Fish movement analysis in diagonal brush fish pass: Innovative approaches

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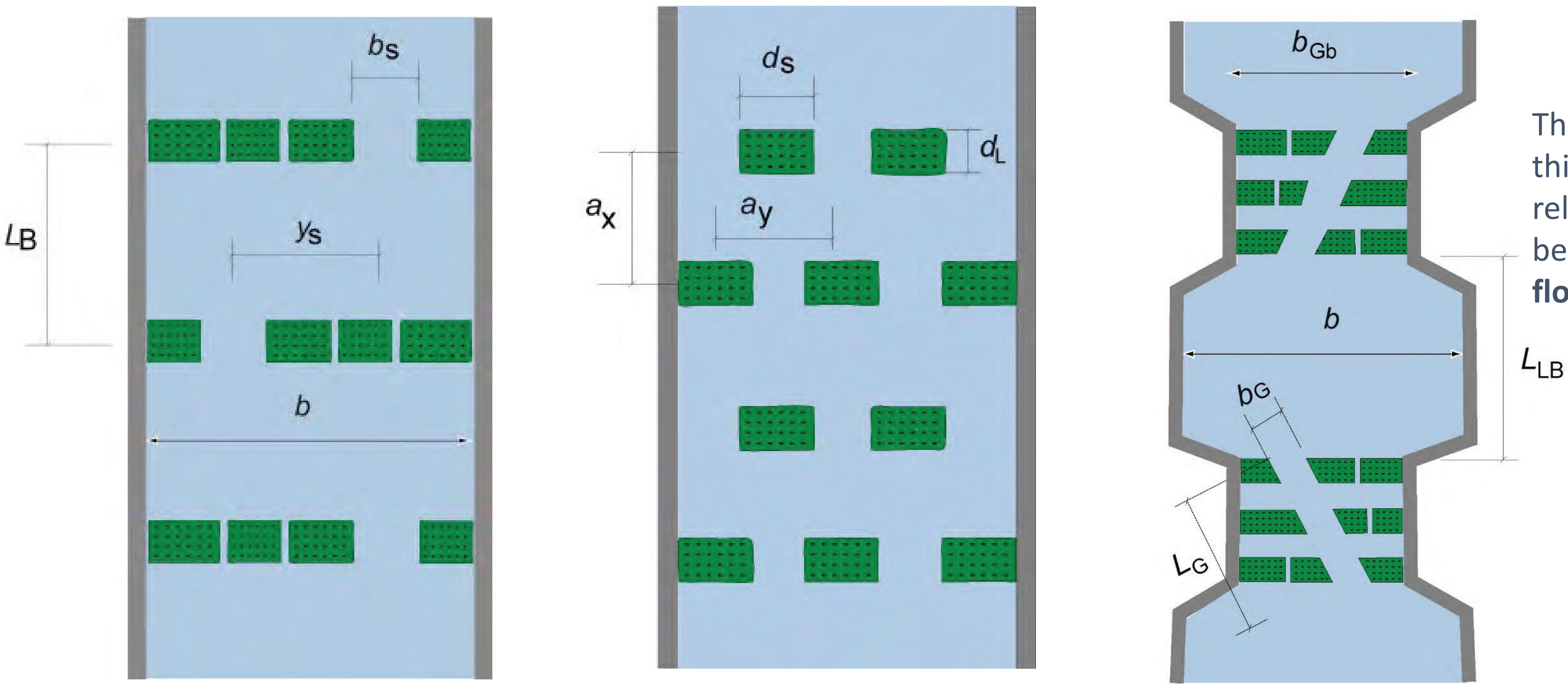
Brush Fish Pass

The technique of using brush elements as hydraulic-energy absorbers in fish passes had been first applied in 2002. Meanwhile around 60 sites are in operation. During that time, more operating experience and functional results were achieved.

