiotes aloides* very scarce, and the occurrence of *Eichhornia crassipes* must be considered a ‘human impact’ This result can be seen as an indication that in still natural riparian zones of large rivers micro-habitats for species with special habitat preferences can exist, however in very small number and spatial extension. It should be noted that all the species listed above are free-floating and may have collected in their habitats lacking higher water flow velocities rather by chance.

In JDS 2 the total number of detected species increased by 57 %. This is due to – at least in part – the extension of sampled river length. As stated above, an absolute minimum length of 3 rkm per sampling site on each side of the river channel, confirmed by our statistical analysis (based on MIDCC data sets, ViennaTeam), seems to be necessary to collect a data set with real relevance to further data processing in accordance with the WFD. This was confirmed by the fact that diving and dredging carried out by the “Mussels and Macro-Zoobenthos” team lead to lesser macrophyte species detected than the regular aquatic plants method. However, the partner-team is thanked for saving all the dredged and manually collected plant material, which was used for taxonomical determination, too.

Mosses dominated the aquatic macrophyte vegetation in the German and Austrian Danube Reach (Sections 1 to 4). The low species numbers (12: section 1; 17: section 3) result from the high water flow velocity and the massive bank protection (mainly rip-rap). In Section 4, following the constrained reach down-river of the March/Morava-confluence near Devin (the “Hungarian Gap”), the species richness increased to 32 in the Slovak reach, as there the Cunovo Reservoir, which forms the uppermost part of the Gabcikovo hydro-electric power plant, provides favourable conditions for macrophyte development. Down-river of Novi Sad, and down-river of Belgrade as well, where the upper reach of the Iron Gate reservoir is located, the species number increases to 32. The same effect is found down-river of the confluences of the Timok and Olt rivers, where organic material was washed into the Danube. Macrophyte development was also promoted down-river of Ruse (BG), Oltenita (RO) and Tutrakan (BG), possibly by enhanced levels of plant nutrients (N, P), supporting higher species numbers and abundances. In the Danube Delta only the Vilkova-Chilia-Arm was rich in aquatic plants, especially along some of the small settlements situated on its banks, and the rare species *Stratiotes aloides* was detected there.

For calculating the impacts of the discharge of the tributaries and municipal wastewater on macrophytes the “downstream sampling sites” should be in a closer distance to the point of impact and those distances should take into account the magnitude of the impact, e.g. smaller tributaries with low water quality are quicker mixed by the high discharge in the main Danube channel.

Section 7, the Iron Gate, holds a special position as ancient cataract stretch between the middle and lower Danube. The constrained width of the Danube in the several gorge stretches guaranteed rocky banks and rapids, whereas in the wider parts of the Iron Gate stretch calm waters and finer substrates forming suitable habitat conditions for many different macrophytes. Despite the typical impoundment conditions in the Iron Gate we can find both aspects - mosses on rocks and quite a high diversity of other macrophytes outside of the distinct gorge stretches. Based on these facts this stretch meets the indication for good conditions, alternating between constrained and wider parts of the Iron Gate river course.

A multivariate statistical comparison was carried out for all river sections, investigating their similarity. JDS 2 data revealed the quite remarkable fact that all river sections were different from each other: each section was characterised by an individual composition of species and by individual indicator species, except Section 4, which was found inhomogenous and it is recommended to discuss the indication of status of this section and possibly to sub-divide it close to Bratislava City. A comparison with the results of other JDS 2 teams will flash-light possible relationships with these other habitat parameters.

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