



LIFE project number

LIFE10 NAT/SI/142

**PRELIMINARY STUDY OF THE HABITAT,
HYDROLOGICAL AND HYDRAULIC CONDITIONS IN
THE LJUBLJANICA RIVER CORRIDOR, ESTIMATION
OF DANUBE SALMON, DANUBE ROACH AND
STRIPED CHUB POPULATION**

Action: A1

Date: December 2013

1 AN OVERVIEW OF THE RECENT STUDIES ON DANUBE SALMON, DANUBE ROACH AND STRIPED CHUB POPULATION

In 2007 dr. Meta Povž and mag. Suzana Šumer took a survey of ecological condition of river Ljubljanica. They monitored the river from the source to the confluence with the Gruber canal in the city of Ljubljana. In addition, historical data about fish on the surveyed part of Ljubljana were collected. 41 different fish species were registered, among them 31 fish and one lamprey were autochthonous and 9 were aliens. On the basis of historical and acquired data of fish populations they judged that the river Ljubljana is in moderate ecological status. Ecological potential of the urban river area was not estimated because of lack of proper recent ichthyologic data.

1.1 River Ljubljana and history of regulations

Ljubljana basin covers an area of 1900 square kilometres what represents almost one tenth of the whole country. The river is 41 kilometres long, which basin is habitat with high diversity, so a real natural museum to comprehend karst secrets, its flora and fauna and human adaptation to nature.

Regulation of Ljubljana started in Roman times, when they were draining and cultivating Ljubljansko Barje and performed regulations of some streams. All the regulations in the 18th and 19th century and in the first half of 20th century were designed for draining and colonising Barje and preventing floods in the city. They intentionally started to manage the stream of River Ljubljana between 1724 and 1758. In 1772 they started building Gruberjev prekop but the channel was too tight and shallow so that there were still floods in case of heavy rain.

River Ljubljana is today more or less regulated with trees and bushes growing on the banks up to the confluence with Gruberjev prekop. Two kilometres long part of the river between confluences with Gruberjev prekop is a candidate for a transformed water body. The reason is stream which is made of concrete and the presence of Plečnik barrier which dams the river. It was built between 1939 and 1944 and has a purpose to regulate the water level in the city centre.



Figure 1: Ambrožev trg barrier

Downstream from the confluence with Gruberjev prekop in Fužine and in Vevče is the stream regulated with soil banks. In this segment by the Fužine castle there is a dam built in 1900, which prevents fish migration from River Sava to River Ljubljana because of the hydroelectric power station. Next to the dam there is a fish pass but it is closed for some decades now.

Downstream from Vevče up to the outflow the stream is less and less regulated, while the banks are more natural and covered with trees and bushes. On both obstacles, by the barrier and by the dam, they build fish passes as a mitigation measure.



Figure 2: Fish pass at the Fužine weir



Figure 3: Fish pass at the Fužine weir

1.2 Fish species and their range in River Ljubljana basin

Informations about fish species were collected for the whole hydrographic basin of Ljubljana from spring to the outflow in River Sava, what exceeds the borders of Community of Ljubljana. Whereas other informations were confined only to the Community of Ljubljana. The area they were dealing with is managed by fish association Barje and Vevče. From fishing breeding plan of this two managers they collected informations about fish species and sport fishing for the period 1981 to 2006. From fishing breeding plan of fish association Vevče they got informations about the catch of fishes from Vevče to the outflow for the period 1981 to 2006. They used this informations to compare historical and recent state of ihtiofauna in Ljubljana and to give an expert estimation of population of different fish species. Other informations were collected from private base of freshwater fishes in Slovenia, unpublished manuscripts, publications in different gazettes, oral tradition of older fishermen and from older literature about River Ljubljana and its tributaries.

This was the first ihtologic survey to estimate the fish population in the Community of Ljubljana. Therefore the only available informations are informations from fishing breeding plan of fish associations Barje and Vevče. According to this informations 41 different species of fish (considering one species of lamprey) live in River Ljubljana from Podpeč to the outflow in River Sava. Among them there are 32 autochthonous and 9 alien species from 13 families: 4 species belong to family Salmonidae, 23 to Cyprinidae, 2 to Percidae, 3 to Cobitidae and 1 to families Thymallidae, Cottidae, Esocidae, Siluridae, Barbatulidae, Centrarchidae, Ictaluridae, Gadidae and Petromyzontidae (Table 1). Ciprinid species are prevailing. Two species (Danube Salmon and Danube Roach) are endemic to Danube basin.

Table 1: Fish species in River Ljubljana from Podpeč to the outflow (source: fishing breeding plan)

SALMONID SPECIES 5 species	CYPRINID SPECIES 35 SPECIES
<p>SALMONIDAE <i>Salvelinus fontinalis</i> <i>Salmo trutta</i> m. <i>fario</i> <i>Hucho hucho</i> <i>Oncorhynchus mykiss</i></p> <p>THYMALLIDAE <i>Thymallus thymallus</i></p>	<p>CYPRINIDAE <i>Rutilus rutilus</i> <i>Rutilus digus</i> <i>Chondrostoma nasus</i> <i>Squalius cephalus</i> <i>Leuciscus souffia</i> <i>Scardinius erythrophthalmus</i> <i>Tinca tinca</i> <i>Alburnoides bipunctatus</i> <i>Gobio obtusirostris</i> <i>Hypophthalmichthys nobilis</i> <i>Hypophthalmichthys molitrix</i> <i>Barbus barbus</i> <i>Barbus balcanicus</i> <i>Alburnus alburnus</i> <i>Phoxinus phoxinus</i> <i>Abramis brama</i> <i>Rhodeus sericeus</i> <i>Carassius carassius</i> <i>Carassius gibelio</i> <i>Cyprinus carpio</i></p>
<p>CYCLOSTOMATA 1 SPECIES</p> <p>PETROMYZONTIDAE <i>Eudontomyzon mariae</i></p>	

Vimba vimba
Ctenopharyngodon idella
Pseudorasbora parva
PERCIDAE
Perca fluviatilis
Lucionerca lucionerca
COTTIDAE
Cottus metae
SILURIDAE
Silurus glanis
ESOCIDAE
Esox lucius
COBITIDAE
Cobitis elongatoides
Misgurnus fossilis
Sabanejewia balcanica
BARBATULIDAE
Barbatula barbatula
GADIDAE
Lota lota
CENTRARCHIDAE
Lepomis gibbosus
ICTALURIDAE
Ameiurus sp.

In the Table 2 is shown the distribution of fishes along the stream of River Ljubljana from spring to the outflow. The oscillation of number of fishes in different sections are minimal. This shows that species appear more or less regularly in the whole stream. That is expected for Ljubljana as a typical karst water with a lot of vegetation, which provides enough food, microhabitats and spawning places for fishes.

