Individual internship report

4th year

Assessment of the effectiveness of the Smardzew Reservoir fishpass on the Myja River

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Introduction

In a context of standardization of the hydrologic management at the European level (Kaczkowski, Frankiewicz, and Góralczyk 2019) thanks to the AMBER project, the uncertainties about global warming remain. What impacts on water resources? The adaptation will be essential (Kundzewicz and al. 2018). In addition, pollution hampers the normal running of freshwater areas and the biodiversity.

In Poland, pollution tend to decrease following the political and economic changes of the 21st century. Despite the investment for water treatment, some issues due to the water deficit and the hydroelectric power central development (Kaczkowski and Grabowska 2015).

The artificial reservoirs change the structure of catchment. A different approach is therefore necessary compared to natural lakes management (Blabolil and al. 2016). Smardzew Reservoir was built in 2013 to prevent floods and to provide water for irrigation. It is equipped by a pool-type fishway intended to preserve the ecological continuity of Myja River. The reservoir is managed to keep a sufficient water level. However, no management has been done on the fishpass since its construction. So, is the fishway really effective? Is fish migration possible?

The objectives of this study is to assess the effectiveness of the fishpass and to identify the potential causes and consequences of dysfunctions. Afterward some solutions or modifications could be suggested. The main assignments during the internship is setting up the fish traps and recording them, counting and measuring fishes and helping during the electric fishing. Then data will be analyzed and discussed. Other tasks may also be performed in a different context than the internship.

This report is composed by the presentation of materials and methods used during the internship, the obtained results and their analysis and finally discussions about results and possible solutions.

Presentation of the host organisation

The University of Lodz was established in 1945. It is one of the biggest and most popular universities in Poland with a total of 32 000 students. All levels are represented, from first- and second level degree programmes, as well as postgraduate, to PhD students. The University is involved in multiple international cooperation. On average around 2600 foreign students are hosted every year, derived from 95 different countries. The University of Lodz offers one hundred fields of study and 160 specializations of any type like educational sciences, management, economics and sociology, physics, biology and environmental protection etc. (University of Lodz, 2011).

The Faculty of Biology and Environmental Protection of the University of Lodz is composed of 5 institutes: biochemistry, biophysics, ecology and environmental protection, experimental biology and microbiology, biotechnology and immunology. Which are each composed of several departments (Faculty of Biology and Environmental Protection University of Lodz, Faculty's structure, 2011).

My internship was carried on in Department of Applied Ecology at the Institute of Ecology and Environmental Protection Department of Applied Ecology. The department was founded in 1990, and since beginning led by Professor Maciej Zalewski. Research problems are focused on Ecohydrology and development of the integrated strategy for sustainable river basin management. The overall goal is also to respond positively to the issues submitted by the Water Framework Directive (WFD) of European Union (EU). Research priorities of this department are essentially focused on aquatic environments:

- **Ecohydrology**: is a sub-discipline of hydrology that seeks to understand the ecological processes controlled by the hydrological cycle. It strives to utilize this understanding in management of both to enhance sustainability in river basins.
- **Ecological biotechnologies**: application of hydrological, biological and biogeochemical processes for regulation of water dynamics in the landscape and biogeochemical cycles e.g. reduction of non-point source pollution, enhancement of self-purification processes in rivers and streams, change of nutrients and pollutants allocation in impacted ecosystems, construction of sequentional biofiltering systems.
- **Monitoring and control** of ecosystem succession processes in subsequent stages of eutrophication, reduction of eutrophication symptoms (such as toxic algal blooms) in reservoirs and lakes by regulation of feedbacks in hydrological and biological systems.
- **Application of bioremediation** toward restoration of freshwater and terrestrial ecosystems.
- **Aquaculture**: methods of fish reproduction for restitution and enhancement of natural fish stocks.
- **Role of fish** as a regulator of biological processes and an indicator of environment status.

Many projects have been directed by this department. One of the most recent and successful is the "Ecohydrologic rehabilitation of recreational reservoirs Arturowek (Lodz) as a model approach to rehabilitation of urban reservoirs" conducted from 2010 to 2014 (Faculty of Biology and Environmental Protection University of Lodz, Department of Applied Ecology, 2011).

The ecological continuity is also a major challenge especially because of the presence of many dams in Poland. Therefore, my role is to study problems for fish migration and to develop and to assess some solutions to enhance fish movement under the supervision of my internship tutor Zbigniew Kaczkowski, PhD.

Materials and methods

The internship was divided in two steps. The first one, during April, was specifically studying literature to understand the context for aquatic resources in Poland and how dams and fishways works. The second one, during May and June, was to study the effectiveness of a fishpass situated downstream of the Smardzew Reservoir on the Myja River.

Localisation of the study site

The study site is the fish pass connecting the Smardzew Reservoir and the Myja River (Figure 1) situated near Sieradz, a small town about 70 km to the west from Lodz in central Poland (Figure 2).

