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**FISH SURVEY REPORT**

**(as a part of River habitat survey report)**

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## Table of contents

<b>I. INTRODUCTION</b> .....	4
<b>I RESULTS OF FISH SURVEY IN RIVERS, REGULATED BY HPP CASCADES, LATVIA</b> .....	5
<b>1. Ciecere River and its fish fauna</b> .....	5
1.1. Ciecere river downstream Ciecere HPP.....	7
1.2. Ciecere river downstream Dzirnavnieku HPP .....	9
1.3. Ciecere river below Pakuļu HPP .....	10
1.4. Comparative analysis of the characteristics of fish communities downstream of different HPPs in the Ciecere River and suggested species for MesoHABSIM.....	11
<b>2. Losis River and its fish fauna</b> .....	13
2.1. Losis River downstream Grantiņu HPP .....	14
2.2. Losis River downstream Lejnieku HPP.....	15
2.3. Comparative analysis of the characteristics of fish communities downstream of different HPPs in the Losis River and suggested species for MesoHABSIM .....	17
<b>II RESULTS OF FISH SURVEY IN RIVERS, REGULATED BY HPP CASCADES, LITHUANIA</b> .....	18
<b>2.Varduve River and its fish fauna</b> .....	18
2.1. Varduva River below Kulšėnai HPP .....	21
2.2. Varduva River below Renavas HPP .....	22
2.3. Varduva River below Vadagiai HPP .....	23
2.4. Varduva River below Ukrinai HPP .....	24
2.5. Varduva River below Juodeikiai HPP .....	25
6. Comparative analysis of the characteristics of fish communities downstream of different HPPs in the Varduva River .....	27
<b>REFERENCES</b> .....	29

## **Abbreviations**

LT	Lithuania
LV	Latvia
LEGMC	Latvian Environment, Geology and Meteorology Centre
LAS	European Vertical Reference System (EVRS) in Latvia
LAS07	European Vertical Reference System (EVRS) in Lithuania

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## I. INTRODUCTION

Fish survey in transboundary rivers were carried out in the frame of the “Joint management of Latvian – Lithuanian trans-boundary river and lake water bodies” project (TRANSWAT) LLI-533 financed by the Interreg V-A Latvia–Lithuania Programme 2014-2020.

Impact of HPP on fish fauna of River Ciecere and River Losis (in Latvia) as well as River Varduve (in Lithuania) was surveyed. Survey in all rivers has been carried out downstream each HPP in the same stretches where measurements for MesoHABSIM is done. Fish fauna of each type of geomorphological unit (GU) represented in the stretch was sampled yet if there were several units of the same type (pool, riffle etc.) sampling was performed in only one of them.

To get better understanding of fish fauna of different stretches of Losis River and Ciecere River as well as impact of HPP of distribution and abundance of different fish and lamprey species we recommend to perform additional survey. Fish survey results in Varduve River show that the cumulative effect of HPP and connectivity disturbance is much stronger than any of these effects taken separately.

However, it implies that only the introduction of ecological flow without opening migration routes will only slightly improve the situation in the cascade of HPP, and a good ecological status in terms of fish may not be achieved.

# I RESULTS OF FISH SURVEY IN RIVERS, REGULATED BY HPP CASCADES, LATVIA

Fish fauna of two rivers – Ciecere and Losis was surveyed. Survey in both rivers has been carried out downstream each HPP in the same stretches where measurements for MesoHABSIM is done. Fish fauna of each type of geomorphological unit (GU) represented in the stretch was sampled yet if there were several units of the same type (pool, riffle etc.) sampling was performed in only one of them.

Fish were sampled in accordance with the EU standard EN 14011 (CEN, 2003) by using of the standard KC Denmark electrofishing device powered by 2 kW generator (National permit for electrofishing surveys No ZD21ZI005). All captured fishes were detected to species level, measured and after recovery released in the river. Results for each GU was registered separately but also pooled results for all surveyed stretch was calculated. Ecological quality of the surveyed stretch was estimated by using of the Latvian Fish index (LVFI)<sup>1</sup>. To give broader look on status of fish fauna of both surveyed rivers, the data from electrofishing surveys performed within other projects (both 2021 and previously) and results of state-wide project for evaluation of importance of Latvian rivers in the protection of fish fauna<sup>2</sup> were also used.

## 1. Ciecere River and its fish fauna

According to the national typology of Latvian rivers, Ciecere belongs to river type 3 i.e., medium-sized rhithral stream. There are three HPP on this river – Pakuļu, Dzirnāvnīku and Cieceres located 32 km, 49 km and 55 km from the rivermouth. Stretch from the rivermouth to Pakuļu HPP have been determined as priority salmonid waters. In the evaluation of importance of Latvian rivers in protection of fish fauna Ciecere was listed among rivers which has a national scale importance. Models developed during this project shows that in general hydromorphological condition of Ciecere is suitable for such ecologically vulnerable species as bullhead (*Cottus gobio*), grayling (*Thymallus thymallus*) and both river and brook lampreys (*Lampetra fluviatilis* and *L. planeri*) and at some extent also for the spawning of sea trout and brown trout (*Salmo trutta*). Stretches suitable for these species can be found downstream of all three HPP. Modelling predicts also high negative anthropogenic impact (mostly the exploitation of HPP and damming of rivers) which considerably reduces the suitability for all mentioned species. In addition dam of Pakuļu HPP is listed among single dams with large impact on fish migration. Individual impact of other dams in Ciecere River is relatively small yet modelled cumulative positive effect of removal of all three barriers is three times greater than that of Pakuļu

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<sup>1</sup> Description available at <https://circabc.europa.eu/sd/a/203dd096-18fc-400e-bd77-b9ff5ffdc19d/LV%20-%20FISH%20-%20RIVERS%20-%20Nov%202016%20final%20accepted.pdf>

<sup>2</sup> Project results available at <https://bior.lv/lv/par-mums/jaunumi/noskaidrotas-zivim-nozimigakas-latvijas-upes-un-svarigakie-tajas-esosie-zivju-migracijas-skersli>

HPP and thus the HPP cascade in Ciecere river is state-wide impact on fish migration. Results of previous surveys shows that due to the very high water temperature that periodically can exceed 26°C the trout population in Ciecere river is in very bad condition and most probably greatly depends on reproduction possibilities in its tributaries.

In surveyed stretches downstream the Cieceres, Dzirnāvnīeku and Pakuļu HPP in total 13 fish species were recorded – schneider (*Alburnoides bipunctatus*), bleak (*Alburnus alburnus*), stone loach (*Barbatula barbatula*), silver bream (*Blicca bjoerkna*), spined loach (*Cobitis taenia*), bullhead, gudgeon (*Gobio gobio*), dace (*Leuciscus leuciscus*), perch (*Perca fluviatilis*), minnow (*Phoxinus phoxinus*), bitterling (*Rhodeus sericeus*), roach (*Rutilus rutilus*) and chub (*Squalius cephalus*). Most abundant and widespread specie downstream all three power plants and in almost all GU was roach (Table 1.1.). Other species found downstream all HPP were bleak and stone loach. Gudgeon, perch, dace and bitterling were found downstream two of three HPP while other species were recorded only downstream one of power plants.

**Table 1.1. Density of different fish species in different geomorphic units and pooled density of individuals of different fish species in Ciecere River downstream each HPP (GU – geomorphological unit; G – glide; B – backwater; Ra – rapid; Ri – riffle)**

Site, GU		Alburnoides bipunctatus	Alburnus alburnus	Barbatula barbatula	Blicca bjoerkna	Cobitis taenia	Cottus gobio	Gobio gobio	Leuciscus leuciscus	Perca fluviatilis	Phoxinus phoxinus	Rhodeus sericeus	Rutilus rutilus	Squalius cephalus	Total
Cieceres HPP	G							5.1	1.7	5.1			44.4		56.4
	B		6.7			13.3	6.7			33.3			240.0		300.0
	Ra						5.6						2.2		7.8
	Ri						3.2								3.2
	<b>Pooled</b>		<b>0.4</b>			<b>0.9</b>	<b>3.5</b>	<b>1.3</b>	<b>0.4</b>	<b>3.5</b>			<b>28.4</b>		<b>38.6</b>
Dzirnāvnīeku HPP	G		1.1			3.3		42.2		5.6		6.7	36.7		95.6
	Ri					0.9		25.0					0.9		26.8
	<b>Pooled</b>		<b>0.5</b>			<b>2.0</b>		<b>32.8</b>		<b>2.5</b>		<b>3.0</b>	<b>17.2</b>		<b>58.0</b>
Pakuļu HPP	G		1.2			4.8			7.1						13.1
	B		2.9		2.9	5.8						8.7	173.9	8.7	202.9
	Ra		7.9	0.7					15.0		0.7		2.9		27.1
	Ri	0.9										0.9	1.9		3.7
	<b>Pooled</b>	<b>0.3</b>	<b>3.5</b>	<b>0.3</b>	<b>0.3</b>	<b>1.6</b>			<b>7.4</b>		<b>0.3</b>	<b>1.1</b>	<b>18.0</b>	<b>0.8</b>	<b>33.6</b>

Largest number of species and greatest density of individuals was found in slower flowing GU (backwater and glide) while in rapids and riffles number of species and density of individuals was lower. Only exception is the stretch

downstream the Pakuļu HPP where number of species and density of individuals in rapid was higher than in glide. Noteworthy that in backwaters increase of density was registered not only for roach, perch and other species preferring slow flowing waters but also for such rheophilic species as bullhead and chub. In general, it can be concluded that distribution of species and specimens during the survey of 2021 most probably was altered by very high water temperature (26.8°C) what caused fishes to seek for cooler water in shaded backwaters and other deeper places.