Brush Fish Pass in Hann-Münden

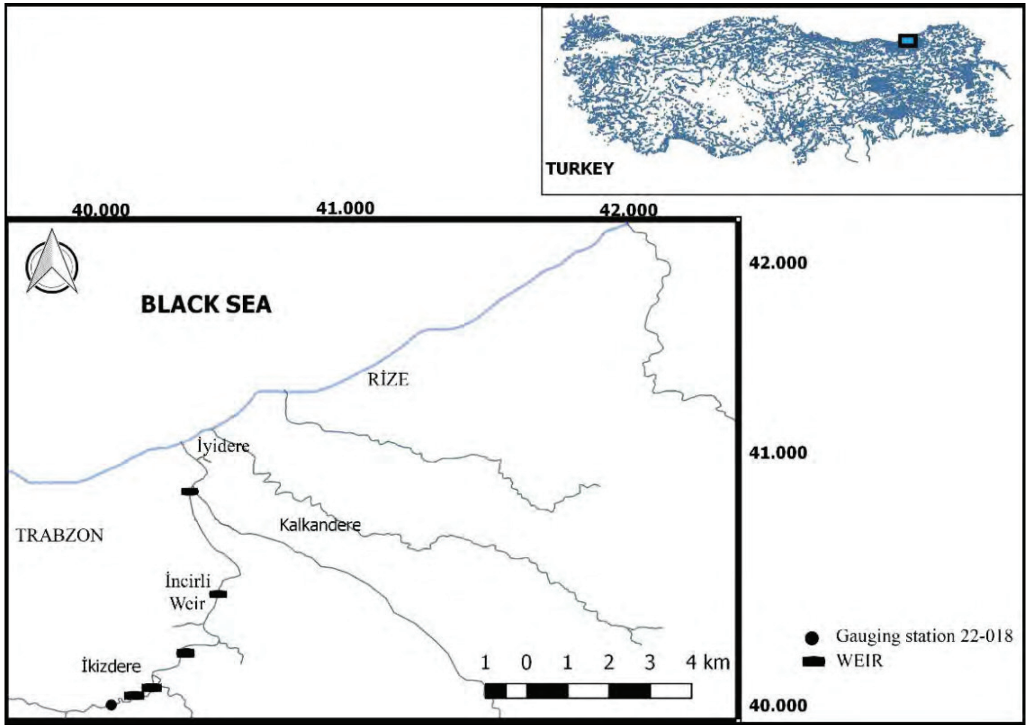
There are three types brush arrangement: TYPE A, TYPE B, and TYPE C (DWA, 2014)



The velocity inside this channel is relatively small because of **lateral flow effects.**

Prototype Measurements: Iyidere Project

The proposed project aims to investigate the relationship between the hydrodynamics and fish behavior (fish entrance, migration corridors and resting areas) characteristics of brush fish passage