The Myja River is one of the tributaries along the left bank of the Warta River, with a total length of 23.97 km. Its source is located near Bugaj village. The river drains a catchment with an area of 134.8 km² of which about 33.7 km² is situated upstream the impoundment. The river has a longitudinal slope of 2.7% (Kaczkowski 2019).

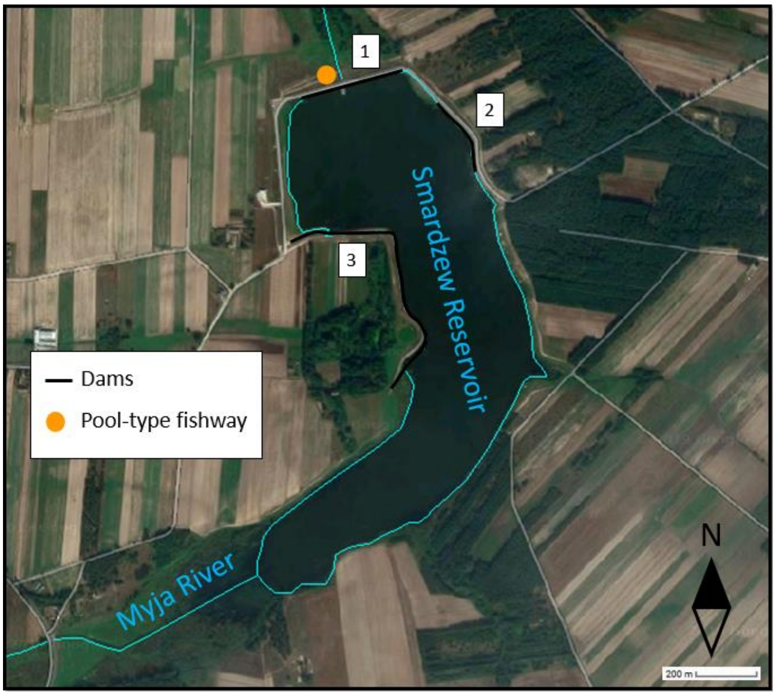

Figure 1 : Aerial view of Smardzew Reservoir on the Myja River, Poland (Source: Google Maps, modified)

The Smardzew Reservoir, built from 2009 to 2013, is located about 9 km from the mouth of Myja to Warta River. It is an artificial reservoir 2 km long and of an average width approximately of 300 m and maximum surface of 60 ha (Piekarczyk 2011; Wyderka 2013). The reservoir has a maximum capacity of 1.4 million m^3 and an average depth of 2.5 m (Misiak and Stainski 2012).

Figure 2 : Location of Smardzew Reservoir on the Myja River, Poland (Source: Google Maps, modified)

Three dams were constructed to create the Smardzew Reservoir, which main function is flood protection and irrigation. Dam n°1 (Figures 1 and 3), crossing the river channel is equipped with fishways. The dam height is 4.95 m and a length of 369 m (Kaczkowski 2019).

Figure 3: Photography of Smardzew Reservoir dam

The fishpass is a pool-type fishway (Figure 4) about 54 m long and 2 m width. It has twenty three pools. The inlet is composed of two gates each equipped with a valve. The entrance to the downstream pool (0.6 x 1 m) is completely submerged. The flow through the fishpass is about 0.212 m^3s^{-1} and the biological flow of the river is estimated on 0.090 m^3s^{-1}. It generates a guiding current of 35 cm s^{-1} in the outlet (Kaczkowski 2019).