In the sampling station located only 700 m from the rivermouth 17 fish and lamprey species were registered – bleak, silver bream, spined loach, pike (*Esox lucius*), three-spined stickleback (*Gasterosteus aculeatus*), gudgeon, sunbleak (*Leucaspius delineatus*), dace, perch, minnow, bitterling, roach, chub, tench (*Tinca tinca*), nine-spined stickleback (*Pungitius pungitius*), vimba bream (*Vimba vimba*) and lamprey larvae (most probably brook lamprey). Larger number of cyprinid species characteristic for slow-flowing waters can be linked with proximity to Venta River.

Most of fish and lamprey species registered in previous years was recaptured also in 2021. The exceptions are bream (*Abramis brama*), eel (*Anguilla anguilla*), Prussian carp (*Carassius gibelio*), crucian carp (*Carassius carassius*), ruff (*Gymnocephalus cernua*), brown trout / sea trout, pikeperch (*Sander lucioperca*) and rudd (*Scardinius erythrophthalmus*). Most of these species previously were registered at only a few sampling sites and in minor abundance. Most probably in 2021 these species were not recaptured due to relatively small survey area confined to stretches where measurements for MesoHABSIM was performed. Most of these species are characteristic for slow-flowing rivers and their occurrence can be linked with proximity of Venta River or HPP reservoirs. Only exception is brown trout / sea trout which has a population downstream Dzirnāvnīeku and Pakuļu HPP<sup>3</sup>.

### **1.1. Ciecere river downstream Ciecere HPP**

Seven fish species have been recorded in the sampling site located downstream the Ciecere HPP. Information on abundance of different species and their assignment to metrics used for calculation of LVFI is compiled in Table 1.1.1. Dominant fish species with the share of more than 70% from the total number of specimens was roach. Only three species used for calculation of LVFI was registered (bullhead, gudgeon and dace) and their total abundance was very low

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<sup>3</sup> report of survey of status of trout population in Ciecere River is available in [http://petijumi.mk.gov.lv/sites/default/files/title\\_file/Petijums\\_8.pdf](http://petijumi.mk.gov.lv/sites/default/files/title_file/Petijums_8.pdf)

**Table 1.1.1. Abundance (ind./100 m<sup>2</sup>) of fish species downstream Ciecere HPP and their assignment to groups used for calculating of the LVFI (IntolO<sub>2</sub> – species intolerant to oxygen depletion; Lithophils – species requiring lithophilic reproduction habitat; STspecies – species belonging to salmonid waters).**

Due to the dominance of roach and perch which are ecologically tolerant eurytopic fish species and very low number of intolerant species and species with intermediate tolerance, the value of LVFI is only 0.13 what corresponds to bad ecological quality.

Species	Ind./100 m <sup>2</sup>	Groups of species		
		IntolO <sub>2</sub>	Lithophils	STspecies
Bleak ( <i>Alburnus alburnus</i> )	0.4			
Spined loach ( <i>Cobitis taenia</i> )	0.9			
Bullhead ( <i>Cottus gobio</i> )	3.5	+		+
Gudgeon ( <i>Gobio gobio</i> )	1.3	+		
Dace ( <i>Leuciscus leuciscus</i> )	0.4		+	
Perch ( <i>Perca fluviatilis</i> )	3.5			
Roach ( <i>Rutilus rutilus</i> )	28.4			

**Table 1.1.2. Abundance (ind./100 m<sup>2</sup>) of fish species downstream Ciecere HPP and their assignment to groups of fish species used for calculating of the LVFI (IntolO<sub>2</sub> – species intolerant to oxygen depletion; Lithophils – species requiring lithophilic reproduction habitat; STspecies – species belonging to salmonid waters).**

Fish metric	Reference level	Measured value	EQR	LVFI value
N100m <sup>2</sup> INTOLO <sub>2</sub>	118	4.9	0.04	<b>0.13</b>
LITHspecies%	100	14.3	0.14	
STspecies	5	1	0.2	

Dominance of roach in the section downstream the Cieceres HPP was registered also in previous years. Noteworthy difference from previous years is that in 2021 two rheophilic species (stone loach and chub) was not recaptured and that in 2021 the total number of recorded species (7 species) was slightly smaller than in previous years (7 to 9 species in one survey). Despite two more rheophilic species recorded in previous years, the value of LVFI (0.12 to 0.17) previously was close to that of 2021 and also corresponded to bad ecological quality. Difference in species composition in 2021 and in previous surveys at some extent can be related to the different location of sampling sites. But it is also possible that very high water temperature during the survey of 2021 influenced the distribution of different species and thus also the results of survey.



## 1.2. Ciecere river downstream Dzirnavnieku HPP

Six fish species have been recorded in sampling site located downstream the Dzirnavnieku HPP. Only one species assigned for calculation of LVFI was recorded in this stretch (Table 1.2.1.). But in the same time, it should be noted that share of ecologically tolerant fish species as well as abundance of these species downstream Dzirnavnieku HPP is lower than downstream the Cieceres HPP.

**Table 1.2.1. Abundance (ind./100 m<sup>2</sup>) of fish species downstream Dzirnavnieku HPP and their assignment to groups used for calculating of the LVFI (Intolo<sub>2</sub> – species intolerant to oxygen depletion; Lithophils – species requiring lithophilic reproduction habitat; STspecies – species belonging to salmonid waters).**

Species	Ind./100 m <sup>2</sup>	Groups of species		
		Intolo <sub>2</sub>	Lithophils	STspecies
Bleak ( <i>Alburnus alburnus</i> )	0.5			
Spined loach ( <i>Cobitis taenia</i> )	2.0			
Gudgeon ( <i>Gobio gobio</i> )	32.8	+		
Perch ( <i>Perca fluviatilis</i> )	2.5			
Bitterling ( <i>Rhodeus sericeus</i> )	3.0			
Roach ( <i>Rutilus rutilus</i> )	17.2			

Due to the presence of only one species belonging to groups assigned for calculation of LVFI (Table 1.2.2.) the calculated index for river stretch downstream of the Dzirnavnieku HPP is only 0.09 what corresponds to the bad ecological quality.

**Table 1.2.2. Abundance (ind./100 m<sup>2</sup>) of fish species downstream Dzirnavnieku HPP and their assignment to groups of fish species used for calculating of the LVFI (Intolo<sub>2</sub> – species intolerant to oxygen depletion; Lithophils – species requiring lithophilic reproduction habitat; STspecies – species belonging to salmonid waters).**

Fish metric	Reference level	Measured value	EQR	LVFI value
N100m <sup>2</sup> INTOLO <sub>2</sub>	118	32.8	0.28	0.09
LITHspecies%	100	0	0	
STspecies	5	0	0	

Dominance of roach and gudgeon in stretch downstream the Dzirnavnieku HPP was recorded also in previous years. Number of species in previous years was higher (7 to 14 species in one site). In addition of species recorded in 2021 previously in this stretch such ecologically intolerant species as brown trout and brook lamprey were captured. One of reasons for such differences is very high temperature during survey of 2021 yet important role most may be played also by different allocation of sampling sites – in 2021 sampling site was located

~0,5 km downstream Dzirnavnieku HPP while in previous years distance from the HPP reached several kilometres.

### **1.3. Ciecere river below Pakulu HPP**

Downstream Pakuļu HPP 10 fish species was recorded and five of them is assigned to the groups of species used for calculation of LVFI (Table 1.3.1.). Dominant fish species in this reach was roach but in the same time this was the only reach where such rheophilic species as schneider, chub, minnow and stone loach was recorded. In the same time, it should be noted that this was the only stretch where such ecologically tolerant species as silver bream was recorded. Half of the species captured in this sampling station belonged to groups of species assigned for calculation of the LVFI.

