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Ref:

Fish Ecological monitoring and accompanying research on the hydrodynamic screw HYDROCONNECT with integrated fish lift at the Hydro power station Jeßnitz.

From the middle of December 2011 to the middle of March 2012 the Institute for Hydrobiology and Water Management (IHG), researched a newly developed hydrodynamic screw with fish lift by Walter Albrecht. During the trial operation a fish ecological monitoring, regarding the passage of fish from the lower into the upper waters was carried out. Special attention was given to the main fish species of the Hyporithrals (Brown Trout, Bullhead, Rainbow Trout, and Grayling). The prototype was installed at the Hydro Power plant Jeßnitz on 13th December 2011, with a downstream connecting bypass stretch and it was then put into operation for a technical test trial. Simultaneously the downstream area was adapted with sufficient gravel (topographically suitable for the upstream migration experiment). Furthermore the upstream exit area with the inner tube screw is connected to a fish slide and a containment basin which was set up for the proper containment of the trial fish.

The aim of the study of the Hydrodynamic screw in the Jeßnitz stream at St Anton was to carry out first pilot trials concerning the passage of fish through this turbine type. Within the framework of this trial, the ascent of the fish via the fish ladder was traced and their exterior state of health was checked after passing through the inner screw.

The most important questions from a fish ecological standpoint were:

- For which fish species was a passage traceable(strong swimmer and weak swimmer species) from lower to upper waters.
- For which age classes (juvenile and adult stages) is a passage possible.
- Is there a risk of injury to fish at the entry point or while passing through the screw.

1 EXPERIMENTAL LAYOUT TO THE HYDRODYNAMIC SCREW WITH INTEGRATED FISH LIFT

The following illustration shows the Hydrodynamic screw with the inner tube ending in the gravel bed, which was redistributed and adapted to form part of the weir pool. The exit of this experimental pool is equipped with a screen in the 'trial pool', it allows experiments with either a closed or open screen. With an open screen, fish from the residual water could migrate upstream, and with a closed screen experiments with fish from other water bodies could be conducted as they could leave the experiment pool but through the inner tube. That way they ended up in the containment basin.



Illustration 1: Panorama picture showing the prototype with tailwater shutoff - dam fill with opened screen at the experiment pool.

At the upstream end of the inner tube it is connected to a fish slide and a containment basin. Here the successfully ascended fish were collected (see illustration 2). From this control pond the fish were taken by dip net for counting, and determination and measurement of the length. They were subsequently released into the upper waters of the power plant.



Illustration 2: Fish Migration Aid (FMA) exit with fish slide into the containment basin

Survey Entrance Area

The entrance area was immediately set up at the downstream end of the hydrodynamic screw HYDROCONNECT with a hydrometric vane (mini wing from company Ott) due to the current conditions in front of the waterworks outlet and fish lift entry.

The coordination system (xyz) takes the zero at the top middle point of inner screw at its lip. The following diagrams should illustrate the current vector fields in the flow direction of the works water (y axis). The exit of the works water at the orthographically left side of the HYDROCONNECT causes a attraction flow of 0.4 - 0.6 m/s. In comparison to this, the flow velocity directly in front of the entry to the fish lift lies in the realm of 0.05 - 0.22 m/s, close to the surface a positive current (in flow direction of the works water) occurs. Towards the bottom, negative current vectors occur (water flows into the screw).