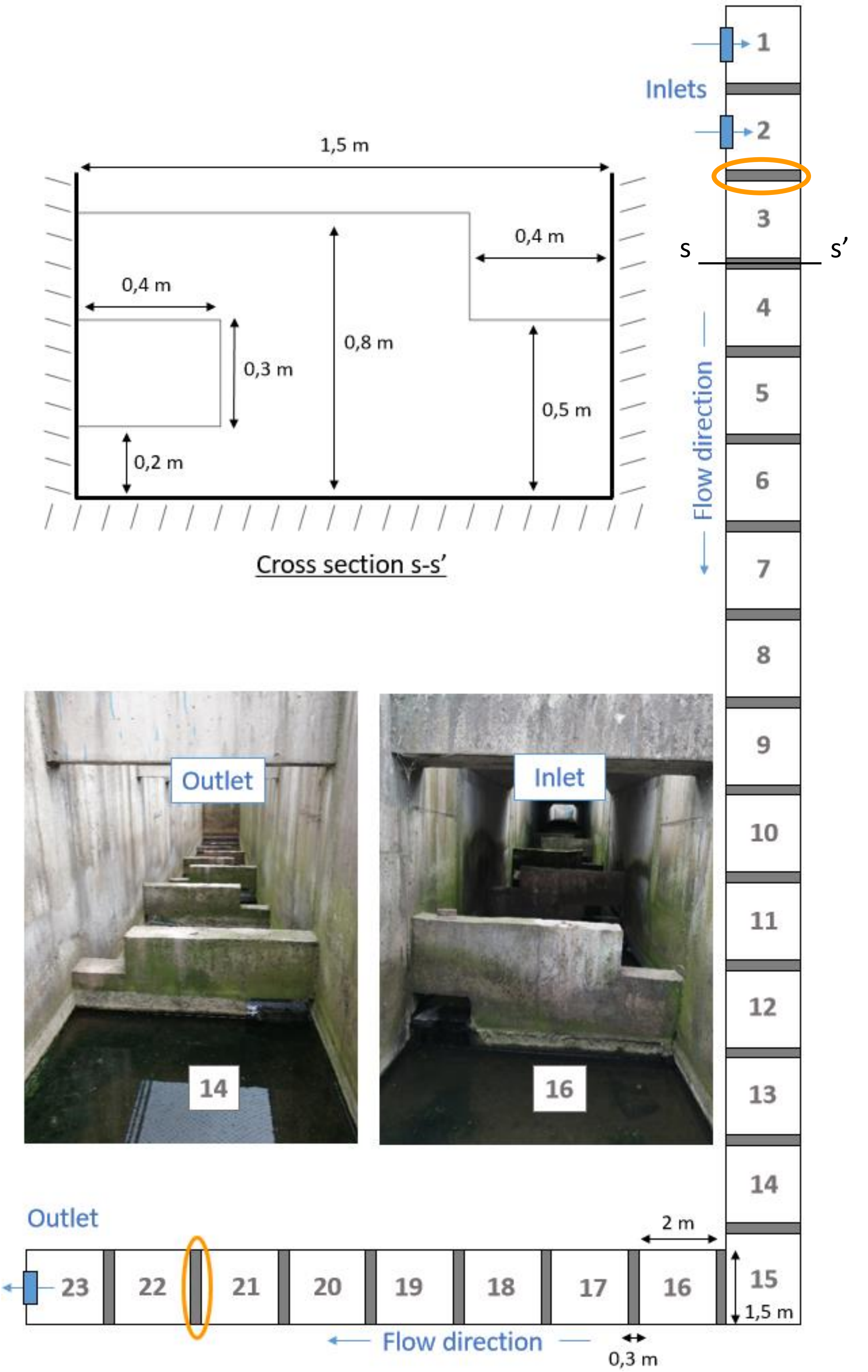

Figure 4: Schematic plan of the Smardzew Reservoir pool-type fishpass

Fish population from electrofishing

In order to determine which fish species are composing fish assemblage in the Myja River, electrofishing was done downstream (50m long) and upstream (100m long) from the Smardzew Reservoir the 24th May 2019.

Additional electricfishing was done in the fishpass the 31st May and 7th June 2019 to establish which species were able to move through migratory construction. Additionally fishtraps were used at the downstream and upstream parts of the fishpass.

Each caught fish was measured and weighted. Sometimes, an anaesthetic solution (1 ml of essential oil of clove + 9 ml of ethanol C_2H_5OH concentration 46.07 $g.mol^{-1}$) could be used to make easier the manipulation and to decrease handling related stress.

The electricfishing operators were equipped with waders and gloves. The backpack portable wade fishing device EFGI 650, Bretschneider Spezialelektronik (Germany) was used. The device manufactured in accordance with IEC 60335 and allow switching between direct current and pulsation output. The pulse envelope (rapid pitch within 2 ms, exponential drop) ensures good galvanotaxis (Figure 5).

Figure 5: Electrofishing battery Jürgen Bretschneider Spezialelektronik (Source: Anglertreff Thüringen)

Fish traps assessment

Design and production

Two models of traps were used: one fitted for the submerged orifices (Figure 6, 1.a and 1.b) and one for the surface notches (Figure 6, 2.a and 2.b). Traps were specially designed and manufactured for the fishpass at Smardzew Reservoir.

Fitting of the traps

The upstream fish traps were installed between pools 2 and 3, and the downstream ones between pools 21 and 22 (Figure 4). The traps gates were directed upstream at the upstream location and downstream at the downstream location. The upper ones were blocking the entrance to the fish pass for the fishes migrating downstream and the downstream ones were catching the fishes attempting to migrate upstream. Each trap was controlled after 1 hour during the survey conducted on the 24th May 2019.

The assessment method was modified during the subsequent survey on the 31st May and 7th June 2019. The downstream traps were controlled every 20 minutes during 1 hour cycle, after which were moved two pools upstream.