Table 2: The distribution of fish species along River Ljubljana from Podpeč to the outflow (green colour – fish is present)

FAMILY	SPECIES	1 spring- Vrhnika	2 Podpeč	3 - outflow Mali Graben	4 Ljubljana - Vevče	5 - Zalog – outflow in Sava
SALMONIDAE	<i>Salmo trutta m. fario</i>					
	<i>Oncorhynchus mykiss</i>					
	<i>Hucho hucho</i>					
	<i>Salvelinus fontinalis</i>					
THYMALLIDAE	<i>Thymallus thymallus</i>					
CYPRINIDAE	<i>Rutilus rutilus</i>					
	<i>Rutilus pigus</i>					
	<i>Chondrostoma nasus</i>					
	<i>Squalius cephalus</i>					
	<i>Leuciscus souffia</i>					
	<i>Scardinius</i>					
	<i>Tinca tinca</i>					
	<i>Alburnoides bipunctatus</i>					

	<i>Gobio obtusirostris</i>						
	<i>Hypophthalmichthys nobilis</i>						
	<i>Hypophthalmichthys</i>						
	<i>Barbus barbus</i>						
	<i>Barbus balcanicus</i>						
	<i>Alburnus alburnus</i>						
	<i>Phoxinus phoxinus</i>						
	<i>Abramis brama</i>						
	<i>Rhodeus sericeus</i>						
	<i>Carassius carassius</i>						
	<i>Carassius gibelio</i>						
	<i>Cyprinus carpio</i>						
	<i>Vimba vimba</i>						
	<i>Ctenopharyngodon idella</i>						
	<i>Pseudorasbora parva</i>						
PERCIDAE	<i>Perca fluviatilis</i>						
	<i>Stizostedion lucioperca</i>						
COTTIDAE	<i>Cottus metae</i>						
SILURIDAE	<i>Silurus glanis</i>						
ESOCIDAE	<i>Esox lucius</i>						
COBITIDAE	<i>Cobitis elongatoides</i>						
	<i>Misgurnus fossilis</i>						
	<i>Sabanejevia balcanica</i>						
BALITORIDAE	<i>Barbatula barbatula</i>						
GADIDE	<i>Lota lota</i>						
CENTRARCHIDAE	<i>Lepomis gibbosus</i>						
IICTALURIDAE	<i>Ameiurus sp.</i>						
PETROMYZONTIDAE	<i>Eudontomyzon mariae</i>						
	Number of species	41	30	28	29	30	26

After the regulation of River Ljubljana in the 18th century fish structure hasn't changed so much. Noticeable changes have been in size of the population of different species and in dominance. Main negative elements like alien species, pollution, regulations, changed hydrologic conditions and other are found also in River Ljubljana in the Community of Ljubljana.

Historical state for the period 1842 to 1926 was summarized after H. Freyer (1842), I. Franke (1892, 1900, 1913) and A. Munda (1926) and completed with data from old records or publications in the first half of 20th century. According to this information there lived cyprinid and salmonid species in River Ljubljana and its tributaries. Different writers mention different number of species (Table 3). The oldest data is from H. Freyer which is believed to be one of the oldest record about distribution of fish species in Slovenia. Dr. Ivan Franke didn't write much in his publications, however he used clear maps to show the presence of each species. In his book D. Avgust Munda described fishes in River Ljubljana from both springs to the outflow, where he already mentions the presence of alien species Brook trout (*Salvelinus fontinalis*) and Rainbow trout (*Oncorhynchus mykiss*). He also mentions that before his writing there were plenty of large Danube salmon (*Hucho hucho*) in the upper part of River Ljubljana. From notes of different authors, above all from magazine Ribič, they found information about presence of 3 new species (Common bream - *Abramis brama*, hybrid between Marble trout - *Salmo marmoratus* and Brown trout - *Salmo trutta m. fario*, European eel - *Anguilla anguilla*) in transition from 20th to 21st century. In 1933 an unknown author even described the numerosity of different species in percentage.

They haven't found any data about fish species which should live in River Ljubljana before any regulation in 18th century. On the basis of historical data it was found out that

already after regulation and in transition from 19th to 20th century there lived or just passed by 37 different species of fish. Among them 4 were dominant (D) and 8 subdominant (S) (Table 4). According to the expert estimation of recent population of fishes they found out that Danube salmon (*Hucho hucho*) isn't among dominant species anymore because of the negative influences (regulations, pollution, habitat fragmentation), while estimation for other species remains the same as for historical state.

Table 3: Historical data for fishes in River Ljubljanica for period 1842 to 1933

species (30 species + hybrid)	Freyer 1842	Franke 1892	Munda- 1926	anonimu s 1933	other authors 1887-1930
<i>Salmo marmoratus x S. trutta m. fario</i>					x
<i>Oncorhynchus mykiss</i>			x		x
<i>Salmo trutta m. fario</i>		x	x		x
<i>Hucho hucho</i>		x	x	x	x -
<i>Thymallus thymallus</i>		x	x	x -	x
<i>Salmo marmoratus</i>			x		
<i>Salvelinus umbla</i>			x		
<i>Barbus barbus</i>		x		x -1	x
<i>Aspius aspius</i>	x	x		x	x
<i>Blicca bjoerkna</i>	x		x		x
<i>Abramis brama danubii</i>					x
<i>Rutilus virgo</i>		x		x	
<i>Cyprinus carpio</i>	x			x	
<i>Carassius carassius</i>			x		
<i>Scardinius erythrophthalmus</i>	x				
<i>Telestes agassizii</i>	x				
<i>Chondrostoma nasus</i>	x	x		x -	
<i>Squalius cephalus</i>	x			x	
<i>Tinca tinca</i>			x	x	
<i>Rhodeus sericeus</i>			x		
<i>Vimba vimba carinata</i>			x	x	
<i>Anguilla anguilla</i>					x
<i>Lota lota</i>	x	x			
<i>Cobitis elongatoides</i>	x				
<i>Barbatula barbatula</i>	x				
<i>Cottus gobio</i>	x			x	
<i>Eudontomyzon mariae</i>	x				
<i>Esox lucius</i>		x		x - 5%	
<i>Aspro streber</i>			x		
<i>Perca fluviatilis</i>		x		x	
Other species - 25%		x		x	

Table 4: Expert estimation of the fish population in River Ljubljanica in the period 1842 to 1933 and now

FISH SPECIES	HISTORICAL ESTIMATION	RECENT ESTIMATION
<i>Salmo trutta m. fario</i>	R	R
<i>Hucho hucho</i>	D	S
<i>Thymallus thymallus</i>	D	D
<i>Abramis brama</i>	R	R
<i>Aspius aspius</i>	R	R
<i>Barbatula barbatula</i>	R	R
<i>Barbus barbus</i>	S	S
<i>Abramis bjoerkna</i>	R	R
<i>Carassius carassius</i>	R	R
<i>Chondrostoma nasus</i>	D	D

<i>Cottus gobio</i>	S	S
<i>Cyprinus carpio</i>	R	R
<i>Leuciscus cephalus</i>	S	S
<i>Leuciscus souffia</i>	R	R
<i>Rhodeus sericeus</i>	R	R
<i>Rutilus pigus</i>	S	S
<i>Scardinius erythrophthalmus</i>	R	R
<i>Tinca tinca</i>	R	R
<i>Vimba vimba</i>	R	R
<i>Perca fluviatilis</i>	R	R
<i>Zingel streber</i>	R	extinct
<i>Cobitis taenia</i>	R	R
<i>Esox lucius</i>	S	S
<i>Lota lota</i>	R	R
<i>Eudontomyzon mariae</i>	R	R

Legend:
D - dominant
S - subdominant
R - rare

2 RANGE, NUMBER OF CAUGHT AND NUMBER OF RE-INTRODUCED DANUBE SALMON

Danube Salmon lives from the source to the outflow of the Ljubljanica River and in its tributaries. Its spawning place is in Zadvor. In Mali Graben it lives from Bokalce to the outflow in Ljubljanica and spawns in Bokalce and two spawning places in the middle stream. In Gradaščica it lives from the confluence of the Velika and Mala Božna to Bokalce. Known spawning areas in Gradaščica are in Dvor, Log, Hrastenice, Stranska vas, Dobrovo and in Bokavci. It is estimated that the population in this two tributaries is relatively large. The species lived also in Horjulka, but in the last ten years they didn't catch it. Most likely, it is still present in some smaller tributaries of Ljubljanica: Podlipščica (recorded spawning place in Ligojna), Ljubija (recorded spawning place in the middle stream), Bistra (recorded spawning place under the castle Bistra), Iška, Iščica and Želimeljščica (recorded spawning place in Remšetovec).