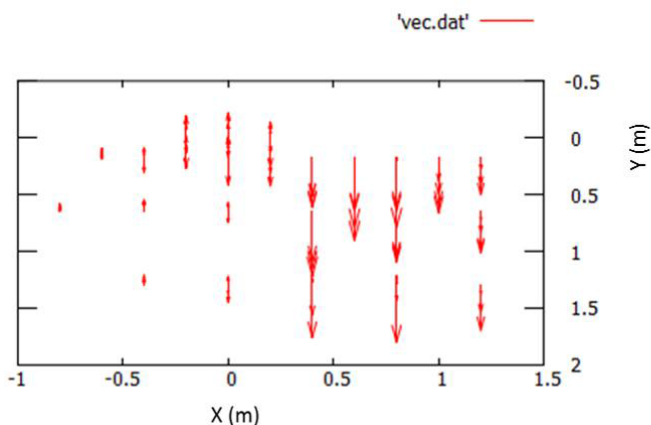


Illustration 3 - Current vector field plan view

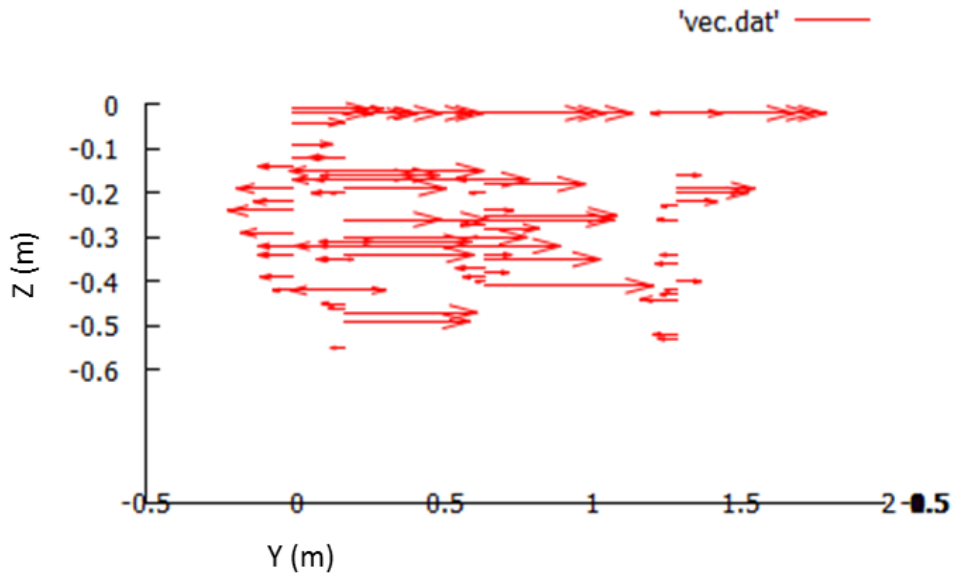


Illustration 4 - Current vector field Elevation

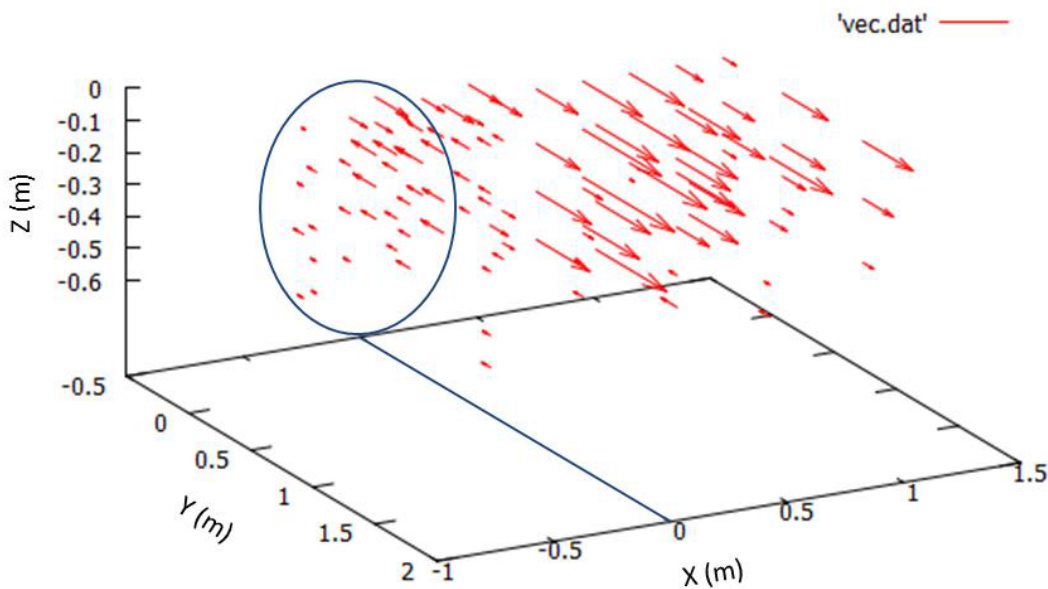


Illustration 5 - Current vector field 3D View (Perspective sketch of tube axis and entry opening in blue)



2 Fish - Trial execution and results

The whole upstream experiment took place during the winter months (Dec.2011 - March 2012) and can be organised into 3 separate phases (orientation trial - phase 1 & 2 ; detail trial - phase 3).