**Table 1.3.1. Abundance (ind./100 m<sup>2</sup>) of fish species downstream Pakuļu HPP and their assignment to groups used for calculating of the LVFI (Intolo<sub>2</sub> – species intolerant to oxygen depletion; Lithophilis – species requiring lithophilic reproduction habitat; STspecies – species belonging to salmonid waters).**

Species	Ind./100 m <sup>2</sup>	Groups of species		
		Intolo <sub>2</sub>	Lithophilis	STspecies
Schneider ( <i>Alburnoides bipunctatus</i> )	0.3	+	+	+
Bleak ( <i>Alburnus alburnus</i> )	3.5			
Stone loach ( <i>Barbatula barbatula</i> )	0.3		+	
Silver bream ( <i>Blicca bjoerkna</i> )	0.3			
Spined loach ( <i>Cobitis taenia</i> )	1.6			
Dace ( <i>Leuciscus leuciscus</i> )	7.4		+	
Minnow ( <i>Phoxinus phoxinus</i> )	0.3	+	+	+
Bitterling ( <i>Rhodeus sericeus</i> )	1.1			
Roach ( <i>Rutilus rutilus</i> )	18.0			
Chub ( <i>Squalius cephalus</i> )	0.8		+	

Due to higher number of species belonging to groups designated for calculation of value of LVFI also the value of the index downstream the Pakulu HPP was slightly higher than downstream the Cieceres and Dzirnavnieku HPP. Nevertheless, the value of the LVFI in this stretch is still very low and lies below the boundaries (0.31) of poor/bad ecological quality (Table 1.3.2.).

**Table 1.3.2. Abundance (ind./100 m<sup>2</sup>) of fish species downstream Dzirnāvnieku HPP and their assignment to groups of fish species used for calculating of the LVFI (Intolo<sub>2</sub> – species intolerant to oxygen depletion; Lithophils – species requiring lithophilic reproduction habitat; Stspecies – species belonging to salmonid waters.**

Fish metric	Reference level	Measured value	EQR	LVFI value
N100m <sup>2</sup> INTOLO <sub>2</sub>	118	0.55	0.005	0.20
LITHspecies%	100	40	0.4	
STspecies	5	1	0.2	

If compared to the previous surveys in 2021 much greater proportion of roach and subsequently – smaller proportion schneider and other ecologically vulnerable and species and species of intermediate ecological vulnerability. Noteworthy that in 2021 such vulnerable species as brown trout and bullhead was not recorded. Likewise stretches downstream other HPP there are two potentially most important factors for different fish survey results in 2021 – possible impact of a very high water temperature during the fish survey on fish distribution and different allocation of the sampling sites.

#### **1.4. Comparative analysis of the characteristics of fish communities downstream of different HPPs in the Ciecere River and suggested species for MesoHABSIM**

Although some differences in distribution and abundance of specific species, the fish fauna downstream of all three HPP has common features (Table 1.4.). Despite some differences in occurrence and abundance of specific species, in general fish fauna downstream the Cieceres HPP and Pakuļu HPP is corresponding. Both stretches of river are dominated by roach yet also species particularly sensitive to littoral zone flushing as well as ecologically tolerant species and species of intermediate tolerance were recorded. Slightly different situation was observed downstream the Dzirnāvnieku HPP. Ecologically intolerant species were not recorded in this stretch yet the abundance of species of intermediate tolerance (gudgeon) was higher and thus the proportion of roach – lower than downstream both other HPP. Noteworthy that in these aspects (no intolerant species and greater abundance of species of intermediate tolerance) fish fauna in the stretch downstream the Dzirnāvnieku HPP was more similar to the fish fauna in the sampling site located 700 m from the Venta River.

The similarities and differences of fish fauna can be linked to different hydromorphology of surveyed sites. Greatest proportion of roach was recorded in sites with the pools. Bullhead was recorded in stone dominated relatively shallow stretch downstream the Cieceres HPP while schneider – in deeper stretch downstream the Pakuļu HPP. Such potadromous species as brook lamprey and chub was captured only downstream the Pakuļu HPP. It may be partly linked with the impact of migration barriers yet it must be taken into account that in previous years chub was recorded both downstream the

Cieceres and Dzirnavnieku HPP but brook lamprey – downstream Dzirnavnieku HPP.

However also the relatively high abundance of species with intermediate ecological tolerance recorded in sampling site located 700 m from the Venta River and relatively higher value) of LVFI (0.4 corresponding to poor ecological quality) for this site should be noted. This indirectly confirms that results of fish survey were dependant not only on the hydromorphological features of the sampling site and very high water temperature during the survey but most probably also on the distance from the HPP.

**Table 1.4. Abundance (ind. 100/m<sup>2</sup>) of key species of different groups of species typical to rhithral middle-sized warmwater rivers similar to the Ciecere River in the river stretches downstream of each of HPP and in sampling site located close to Venta River.**

Group of species	Species	Downstream Cieceres HPP	Downstream Dzirnavnieku HPP	Downstream Pakuju HPP	700 m from the rivermouth
Species particularly sensitive to littoral zone flushing or level fluctuation	<i>Lampetra planeri</i> <sup>1</sup>				0.4
	<i>Cobitis taenia</i>	0.9	2.0	1.6	0.4
Intolerant species	<i>Alburnoides bipunctatus</i>			0.3	
	<i>Cottus gobio</i>	3.5			
Species of intermediate tolerance typical for small and medium size warmwater rhithral streams	<i>Barbatula barbatula</i>			0.3	
	<i>Phoxinus phoxinus</i>			0.3	48.1
	<i>Gobio gobio</i>	1.3	32.8		8.6
	<i>Leuciscus leuciscus</i>	0.4		7.4	0.4
	<i>Squalius cephalus</i> <sup>1</sup>			0.8	13.2
Tolerant eurytopic species	<i>Perca fluviatilis</i>	3.5	2.5		1.2
	<i>Rutilus rutilus</i>	28.4	17.2	18.0	26.6

<sup>1</sup> Potadromous species

Provisionally we offer to use following species for MesoHABSIM model: Ciecere HPP – spined loach, bullhead, gudgeon and dace; Dzirnavnieku HPP – spined loach, gudgeon, dace and brown trout; Pakulu HPP – schneider, bullhead, dace and brown trout.

To get better understanding of fish fauna of different stretches of Ciecere River as well as impact of HPP of distribution and abundance of different species we recommend to perform additional survey. In this survey general hydromorphologic features of Ciecere River should be surveyed in at least

several kilometres long stretch downstream all HPP. In this survey at least general hydromorphologic features of the river should be registered and several electrofishing sites surveyed to get broader information on distribution of ecologically vulnerable fish species and impact of HPP.

## **2. Losis River and its fish fauna**

According to the national typology of Latvian rivers, Losis belongs to river type 3 i.e., medium-sized rhithral stream. There are two HPP on this river – Lejnieku and Grantiņu located 2 km and 7.5 km from the rivermouth. In the project for evaluation of importance of Latvian rivers in protection of fish fauna Losis was listed among rivers which has an importance of local scale. Models developed during this project shows that in general hydromorphological condition of Losis River downstream both HPP is suitable for such ecologically vulnerable species as bullhead, grayling, river and brook lampreys and at some extent also for the spawning of sea trout and brown trout. In the same time created models predicts also high negative anthropogenic impact (mostly the exploitation of HPP and damming of rivers) which considerably reduces the suitability for all mentioned species. Impact of each single HPP dam on fish migration is relatively small, however cumulative impact of both dams is much larger and is approximately equal to the impact of Pakuļu HPP in Ciecere River.

In surveyed stretches downstream the Grantiņu and Lejnieku HPP 15 fish species were recorded – bleak, eel, stone loach, spined loach, bullhead, pike, three-spined stickleback, gudgeon, sunbleak, perch, minnow, bitterling, roach, chub and tench (Table 2.1). Different species was dominating in different GU and in general species composition and distribution was closer to typical fish fauna of middle-sized rhithral warmwater stream as in Ciecere River. Also, the water temperature during the survey (24.2°C) in Losis River was closer to normal than in Ciecere River.

Downstream the Grantiņu HPP six species were recorded. Such rheophilic species like stone loach and bullhead was captured only in riffle, chub was recorded in both riffle and glide while gudgeon perch and roach – only in glide. Downstream Lejnieku HPP very high number of individuals was reached in both backwater (mostly minnow and spined loach) and riffle (mostly stone loach but also minnow). Relatively high density of individuals was recorded also in the pool (mostly spined loach) while number of species and density of individuals in the glide was relatively small.