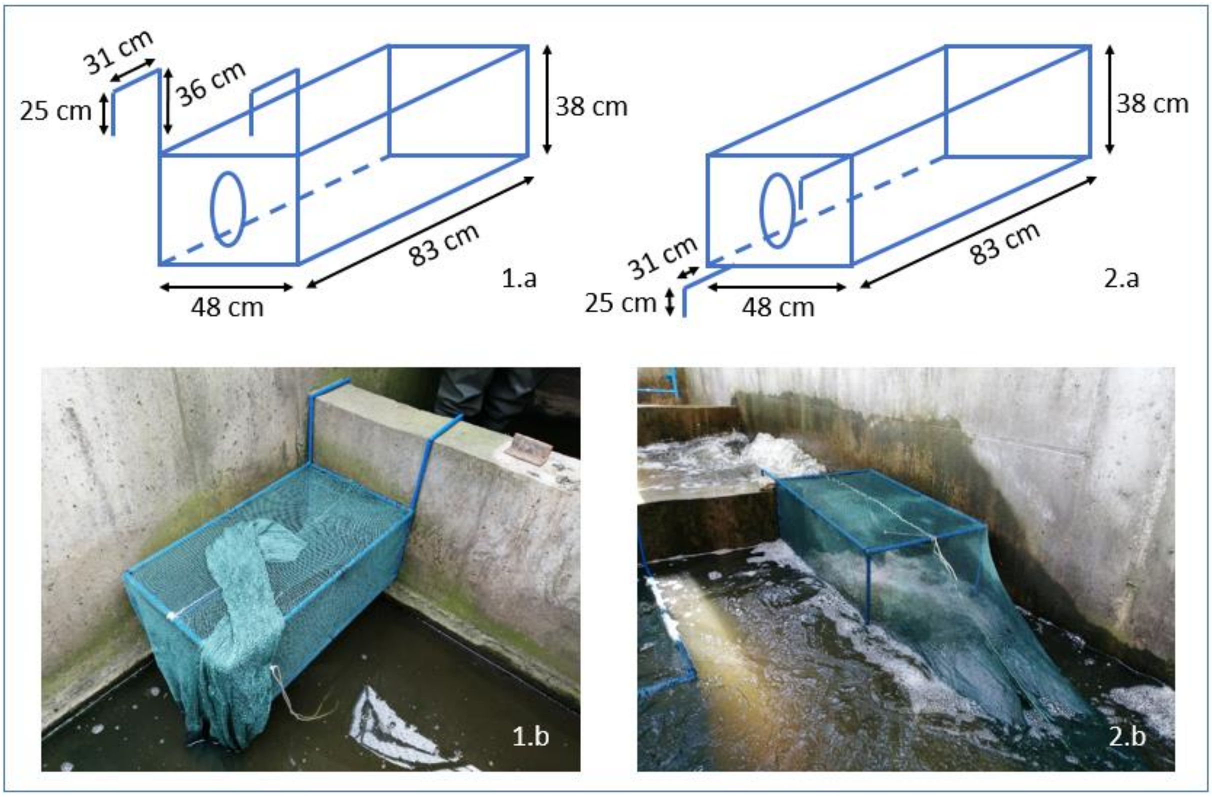

Figure 6: Schemas and photographs of fishing traps (1. submerged orifice, 2. surface notch)

Hydraulic and water data collection

Figure 7: WTW meter used during the water data collections

During each fishing collection (traps or electrofishing), water data collection has been done with a multiparametric WTW meter (Figure 7). Temperature, pH, conductivity, oxygen concentration were measured downstream and upstream from the reservoir but also in the fishpass. Moreover, drop heights were measured for each fish pass pool on the 7th June 2019. The flow rate and the speed of the current have also been determined with a magnetic flowmeter.

Statistical analysis

Data from electrofishing and fish traps was compared with gillnetting data from a study on Smardzew in 2018. Each dataset was converted in percentage to overcome the differences in sample sizes and represented as tables or histograms. The objective is to determine:

- The comparison between the fish assemblage in the reservoir and the river upstream and downstream the reservoir to assess the impoundment impact on river ichtiocenose;
- To assess the fish pass efficiency for upstream and downstream migration;
- To evaluate the current management of the fish pass (water levels at the reservoir, the extent of the opening of the fish pass exit) and propose the new recommendations to improve fish pass management.

Results

Fish biomass in the Smardzew Reservoir and the Myja River

According to the following table (Table 1), the fish population in the Smardzew Reservoir is estimated at thirteen species. Six species in the upstream Myja River and nine in the downstream river are present. In total, eighteen species are susceptible to cross over in the fishpass.

Roach (*Rutilus rutilus*) is present in each site and dominant in the reservoir and downstream. Perch (*Perca fluviatilis*) is one of dominant species too, especially in the upstream Myja River where we also find a large population of stone loach (*Barbatula barbatula*) and chub (*Squalius cephalus*). Smardzew Reservoir is settled by many cyprinids with an important population of common bream (*Abramis brama*). Gibel carp (*Carassius gibelio*) is also a species common in the river downstream the reservoir.

The phyto-lithophils (A.1.4) are the most common (73.81%) in the whole system. This is the dominant reproductive guild in the three sites. While the guarding phytophils (B.1.4) are almost absent (0.02%), the non-guarding phytophiles (A.1.5) are common too (20.26%). The upstream Myja River is settled by all of the guilds present in the whole system. However, it is also the poorest site in number of species.

