Test Case Presentation

Günz

Günz, Germany

The Test Case Günz includes 5 HPPs with fish ladders:
Deisenhausen, Höselhurst, Wattenweiler, Ellzee and Waldstetten

Figure 1: Fish counting station at the bypass-channel Deißenhausen

Table of Contents

List of Figures

List of Tables

1. Description of the Test-Case

1.1. Description of the water bodies related to the hydropower plan

The 5 hydropower plants (HPPs) of the river Günz are within the water body 1_F041 between the water bodies 1_F030 (downstream) and upstream water bodies östliche ("eastern") Günz 1_F044 and westliche ("western") Günz 1_F038. All water bodies have a moderate ecological potential.

Ecological status

Eastern Günz:	moderate
Western Günz:	moderate
Günz:	moderate
Danube:	good

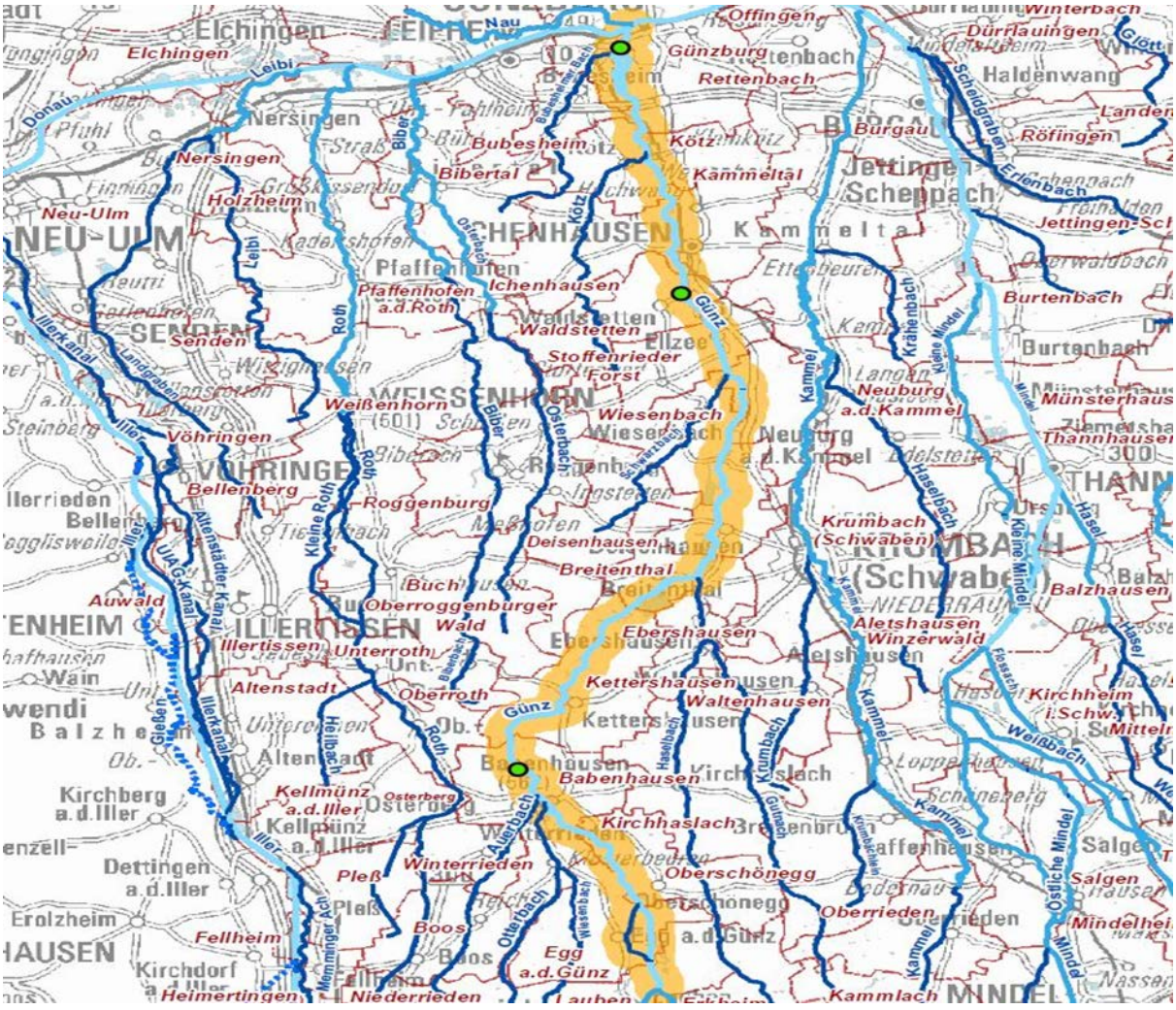

Figure 2: Water body 1_F041 Günz

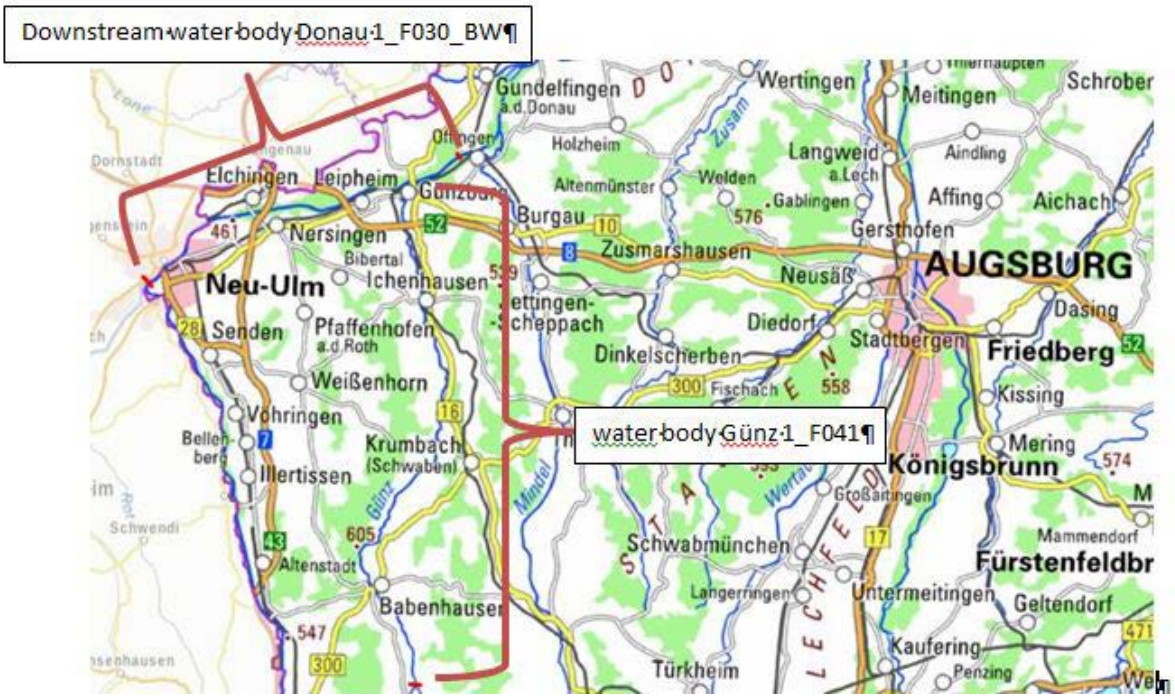

Figure 3: Water body Günz and downstream water body Donau

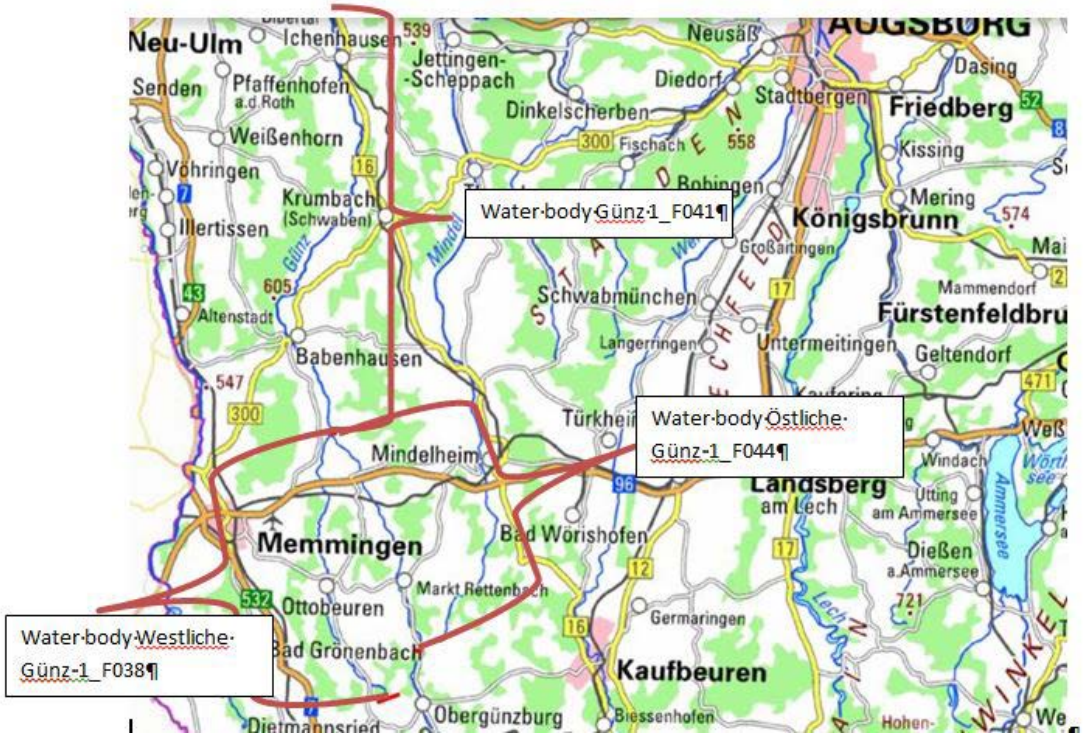

Figure 4: Water body of eastern and western Günz

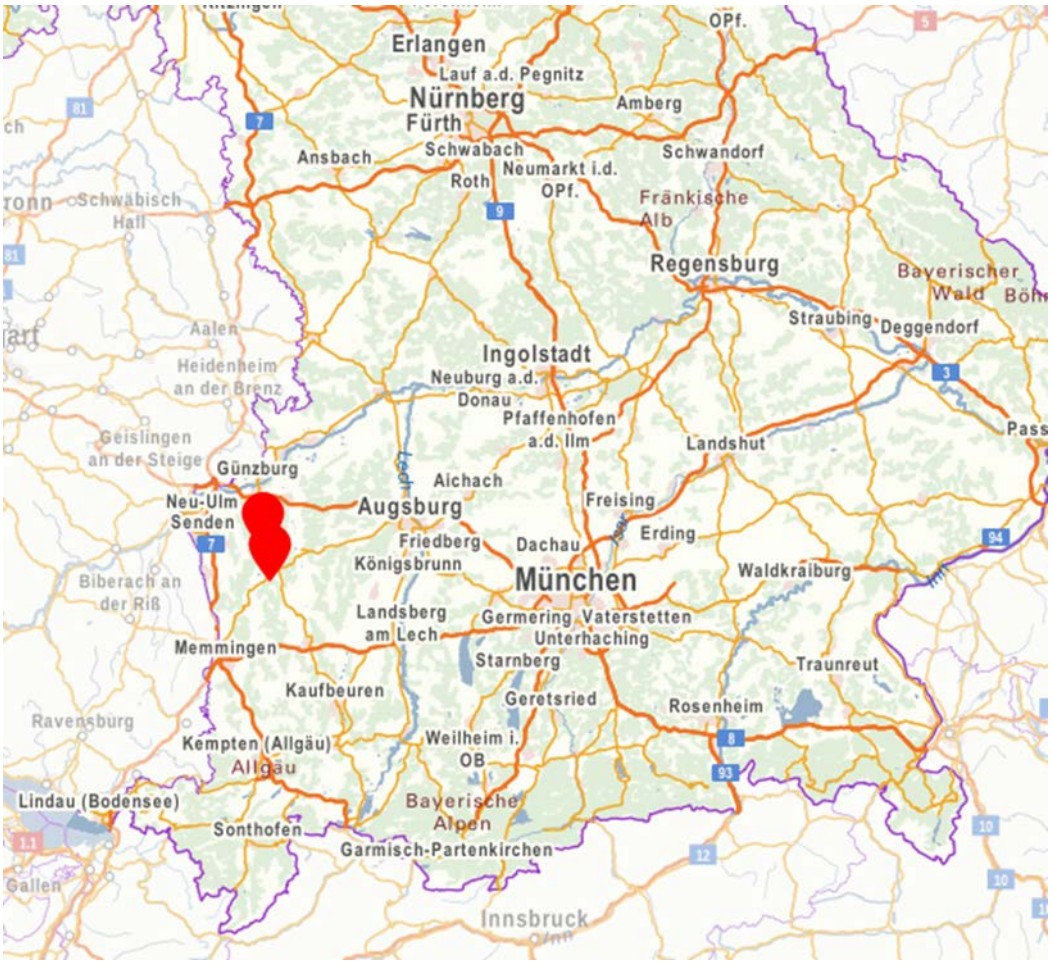