No additional species was recorded in the sampling site located 200 m from the rivermouth. Dominant species in this site was stone loach and minnow and fish fauna in general was close to that at the site downstream of the Lejnieku HPP.

**Table 2.1. Density of different fish species in different geomorphic units and pooled density of individuals of different fish species in Ciecere River downstream each HPP (GU – geomorphological unit; G – glide; B - backwater; P - pool; Ri – riffle)**

Site, GU		Alburnus alburnus	Anguilla anguilla	Barbatula barbatula	Cobitis taenia	Cottus gobio	Esox lucius	Gasterosteus aculeatus	Gobio gobio	Leucaspis delineatus	Perca fluviatilis	Phoxinus phoxinus	Rhodeus sericeus	Rutilus rutilus	Squalius cephalus	Tinca tinca	Total
Grantiņu HPP	G								1.1		1.1			4.3	4.3		10.7
	Ri			5.1		12.8									2.6		20.5
	<b>Pooled</b>			<b>1.5</b>		<b>3.8</b>			<b>0.8</b>		<b>0.8</b>			<b>3.0</b>	<b>3.8</b>		<b>13.6</b>
Lejnieku HPP	G				15.6		2.2					2.2		2.2	2.2		24.4
	B	5.6		11.1	55.6	5.6			11.1	5.6	5.6	77.8			22.2		200.0
	P	1.3			72.4			3.9		6.6	21.1		21.1	13.2		1.3	140.8
	Ri		2.2	204.4	11.1				4.4			86.7		2.2			311.1
	<b>Pooled</b>	<b>1.1</b>	<b>0.5</b>	<b>51.1</b>	<b>41.8</b>	<b>0.5</b>	<b>0.5</b>	<b>1.6</b>	<b>2.2</b>	<b>3.3</b>	<b>9.2</b>	<b>29.3</b>	<b>8.7</b>	<b>6.5</b>	<b>2.7</b>	<b>0.5</b>	<b>159.8</b>

In previous surveys 20 fish species were recorded and 8 of them was captured also in 2021. Abundance of most of species recorded previously and not captured in 2021 was small (<5 ind./100 m<sup>2</sup>) and great part these species (silver bream, crucian carp, rudd etc.) are not typical for medium size rhithral streams. However, such species as brown trout / sea trout and dace should be highlighted. These are rheophilic and lithophilic species typical for middle-size rhithral streams and their absence is indirectly confirming the deterioration of ecological situation in Losis River during the last years. The same can be said regarding failing of capture of lamprey larvae which can be found in most other tributaries of Venta River. In the same time, it is possible also that smaller number of registered species in 2021 is linked to the relatively short stretch of river surveyed and low density of most of species not captured in this year.

### 2.1. Losis River downstream Grantiņu HPP

Six fish species have been recorded in the sampling site located downstream the Grantiņu HPP. Information on abundance of different species and their assignment to metrics used for calculation of LVFI is compiled in Table 2.1.1. Four of these species (stone loach, bullhead, gudgeon and chub) are used for calculation of LVFI yet abundance of these and other species was very low (<5 ind./100 m<sup>2</sup>).

**Table 2.1.1. Abundance (ind./100 m<sup>2</sup>) of fish species downstream Grantiņu HPP and their assignment to groups used for calculating of the LFI (Intolo<sub>2</sub> – species intolerant to oxygen depletion; Lithophils – species requiring lithophilic reproduction habitat; STspecies – species belonging to salmonid waters).**

Species	Ind./100 m <sup>2</sup>	Groups of species		
		Intolo <sub>2</sub>	Lithophils	STspecies
Stone loach ( <i>Barbatula barbatula</i> )	1.5		+	
Bullhead ( <i>Cottus gobio</i> )	3.8	+		+
Gudgeon ( <i>Gobio gobio</i> )	0.8	+		
Perch ( <i>Perca fluviatilis</i> )	0.8			
Roach ( <i>Rutilus rutilus</i> )	3.0			
Chub ( <i>Squalius cephalus</i> )	3.8		+	

Due to very low abundance of species used for calculation of fish index and presence of only one sentinel species the calculated value of LVFI for this stretch is only 0.19 what corresponds to bad ecological quality (Table 2.1.2.).

**Table 2.1.2. Abundance (ind./100 m<sup>2</sup>) of fish species downstream Grantiņu HPP and their assignment to groups of fish species used for calculating of the LVFI (Intolo<sub>2</sub> – species intolerant to oxygen depletion; Lithophils – species requiring lithophilic reproduction habitat; Stspecies – species belonging to salmonid waters).**

Fish metric	Reference level	Measured value	EQR	LVFI value
N100m <sup>2</sup> INTOLO <sub>2</sub>	118	4.5	0.04	<b>0.19</b>
LITHspecies%	100	33.3	0.33	
Stspecies	5	1	0.2	

In previous surveys much greater number of species was registered in this stretch of river. We suppose that differences in results of 2021 and previous surveys can be explained mostly by different placement of sampling sites and relatively short reach of river surveyed in 2021. However, it is also possible that fish fauna of this stretch of river is influenced also by exploitation of Grantiņu HPP and relatively short stretch of river (~4 km) confined between the reservoir of Lejniēku HPP and dam of Grantiņu HPP.

## 2.2. Losis River downstream Lejniēku HPP

In total 15 fish species were recorded downstream Lejniēku HPP and five of them is assigned to metrics used for calculation of LVFI (Table 2.2.1.). Relatively large abundance of stone loach and minnow as well as presence of such rheophilic species typical for middle-sized rhythral as bullhead, gudgeon and chub must be noted. From this perspective fish fauna of surveyed stretch is close to typical ichthyofauna of similar rivers. In the same time this stretch of river was hosted also by large number of ecologically tolerant species and

species often found in pothamal waters – silver bream, eel, pike, belica, perch, roach etc.

**Table 2.2.1. Abundance (ind./100 m<sup>2</sup>) of fish species downstream Lejnieku HPP and their assignment to groups used for calculating of the LVFI (Intolo<sub>2</sub> – species intolerant to oxygen depletion; Lithophils – species requiring lithophilic reproduction habitat; STspecies – species belonging to salmonid waters).**

Species	Ind./100 m <sup>2</sup>	Groups of species		
		Intolo <sub>2</sub>	Lithophil s	STspecie s
Bleak ( <i>Alburnus alburnus</i> )	1.1			
Eel ( <i>Anguilla anguilla</i> )	0.5			
Stone loach ( <i>Barbatula barbatula</i> )	51.1		+	
Spined loach ( <i>Cobitis taenia</i> )	41.8			
Bullhead ( <i>Cottus gobio</i> )	0.5	+		+
Pike ( <i>Esox lucius</i> )	0.5			
Three-spined stickleback ( <i>Gasterosteus aculeatus</i> )	1.6			
Gudgeon ( <i>Gobio gobio</i> )	2,2	+		
Belica ( <i>Leucaspis delineatus</i> )	3.2			
Perch ( <i>Perca fluviatilis</i> )	9.2			
Minnow ( <i>Phoxinus phoxinus</i> )	29.3	+	+	+
Bitterling ( <i>Rhodeus sericeus</i> )	8.7			
Roach ( <i>Rutilus rutilus</i> )	6.5			
Chub ( <i>Squalius cephalus</i> )	2.7		+	
Tench ( <i>Tinca tinca</i> )	0.5			

Despite the noteworthy abundance of fishes which are typical for middle-sized rhytral stream, the metrics used for calculation of LVFI (abundance of species intolerant to oxygen depletion as well as proportion of lithophile and sentinel specie) calculated value of LFI for this stretch (0.29) was low and corresponded to bad ecological quality (Table 2.2.2.).

If compared to previous surveys relatively large difference of survey results can be observed. First of all, in previous research spined loach was not registered but also the proportion of minnow and stone loach was smaller than in 2021. Taking into account that exploitation of HPP and other anthropogenic pressure often reduces abundance of these species it can be put forward that observed differences can be linked mostly to different allocation of sampling sites and different GU sampled. On other hand absence of brown trout / see trout and brook lamprey should be noted. These species are found in most of tributaries of Venta River and failing to capture it in Losis River can be linked with a



relatively small length of surveyed stretch of river but in the same time it is also possible that this species is absent due to operation of HPP and other anthropogenic impact

**Table 2.2.2. Abundance (ind./100 m<sup>2</sup>) of fish species downstream Lejnieku HPP and their assignment to groups of fish species used for calculating of the LVFI (Intolo<sub>2</sub> – species intolerant to oxygen depletion; Lithophils – species requiring lithophilic reproduction habitat; Stspecies – species belonging to salmonid waters).**

Fish metric	Reference level	Measured value	EQR	LVFI value
N100m <sup>2</sup> INTOLO <sub>2</sub>	118	32.1	0.27	0.29
LITHspecies%	100	20	0.2	
STspecies	5	2	0.4	

### 2.3. Comparative analysis of the characteristics of fish communities downstream of different HPPs in the Losis River and suggested species for MesoHABSIM

Comparing results of surveys in different stretches of Losis river several differences and similarities can be found (Table 2.3). Abundance of most common ecologically tolerant species (roach and perch) in all three stretches was relatively low and in all stretches almost all most common species with intermediate ecological tolerance was represented, including such potadromous species as chub. In the same time large abundance of such species as spined loach which is vulnerable to littoral zone flushing was registered only downstream of Lejnieku HPP. The site downstream of this HPP hosted also largest number of stone loach and minnow.