2.1 Orientation trial (Phase 1 & 2)

Initially, during the machine test immediately after plant startup, a totally free motivated ascent of individual fish was registered through the inner tube (screen in the experiment pool was open). Listed in Table 1 are detailed ascent numbers from the first trial phase. The ascended fish were taken from the containment basin and recorded by Walter Albrecht. They were then released into the upper water of the power plant. In this trial phase, the ascent of 16 Brown trout (5 juveniles and 11 adult), 1 Bullhead and 1 adult Rainbow trout were documented.

Table 1 - Ascent numbers during the first trial phase (screen at the experiment pool was open).

Aufstieg	Fischart			Tagessumme
	Bachforelle	Koppe	Regenbogenforelle	
Datum	Ind. (n)	Ind. (n)	Ind. (n)	Σ Ind. (n)
13.12.2011 - Start Probebetrieb				
14.12.2011	1			1
16.12.2011	1			1
18.12.2011	1			1
19.12.2011	1			1
22.12.2011	1			1
23.12.2011	1			1
24.12.2011			1	1
25.12.2011	1			1
04.01.2012	1			1
05.01.2012	1			1
09.01.2012	1			1
12.01.2012	6	1		7
Gesamtergebnis - Σ Ind. (n)	16	1	1	18

On the 12th of January 2012 electro-fishing at the head and tail water of the HYDROCONNECT at the river Jeßnitz was conducted by IHG staff, with the aim of collecting several different fish species and individuals for a compact upstream migration experiment with a closed screen at the experiment pool. The fishing was conducted by a generator (EFKO 1500w) with a pole and dip net. Through that, more than 160 individuals were caught for the trial (mainly Brown Trout, plus a few Rainbow Trout and Bullheads). The fish were then put in the pool at the tail water area of the screw and due to the screen at the pool, the fish could only leave the pool via the fish lift. The trial was concluded on the 19th of January 2012 due to increased water level on the Jeßnitz and because the screen



in the experiment pool was destroyed. Table 2 shows detailed ascending numbers of the second trial phase. The ascend fish were again recorded by Walter Albrecht. In this trial phase 79 Brown Trout (68 juveniles, 11 adult), 2 Bullhead and 1 adult Rainbow Trout ascended via the screw. During this trial phase the IHG team made several control visits.

Table 2 - Ascending numbers during the 2nd trial phase (closed screen at the experiment pool.

Aufstieg	Fischart			Tagessumme
	Bachforelle	Koppe	Regenbogenforelle	
Datum	Ind. (n)	Ind. (n)	Ind. (n)	\sum Ind. (n)
12.01.2012 - E-Befischung				
12.01.2012	5			5
13.01.2012	33	1		34
14.01.2012	2		1	3
16.01.2012 - Installation Kamera und Licht				
17.01.2012	30	1		31
18.01.2012	9			9
Gesamtergebnis - \sum Ind. (n)	79	2	1	82

2.2 Detail Trial (Phase 3)

On the 7th and 8th of March 2012, the IHG team conducted extensive electro-fishing at the head and tail waters of the power plant at Neubruck on the river Erlauf. We would like to thank Head Forester Dipl. Ing. Gabler for supporting this project. The goal of this electro-fishing was primarily to have as many individuals of different species and age classes as possible at our disposal for the detailed experiment. With the Grayling we could take an additional fish species into the programme. The fishing was carried out with a small motor boat which was equipped with a power unit of 5Kw DC current, that was connected with an anode rake. The caught fish were held until the beginning of the trial in a Setzkalter (hydrobiom) holding tank with fresh water supply, they were then determined, measured, checked for external injury, and photographed.