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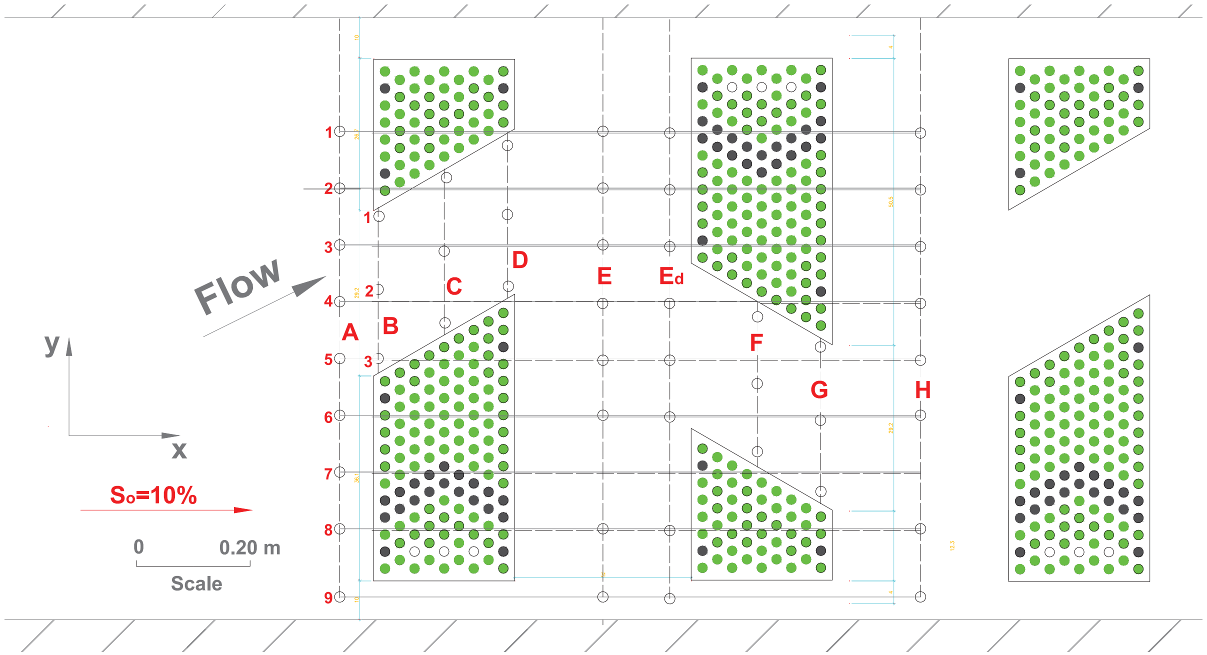
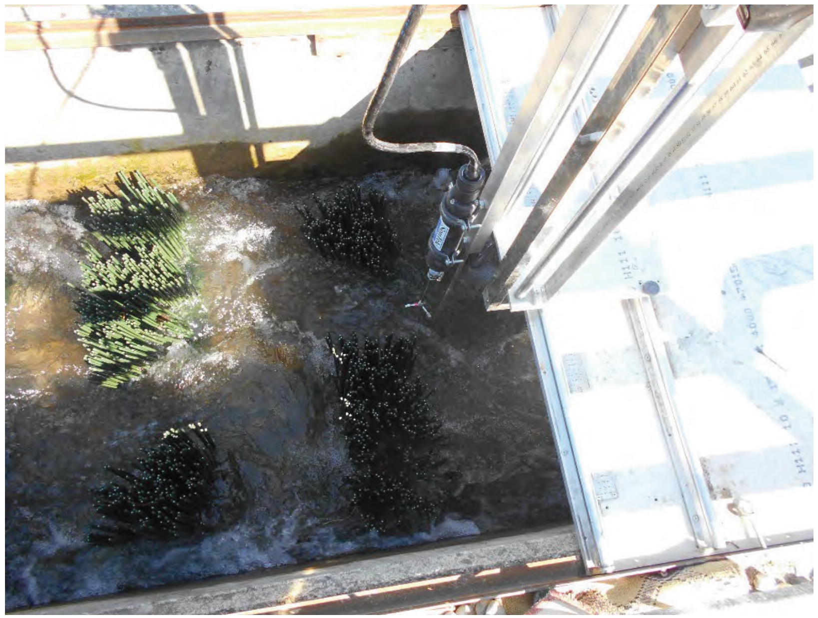
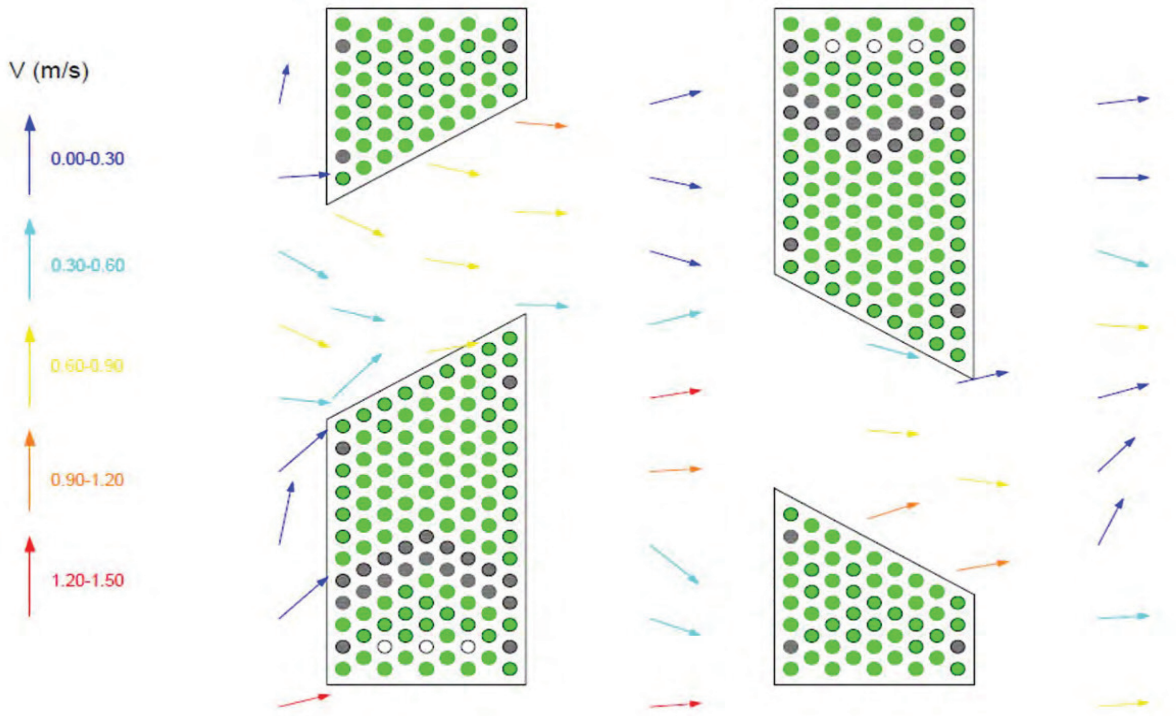
Construction of Brush Fish Pass