Table 5: Catch of Danube Salmon from year 1986 to 2006.

year	number	kg
1986	0	0
1987	0	0
1988	3	22,15
1989	2	16
1990	3	26,6
1991	2	14,8
1992	2	10,8
1993	5	35
1994	2	20
1995	3	24
1996	6	49
1997	9	58,4
1998	13	87,92
1999	4	30
2000	2	18,5
2001	2	18,5
2002	4	37
2003	3	22
2004	3	24
2005	6	48
2006	7	56

Table 6: Number of re-introduced specimens from year 1986 to 2007.

year	< 5	5-9	9-12	12-15	15-20	20-30	30-50	market fish
1984	300	0	0	0	0	0	0	0
1985	0	190	0	0	0	0	24	0
1986	0	0	0	0	18	0	0	19
1987	0	0	0	0	0	0	0	90
1988	0	250	0	0	0	0	0	0
1988	0	700	0	0	0	0	7	45
1991	0	750	0	0	0	0	0	0
1991	0	150	0	0	0	0	0	0
1992	0	620	0	0	0	0	0	0
1993	0	250	0	0	0	0	0	76
1994	800	0	0	0	0	0	0	0
1995	0	480	0	0	0	0	0	0
1995	0	200	0	0	0	0	0	0
1996	0	900	0	400	0	0	0	0
1996	0	0	0	250	0	0	0	0
1996	0	0	0	200	0	0	0	0
1997	0	300	0	0	0	0	0	0
1997	0	0	0	0	0	0	6	0
1999	0	957	0	0	0	0	0	0
2000	0	0	412	0	0	0	0	0
year	< 5	5-9	9-12	12-15	15-20	20-25	30-35	> 35 cm
2001	0	0	0	0	0	1000	0	0
2002	0	0	0	1000	0	0	0	0
2003	0	0	0	0	0	500	0	0
2004	0	0	0	0	0	1130	0	0
2005	0	0	2200	0	0	0	250	0
2006	0	0	0	0	0	0	0	500
2007	0	0	0	0	0	0	300	0

The data was collected on the section of the Sava River from the confluence with the Ljubljanica River to the bridge in Litija.

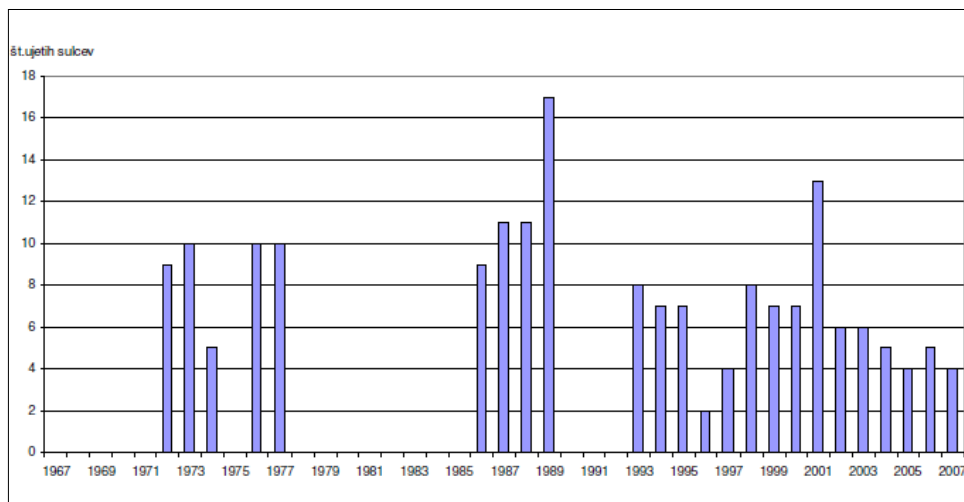


Figure 4: : Catch of Danube Salmon in Ljubljanica River from the confluence of Mala and Velika Ljubljanica to the motorway bridge in Podpeč from 1967 to 2007.

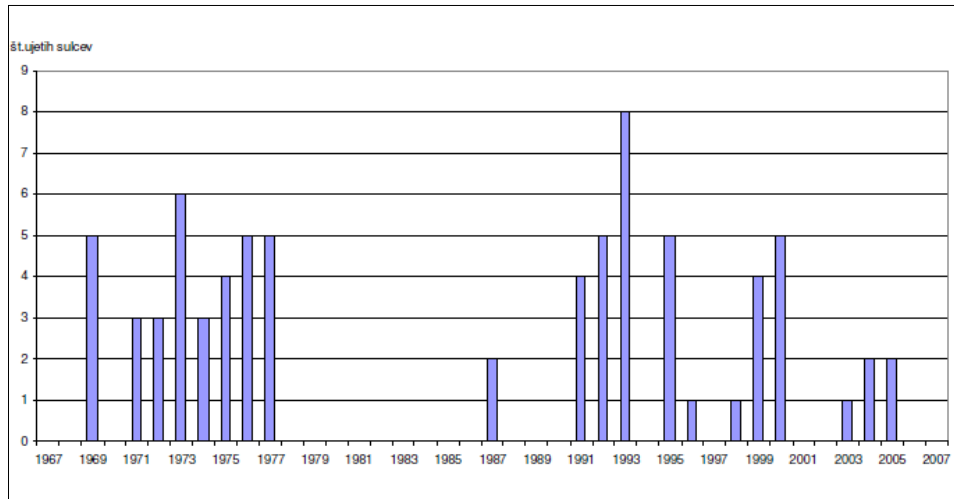


Figure 5: Catch of Danube Salmon in Ljubljana River from the motorway bridge in Podpeč to the dam at Ambrožev trg and in Mali Graben from 1967 to 2007.

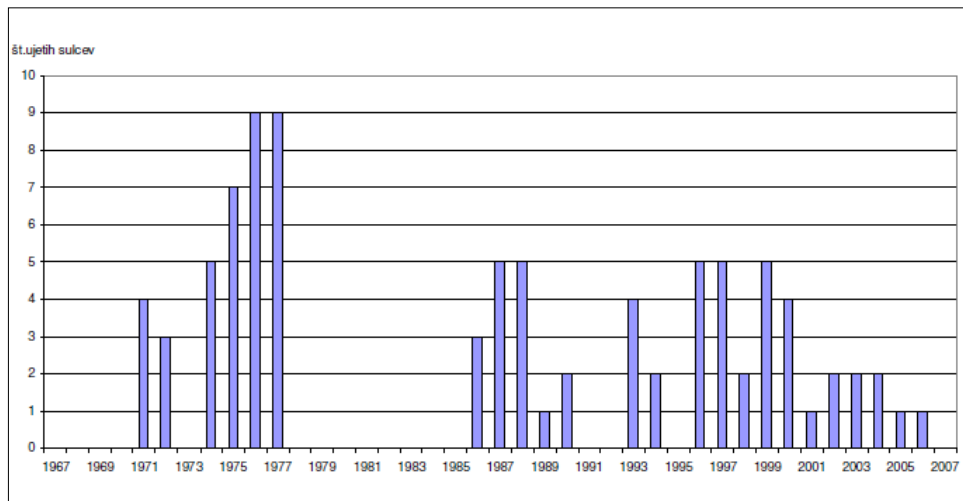


Figure 6: Catch of Danube Salmon in Ljubljana River from the dam at Ambrožev trg to the dam in Vevče paper factory from 1967 to 2007.