Altogether, 4 fish species were used for the upstream migration experiment (Brown Trout, Grayling, Rainbow Trout and Bullhead). The fish were stocked in the experiment pool (at the tail water of the HYDROCONNECT). In order to hinder small fish from escaping the pool, the screen was additionally equipped with a fine meshed net. That way, all fish could only leave the experiment pool via the fish lift. Immediately after their passage into the



head water, the fish were caught in the containment basin. The ascended fish were again determined, measured, examined for external injury (loss of scales, flesh wounds, bruising and scratches etc.) and again photographed. All operations, namely fish collection, stocking in the experiment pool, and processing after upstream migration within the framework of the 3rd trial phase, were carried out through IHG personnel.

Stocking

Altogether, 372 individuals of 4 different fish species from the Erlauf were caught, checked for external injuries and introduced into the experiment pool in the tail water of the HYDROCONNECT. The trial fish consisted of 27 Grayling, 185 Brown Trout, 94 Bullhead, and 66 Rainbow Trout (see Table 3). Different age-classes were used in the experiment. Individuals ranged from 3cm and 48 cm in length (see Length Frequency Diagramme of used species shown in Fig. 6 - 9).

Table 3 - Number of fish for the 3rd trial phase

Besatz	Fischart				Tagessumme
	Äsche	Bachforelle	Koppe	Regenbogenforelle	
Datum	Ind. (n)	Ind. (n)	Ind. (n)	Ind. (n)	Σ Ind. (n)
07.03.2012	6	103	57	31	197
08.03.2012	20	82	37	35	174
09.03.2012	1 ^{*)}				1
Gesamtergebnis - Σ Ind. (n)	27	185	94	66	372

^{*)} Äsche adult nach Aufstieg wiederbesetzt

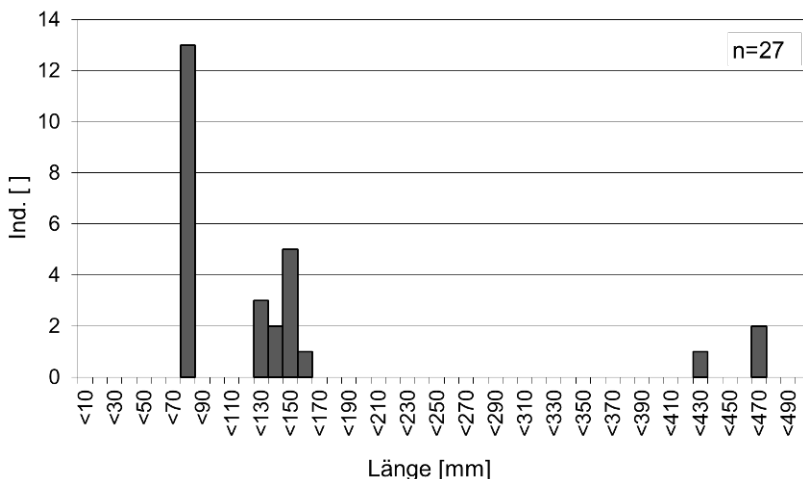


Illustration 6 - Length Frequency Diagram of Grayling (Stocked)

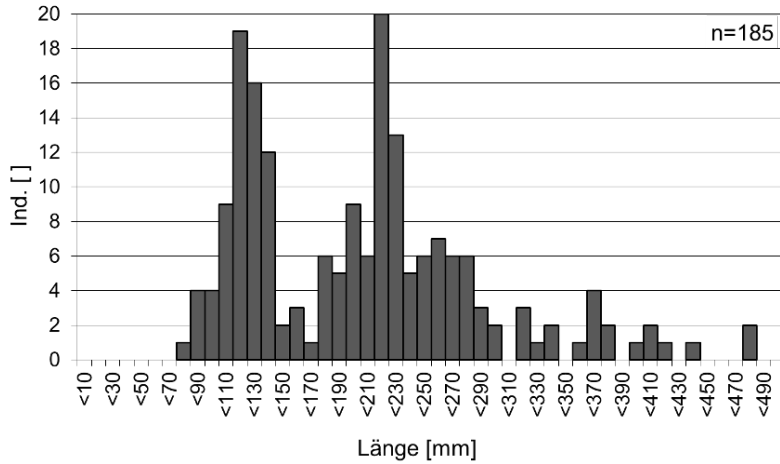


Illustration 7 - Length Frequency Diagram of Brown Trout (Stocked)