Measurement Grid for ADV



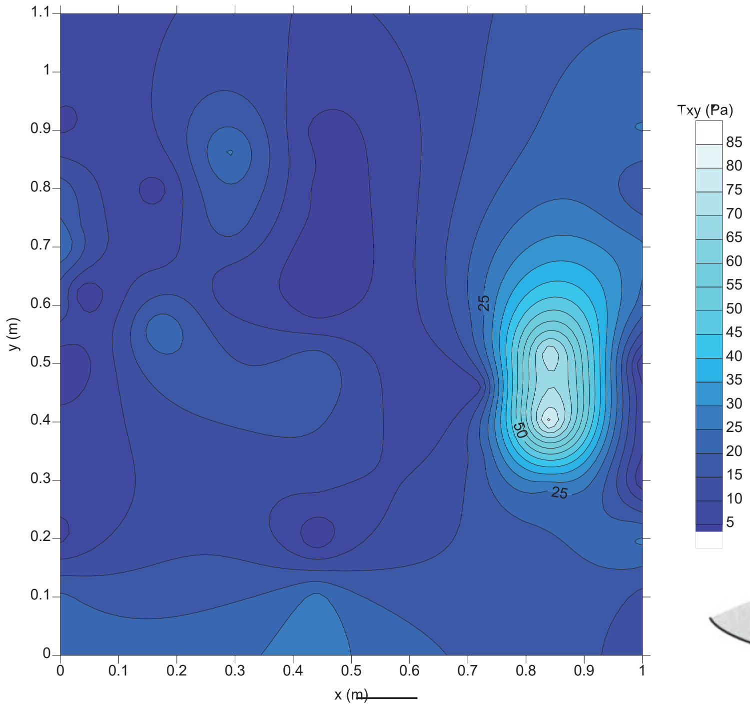


Velocity Field Around Brush Blocks (Field Study)

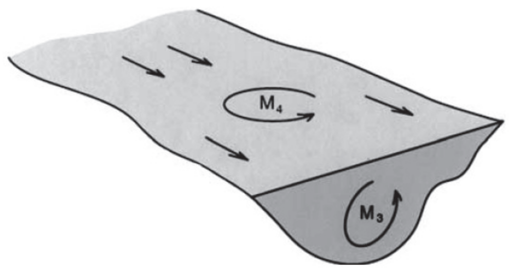


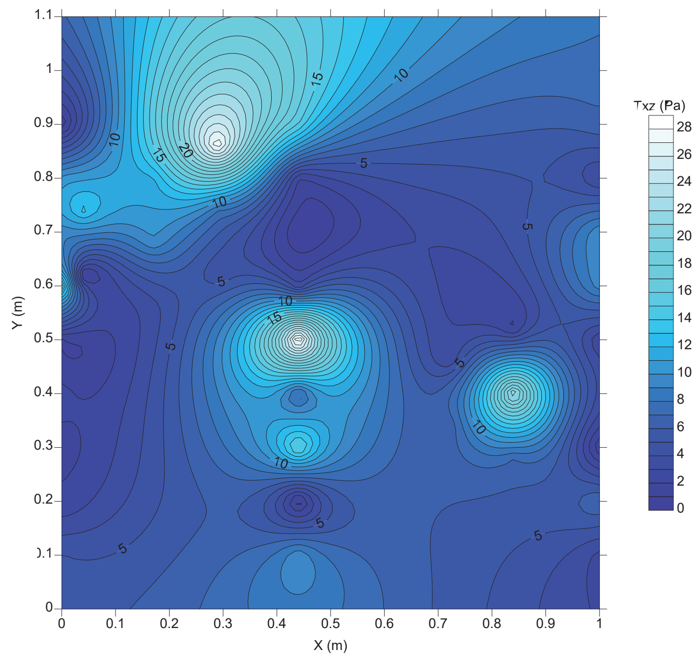
Maximum velocity is reduced about 30% with respect to pool-orifice type