Table 1: Comparison of the dominance (Di) and the occurrence stability (Ci) for given species and the reproductive guilds (Dgr) in the Myja River system (see Appendix 1 for classification of species)

Species	Smardzew Reservoir		Myja River - Upstream		Myja River - Downstream		Whole system		
	Di	Dgr	Di	Dgr	Di	Dgr	Di	Dgr	Ci
Lithophils (A.1.3)		8,82		26,04		0		4,64	
Aspius aspius	5,68		0		0		2,57		33
Squalius cephalus	3,14		26,04		0		2,07		66
Phyto-lithophils (A.1.4)		80,04		47,12		69,69		73,81	
Abramis brama	29,76		0		5,6		16,41		66
Alburnus alburnus	0,36		0		0		0,16		33
Gymnocephalus cernua	4,09		0		0,73		2,23		66
Leuciscus idus	2,2		0		0		1		33
Perca fluviatilis	4,26		36,13		21,56		14,08		100
Rutilus rutilus	39,37		10,99		41,8		39,93		100
Phytophils (A.1.5)		11,1		2,67		29,06		20,26	
Blicca bjoerkna	1,91		0		3,29		2,58		66
Carassius gibelio	0		2,67		24,4		12,8		66
Esox lucius	7,05		0		0		3,2		33
Misgurnus fossilis	0		0		0,17		0,09		33
Scardinius erythrophthalmus	2,11		0		1,2		1,58		66
Tinca tinca	0,03		0		0		0,01		33
Psammophils (A.1.6)		0		24,14		1,24		1,25	
Barbatula barbatula	0		24,14		0		0,6		33
Gobio gobio	0		0		1,24		0,65		33
Phytophils (B.1.4)		0,05		0,03		0		0,02	
Leuciscus delineatus	0,05		0		0		0,02		33
Pseudorasbora parva	0		0,03		0		0		33
Number of species	13		6		9		18		

Fish biomass in the fishpass

As shown in the histogram below (Figure 8), six species were caught in the fishpass during three surveys. However, only two silver bream (*Blicca bjoerkna*) and one common bream were captured. Perch is clearly the most represented species on each date, followed by rudd (*Scardinius erythrophthalmus*) and roach. As well, ruffe (*Gymnocephalus cernua*) was present only on the first date.

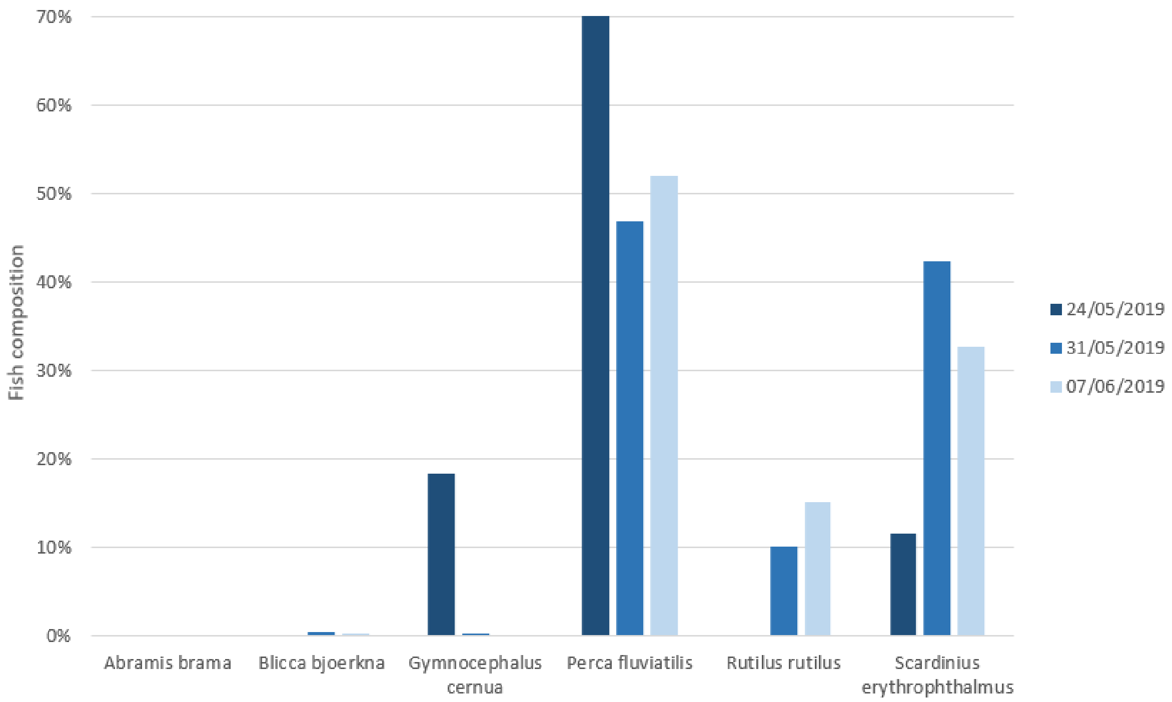

Figure 8: Fish composition in the fishpass from electrofishing during different surveys

Length and weight distribution

The graph hereafter (Figure 9) compares the length distribution of species caught in the fishpass and those in the reservoir and the river. The average length of individuals captured in the fishpass and the reservoir corresponds overall to each other except for the common bream. The fishes having a great average length are essentially present in the reservoir and completely absent in the fish population from the fishpass.