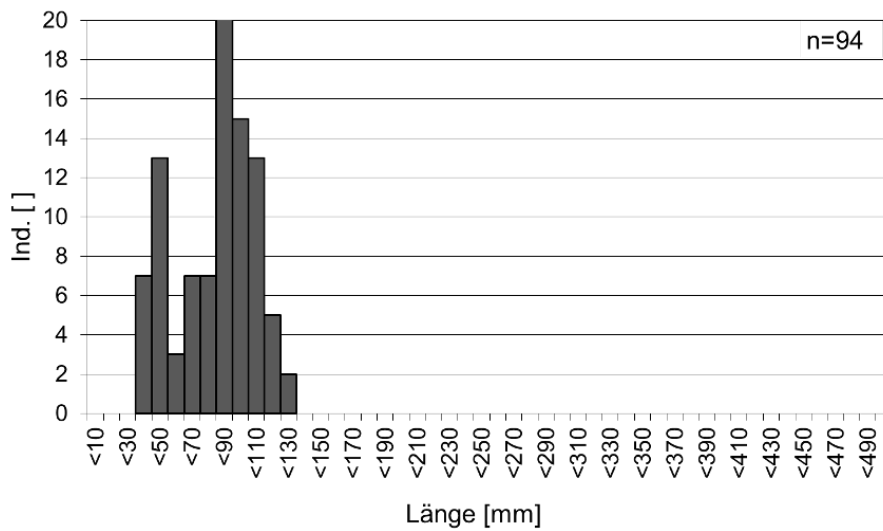


Illustration 8 - Length Frequency Diagram Bullhead (Stocked)

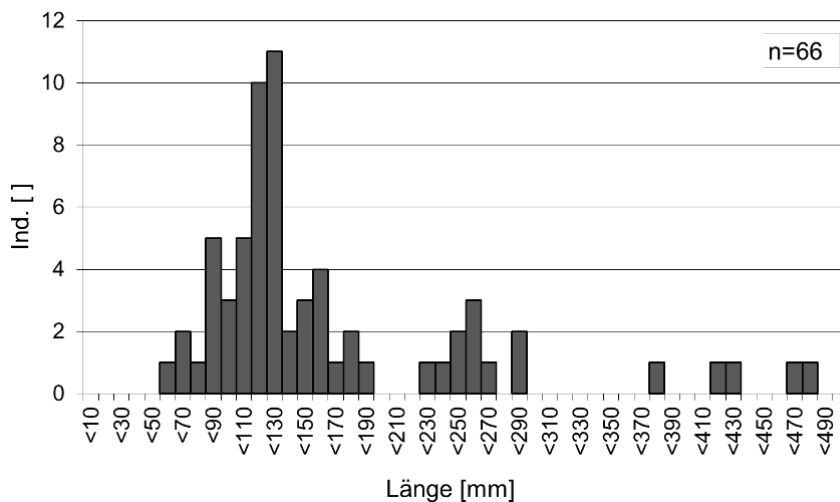


Illustration 9 - Length Frequency Diagram Rainbow Trout (Stocked)



Upstream Migration Experiment

The containment basin was checked at least twice per day during the upstream migration experiment. It lasted from 8th -18th of March 2012 (period of 11 days). Altogether, an ascent of 151 fish via the inner screw tube was documented. Amongst the 151 ascended fish there were 15 Grayling, 107 Brown Trout, 9 Bullhead, and 20 Rainbow Trout (and 1 frog !!) represented (see Table 4). Around 80% of the ascended fish passed through the screw within 3 days of the start. The size distribution of these fish ranged from 7cm - 48cm length (see illustrations 10 - 13) and therefore covers completely the spectrum of fish species and their various stages introduced into the experiment pool. The monitoring revealed that no fish were harmed by passing through the screw.

Table 4 Ascent numbers during the trial phase (closed screen mechanism at the experiment pool).