Figure 5: Water bodies related to the HPPs of the river Günz

1.1.1. Hydrology of the Günz

The hydrology is characterized by peak flows in winter due to snow melting and some peak flows in the summer after heavy rain events.

The mean interannual discharge of the river Günz is estimated at 7,8 m^3/s.

1.1.2. Main pressures

Several pressures are listed for the Günz:

Table 1: Main pressures on the Günz

Water treatment plant effluents	medium
Spillover of Stormwater overflows	minimal
Nitrogen derived from agriculture	not significant
Pesticides	significant
Water supply	not significant
Continuity	Former times high, since 2014 the continuity is built through fish bypass channels
Hydrology	high
Morphology	moderate

Table 2: Measures to be implemented at the river basin scale of the Günz

Flow change	No hydro-peaking for many years, homogenous water flow
Fish migration measures	Nature like fish ladder (fish bypass channel) combined with sections of technical ones at every LEW power plant of the river Günz
Pollution control	no

1.2. Presentation of the HPP's

1.2.1. Location of the HPP's

© left: geoportal.bayern.de; right: LEW

Figure 6: Location of the HPPs and respective fish passes at the river Günz

Table 3: Main characteristics of the HPPs

Watercourse	Günz
Situation :	Run-of-river hydropower plants
Inter-annual discharge	8,2 m³/s
Low-water flow :	3,5 m³/s
Function of the dam :	Hydropower Plant
Maximum turbine discharge:	17 m³/s
Species concerned :	reophilic fish population

Equipment and Technical Data:

- Flow through the turbines: 16,3 m³/s
- 1 Kaplan-turbine for each HPP, 150 – 250 rotations per minute
- Drop height: 3,9 - 8,30 m
- Mid Flow over the year: 8,0 m³/s
- 1,8 – 3,7 million kWh annual production for each HPP

1.2.2. E-flow

There are 5 HPP's. 4 of them are run-off-river. 1 the HPP Oberegg is a HPP with a diverted reach. The mean flow runs over the basin Oberegg, there is no hydropeaking. The old river called "Alte Günz" is used as a flood channel. The e-flow is 500 l/s at all time, which is the natural minimum water flow. This is the e-flow the authorities specified.

1.2.3. Downstream migration devices

There is no special downstream migration device, but downstream migration is possible during weir overflow.

1.2.4. Upstream migration devices

There is a fish bypass channel for upstream migration at every HPP (see pictures7 to 10):
Fish bypass channel at Deisenhausen (Source: LEW)

- Flow in the fishpass Deisenhausen: 500 l/s
- The others: about 300 l/s
- Length of the fish pass Deisenhausen 500 m.
- The others: 130 -180 m
- Fish bypass channel should also fulfil a compensation habitat function. Therefore, juvenile and spawning habitats have been built in the fish-bypass channel.

The bypass channel at HPP Deisenhausen has a flow of 500 l/s and is 500 m long. All other fish bypass channels have a flow of 300 l/s and a length of 130 – 180 m. All fish bypass channels are built as a nature like pond system. The first 10 m of every fish bypass channel is built as a technical vertical slot pass to ensure a more or less consistent water flow. In every fish bypass channel there is furthermore a fish counting pool to register all (upward) migrating fish. This research study is done by Thomas Lechner (IBF Umwelt).