Reynolds Shear Stress Distributions



$$\tau_{xy} = -\rho \overline{u'v'}$$



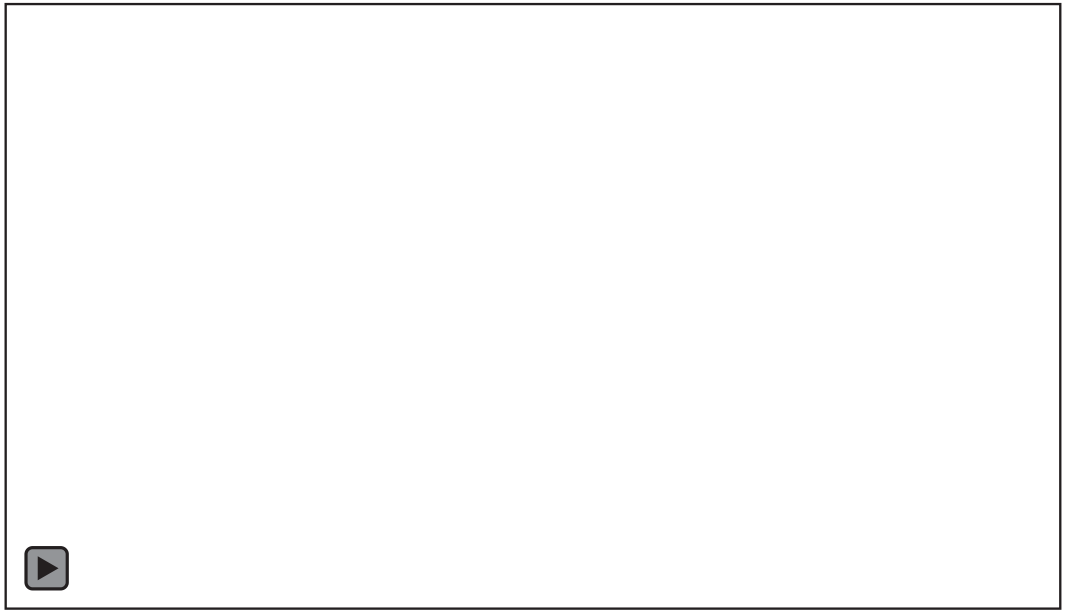


$$\tau_{xz} = -\rho \overline{u'w'}$$

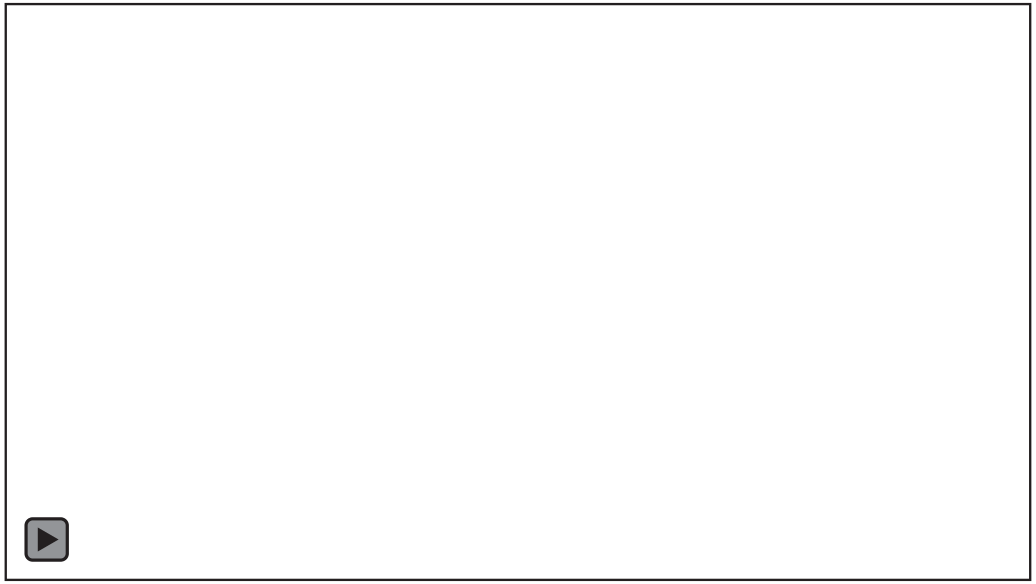
Flow patterns (S flow) in the diagonal brush fish pass

$$St = \frac{U_a}{D \times w_b}$$

This flow pattern may have important implications for upstream fish migration.

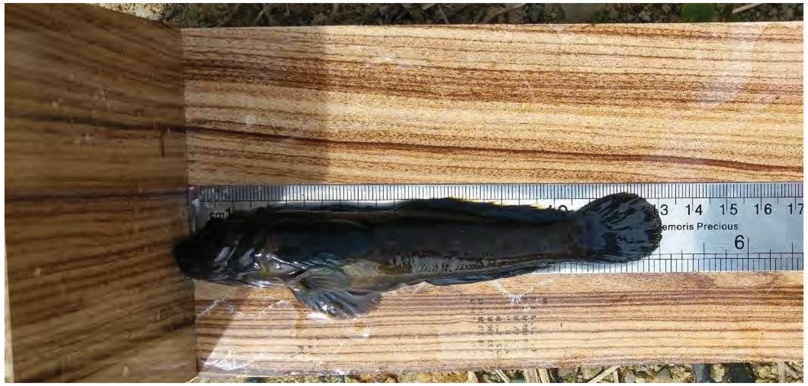


Horizontal turbulent momentum exchange which matches the body undulation of the swimming fish can be more beneficial for fish passage than vertical momentum exchange



Fish would occupy positions with energetically hydrodynamic conditions that are likely to minimize swimming costs

PIT Telemetry: Tagged Fish



Ponticola rizeensis

Salmo coruhensis

Alburnoides fasciatus

Barbus tauricius

Sea trout (*Salmo coruhensis*)