Aufstieg	Fischart				Tagessumme
	Äsche	Bachforelle	Koppe	Regenbogenforelle	
Datum	Ind. (n)	Ind. (n)	Ind. (n)	Ind. (n)	Σ Ind. (n)
08.03.2012		23	1	4	28
09.03.2012	13	39		5	57
10.03.2012	1	21	1	6	29
11.03.2012		5	3	2	10
12.03.2012		8	1	1	10
13.03.2012			1	2	3
14.03.2012		8			8
15.03.2012		1	1		2
16.03.2012					0
17.03.2012	1	1			2
18.03.2012 ^{*)}		1	1		2
Gesamtergebnis - Σ Ind. (n)	15	107	9	20	151
^{*)} Frosch - Aufstieg unbeschadet					

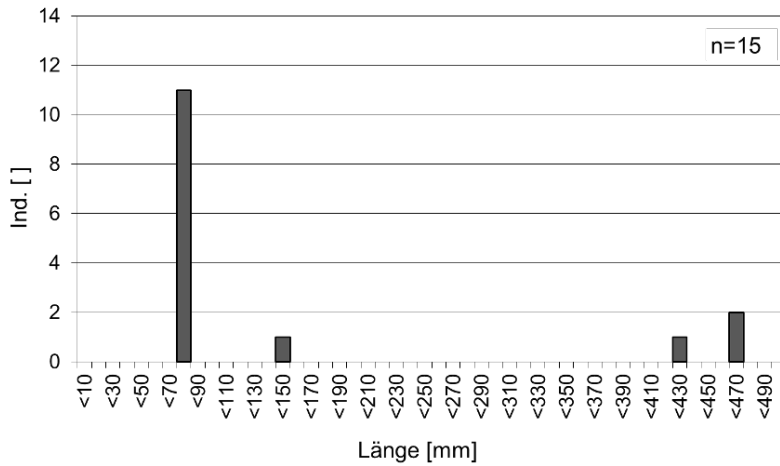


Illustration 10 Length-Frequency Diagram of Grayling (ascended)

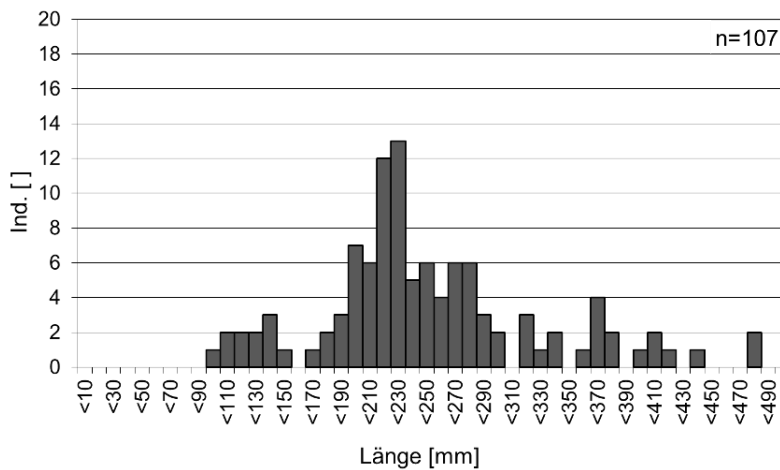


Illustration 11 Length-Frequency Diagram of River Trout(ascended)

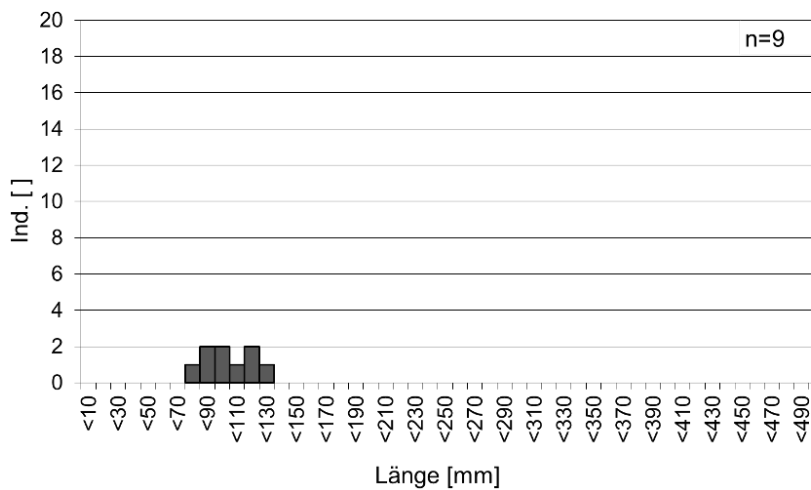


Illustration 12 Length-Frequency Diagram of Bullhead (ascended)