Group of species	Species	Downstream Grantiņu HPP	Downstream Lejnieku HPP	200 m from the rivermouth
Species particularly sensitive to littoral zone flushing or level fluctuation	<i>Cobitis taenia</i>		41.8	4.8
Intolerant species	<i>Cottus gobio</i>	3.8	0.5	
Species of intermediate tolerance typical for small	<i>Barbatula barbatula</i>	1.5	51.1	19.2
	<i>Phoxinus phoxinus</i>		29.3	16.0

and medium size warmwater rhythral streams	<i>Gobio gobio</i>	0.8	2.2	2.4
	<i>Squalius cephalus</i> <sup>1</sup>	3.8	2.7	4.4
Tolerant eurytopic species	<i>Perca fluviatilis</i>	0.8	9.2	0.4
	<i>Rutilus rutilus</i>	3.0	2.7	0.4

**Table 2.3. Abundance (ind. 100/m<sup>2</sup>) of key species of different groups of species typical to rhithral middle-sized warmwater rivers similar to the Losis River in the river stretches downstream of each of HPP and in sampling site located close to Venta River.**

<sup>1</sup> Potadromous species

In general, it can be concluded that most probably the relatively small number of species and abundance of specimens downstream the Grantiņu HPP as well as larger number of species of intermediate tolerance downstream Lejnieku HPP can be related mostly to hydromorphic features of the surveyed stretches. There is great possibility that increasing the number of sampling sites and diversity of surveyed reaches of the river will give the better picture on actual status of fish fauna in stretches downstream both HPP. It should be also noted that such relatively common species for rhithral tributaries of Venta River as brook lamprey and brown trout / sea trout was not recorded in 2021 and additional research is needed to confirm absence or presence of these species.

Provisionally we offer to use following species for MesoHABSIM model: Grantiņu HPP – bullhead, chub and gudgeon; Lejnieku HPP – spined loach, bullhead, chub and gudgeon.

To get better understanding of fish fauna of different stretches of Losis River as well as impact of HPP of distribution and abundance of different fish and lamprey species we recommend to perform additional survey. In this survey general hydromorphologic features of Losis River should be surveyed in the stretch from Grantiņu HPP to the rivermouth and several electrofishing sites surveyed to get broader information on distribution of ecologically vulnerable fish species and impact of HPP. Special attention should be paid to the evaluation of presence of populations of the brown trout / sea trout and brook lamprey. If necessary additional methods (bottom sampling for lamprey larvae etc.) can be applied.

## **II RESULTS OF FISH SURVEY IN RIVERS, REGULATED BY HPP CASCADES, LITHUANIA**

### **2.Varduve River and its fish fauna**

Fish surveys were carried out in the stretches of the river below each of the 5 HPPs on the Varduva River. Fish were sampled in accordance with the EU standard EN 14011 (CEN, 2003), using IG200/2B pulsed current electric fishing

gear powered by a 12 V battery. The electrofishing was carried out by wading. Fish species individuals were counted separately in each geomorphological unit (GU) delineated in the river stretch on a mesohabitat scale. To calculate Lithuanian fish-based index for assessment of ecological status of rivers, fish counts from all GUs we pooled in each of the surveyed stretches. The catchment size of the entire studied river stretch (covering all 5 studied stretches below each of the HPPs) ranges from 342 to 580 km<sup>2</sup>, and the slope of the river bed ranges from 0.96 to 1.3 m/km in the different stretches.

According to the national typology of Lithuanian rivers, all the studied stretches belong to river type 3, and therefore the ecological status in terms of fish was assessed using the fish metrics and their reference values characteristic of this type of rivers (TAR, 2016-08-09, Nr. 21813). The position of the HPPs in the longitudinal gradient of the Varduva River is shown in Figure 2.1. None of the hydropower plants has fish passes, therefore fish migration through the hydropower plants is not possible. Only the stretch of the river below the lowermost Juodeikiai HPP dam is accessible for migratory fish species.

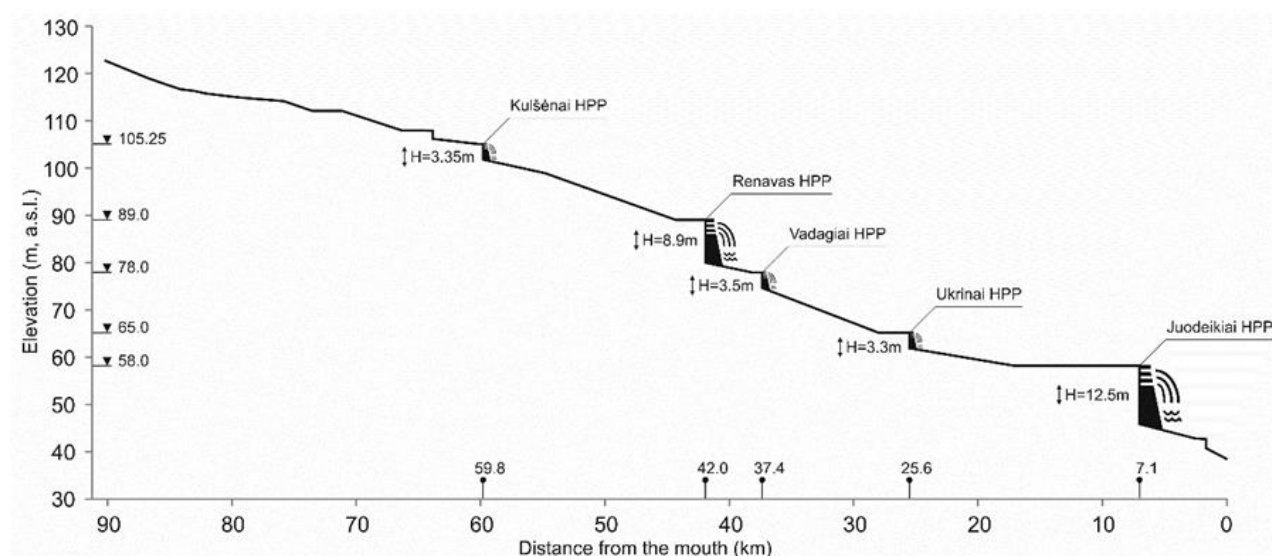


Fig. 2.1. The position of the HPPs in the longitudinal gradient of the Varduva River

A total of 19 species were recorded in the river, ranging from 8 to 15 species in different stretches (Table 2.1). Only 4 fish species were present in the river stretches below all 5 HPPs: stone loach (*Barbatulus barbatulus*), gudgeon (*Gobio gobio*), chub (*Squalius cephalus*) and roach (*Rutilus rutilus*). The other 2 species, the bleak (*Alburnus alburnus*) and the bullhead (*Cottus gobio*), were present in 4 of the 5 studied stretches. Six fish species – spined loach (*Cobitis taenia*), ruff (*Gymnocephalus cernua*), burbot (*Lota lota*), salmon (*Salmo salar*), brown trout (*Salmo trutta*) and vimba (*Vimba vimba*) - were present only in one of the surveyed stretches, with the latter five species recorded only in the river

stretch below the lowermost HPP dam. The species diversity of fish, as well as the number of individuals, was the largest in the GUs of glides in all 5 surveyed stretches of the river. The smallest abundance and diversity was in the GUs of rapids and riffles, which under natural conditions are usually preferred by typical rheophilic fish species.