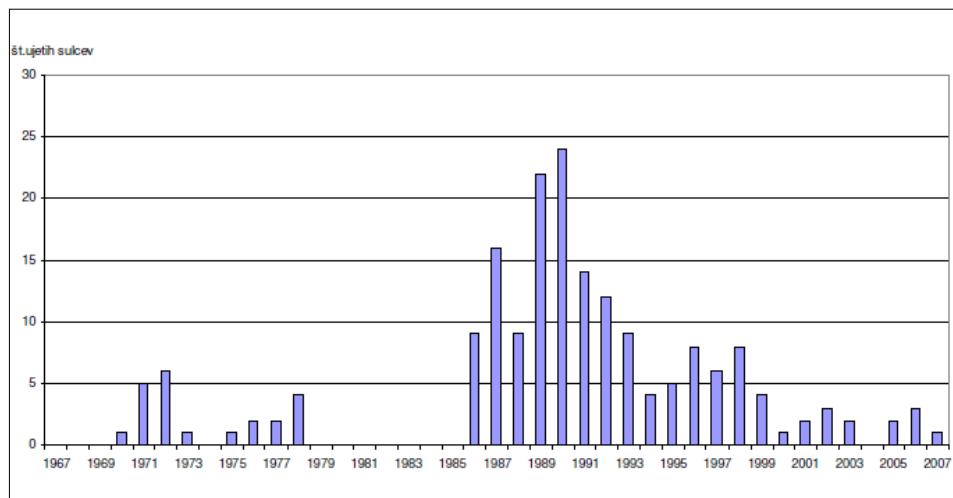


Figure 7: Catch of Danube Salmon in Gradaščica and Horjulka from 1967 to 2007.

In the segment from the confluence of Mala and Velika Ljubljanica to the motorway bridge in Podpeč the catch was constant in the last 15 years and represented from 4 to 8 caught species of Danube Salmon per year (Figure 1). For the earlier period the data is incomplete. In this segment the population of Danube Salmon was estimated as vital.

In the segment from Podpeč to Ambrožev trg and in Mali Graben the catch of Danube Salmon was less constant and generally reached from 2 to 5 caught specimens per year (Figure 2).

The catch of Danube Salmon from Ambrožev trg to Vevče was in constant decline since 1990. In 1990 it reached 24 caught specimens and since year 2000 it didn't reach even five specimens per year (Figure 3).

In Horjulka only individual specimens of Danube Salmon got caught, in the last fifteen years seven of them (Figure 4). In Gradaščica the amount of caught fish wasn't large, but constant.

According to the data of caught fish and numerous spawning places they estimated, that in 2007 the population of Danube Salmon in Ljubljana River basin was vital and in satisfying condition. Since year 1990 a trend of decline was noticed. Population in this area was estimated to be one of the most numerous and vital, but because of impassable barriers there is a risk of quality deterioration and extinction of isolated populations.

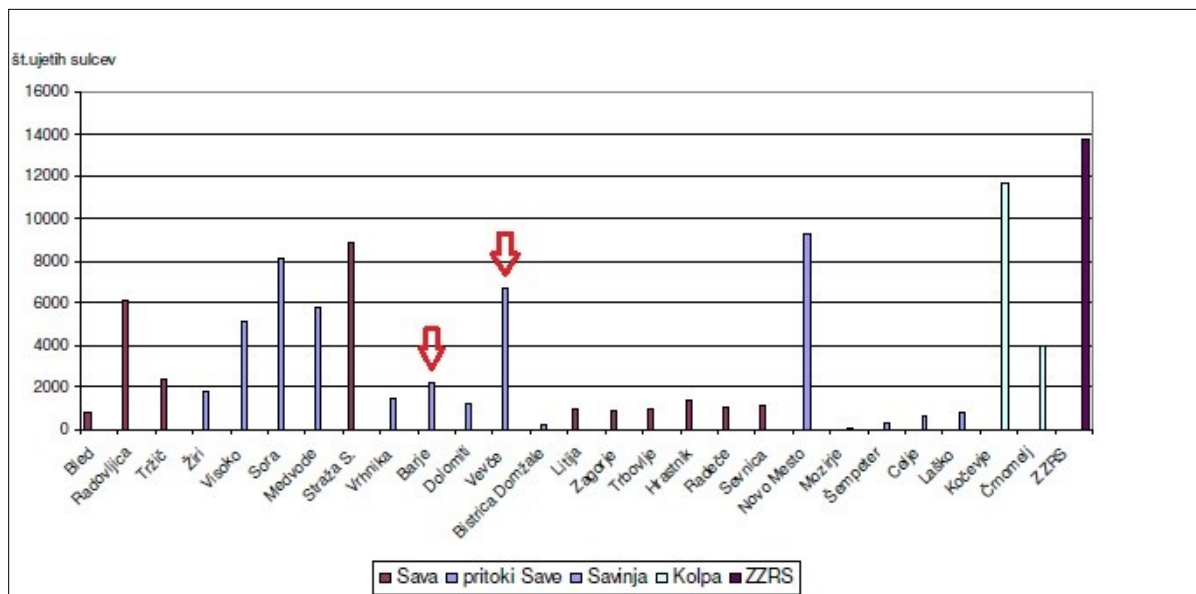


Figure 8: Re-introduction of Danube Salmon in sport fishing waters in Slovenia by managers from 1986 to 2007.

Re-introduction of Danube Salmon was in the last 21 years in the area of angling club Vevče (Ljubljana from the dam at Ambrožev trg to the outflow of Besnica) among the largest, while in the area of angling club Barje it was average.

2.1 Expert opinion on fish population

Table 7: Expert estimation on the size of fish population in Ljubljana River from year 1842 to 1933 and in 2007 (D - dominant, S - subdominant, R - rare).

fish species	HISTORICAL ESTIMATION	ESTIMATION FOR 2007
<i>Salmo trutta m. fario</i>	R	R
<i>Hucho hucho</i>	D	S
<i>Thymallus thymallus</i>	D	D
<i>Abramis brama</i>	R	R
<i>Aspius aspius</i>	R	R
<i>Barbatula barbatula</i>	R	R
<i>Barbus barbus</i>	S	S
<i>Abramis bjoerkna</i>	R	R
<i>Carassius carassius</i>	R	R
<i>Chondrostoma nasus</i>	D	D
<i>Cottus gobio</i>	S	S
<i>Cyprinus carpio</i>	R	R
<i>Leuciscus cephalus</i>	S	S
<i>Leuciscus souffia</i>	R	R
<i>Rhodeus sericeus</i>	R	R
<i>Rutilus pigus</i>	S	S
<i>Scardinius erythrophthalmus</i>	R	R
<i>Tinca tinca</i>	R	R
<i>Vimba vimba</i>	R	R
<i>Perca fluviatilis</i>	R	R
<i>Zingel streber</i>	R	disappeared
<i>Cobitis taenia</i>	R	R
<i>Esox lucius</i>	S	S
<i>Lota lota</i>	R	R
<i>Eudontomyzon mariae</i>	R	R

Based on expert opinion, fish populations in Ljubljana River were evaluated. It was found that in 2007 Danube Salmon was no longer the dominant species, because its habitat shrank due to all the negative effects, which occur due to regulations, pollution, habitat fragmentation and other impacts. Evaluation for other species remained the same like in the past. Common Nase and Grayling remained dominant species. Subdominant species also remained the same except Danube Salmon, which passed into lower hierarchical category. In the group of rare species Streber disappeared, while others were still present.