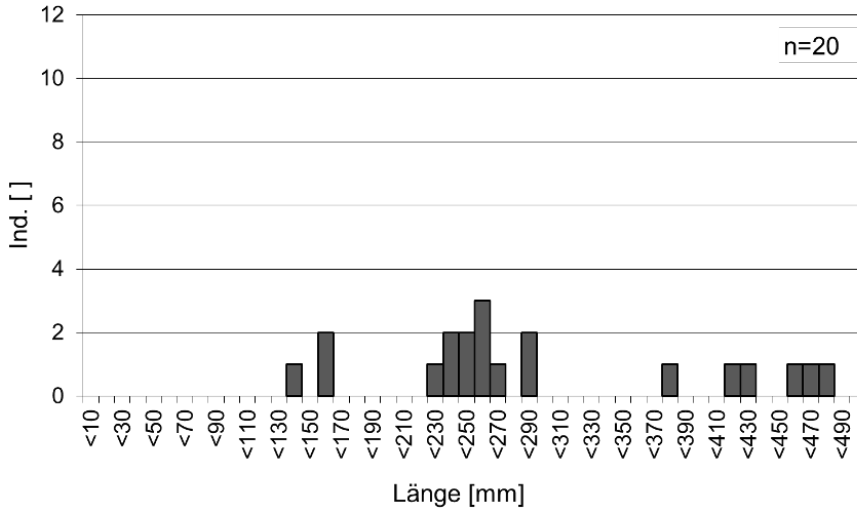


Illustration 13 Length-Frequency Diagram of Rainbow Trout (ascended)

Due to an increased water level on 20 - 22nd of March, the experiment pool overflowed. Furthermore, the screen stopped functioning from this point in time. Especially at night, the fine meshed screen was completely blocked with leaves and detritus, apparently causing the screen mechanism and the dam crest to overflow. Therefore it was concluded that after the upstream migration experiment many of the remaining fish migrated and drifted away from the area. The last electro-fishing in the experiment pool of the 28th of March proved that only 21 of the theoretically possible 221 fish after the upstream migration experiment remained in the system (around 10%). In spite of all this, the ascent result was amazingly high. The share of the ascended fish (based on the number of stocked fish) consisted of 50% Grayling, 58% Brown Trout, 10% Bullhead and 30% Rainbow Trout.

Table 5 Statement of the stocked and respectively ascended fish

Bilanz	Fischart				Summe
	Äsche	Bachforelle	Koppe	Regenbogenforelle	
	Ind. (n)	Ind. (n)	Ind. (n)	Ind. (n)	$\Sigma Ind. (n)$
Besatz bis 09.03.2012	27	185	94	66	372
Aufstieg bis 18.03.2012	15	107	9	20	151
E-Befischung am 28.03.2012	-	3	3	15	21
Fehlende Individuen	12	75	82	31	200
Anteil der aufgestiegenen Fische ausgehend vom Besatz (%)	56%	58%	10%	30%	41%



3 Conclusion

In order to examine the Hydrodynamic Screw with integrated fish lift at the Jeßnitz in view of up-river pointing passage of fish, several ascent trials took place in the winter months of 2011 until March 2012. During the startup phase of the trial operation of the plant, the ascent through the inner tube screw of 17 adult and juvenile trout and 1 Bullhead was verified. At this point in time during the orientation trial, the screen mechanism of the artificially filled experiment pool in the tail water of the screw was completely open i.e the ascended fish passed through the screw totally of their own volition.

For the detailed trial in March 2012, altogether 372 individuals from the 4 main fish species, Brown Trout, Rainbow Trout, Bullhead, and Grayling were stocked. The fish length ranged from 3cm - 48cm and contained both juvenile and adult individuals of all 4 stocked species. During the trial, altogether 151 fish were verified passing through the screw. Represented amongst the ascended fish were 15 Grayling, 107 Brown Trout, 9 Bullhead and 20 Rainbow Trout. Furthermore, it was verified that the passage for all stocked fish species of all age classes through the inner tube screw was possible, unharmed.