Alburnoides fasciatus

Fish Pass Structure Connection to River

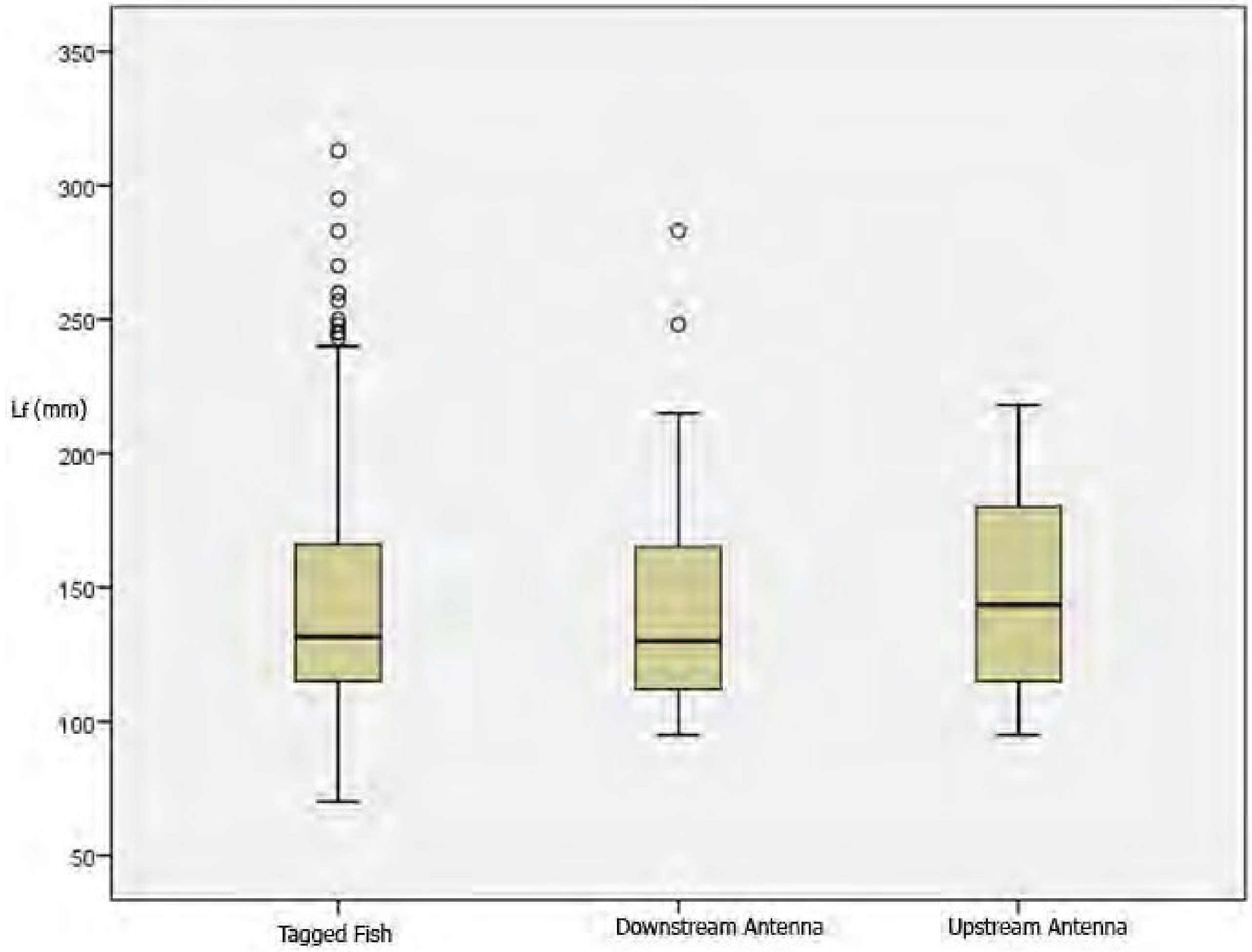
Fish Pass Entrance

Passage Efficiency for Different Fish Species

Species	Tagged Fish	Detected Fish Downstream Antenna	Detected Fish Upstream Antenna	Passage Efficiency (%)
SÇ	**55**	**17**	**14**	**82.35**
A	96	32	18	56.25
B	99	13	8	61.54
C	18	4	4	100.00
S	40	8	7	87.50
P	65	8	4	50.00
Total	373	82	55	**67.07**

Fish Species: SÇ: Salmo çoruhensis; A: Alburnus fasciatus; B. Barbus tauricus; C: Capoeta sp S: Squalius sp.; P: Ponticola rizeensis