©LEW

Figure 7: Teilungswehr Günz Channel and Old Günz HPP Oberegg

©LEW

Figure 8: Fish pass Deisenhausen

©LEW

Figure 9: Fish ladder Ellzee

©LEW

Figure 10: Fish ladder Höselhurst

1.2.5. Sediment Management

There is no sediment management done at the river Günz. Fine sediments can be transported through the HPP.

2. Objectives of this Test Case

What we are planning?

Improvement of the compensation habitat function, specifically as spawning habitat and habitat for reophilie fish species. Comparison with comparable small side waters like *Schwarzenbach* in view of the present fish fauna.

Why are we planning this on this Test Case?

This section of the Günz is strongly morphologic downgraded and channelized. The morphologic improvement of the Günz itself is difficult because of the closeness to the settlements and no available areas. The improvement of habitat functions within the fish ladders itself is considered to have a good cost-benefit effect and could be a model for other existing and planned fish ladders.

What are we expecting?

The fish ladders will be even more attractive as habitat for the reophile fish population

Relevance in FIThydro?

We hope to find ways to build compensation habitat structures in fish-bypass channels. These structures can play a big role in upgrading the ecology of a strongly channelized river. If the plan to build compensation habitats like spawning and juvenile habitats in bypass-channels is successful, these methods could be applied in other rivers. The results could thus be introduced as successful compensation measures in the Decision Support Tool.

3. Presentation of results and activities in FIThydro

3.1. Improvement of spawning habitats within the fish bypass

A number of measures for the improvement of the habitat function of the fish passes were considered (Table 4). The creation of spawning habitats through the addition of gravel was chosen as the most effective and cost-efficient measure for improving the habitat functioning at the fish passes of the test case Günz.

Table 4: Overview of possible measures for improving the habitat function of the fishways, their restrictions and cost-benefit evaluations

Measure	Realisation/restrictions/cost-benefits
Creation of spawning habitat through adding of gravel (d>60mm)	• Easily realisation • Potentially good cost-benefit ratio • Potential restrictions: possible restriction of fish pass due to reduction of gap diameter between pools
Building additional slack water and resting areas for larva and juvenile habitat	• Limited space available • Very high costs, cost-benefit ratio unknown • Already existing in Deisenhausen
Planting of shrubs and wood for providing shade and as structural measure	• Planting of plants not possible, as channels are lined with smectite mats and roots might cause these to become leaky • Long timespan till function is effective • High protection and maintenance effort for beaver protection required • Potentially good cost-benefit ratio
Inserting structural elements, e.g. rootstocks	• Realisation not possible due to space limitations • Structural and flow velocity diversion is already good • Potentially restriction of passability of fish pass
Increase of fish pass length	• Limited space availability • Very high costs and unclear cost-benefit ratio

In accordance with the Test Case objectives, the LEW placed gravel in 4 of 5 fish ladders to improve their function as spawning habitat for the reophile target fish-species such as nase and barbel. To monitor the success of the measures the pools with fresh gravel as well as the pools with the existing substrate were sighted daily from the day of gravel placement until about the end of Mai. This period was chosen to cover the spawning time of nase and barbel.

3.1.1. Placing gravel into the fishways

In spring 2018 and 2019, the LEW placed all in all about 42 tons of washed gravel with a grain size of 16/32 mm into several pools of the fishways Wattenweiler, Ellzee, Waldstetten and Höselhurst. In each case the gravel was placed in three pools of the fishways. The amount of

gravel per pool varied between 2 – 6 tons. The placing of gravel was done just before the spawning time of the nase at the beginning of April. Before adding the gravel, the water flow in the fish pass was reduced to ensure that no fish were in the fish pass and to enable an even distribution. The amount of added gravel was adapted to the size of the respective pool. In order to assess whether the newly created spawning grounds would be used in the following year as well, gravel was added to different pools of the fish passes at Wattenweiler and Ellzee in 2019 than in 2018. Furthermore, one pool at each of these two fish passes was covered with a screen to offer shading. This way, shaded and non-shaded pools could be compared for preferred use.

Figure 11: placing gravel into fish ladder Wattenweiler

The following aerial photos show the spots where the gravel has been placed.