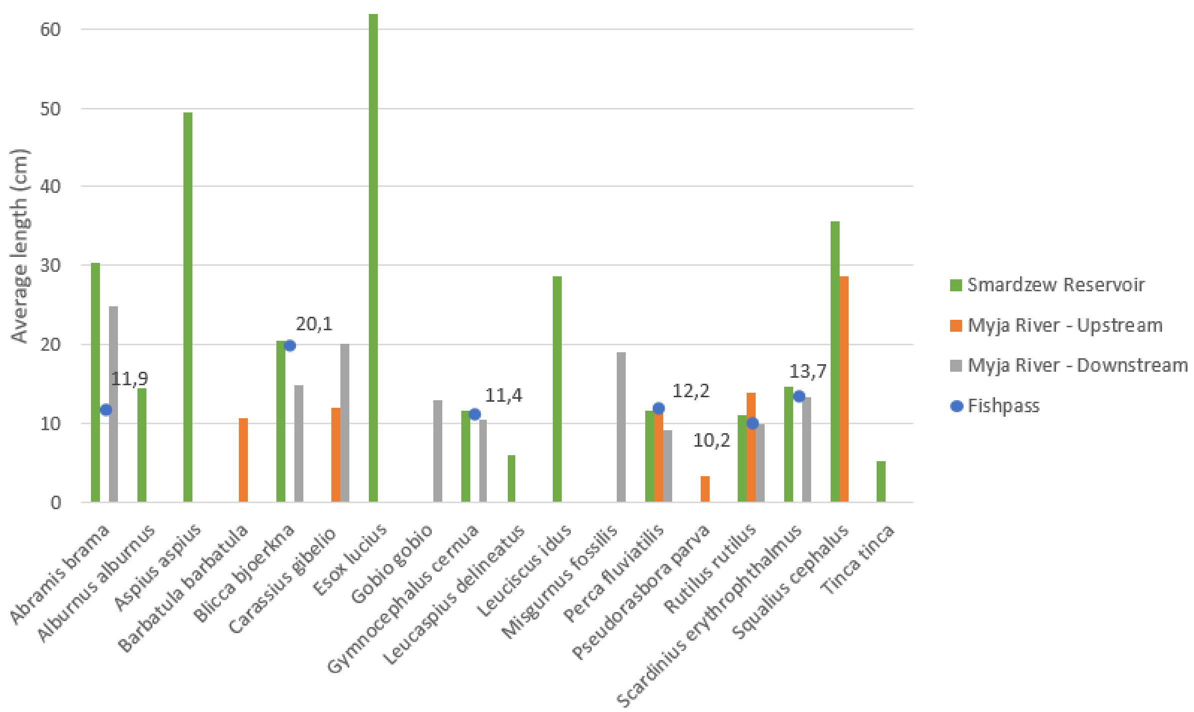

Figure 9: Length distribution of different species in the Smardzew Reservoir, the Myja River and the fishpass

During the electricfishing in the fishpass and downstream from the reservoir, the fishes seemed to be skinny. The following analysis of variance (Tables 2 and 3) were realised with samples of perches (largest number of individuals). Outliers were removed. They show there is not any statistical relation between length or weight and the capture site.

Table 3: ANOVA of perch weight in Smardzew Reservoir and Myja River downstream

Weight (g)	Number of samples	Sum	Average	Variance	F	Probability
Smardzew Reservoir	13	274	21,08	770,08	0,1285	0,7229
Myja River - Downstream	15	363,8	24,25	355,57		

Table 2: ANOVA of perch lengths in Smardzew Reservoir and Myja River downstream

Length (cm)	Number of samples	Sum	Average	Variance	F	Probability
Smardzew Reservoir	13	136,9	10,53	19,3	1,2008	0,2832
Myja River - Downstream	15	182,6	12,17	12,52		

However, according to the following diagram (Figure 10), the specimens captured in the downstream Myja River are thinner than those caught in the Smardzew Reservoir. Furthermore, the coefficients of determination are high for both sites.