Fish Body Length Distributions



Computer Vision: Fish Detection

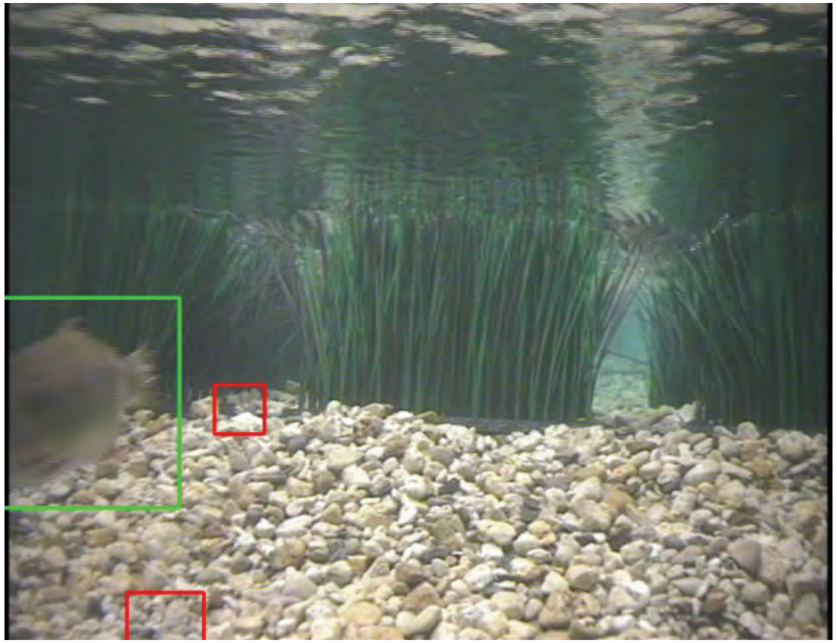
- Proposed model:

- Preprocessing:
  - Gamma (γ) correction: $$\gamma = \frac{\mathrm{d}\log(V_{\mathrm{out}})}{\mathrm{d}\log(V_{\mathrm{in}})}$$

Computer Vision: Fish Detection

- Candidate dynamic regions are classified for fish detection:
  - (a) Foreground mask image found after the background subtraction step.
  - (b) Result of our fish detection framework where green rectangle represents regions classified as fish and red rectangle represents candidate regions that are classified as background.

(a)



(b)

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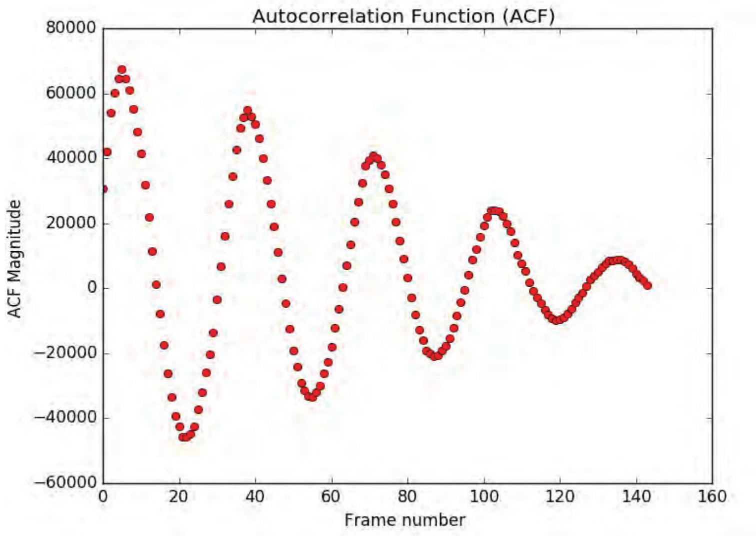
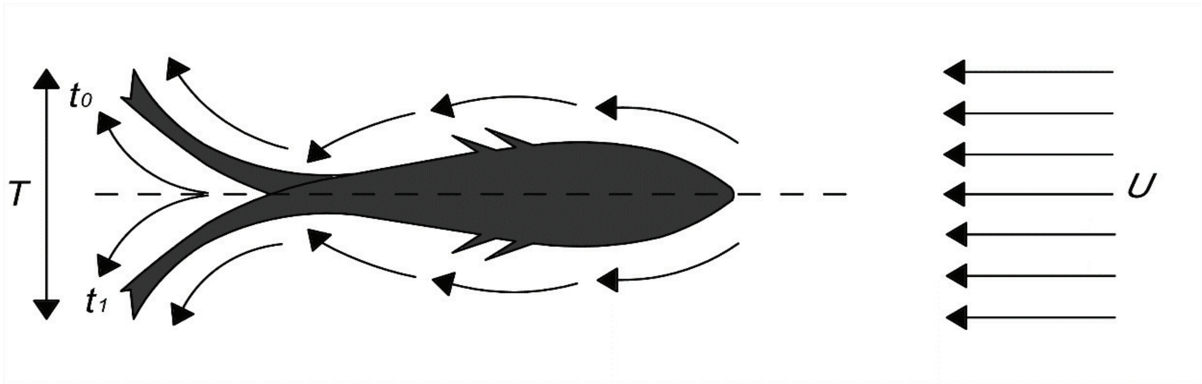
Computer Vision: Fish Tail Beat Frequency Estimation

- Auto-correlation Function (ACF):
  - Similar to AMDF, ACF shows periodic patterns for periodic inputs.