Figure 12: Location of gravel input at the fishway Wattenweiler in 2018 (left) and 2019 (right)

Figure 13: Location of gravel input at the fishway Ellzee in 2018 (left) and 2019 (right)

Figure 14: Location of gravel input at the fishway Waldstetten in 2018 (left) and 2019 (right)

Figure 15 Location of gravel input at the fishway Höselhurst in 2019

3.1.2. Monitoring and success control

The nase was selected as a success indicator for the design of the spawning grounds, because their spawning activities depend on the water temperature. This way, the point in time can be narrowed down relatively good. As the spawning period of the species nase was expected to run within the time when gravel was placed in the fishways, they were sighted daily in order to record any spawning. For this, samples of substrate from the ground of the pools with fresh gravel and also from a comparable number of pools without fresh gravel were extracted. These samples of substrate were sighted for fresh spawn.

3.1.3. Results

In 2018, only 4 days after adding the gravel- successful spawning of nases at the fishway Wattenweiler could be documented. On 50% of the stones in all 3 pools with fresh gravel at least one or several glued on nase-eggs could be found. Spawning activities of nase could also be documented on the existing coarse substrate at the fish ladder Ellzee. On some of the chunks of the old substrate glued on eggs of nase were detected. Apart from that, no spawing activity could be recorded in 2018.

Figure 16: spawn of nase on fresh gravel

In 2019, successful spawning of nase could be recorded for all fish passes – in several pools with fresh and pools with one year old gravel. Table 5 provides an overview of the pools in each fish pass where gravel was added and spawn was found. The details for each fish pass are given below.

Table 5: Overview of the pools gravel was added to and spawn was found in for the fish passes Wattenweiler, Ellzee and Waldstetten

Year	2018		2019	
Fish pass	**Gravel added to pool no.**	**Spawn found**	**Gravel added to pool no.**	**Spawn found**
Wattenweiler	8	Yes		No
	9	Yes		Yes*
	10	Yes		No
			1	No
			2	No
			3	No
			15	No
			16	Yes
			17	Yes
Ellzee	29	No	redistributed	No
	30	No	redistributed	No
	31	No		No
			4	No
			7	No
			8	No
			9	No
			11	Yes
Waldstetten	8	No	8	No
	9	No	9	Yes
	10	No	10	Yes
			12	No
			13	No
			14	No
			16	No
			19 redistributed	Yes
			21 redistributed	Yes

Results for the fish pass at Wattenweiler

The adding of gravel into the fish pass pools in 2018 was done right before the spawning period of the nase. Only four days late successful spawning was registered in all three pools with new gravel. Large quantities of spawn were mostly evenly distributed within the three pools with the majority of eggs being found on surface of the substrate. More than half the eggs were in the interstitial spaces between the gravel stones up to 15 cm depth. Nearly every second stone was covered with one to several eggs as can be seen in Figure 16. While all pools were checked, spawn was only found in the pools with newly added gravel.

In 2019, after adding gravel to 6 pools, spawn was found in two pools with new gravel concentrated on an area of ca. 1-2 m² each. Eggs were hardly found on the substrate surface but in the gaps between gravel up to a depth of ca. 20 cm, with most eggs in a depth between 5 – 15 cm. Spawn was also found in pools that had gravel added to in the previous year.

Figure 17: Spawn of nase on gravel in the fishway Wattenweiler 2019

Results for the fish pass at Ellzee

In 2018, spawn was only found in the shaded area underneath a small bridge on old gravel in the form of ‘spawning nests’ from a few fish. In 2019, gravel was added to 5 pools at the fish pass Ellzee and in two pools the gravel added in the previous year was dispersed to clean it from fine sediments. In two of the pools with fresh gravel, spawn of Chondrostoma nasus was found in individual sections. On the substrate surface very few eggs were found, most could be found in a depth of 8-15 cm. Additionally, span of Leucisus leucisus was found in a pool with old substrate.

Figure 18: Spawn of nase at fishway Ellzee

Results for the fish pass at Waldstetten

In 2018 no spawning was recorded in the fish pass at Waldstetten. A reason for this could be that the spawning of nase started early and the addition of the gravel might have been too late in this section. In 2019, spawn was found in two pools with newly added gravel and in two additional pools with reallocated gravel from the previous year. On April 19. About 40 – 50 nase were sighted during spawning in the fish pass. Five days after this, eggs could be found on nearly all areas of the pools in a depth of 5 – 15 cm while hardly any eggs were found on the substrate surface.