Lastly, it is a considerable result and has to be pointed out that even for small fish species like Bullhead, which are strongly bound to the substrate, a successful passage was verified. Furthermore it has to be stated that no external injuries could be found on any fish having passed through the screw.

The overall conclusion of these pilot trials can be summed up as a clear indication that these newly developed screw types give high hopes for the future, at least in small to medium waters of the Trout and Grayling regions, with ground cill weirs and/or weir plants (especially with limited space). At the same time the problems of up and downstream pointing fish migration can be brought to a solution.

Best regards

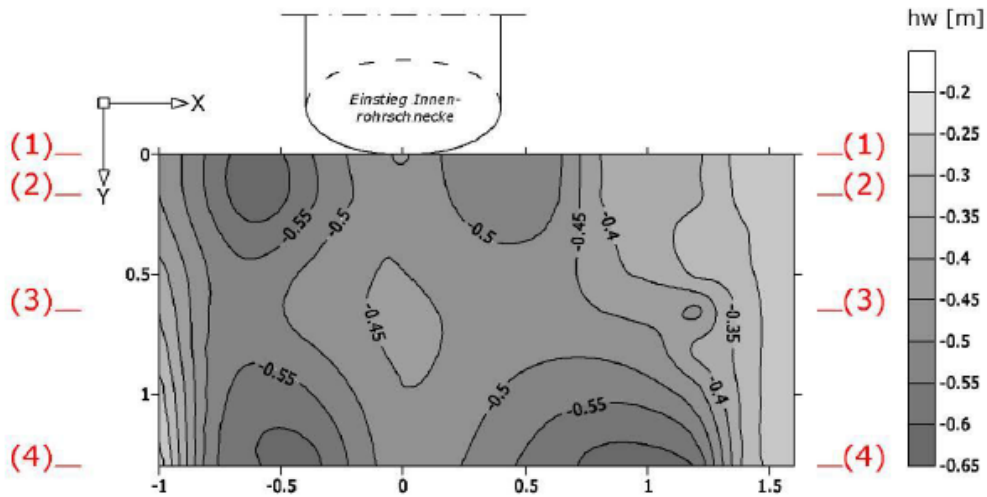
DI Bernhard Zeiringer
Prof. Mathias Jungwirth

Vienna, 14.Mai 2012

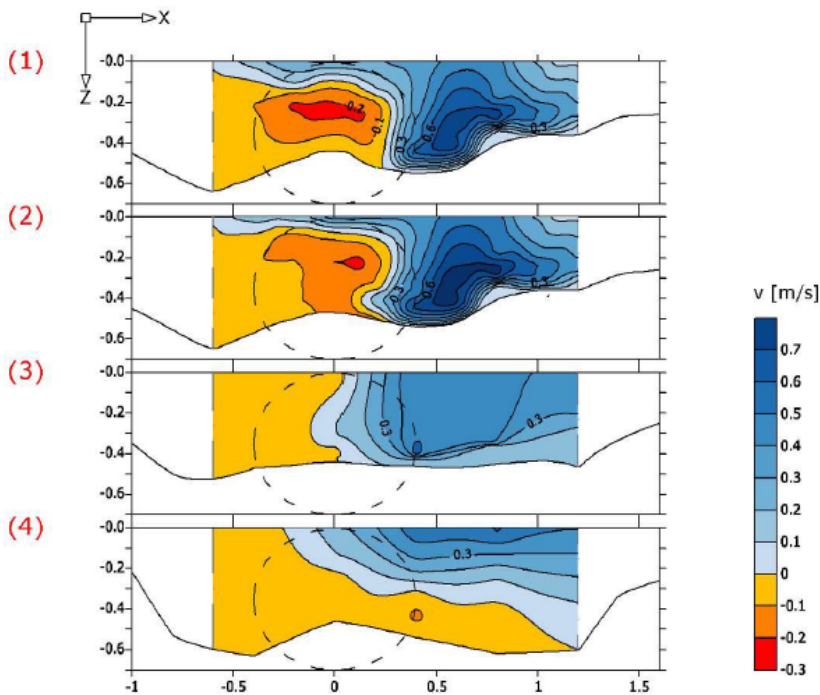


Addendum Hydromorphology

Top View of Lower water River bed



Flow rate distribution in cross section 4 cross sections



B. Zeiringer (2012)