3 DANUBE SALMON, DANUBE ROACH AND STRIPED CHUB SPAWNING AND NURSERY PLACES AND ESTIMATION OF ITS POPULATION

3.1 Research location

Torrential Gradaščica River rises at confluence of streams Mala voda and Božna in Polhov Gradec. Near Castle Bokalce it forks in two artificial branches named Mestna Gradaščica and Mali graben, both outflowing in Ljubljanica River. Entire Mestna gradaščica is regulated in the form of concrete channel, while Mali graben was regulated in the past because of frequent floods. Horjulščica stream arises in the surroundings of place Horjul and flows into Gradaščica as a right affluent in Dobrova. Upper Podlipščica River Basin is situated in the vicinity of Smrečje in municipality of Vrhnika or in the vicinity of Rovte in municipality of Logatec. It flows through Podlipa valley and as stream Črna mlaka flows into Ljubljanica in the east part of city Vrhnika.

Gradaščica is around 14,5 km long (until division), Horjulščica around 16 km and Podlipščica around 13 km (from Smrečje) or around 9,5 km long (from Rovte). Banks of all streams are more or less overgrown with various vegetation and riverbeds have a good ratio between morphological elements (pools, riffles, gravel pits) (Figure 1, 2 and 3). Informations about sampling sites are listed in Table 1.

Table 8: Sampling sites width, length and depth

sampling site	Gradaščica 1 (Srednja vas pri Polhovem Gradcu)	Gradaščica 2 (Cesta na Vrhovce)	Horjulščica (Brezje pri Dobrovi)	Podlipščica 1 (Podlipa)	Podlipščica 2 (Velika Ligojna)
GIS coordinates-start	x = 447811 y = 101747	x = 457103 y = 100730	x = 451274 y = 99144	x = 444444 y = 94214	x = 445557 y = 93999
GIS coordinates-end	100-120 m upstream	100-120 m upstream	80 m upstream	70 m upstream	50 m upstream
sampling width (m)	11-12	8-12	3	3-4	3-4
sampling length (m)	120	120	80	70	50
average sampling depth (m)	0.75	0.75	0.75	0.75	0.85
sampling area (m ²)	1380	1200	240	245	175



Figure 9: Gradaščica River



Figure 10: Podlipščica stream



Figure 11: Horjulščica stream

3.2 Methods

3.2.1 Danube salmon, Danube roach and striped chub spawning and nursery places

Data about spawning and nursery places were collected from Fisheries management plan from 2010, from local fish societies registers and with observations on the field (Table 3, 4 and 5).

Field observations were performed along entire Ljubljanica River Basin in districts under the supervision of four local fish societies (RD Barje, RD Vevče, RD Dolomiti and RD Vrhnika). Members of each fish society took us to the (parts, that are currently used for spawning and nursery place by Danube salmon, Danube roach and striped chub) current spawning and nursery places of Danube salmon, Danube roach and striped chub. Spots coordinates were recorded with GPS and later processed with ArcGIS 10.1 (Esri) (Figure 5, 6 and 7).

3.2.2 Estimation of Danube salmon, Danube roach and striped chub population

Sampling location was chosen after consultation with people in charge in fish societies Dolomiti and Vrhnika. We chose five sampling sites altogether – three in RD Dolomiti district (Gradaščica River and Horjulščica stream) and two in RD Vrhnika district (Podlipščica stream) (Figure 4).

Field work was performed in September with team consisting of members of fish societies Dolomiti and Vrhnika and Croatian ichthyologic society, who carried out the electrofishing. Their team was made up of four members. To catch the fish they followed fishing procedures for passable regions using Hans Grassl electrofisher with two electrodes (7.5 kW, 600 V, 12 A). The other part of the team contemporary determined each caught fish by species and took measurements, however just interesting ones were weighed and their scale sample was taken for further data analysis (age determination) (for accurate methodology description see Deliverable A1 - Protocols and guides for survey of the ecological status, hydrological and hydraulic conditions of the Ljubljanica River corridor, from 30th June 2012). On each sampling site we measured its dimensions and water physico-chemical parameters (Table 3).

Table 9: Sampling sites physico-chemical parameters (T – temperature, DO – dissolved oxygen, TDS – total dissolved solids, EC – electrical conductivity, U - electrical potential difference)

sampling site	Gradaščica 1 (Srednja vas pri Polhovem Gradcu)	Gradaščica 2 (Cesta na Vrhovce)	Horjulščica (Brezje pri Dobrovi)	Podlipščica 1 (Podlipa)	Podlipščica 2 (Velika Ligojna)
T (°C)	12.3	12.8	14.2	14.6	14.8
DO (mg/l)	7.05	7.29	5.97	7.37	13.45
%O ₂	66.4	79	54.1	73.3	136.5
TDS (mg/l)	309	392	353	337	347
EC (µS/cm)	368	330	421	401	411
pH	8.45	8.28	7.84	8.22	8.16
U (mV)	-90.3	-82.9	-56.7	-83	-77.9

3.3 Results

3.3.1 Danube salmon, Danube roach and striped chub spawning and nursery places

Table 10: List of Danube salmon spawning and nursery places

area (square m)	district name	x	y
1000	Ljubljana R-47/A	469802	99963
20	Bistra	448814	89248
50	Ljubija	447320	90892
150	Podlipščica	444629	94164
50	Mala Ljubljana	446117	90690
30	Gradaščica	456364	101220
20	Gradaščica	455703	101422
20	Gradaščica	450456	103082
30	Gradaščica	449888	102224
20	Horjulščica	455149	100983
length 100 m	Gradaščica	457098	100729
length 60 m	Gradaščica	456610	101094
length 100 m	Gradaščica	456899	100905
length 100 m	Gradaščica	455386	101695
length 100 m	Gradaščica	448187	101501
length 100 m	Gradaščica	452566	103442
400	Iška	463093	87964
100	Želimeljščica	467375	86838
400	Mali graben	457806	100024
200	Mali graben	459209	99040
200	Mali graben	459849	98918
	Želimeljščica	465823	89974
	Želimeljščica	465988	89682
	Želimeljščica	466149	89410
	Želimeljščica	466277	89177
	Želimeljščica	466428	88632
	Želimeljščica	466524	88466
	Želimeljščica	466600	88358
	Mali graben	457726	100233
	Mali graben	457773	100210
	Mali graben	457816	99974
	Mali graben	457827	99951
	Mali graben	457840	99937
	Mali graben	458199	99696
	Mali graben	458241	99684
	Mali graben	458495	99375
	Mali graben	458535	99221
	Mali graben	458566	99135
	Mali graben	458742	99027
	Mali graben	460469	98660
	Mali graben	461283	98727

Table 11: List of Danube roach spawning and nursery places

area (square m)	district name	x	y	year of record
200	Ljubljana R-45	465479	101040	
	Ljubljana R-47/A	471058	101555	
	Ljubljana	472080	103118	1990
800	Ljubljana	453717	92121	
500	Podpeški graben	455105	91903	
	Podlipščica	445882	93763	
40	Bistra	449082	89756	
	Ljubija	447664	90998	1979
	Ljubljana (Podpeč)	455187	92413	1979
60	Horjulščica	450337	98438	
	Gradaščica (Bokalce)	457405	100435	1979
	Horjulščica	457043	100504	1979
	Horjulščica	456220	101074	1979
1500	Ižica	463449	95954	
1500	Mali graben	461040	98648	
1500	Mali graben	459380	99107	
	Ižica	462826	96983	
	Ižica	463057	95153	
	Mali graben	457726	100233	
	Mali graben	457773	100210	
	Mali graben	457962	99854	
	Mali graben	457999	99824	
	Mali graben	458241	99684	
	Mali graben	458342	99597	
	Mali graben	458410	99509	
	Mali graben	458495	99375	
	Mali graben	458517	99297	
	Mali graben	458888	98952	
	Mali graben	459163	99030	
	Mali graben	459678	99020	
	Mali graben	459870	98905	
	Mali graben	459981	98814	
	Mali graben	461322	98748	
	Mali graben	461706	98876	
	Mali graben	461782	98978	
	Mali graben (Bonifacij - Bokalce)	455356	96043	1979