Results for the fish pass at Höselhurts

Of the 6 pools that gravel was added to in 2019, eggs were found in one of them. The spawn was unevenly distributed over the whole pool.

Figure 19: Spawn found in pool 5 of the fish pass at Höselhurst

Impact of shading, water depth and flow velocity on spawning behaviour

Shading some of the pools had no influence on the spawning behaviour, as eggs were found in pools with and without shades. No apparent preferences regarding water depth or flow velocity could be found for the choice of spawning grounds. Spawn was found in conditions of 0.2 – 0.7 water depth and 0.8 to 1.5 m/s flow velocity. It is therefore assumed, that the preference of spawning ground for nase is primarily influenced by the quality of the substrate.

Functionality and cost effectiveness

The functionality of the new gravel as a suitable spawning ground is expected to last at least two years. Eggs were mainly found in a depth of 5 to 20 cm. While many eggs are being placed on the substrate surface, the ones in the interstitial seem to have a much better chance of hatching.

Colmation of substrate is caused by the steady water flow common to fish passes. A natural dynamics in terms of reallocation of substrate is thus missing. It is therefore recommended to already consider measures to 'flush' the fish pass and gravel during the planning phase. This could for example be achieved through pipes that cross the dam and enable a temporary increase in flow magnitude, creating a nature like dynamic for reallocation/washing out of substrate.

The focus of the monitoring of the function of the artificial spawning grounds has been the nase. Potentially, the variety of the substrates implemented, together with the existing coarse substrate at the ponds of the fish passes, are suitable for almost all reophile fish species (e.g. brown trout). It can therefore be expected that various species use them for spawning.

Compared to the creation of spawning grounds within the Günz itself, is the creation of spawning ground in the fish passes a much easier, efficient and cost-effective measure. Per functioning spawning ground in the main river, a min. of 20x the gravel per m^3 in relation to MQ (m^3/s) would be needed. For the Günz, with an MQ of 8.26 m^3/s this would result in a min. of 165 m^3 gravel per spawning ground compared to about 42 m^3 gravel (70 t) for 9 spawning grounds in the fishways.

3.2. Population analysis

As a success control of the planned and already realised measures, inventories of the fish stock present in the fishway were made. Between August and September of 2018 and 2019 electrofishing was carried out in all five fish passes and the fish species were recorded. Additionally, the fish species present in the river Günz downstream of the five hydropower plants were recorded in 2019 in order to have a comparison of species in the main river and the fish passes.

3.2.1. Methodology

The inventory of the fish-stock was done by electric fishing. For this, a battery fed backpack electric-fishing device was used.

Data of the electric-fishing device:

- Type: Efgi 650
- Manufacturer : Bretschneider Spezialelektronik, Chemnitz
- Power: 650 W DC Power and 1300 W Pulse current

In order to catch the fish gently, only DC – power was used. Before fishing, the flow of each fish ladder was throttled to about 50 % to increase the catch-effectivity. At the point of throttling the flow, the underwater entrance was closed with a net so that no fish could escape into the river. The fishing was done upstream pool after pool with a personnel strength of 3. All caught fish were kept within a basin and after measurement and documentation released back into the fish ladder.

Figure 20: Electric fishing at fish ladder Höselhurst

3.2.2. Results of the fish stock inventory

In the five fish passes, a total of 3105 individual fish from 25 fish species were caught and recorded in 2018 compared to 2697 individuals from 23 species in 2019.

Most fish species were found in the fish pass of Deisenhausen. In Waldstetten, which is the shortest and, together with Höselhurst, the steepest, fish pass, the fewest with 9/8 and 10/8 fish species were found in 2018/2019 respectively. Barbel was present in all fish passes but Ellzee in a relative high number. The nase was present in moderate numbers in all fish passes with a high number of individuals in Ellzee in both years and also in Deisenhausen in 2019. Noteworthy numbers of brown trout could only be found in Wattenweiler and Ellzee – these were identified (visually) as being wild fish and not cultured fish.

Table 6 provides an overview of the no. of fish per species caught in the fish passes of the five test case HPPs.