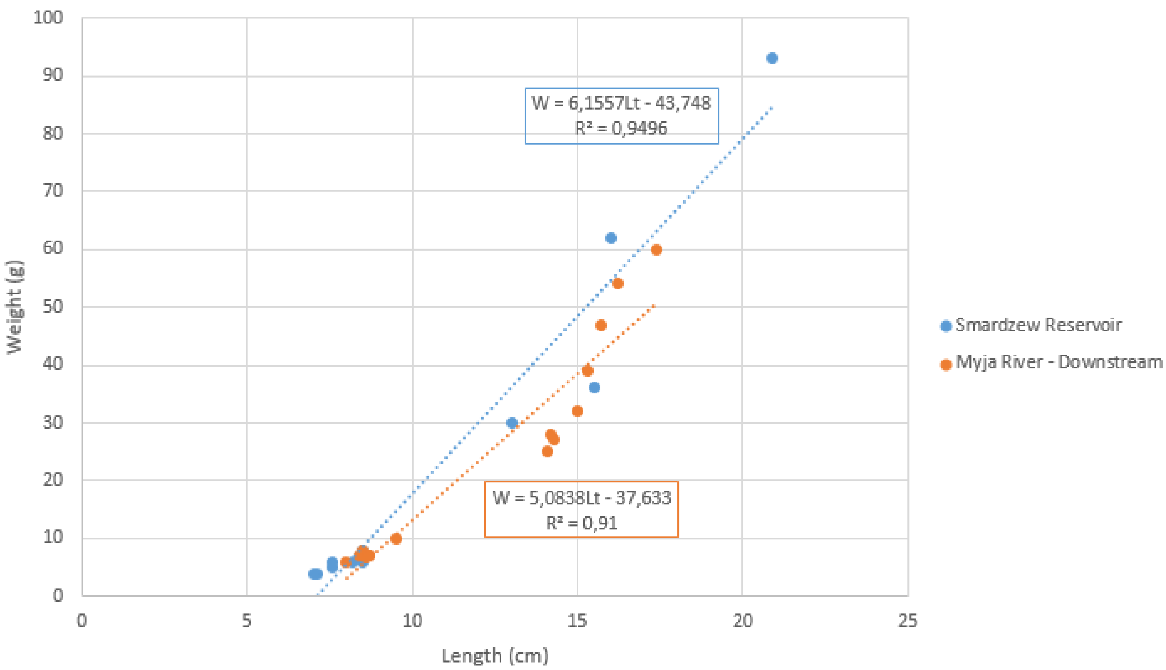

Figure 10: Weight (g) expressed in function of length (cm) for two samples of perches from Smardzew Reservoir and downstream Myja River

Heights water overflow

Table 4: Heights water overflow of surface notches in the fishpass

Pool number	Height (cm)	
1	6,3	
2	10	
3	9,9	
4	10,7	
5	10,1	
6	7,1	
7	8	
8	7,2	
9	5,3	Min
10	10,6	
11	9	
12	8,9	
13	5,3	Min
14	5,5	
15	10,1	
16	5,6	
17	11	Max
18	7,9	
19	Flooded	

The heights water overflow of surface notches in the fishpass (Table 4) are between 5.3 and 11 cm. The opening height of the inlet was measured at 2.5 cm. The three downstream pools were flooded over the pool-separating walls.

Fishpass flow measurements

The total flow is 0.1285 m^3s^{-1} (Table 5) when the upper entrance trap is fully opened.

Table 5: Fishpass flow measurements

Measurment	Fishpass flow characteristic
Total Q (m3s-1)	0,1285
V mean (ms-1)	0,168
V max (ms-1)	0,597
Cross-section depth (m)	0,51
Cross-section width (m)	1,5

Additional data from fish traps

Two traps were settled on the wall between pools 1 and 2 before the impoundment of the fishpass. The upper entrance window was opened. The objective was to make sure that the fishes are able to ride up the edifice. After 7 hours (12:30 pm – 19:30 pm), the traps were retired. The obtained results (Table 6) were much better than the expected ones.

Table 6: Fish composition from traps settled in the last chamber of the fishpass

Species	Number of specimens		
	Surface notch	Submerged orifice	Total
Abramis brama	1	1	2
Blicca bjoerkna	4	5	9
Carassius gibelio	1	1	2
Perca fluviatilis	0	77	77
Scardinius erythrophtalmus	1	11	12
Total	7	95	102

Discussion

Despite the eighteen species present in the reservoir and the river, only six of them were found in the fishpass. The large size of some species as pike (*Esox lucius*), asp (*Aspius aspius*) or chub can explain their absence in the fishpass. However the fishpass is theoretically adapted to large fishes. Do they have more difficulties finding entries? Or do the entries design with poorly sizes?

Statistically, there is not any relation between fish size and site. However, the thinness of fishes caught in the fishpass was obvious and the trends (Figure 10). Moreover, the capacity of fish passage facilities depends on swimming performance and endurance of the fish which is directly linked to the length-weight relation (Larinier 2002). Therefore, it would be interesting to realize a complete analysis using standard length and eviscerated weight to decrease the number of uncertainties.

Roach is less represented in the fishpass samples compared to Myja and Smardzew catches. We can suppose that roach does not support well the flow inside of the fishpass according to the presence of many injuries on caught individuals (Figure 11). Perch is very present at every site. Its migration seems to be easy between different places. Nevertheless, it could be also due to its good reproductive capacity.

Moreover according to Larinier (2002), the fishways are not well sized. Indeed, this one recommend surface notches and submerged orifices for coarse fishes of 0.25 X 0.30 m to make easier the formation of calm zones in the middle of pools and so creating a place for fishes to rest.