Table 12: List of striped chub spawning and nursery places

district name	x	y	year of record
Ljubljana	466208	100874	1996
Ljubljana	470900	101487	1996
Ljubljana	445537	90311	2001
Ljubljana	445990	90073	1992
Ljubljana (Retovje)	446016	90123	1992
Horjulščica (Lesno Brdo)	454767	100632	1996
Horjulščica (Lesno Brdo)	447835	97438	1996
Glinščica	458179	102902.5	1967
Glinščica	458179	102903	1967
Glinščica	458785	101054	1958
Glinščica	458639	101111	1991
Glinščica	458639	101111	2004
Glinščica	458639	101111	1991
Gradaščica	454116	102878	1958
Mali graben (Dolgi most)	459428	99114	1990
Mali graben (Koprška ulica)	461346	98757	1995
Mali graben (Cesta dveh cesarjev)	458675	99046.5	1990

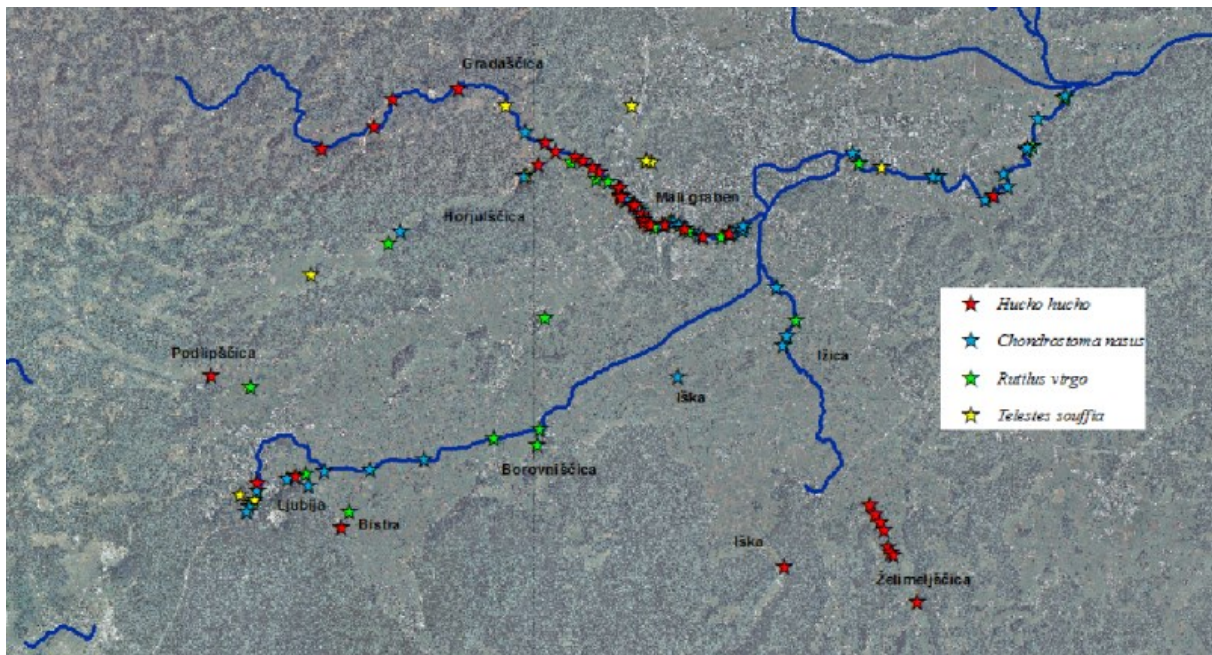


Figure 12: Spawning and nursery places of Danube salmon, Common nase, Danube roach and striped chub on Ljubljana River and its tributaries

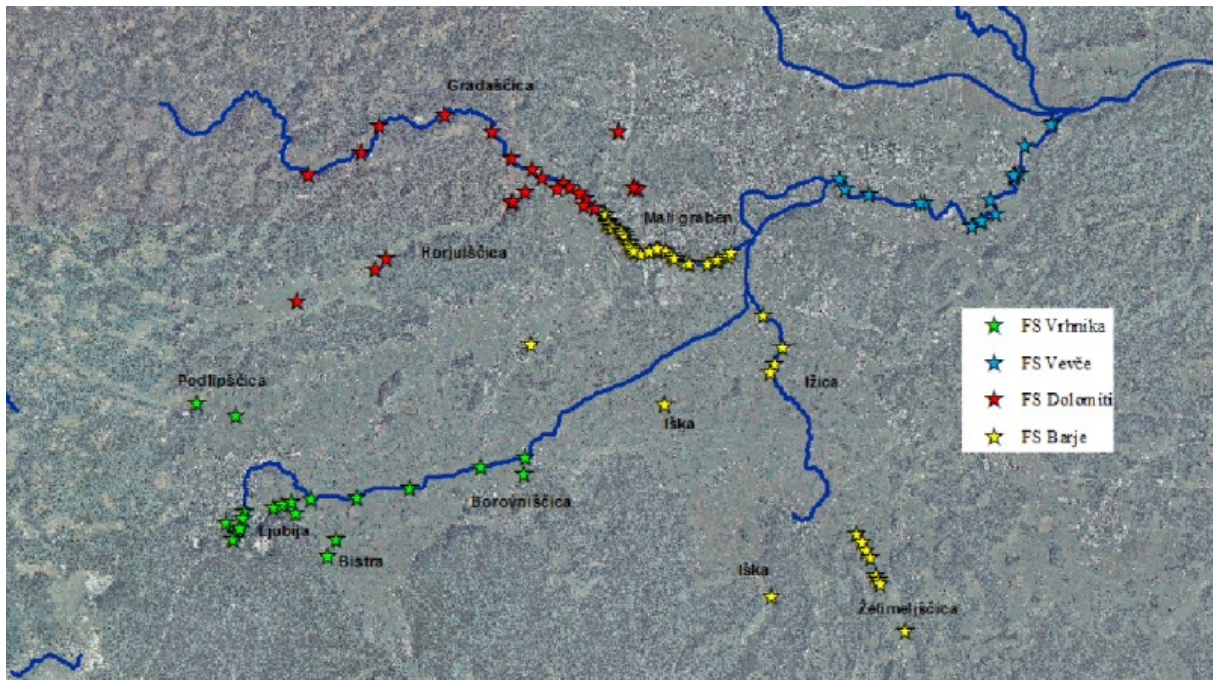


Figure 13: Distribution of spawning and nursery places into Ljubljana local fish societies