Table 6 : Fish stock inventory of the fish passes at Deisenhausen, Höselhurs, Wattenweiler, Ellzee and Waldstetten in 2018 and 2019 in no. of fish per fish species

Species		Deisenhausen		Höselhurst		Wattenweiler		Ellzee		Waldstetten	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Barbel	Barbus barbus	269	247	154	84	203	122	26	63	69	116
Bleak	Alburnus alburnus	67	127				5	75	4	110	53
Brown trout	Salmo trutta f.	1		3		16	6	11	5		
Bullhead	Cottus gobio	4	15								
Carp	Cyprius carpio	2	1								
Catfish	Silurus glanis			2			5				
Chub	Squalius cephalus	215	154	69	35	82	48	84	91	44	64
Dace	Leucisus leucisus	70	224	1		5		1	6		
Eel	Anguilla Anguilla	11	3	4	12	7	13	12	12	19	18
Grayling	Thymallus thymallus	2	1			1					
Gudgeon	Gobio gobio	95	151	30		2	1		1	3	1
Minnow	Phonixus phonixus	48	3								
Nase	Chindrostoma nasus	6	95	13	11	31	30	117	112	14	11
Perch	Perca fluviatilis	40	41	1				2	3	1	
Pike	Esox lucius	1	7				1		2		
Prussian crap	Carassius gibelio	2			5			1	1	1	
Rainbow trout	Oncorhynchus mykiss						1	1			
Roach	Rutilus rutilus	47	70	1	3	31	33	179	146		3
Rudd	Scardinius erythrophthalm	1									
Silver bream	Abramis bjoerkna	2	1		1		1	45	29		
Spirlin	Alburnoides bipunctatus	159	300	104	10	105	20	44	11	59	48
Sticklback	Gasterosteus aculeatus	55	7								
Stone loach	Barbatula barbatula	217	12								
Tench	Tinca tinca	7	8			1		1			
Topmouth gudgeon	Pseudorasbora parva	2									
Total no. of fish		1323	1447	379	164	484	286	599	486	320	314
No. of fish species present		23	17	10	8	11	13	14	14	9	8

3.1.3. Comparing species inventory of the river and the fish pass

Next to the electrofishing in the fish passes, a fish species inventory was done at each HPP in the Günz itself. Table 7 shows the number of nase and barbel caught during the electrofishing campaign in the fish passes and in the river section downstream of the hydropower plant.

Table 7: Comparison of no. of nase and barbel found in the fish passes and in the river Günz downstream of the hydropower plants

Section	Nase [n]	Barbel [n]
Deisenhausen fish pass	95	247
Oberegg Günz	4	29
Höselhurst Günz	7	24
Höselhurst fish pass	11	84
Wattenweiler Günz	4	14
Wattenweiler fish pass	30	122
Ellzee Günz	1	0
Ellzee fish pass	112	63
Waldstetten Günz	6	32
Waldstetten fish pass	11	116

The target species of the Günz were found by far more frequently in the fish pass, than in the river itself. Especially sub-adult and adult nase as well as barbel use these nature-like habitats. With the exception of very young and very old fish, a huge range of age groups were found in the fish passes.

Figure 21: Brown trout (salmo trutta f.), barbel (barbus barbus) and juvenile nase (chandrostoma nasus) caught during the electrofishing campaign in the fish passes

The fish passes, having the character of secondary rivers, provide a valuable refugium for discerning species, which were secondary species in the original river Günz, namely brown trout, bullhead, grayling and minnow. These species were only found in the fish passes.

However, it has to be kept in mind that the fish passes are and remain artificial water bodies. This shows, for example, in the water temperatures that are higher in the fish pass compared to the river itself. In the summer 2018 and 2019 extremely high water temperatures were detected, which limit the quality and function of the fish pass as a habitat during certain times.

It was possible to verify that the fish passes at the river Günz provide valuable habitats, which have the character of a refugium, for most domestic, usually reophile, fish species. This function as a nature-like habitat should be considered while planning and building future fish passes, especially at heavily modified water bodies such as the Günz.

It could especially be recommended to provide key habitats such as spawning grounds for gravel spawning fish, as well as habitats for larvae and juvenile fish. These measures can be implemented with relatively low additional efforts and a very good cost-benefit-ratio. As research has shown, it is also possible to effectively improve existing fish passes by implementing suitable gravel as a spawning ground.

4. References

Lechner, T. (2020). Präsentation des “Alpinen Test Case”: Günz. Projektbericht.