In addition, the otter presence (Figure 12) can disturb the fish migration in the fishways. Verticals bars at the downstream entrance could stop these piscivores without compelling the fish passage.

Figure 11: Photography of an injured roach caught in the fishpass

The study depends on the flow provided by the reservoir. Nevertheless, the company which manage the reservoir keeps a water level sufficient and let only a low flow pass within the fishpass (Kaczkowski 2019). The management of the fishpass might be done in close collaboration with that of the reservoir.

Adapting dimensions of the fishpass according to Larinier's recommendations could be a possible way to improve the effectiveness of the fishpass. Another solution could be changing the pool-type fishways in a vertical slot type. It would be functional even during low flow period.

The study was conducted only by day. It could be interesting to do it also by night. Also the measures were realized on the ground and could be biased. The values for small individuals are often imprecise.

Figure 12: Photography of otter faeces in the fishpass

Conclusion

Synthesis

The results showed that the fishpass works globally. However, some corrections are necessary to improve its effectiveness. Indeed, according to the fish compositions of Smardzew Reservoir and Myja River, only few fish species are able to pass by the fishway. Moreover, the dimensions of the fishpass are not well adapted for coarse fish. Resizing could be a good alternative to the complete change of the pool-type fishway in a vertical slot type.

In conclusion, the fishpass is effective but it can be improve by management and consultations with Smardzew managers. Although the continuity of Myja River is perturbed, fish migration is still possible.

The Myja River system is one of many lack of management examples in Poland. The rehabilitation of this one could become a management model.

Feedback on experience

This internship allowed me to acquire some skills about fish migration management and use different materials (multiparametric meter, magnet flowmeter, electrofishing battery). I also learnt many knowledges during the realization of the internship on one hand and during other activities I was able to participate during my stay on the other hand:

- Economic and environmental management class on Arturówek Reservoirs
- Conference “Ecohydrology of forest ecosystems: a retrospective reflection and prospectus of future work”
- Sampling of fish with multi-mesh gillnets on Sulejów Reservoir
- Educative trip: visit at National Park of Babia Góra at Slovak-Polish border; visit at fish farm and hatchery in Świnna Poręba near Mucharski Reservoir (Skawa River)
- Sampling of fish with multi-mesh gillnets on Jeziorsko Reservoir

I would like to continue my studies in the field of fishpass because I really enjoyed working on this topic. Moreover, it could be a great opportunity to mix engineering and research, hydraulic and biology, in my future work. That is why I strongly plan to do my end of study internship in a company specialized in construction and monitoring of fishways.

Finally, I sincerely thank my internship tutor, Zbigniew Kaczkowski, who was really interesting and interested by my work. For me it was a privilege to work with him. I learnt many things thank to him about biology, ecology but also on work management, Polish history and usages.

Thank you very much.

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Appendix 1: List of fish and lamprey species recorded in the Myja River system. Classification of reproductive guilds according to (Balon 1990)

- A – Species origin: R – native, I – introduced;
- B – Habitat preferences: Ra – rheophilic species of big streams, Rb – rheophilic species of small streams, E – eurytopic species, L – limnophilic species;
- C – IUCN categories of threat

Reproductive guilds	A	B	C
Lithophils (A.1.3*)			
Aspius aspius	R	Ra	LC
Squalius cephalus	R	Ra	LC
Phyto-lithophils (A.1.4*)			
Abramis brama	R	E	LC
Alburnus alburnus	R	E	LC
Gymnocephalus cernua	R	L	LC
Leuciscus idus	R	Ra	LC
Perca fluviatilis	R	E	LC
Rutilus rutilus	R	E	LC
Phytophils (A.1.5*)			
Blicca bjoerkna	R	E	LC
Carassius gibelio	I		
Esox lucius	R	E	LC
Misgurnus fossilis	R	L	VU
Scardinius erythrophthalmus	R	L	LC
Tinca tinca	R	L	LC
Psammophils (A.1.6*)			
Barbatula barbatula	R	Rb	LC
Gobio gobio	R	Rb	LC
Phytophils (B.1.4*)			
Leuciscus delineatus	R	L	LC
Pseudorasbora parva	I		

* A.1 - non-guarding and open substratum eggs scattering

A.2 - non-guarding and brood hiding

B.1 - guarding and clutch tending

B.2 - guarding and nesting

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Amaury Rabouan

2018-2019

Title: Assessment of the effectiveness of the Smardzew Reservoir fishpass on the Myja River

Subtitle: Towards a restoration of ecological continuity of the Myja River

Abstract: This study aims to assess the effectiveness of a pool-type fishway on Myja River. Indeed, Smardzew Reservoir impacts downstream and upstream river. The assessment was did using fishing traps and electrofishing. Results showed the fishpass is effective only for few species. The modification of fishpass sizing is one of the possibilities to improve its effectiveness.

Key words: Myja River, Smardzew Reservoir, fishways, effectiveness, fishing traps, electrofishing, monitoring

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