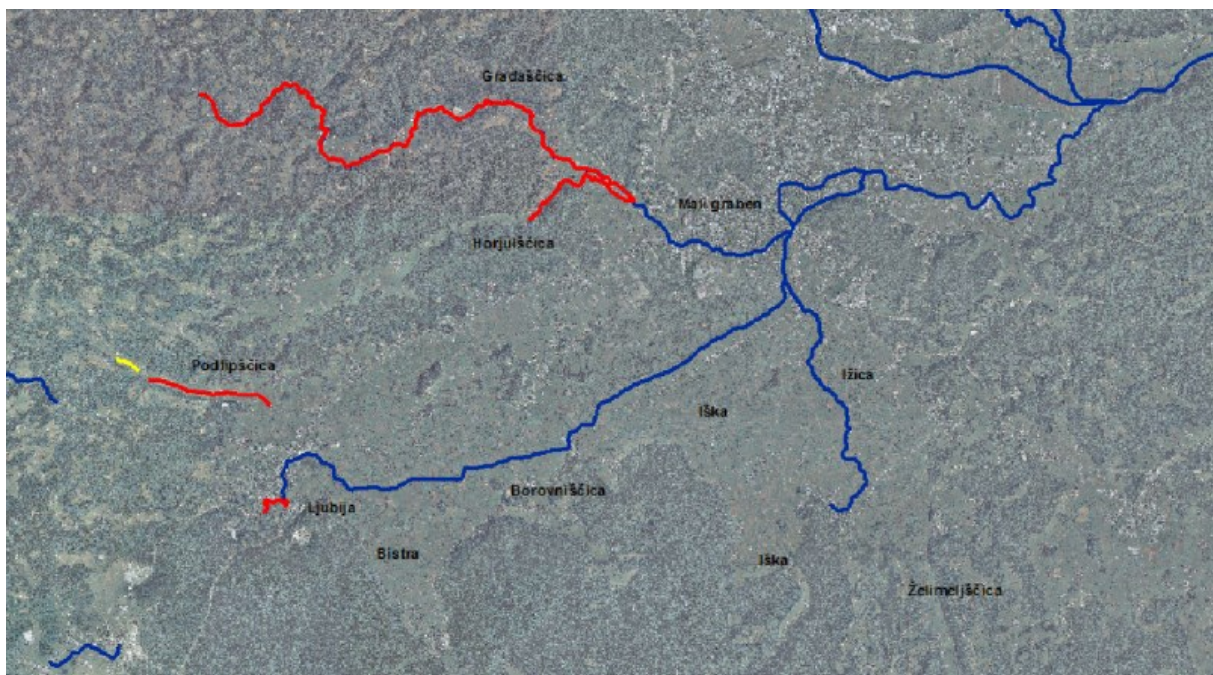


Figure 14: Potential spawning and nursery zone on Ljubljanica River and its tributaries (red for Danube salmon, yellow for striped chub)



Figure 15: Common nase spawning in Dobrunjščica stream (april)



Figure 16: Danube salmon spawning and nursery place in Podlipščica stream (Podlipa)



Figure 17: Danube salmon spawning and nursery place in Gradaščica stream (Srednja vas pri Polhovem Gradcu)

3.3.2 Estimation of Danube salmon, Danube roach and striped chub population

Sampling was performed on total length of 440 m and area of 3240 m². We caught 21 species of fish from 8 different families (Petromyzontidae, Salmonidae, Cyprinidae, Thymallidae, Cottidae, Cobitidae, Balitoridae, Esocidae) (Table 7). The highest number of fish species (19) was caught in stream Horjulščica, while sampling site with the lowest abundance belongs to the first location on stream Gradaščica (9). Brown trout (*Salmo trutta fario*), striped chub (*Telestes souffia*), European chub (*Squalius cephalus*), large-spot barbel (*Barbus balcanicus*), European bullhead (*Cottus gobio*) and stone loach (*Barbatula barbatula*) were founded on all sampling sites, on the other hand barbel (*Barbus barbus*), Danube roach (*Rutilus virgo*), European bitterling (*Rhodeus amarus*) and northern pike (*Esox lucius*) just on one. We caught Danube salmon (*Hucho hucho*) in each examined stream, only the second location on stream Podlipščica unexpectedly show no results.

Table 13: Fish species caught on sampling sites (1 - Gradaščica 1, 2 - Gradaščica 2, 3 - Horjulščica, 4 - Podlipščica 1, 5 - Podlipščica 2)

family	species	1	2	3	4	5
PETROMYZONTIDAE	lamprey (<i>Eudontomyzon</i> sp.) (Regan, 1911)			x	x	x
	lamprey (larva)		x	x	x	x
SALMONIDAE	Danube salmon (<i>Hucho hucho</i>) (Linnaeus, 1758)	x	x	x	x	
	brown trout (<i>Salmo trutta fario</i>) (Linnaeus, 1758)	x	x	x	x	x
CYPRINIDAE	striped chub (<i>Telestes souffia</i>) (Risso, 1827)	x	x	x	x	x
	common minnow (<i>Phoxinus phoxinus</i>) (Linnaeus, 1758)	x		x	x	
	European chub (<i>Squalius cephalus</i>) (Linnaeus, 1758)	x	x	x	x	x
	Danube gudgeon (<i>Gobio obtusirostris</i>) (Valenciennes, 1842)		x	x	x	x
	whitefin gudgeon (<i>Romanogobio vladykovi</i>) (Fang, 1943)			x		x
	barbel (<i>Barbus barbus</i>) (Linnaeus, 1758)			x		
	large-spot barbel (<i>Barbus balcanicus</i>) (Kotlík, Tsigenopoulos, Ráb & Berrebi, 2002)	x	x	x	x	x
	common roach (<i>Rutilus rutilus</i>) (Linnaeus, 1758)		x	x		
	Danube roach (<i>Rutilus virgo</i>) (Heckel, 1852)			x		
	common nase (<i>Chondrostoma nasus</i>) (Linnaeus, 1758)		x	x		
	schneider (<i>Alburnoides bipunctatus</i>) (Bloch, 1782)		x	x	x	x
European bitterling (<i>Rhodeus amarus</i>) (Bloch, 1782)				x		
THYMALLIDAE	grayling (<i>Thymallus thymallus</i>) (Linnaeus, 1758)	x	x			
COTTIDAE	European bullhead (<i>Cottus gobio</i>) (Linnaeus, 1758)	x	x	x	x	x
COBITIDAE	Danube loach (<i>Cobitis elongatoides</i>) (Bacescu & Maier, 1969)		x	x		
BALITORIDAE	stone loach (<i>Barbatula barbatula</i>) (Linnaeus, 1758)	x	x	x	x	x
ESOCIDAE	northern pike (<i>Esox lucius</i>) (Linnaeus, 1758)				x	
	total	9	14	19	13	11

Table 14: Weight of each caught fish species and total weight for sampling site (1 - Gradašćica 1, 2 - Gradašćica 2, 3 - Horjulšćica, 4 - Podlipšćica 1, 5 - Podlipšćica 2; / - lack of data)