**Table 2.1. Number of individuals of different fish species in different geomorphic units and total number of individuals of different fish species in the surveyed stretches of the Varduva River below each HPP dam (GU – geomorphological unit; G – glide; P – pool; Ra – rapid; Ri – riffle; Tot – total number of individuals).**

Site, GU		Alburnoides bipunctatus	Alburnus alburnus	Barbatula barbatula	Cobitis taenia	Cottus gobio	Esox lucius	Gobio gobio	Gymnocephalus cernua	Leuciscus leuciscus	Lota lota	Perca fluviatilis	Phoxinus phoxinus	Rhodeus sericeus	Rutilus rutilus	Salmo salar	Salmo trutta	Squalius cephalus	Tinca tinca	Vimba vimba
Kulšėnai HPP	G	148	108	5		10		206					165	2	8			8	1	
	P	2	26	2				8					5		13			5		
	Ra					3		1					8							
	Ri	3		5		17		57					81							
	<b>Tot</b>	<b>153</b>	<b>134</b>	<b>12</b>		<b>30</b>		<b>272</b>					<b>259</b>	<b>2</b>	<b>21</b>			<b>13</b>	<b>1</b>	
Renavas HPP	G		263	2				193	2	6		5			409					1
	P		198					1		2		1			286			3		
	Ra		25	3				13				2			36					
	<b>Tot</b>		<b>486</b>	<b>5</b>				<b>207</b>	<b>2</b>	<b>8</b>		<b>8</b>			<b>731</b>			<b>3</b>	<b>1</b>	
Vadagiai HPP	G	2	104	16				46		8			25	1	19					
	P		102				1	6					5	5	27				1	
	Ra	10	12	14		6		11					129		18					
	Ri	1	30	8		2		27					4							
	<b>Tot</b>	<b>13</b>	<b>248</b>	<b>38</b>		<b>8</b>	<b>1</b>	<b>90</b>		<b>8</b>			<b>163</b>	<b>6</b>	<b>64</b>				<b>1</b>	
Ukrinai HPP	G		1			17		69			1	115			9				1	
	P					3		4				13			4					
	Ri			1		6						8								
	<b>Tot</b>		<b>1</b>	<b>1</b>		<b>26</b>		<b>73</b>			<b>1</b>	<b>136</b>			<b>13</b>				<b>1</b>	
Juodeikiai HPP	G	4		28	4	1		53		1		3	20	7	36	1		34		5
	P						2	2				10	3		2			3		2
	Ra			2		3		5					8				4			
	<b>Tot</b>	<b>4</b>		<b>30</b>	<b>4</b>	<b>4</b>	<b>2</b>	<b>60</b>		<b>1</b>		<b>13</b>	<b>31</b>	<b>7</b>	<b>38</b>	<b>1</b>	<b>4</b>	<b>37</b>		<b>7</b>

The fish communities in the river stretches studied differed in structure and composition as well as in status. The descriptions of the fish assemblages in the studied stretches below each of the HPP are given in the following subsections below in order from uppermost to lowermost HPP.

## 2.1. Varduva River below Kulšėnai HPP

Ten fish species have been recorded in this stretch of the river. The share of abundance of different fish species and the assignment of species to ecological guilds (FAME CONSORTIUM 2004), which are used to calculate the Lithuanian fish index for rivers (WFD Intercalibration Report 2011; TAR, 2016-08-09, Nr. 21814), are presented in Table 2.1.1. Several type-specific intolerant fish species are present in the river stretch; rheophilic fish predominate in the fish assemblage. However, the abundance and diversity of intolerant and lithophilic species is much less than under natural conditions (Table 2.1.2). According to fish metrics, the ecological status of the studied stretch is moderate, although close to the good/moderate status boundary.

**Table 2.1.1. Relative abundance (N%) of fish species in the stretch of the Varduva River below the Kulšėnai HPP and their assignment to ecological guilds for calculating the fish index (INTOL – intolerant to habitat degradation; TOLE – tolerant to habitat degradation; RH – rheophilic; LITH – lithophilic; OMNI – omnivorous).**

Species	N%	Ecological guild			
		Tolerance	Rheophily	Spawning	Feeding
Schneider <i>(Alburnoides bipunctatus)</i>	17.1	INTOL	RH	LITH	
Bleak <i>(Alburnus alburnus)</i>	14.9	TOLE			OMNI
Stone loach <i>(Barbatula barbatula)</i>	1.3		RH	LITH	
Bullhead <i>(Cottus gobio)</i>	3.3	INTOL	RH	LITH	
Gudgeon <i>(Gobio gobio)</i>	30.3		RH		
Minnow <i>(Phoxinus phoxinus)</i>	28.9		RH	LITH	
Bitterling <i>(Rhodeus sericeus)</i>	0.2	INTOL			
Roach <i>(Rutilus rutilus)</i>	2.3	TOLE			OMNI
Chub <i>(Squalius cephalus)</i>	1.4		RH	LITH	OMNI
Tench <i>(Tinca tinca)</i>	0.1	TOLE			OMNI

**Table 2.1.2. Reference and measured values of fish metrics that are used in the Lithuanian fish-based method for assessing the ecological status of medium-sized rhithral rivers (national type 3), metrics EQR values, fish index value and the corresponding class of ecological status.**

Fish metric	Reference	Measured value	Metric EQR*	Fish index*
INTOL abundance (%)	≥45	20.6	0.46	0.70

LITH abundance (%)	≥93	52.1	0.6	
LITH number of species (%)	≥72	50	0.69	
INTOL number of species	≥5	3	0.6	
RH number of species	≥8	6	0.75	
TOLE abundance (%)	≤2	17.4	0.84	
OMNI abundance (%)	≤4	18.8	0.85	
TOLE number of species (%)	≤14	30	0.81	

\*Green-good status class, yellow-moderate

## 2.2. Varduva River below Renavas HPP

In total, 9 species of fish were present in this stretch of the river (Table 2.2.1). No intolerant fish species were recorded. The fish assemblage is dominated by species that are resistant to general habitat degradation (84.5% of all fish individuals), and typical riverine species (rheophilic lithophils) make up only a small part of all fish. More than half of all fish species are not specialized in food objects (omnivorous). The values of none of the type-specific metrics of fish do not meet at least good status criteria, most of the metrics indicate either bad or poor ecological status (Table 2.2.2). According to the fish index, the ecological status of the studied stretch is poor.

**Table 2.2.1. Relative abundance (N%) of fish species in the stretch of the Varduva River below the Renavas HPP and their assignment to ecological guilds for calculating the fish index (INTOL – intolerant to habitat degradation; TOLE – tolerant to habitat degradation; RH – rheophilic; LITH – lithophilic; OMNI – omnivorous).**

Species	N%	Ecological guild			
		Toleranc e	Rheophil y	Spawnin g	Feedin g
Bleak ( <i>Alburnus alburnus</i> )	33.5	TOLE			OMNI
Stone loach ( <i>Barbatula barbatula</i> )	0.3		RH	LITH	
Gudgeon ( <i>Gobio gobio</i> )	14.3		RH		
Ruff ( <i>Gymnocephalus cernua</i> )	0.1				
Dace ( <i>Leuciscus leuciscus</i> )	0.6		RH	LITH	OMNI
Perch ( <i>Perca fluviatilis</i> )	0.6	TOLE			
Roach ( <i>Rutilus rutilus</i> )	50.4	TOLE			OMNI
Chub ( <i>Squalius cephalus</i> )	0.2		RH	LITH	OMNI
Tench ( <i>Tinca tinca</i> )	0.1	TOLE			OMNI

**Table 2.2.2. Reference and measured values of fish metrics that are used in the Lithuanian fish-based method for assessing the ecological status of medium-sized rhithral rivers (national type 3), metrics EQR values, fish index value and the corresponding class of ecological status.**

Fish metric	Reference	Measured value	Metric EQR*	Fish index*
INTOL abundance (%)	≥45	0	0	0.24
LITH abundance (%)	≥93	1.1	0.01	
LITH number of species (%)	≥72	33.3	0.46	
INTOL number of species	≥5	0	0	
RH number of species	≥8	4	0.5	
TOLE abundance (%)	≤2	84.5	0.16	
OMNI abundance (%)	≤4	84.7	0.16	
TOLE number of species (%)	≤14	44.4	0.65	

\*Yellow-moderate status class, brown-poor, red-bad

### 2.3. Varduva River below Vadagai HPP

In this section of the river, 11 species of fish were found, of which 7 were rheophilic (Table 2.3.1). There were also some fish species especially sensitive to habitat degradation, but their share in the fish community is insignificant (4.2%). Half of all fish individuals (50.2%) are tolerant and/or omnivorous fish species. Thus, although the metric of the relative number of tolerant fish species even meets the criteria for high status, the relative abundance of individuals of tolerant as well as omnivorous species is significantly higher than would be expected under natural conditions, and indicates moderate ecological status (Table 2.3.2).

**Table 2.3.1. Relative abundance (N%) of fish species in the stretch of the Varduva River below the Vadagai HPP and their assignment to ecological guilds for calculating the fish index (INTOL – intolerant to habitat degradation; TOLE – tolerant to habitat degradation; RH – rheophilic; LITH – lithophilic; OMNI – omnivorous).**

Species	N%	Ecological guild			
		Tolerance	Rheophily	Spawning	Feeding
Schneider ( <i>Alburnoides bipunctatus</i> )	2.0	INTOL	RH	LITH	
Bleak ( <i>Alburnus alburnus</i> )	38.8	TOLE			OMNI
Stone loach ( <i>Barbatula barbatula</i> )	5.9		RH	LITH	
Bullhead ( <i>Cottus gobio</i> )	1.3	INTOL	RH	LITH	
Pike ( <i>Esox lucius</i> )	0.2				
Gudgeon ( <i>Gobio gobio</i> )	14.1		RH		
Dace ( <i>Leuciscus lauciscus</i> )	1.3		RH	LITH	OMNI

Minnow	<i>(Phoxinus phoxinus)</i>	25.5		RH	LITH	
Bitterling	<i>(Rhodeus sericeus)</i>	0.9	INTOL			
Roach	<i>(Rutilus rutilus)</i>	10.0	TOLE			OMNI
Chub	<i>(Squalius cephalus)</i>	0.2		RH	LITH	OMNI

**Table 2.3.2. Reference and measured values of fish metrics that are used in the Lithuanian fish-based method for assessing the ecological status of medium-sized rhithral rivers (national type 3), metrics EQR values, fish index value and the corresponding class of ecological status.**

Fish metric	Reference	Measured value	Metric EQR*	Fish index*
INTOL abundance (%)	≥45	4.2	0.09	0.59
LITH abundance (%)	≥93	36.1	0.39	
LITH number of species (%)	≥72	54.5	0.76	
INTOL number of species	≥5	3	0.6	
RH number of species	≥8	7	0.88	
TOLE abundance (%)	≤2	48.8	0.52	
OMNI abundance (%)	≤4	50.2	0.52	
TOLE number of species (%)	≤14	18.2	0.95	

\*Blue-high status class, green-good, yellow-moderate, brown-poor, red-bad

The opposite is true for lithophilic species: although the species diversity is relatively high, the relative abundance of individuals is low. According to the fish index, the ecological status of the stretch of the Varduva River below the Vadagiai HPP is moderate.

#### 2.4. Varduva River below Ukrinai HPP

In total, 8 fish species were recorded in this stretch of the river (Table 2.4.1). Individuals of tolerant species (perch) make up the major part (54.2%) of all fish in the assemblage. Among the intolerant species, only the bullhead is present. Most of river type-specific metrics of fish indicate either poor or moderate ecological status (Table 2.5.2). According to the fish index, the ecological status of the studied stretch is moderate.

**Table 2.4.1. Relative abundance (N%) of fish species in the stretch of the Varduva River below the Ukrinai HPP and their assignment to ecological guilds for calculating the fish index (INTOL – intolerant to habitat degradation; TOLE – tolerant to habitat degradation; RH – rheophilic; LITH – lithophilic; OMNI – omnivorous).**

Species	N%	Ecological guild			
		Tolerance	Rheophily	Spawning	Feeding
Bleak <i>(Alburnus alburnus)</i>	0.4	TOLE			OMNI



Stone loach	<i>(Barbatula barbatula)</i>	0.4		RH	LITH	
Bullhead	<i>(Cottus gobio)</i>	10.4	INTOL	RH	LITH	
Gudgeon	<i>(Gobio gobio)</i>	29.1		RH		
Burbot	<i>(Lota lota)</i>	0.4			LITH	
Perch	<i>(Perca fluviatilis)</i>	54.2	TOLE			
Roach	<i>(Rutilus rutilus)</i>	5.2	TOLE			OMNI
Chub	<i>(Squalius cephalus)</i>	0.4		RH	LITH	OMNI

**Table 2.4.2. Reference and measured values of fish metrics that are used in the Lithuanian fish-based method for assessing the ecological status of medium-sized rhithral rivers (national type 3), metrics EQR values, fish index value and the corresponding class of ecological status.**

Fish metric	Reference	Measured value	Metric EQR*	Fish index*
INTOL abundance (%)	≥45	10.3	0.23	<b>0.48</b>
LITH abundance (%)	≥93	11.5	0.12	
LITH number of species (%)	≥72	50	0.69	
INTOL number of species	≥5	1	0.2	
RH number of species	≥8	4	0.5	
TOLE abundance (%)	≤2	59.5	0.41	
OMNI abundance (%)	≤4	6.0	0.98	
TOLE number of species (%)	≤14	37.5	0.73	

\*Blue-high status class, green-good, yellow-moderate, brown-poor

## 2.5. Varduva River below Juodeikiai HPP

The fish assemblage in the stretch of the Varduva River below the lowermost HPP dam is the most diverse in comparison with the rest of the surveyed stretches. Fifteen species of fish have been recorded here, most of them are typical riverine fish (Table 2.5.1). Migratory fish species can access the stretch, therefore the total number of species as well as the number of intolerant species is higher compared to stretches of the river with the barriers for migration. In terms of abundance, individuals of rheophilic fish species make up the majority of fish assemblage (73.7%), but specialized gravel-spawners (lithophilic species) are less numerous. The proportion of individuals of lithophilic species, as well as intolerant species, is much less than would be expected under natural conditions (Table 5.2). But the diversity of type-specific riverine species corresponds (intolerant and rheophilic species) or only slightly deviates (lithophilic species) from the reference values. According to fish index, the status of the stretch of the Varduva River downstream of the Juodeikiai HPP is good, although close to good/moderate status boundary.

**Table 2.5.1. Relative abundance (N%) of fish species in the stretch of the Varduva River below the Juodeikiai HPP and their assignment to ecological guilds for calculating the fish index (INTOL – intolerant to habitat degradation; TOLE – tolerant to habitat degradation; RH – rheophilic; LITH – lithophilic; OMNI – omnivorous).**

Species	N%	Ecological guild			
		Tolerance	Rheophily	Spawning	Feeding
Schneider ( <i>Alburnoides bipunctatus</i> )	1.6	INTOL	RH	LITH	
Stone loach ( <i>Barbatula barbatula</i> )	12.3		RH	LITH	
Spined loach ( <i>Cobitis taenia</i> )	1.6				OMNI
Bullhead ( <i>Cottus gobio</i> )	1.6	INTOL	RH	LITH	
Pike ( <i>Esox lucius</i> )	0.8				
Gudgeon ( <i>Gobio gobio</i> )	24.7		RH		
Dace ( <i>Leuciscus lauciscus</i> )	0.4		RH	LITH	OMNI
Perch ( <i>Perca fluviatilis</i> )	5.3	TOLE			
Minnow ( <i>Phoxinus phoxinus</i> )	12.8		RH	LITH	
Bitterling ( <i>Rhodeus sericeus</i> )	2.9	INTOL			
Roach ( <i>Rutilus rutilus</i> )	15.6	TOLE			OMNI
Chub ( <i>Squalius cephalus</i> )	15.2		RH	LITH	OMNI
Salmon ( <i>Salmo salar</i> )	0.4	INTOL	RH	LITH	
Brown trout ( <i>Salmo trutta</i> )	1.6	INTOL	RH	LITH	
Vimba ( <i>Vimba vimba</i> )	2.9		RH	LITH	

**Table 2.5.2. Reference and measured values of fish metrics that are used in the Lithuanian fish-based method for assessing the ecological status of medium-sized rhithral rivers (national type 3), metrics EQR values, fish index value and the corresponding class of ecological status.**

Fish metric	Reference	Measured value	Metric EQR*	Fish index*
INTOL abundance (%)	≥45	8.2	0.18	0.76
LITH abundance (%)	≥93	49.0	0.53	
LITH number of species (%)	≥72	60.0	0.83	
INTOL number of species	≥5	5	1	
RH number of species	≥8	10	1	
TOLE abundance (%)	≤2	21.0	0.81	
OMNI abundance (%)	≤4	32.9	0.70	

TOLE number of species (%)	≤14	13.3	1	
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\*Blue-high status class, green-good, yellow-moderate, brown-poor

## 6. Comparative analysis of the characteristics of fish communities downstream of different HPPs in the Varduva River

According to the results of State monitoring, the metrics of all water quality elements meet the criteria of high or good ecological status in the Varduva River. The presence of HPPs is the only pressure affecting fish assemblages (see Deliverable T1.1.1 “Review of existing hydro-morphological data and HPPs technical specification”). However, the structure and composition of fish assemblages, as well as ecological status in terms of fish metrics, differ in stretches of the river downstream of different HPPs.