family	species	1	2	3	4	5	total
PETROMYZONTIDAE	lamprey (<i>Eudontomyzon</i> sp.) (Regan, 1911)			/	40	40	80
	lamprey (larva)		19	76	76	57	228
SALMONIDAE	Danube salmon (<i>Hucho hucho</i>) (Linnaeus, 1758)	9807	2286	2803	1050		15946
	brown trout (<i>Salmo trutta fario</i>) (Linnaeus, 1758)	452	148	303	1346	65	2314
	striped chub (<i>Telestes souffia</i>) (Risso, 1827)	412	495.5	115	456	145	1623.5
	common minnow (<i>Phoxinus phoxinus</i>) (Linnaeus, 1758)	6		46	22		74
	European chub (<i>Squalius cephalus</i>) (Linnaeus, 1758)	37	4130	4904	3445	3206	15722
CYPRINIDAE	Danube gudgeon (<i>Gobio obtusirostris</i>) (Valenciennes, 1842)		21	551.5	34	57	663.5
	white fin gudgeon (<i>Romanogobio vladykovi</i>) (Fang, 1943)			3		6	9
	barbel (<i>Barbus barbus</i>) (Linnaeus, 1758)			710			710
	large-spot barbel (<i>Barbus balcanicus</i>) (Kotlík, Tsigenopoulos, Ráb & Beribi, 2002)	67	27.5	324	21	172	611.5
	common roach (<i>Rutilus rutilus</i>) (Linnaeus, 1758)		25	407			432
	Danube roach (<i>Rutilus virgo</i>) (Heckel, 1852)			703			703
	common nase (<i>Chondrostoma nasus</i>) (Linnaeus, 1758)		3830	13044			16874
	schneider (<i>Alburnoides bipunctatus</i>) (Bloch, 1782)		133	2229.9	380.9	168.5	2912.3
	European bitterling (<i>Rhodeus amarus</i>) (Bloch, 1782)			18			18
	grayling (<i>Thymallus thymallus</i>) (Linnaeus, 1758)	6937	2373.6				9310.6
COTTIDAE	European bullhead (<i>Cottus gobio</i>) (Linnaeus, 1758)	335	442	22	56	189	1044
	Danube loach (<i>Cobitis elongatoideus</i>) (Bacescu & Maier, 1969)		/	/			0
BALITORIDAE	stone loach (<i>Barbatula barbatula</i>) (Linnaeus, 1758)	30	14	9	12	79	144
ESOCIDAE	northern pike (<i>Esox lucius</i>) (Linnaeus, 1758)				120		120
	total	18083g	13944.6g	26268.4g	7058.9g	4184.5g	

As seen on Figure 11 is Danube salmon catch prevailing among project target species in the analysed watercourses (34.11% of the entire catch in Gradašćica, 9.75% in Horjulščica and 8.56% in Podlipščica). Striped chub was caught in all three watercourses (2.96% of the entire catch in Gradašćica, 0.48% in Horjulščica and 5.39% in Podlipščica), while Danube roach was caught only in Horjulščica, but with 2.69% of the entire catch it surpassed striped chubs catch.

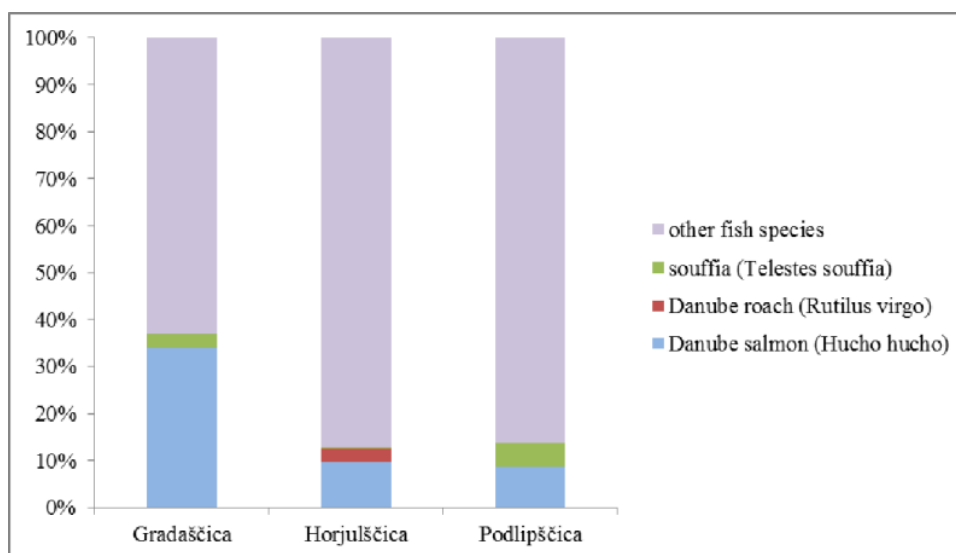


Figure 18: Percentage of Danube salmon, Danube roach, striped chub and other fish species caught in streams Gradašćica, Horjulščica and Podlipščica

Density and biomass

The highest density on all three sampled watercourses belongs to striped chub with by far the biggest contribution of stream Podlipščica (1500 N/ha). Danube salmon density is several times lower, but as we can see on Table 10 its biomass in each watercourse considerably exceeds Danube roachs and striped chubs biomass.

Table 15: Estimation of Danube salmon, Danube roach and striped chub density (N/ha - number of fish per hectar)

	Gradašćica	Horjulščica	Podlipščica
Danube salmon (<i>Hucho hucho</i>)	31	83	48
Danube roach (<i>Rutilus virgo</i>)	0	333	0
striped chub (<i>Telestes souffia</i>)	353	542	1500

Table 16: Estimation of Danube salmon, Danube roach and striped chub biomass (kg/ha – kilogram of fish per hectar)

	Gradašćica	Horjulščica	Podlipščica
Danube salmon (<i>Hucho hucho</i>)	46.87	116.79	25.00
Danube roach (<i>Rutilus virgo</i>)	0.00	32.22	0.00
striped chub (<i>Telestes souffia</i>)	4.06	5.75	15.74

Age and growth

Table 17: Target species estimated age on first sampling site in Gradaščica (Gradaščica 1)

	length (cm)	age (years)
striped chub (<i>Telestes souffia</i>)	6	1
	6,5	1
	7	1
	8,5	2
	9	2
	9,5	2
	10	2
	10	3
	10,5	3
	11	3
	11,5	3
	12	3
	13	4
	14	4
14	5	
15	5	
Danube salmon (<i>Hucho hucho</i>)	11	0+
	46	3
	48	3
	69	4+
	80	6

Table 18: Target species estimated age on second sampling site in Gradaščica (Gradaščica 2)

	length (cm)	age (years)
striped chub (<i>Telestes souffia</i>)	7	2
	7-10	2-3
	7-13,5	2-4
	8-10	2
	8-12	2-3
	13	4
Danube salmon (<i>Hucho hucho</i>)	44	4
	60	6

Table 19: Target species estimated age on Horjulščica sampling site

	length (cm)	age (years)
striped chub (<i>Telestes souffia</i>)	5	0
	5	1
	7	1
	8	2
	8	3
	10	3
	12	4
	13	4
	20	7
Danube salmon (<i>Hucho hucho</i>)	58	5
Danube roach (<i>Rutilus virgo</i>)	11	1
	12	1
	13	1
	17	3
	27	5

Table 20: Target species estimated age on first sampling site in Podlipščica (Podlipščica 1)

	length (cm)	age (years)
striped chub (<i>Telestes souffia</i>)	3-4	0
	7	2
	7-8	2
	8	3
	8-9	3
	9	3
	10,5	3
	13	4
Danube salmon (<i>Hucho hucho</i>)	14	5
	40	3
	40	4

Table 21: Target species estimated age on second sampling site in Podlipščica (Podlipščica 2)

	length (cm)	age (years)
striped chub (<i>Telestes souffia</i>)	6	1
	7	2
	8	2
	9	3
	10	3



Figure 19: Electrofishing and net setting on sampling sites



Figure 20: Fish measurements



Figure 21: Samples of caught fish

3.3.3 Proposals for minimisation and/or elimination of negative impacts

Fish species diversity and age structure in investigated streams is generally well represented. What still remains a problem are environmental and stream morphology issues. To meliorate habitat conditions it is necessary to register and eliminate local sources of pollution and to renovate or construct new dams.



Figure 22: Example of suitable dam construction on Podlipščica stream

Past data collection considering fish fauna in river Ljubljana and its tributaries:

This part has already been written partially in the Interception Report and partially in Progress Report n°1.