In stretch of the river downstream of the Kulšėnai HPP, which is the uppermost in the cascade of HPPs, there are no species sensitive to water level fluctuations, migratory species are also absent. However, some intolerant species are still found, and the number of individuals of tolerant species is relatively small (Table 2.6). The fish index score corresponds to the moderate status, however, it is quite close to the boundary of the moderate and good status. The situation is much worse in the stretch of the Varduva River below the Renavas HPP, which is the second in the chain of HPPs. The distance to the next HPP is the shortest (see Figure 1), which means that semi-migratory and typical rheophilic species have less space to survive compared to stretches of the rivers below other HPPs. There are no water level fluctuation-sensitive and intolerant species here. Over 83% of all fish in the community are roach and bleak, which are the most resistant to habitat degradation. According to the fish index, the status is poor. The third in the chain is the Vadagiai HPP. This hydropower plant does not operate in the summer, therefore the fluctuation of discharge is slightly less than below the Renavas HPP. In addition, the distance to the next impoundment is greater. Some of the intolerant fish species are still present here; however, almost half of all fish are individuals of tolerant species. According to the fish index, the status is moderate, which is one class of status better than in the stretch below the Renavas HPP. The fourth is the Ukriņai HPP, which operates all year round. The distance to the next impoundment is relatively long, but the fish community is significantly altered. Among the intolerant species, only the sculpin is present, while the tolerant species, mainly perch, make up almost 60% of all fish individuals. According to fish index, the status is moderate.

The situation is different in the lower reaches of the Varduva River, below the Juodeikiai HPP, which is accessible to migratory fish. Fifteen species of fish were recorded here, which is almost twice as many as in other surveyed stretches. Almost all type-specific intolerant species of fish, as well as migratory species are present, including salmon, trout and vimba. Tolerant species no

longer dominate, but still make up approximately 20% of all individuals in the assemblage. Lamprey larvae, which are particularly sensitive to littoral washout, are absent, but spined loach is already found in small numbers. According to the fish index, good status has been achieved, but the index value is close to the boundary of good/moderate status.

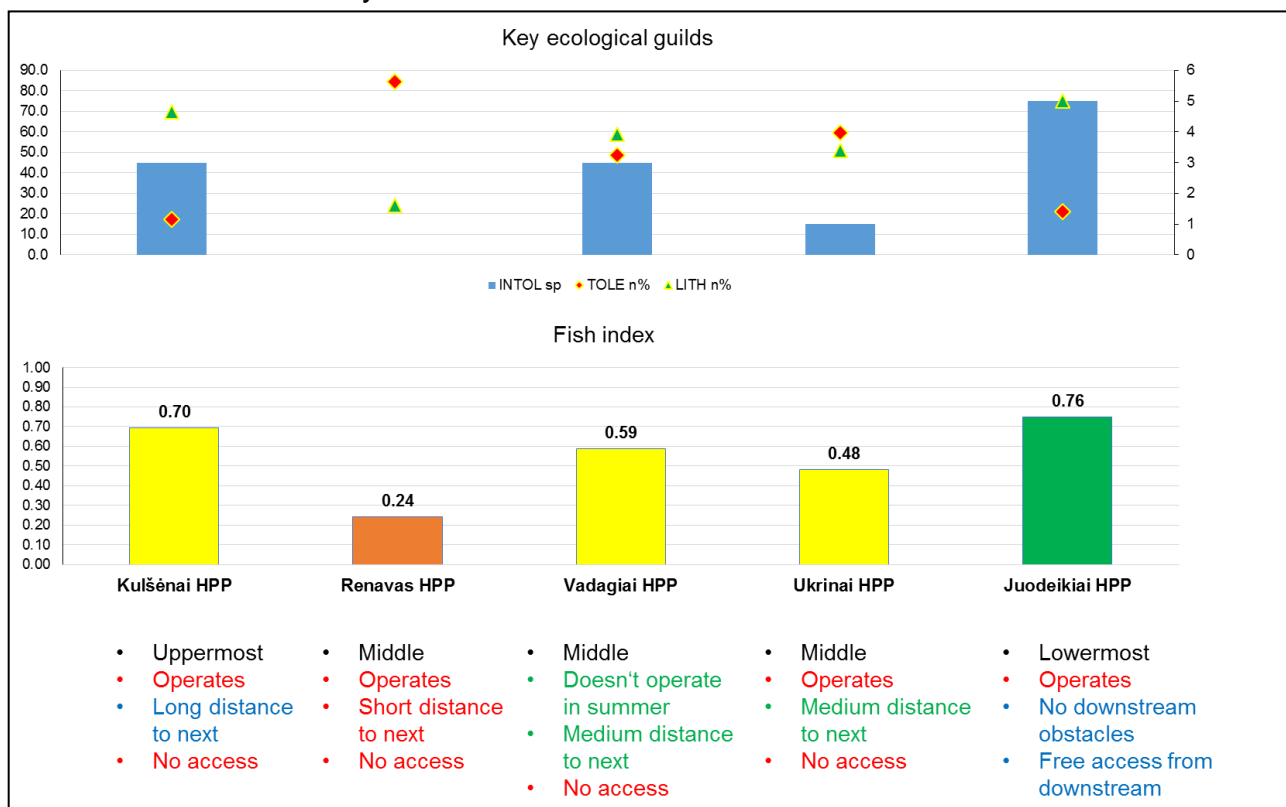
**Table 2.6. Key species of the different ecological guilds that should be present in rivers of the Varduva type and the actual relative abundance (in %) of the species in the river stretches downstream of each of HPP. Species that make up >30% of the total abundance in certain stretches are indicated in bold.**

Main characteristics of the species group	Species	Kulšėnai HPP	Renavas HPP	Vadagiai HPP	Ukrinai HPP	Juodeikiai HPP
Particularly sensitive to littoral zone flushing or level fluctuation	<i>Lampetra sp.</i>					
	<i>Cobitis taenia</i>					1.7
Intolerant and/or long distance migratory	<i>Salmo salar</i> <sup>1,2</sup>					0.4
	<i>Salmo trutta</i> <sup>1,2</sup>					1.7
	<i>Vimba vimba</i> <sup>2</sup>					2.9
	<i>Alburnoides bipunctatus</i> <sup>1</sup>	17		13		4
	<i>Rhodeus sericeus</i> <sup>1</sup>	0.2		0.9		2.9
	<i>Cottus gobio</i> <sup>1</sup>	3.3		1.3	10	1.7
Intermediate tolerance, Lithophilic	<i>Phoxinus phoxinus</i>	29		25		13
	<i>Leuciscus leuciscus</i>		0.6	1.3		0.4
	<i>Squalius cephalus</i>	1.4	0.2	0.2	0.4	15
	<i>Barbatula barbatula</i>	1.3	0.3	5.9	0.4	12
Tolerant, Eurytopic	<i>Rutilus rutilus</i>	2.3	<b>50</b>	10	5.2	<b>16</b>
	<i>Alburnus alburnus</i>	15	<b>33</b>	<b>39</b>	0.4	
	<i>Perca fluviatilis</i>		0.6		<b>54</b>	5.4

<sup>1</sup> – intolerant; <sup>2</sup> – long distance migratory

The change in the situation in the river gradient, both in terms of the diversity and abundance of the main ecological guilds, and in terms of the ecological status according to the fish index, is visualized in Figure 6.1. It can be seen that if the HPP is operating, migration of fish is disrupted at both ends, but the distance to the next obstacle is relatively large (Kulšėnai HPP), the impact of connectivity disturbance is smaller compared to the situation where the distance between obstacles to migration is relatively short. The latter scenario is the worst one (Renavas HPP). Accordingly, if the distance to the next impoundment is relatively medium, but the HPP does not operate during the low flow period (Vadagiai HPP), the situation is better compared to the situation when the HPP operates all year round (Ukrinai HPP). However, in both cases, good status is not achieved. And, finally, if the access of fish from the lower reaches is free, the situation is better than in other cases, despite the fact that

the HPP is operating. But the difference in the value of the fish index in the stretches of the river below the lowermost and uppermost HPPs is small. All this indicate that the cumulative effect of HPP and connectivity disturbance is much stronger than any of these effects taken separately. However, it implies that only the introduction of ecological flow without opening migration routes will only slightly improve the situation in the cascade of HPP, and a good ecological status in terms of fish may not be achieved.



**Fig. 2.6.1. Values of metrics of key ecological guilds (upper graph), fish index values and the corresponding class of ecological status (brown – poor, yellow – moderate, green – good) (lower graph) and a description of the position of HPP in the cascade of HPPs, operation, distance to the next HPP and accessibility for migratory fish.**

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