1 Günay, O., Taşdemir, K., Töreyin, B. U., & Çetin, A. E. (2009). Video based wildfire detection at night. Fire Safety Journal, 44(6), 860-868.

Fish Tail Beat Frequency

Free stream

Vortex street

Kármán Gait

Liao et al. (2003) J Exp Biol 206

Videos from http://jeb.biologists.org/content/206/6/1059/suppl/DC1

Fish Trajectory and Tail Beat Frequency

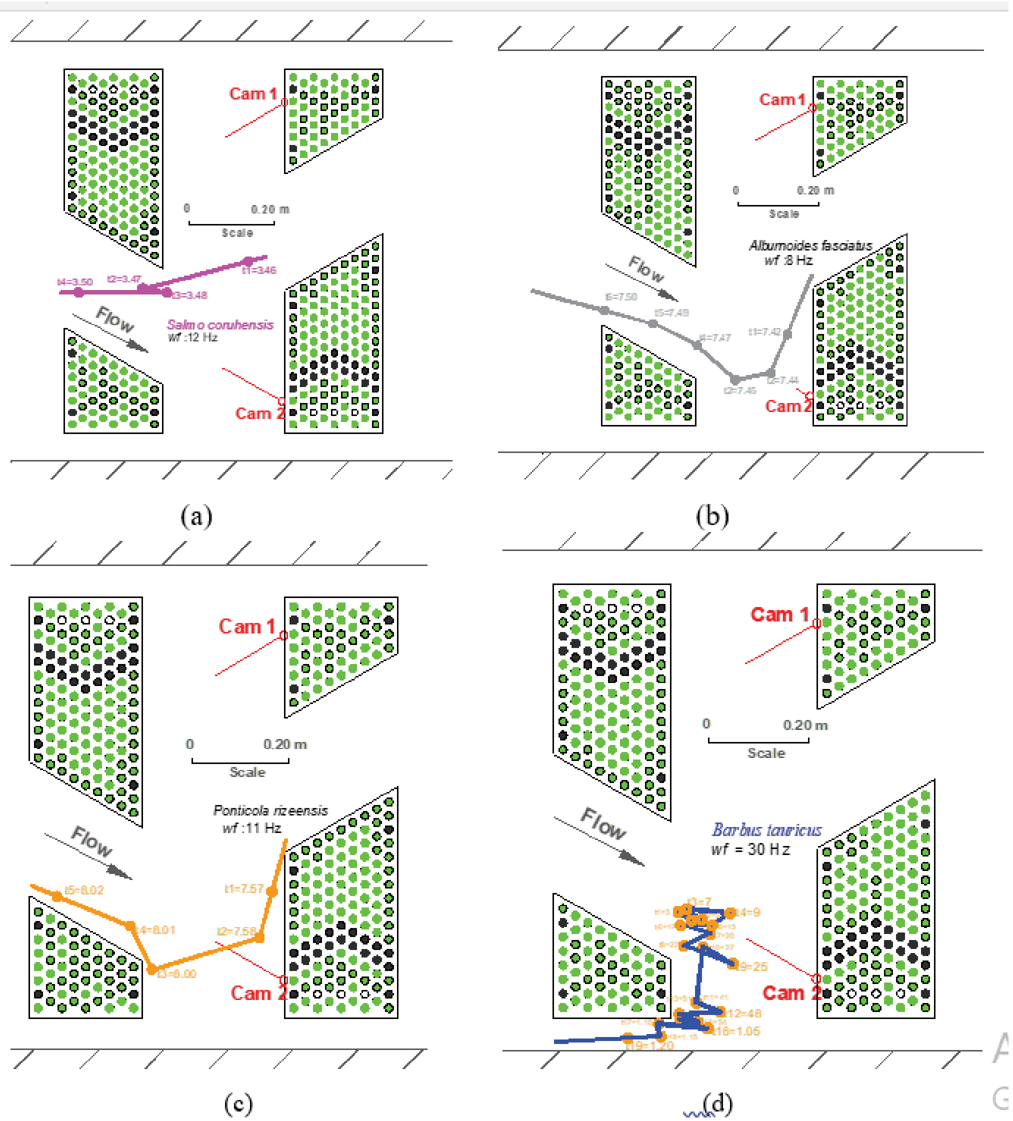
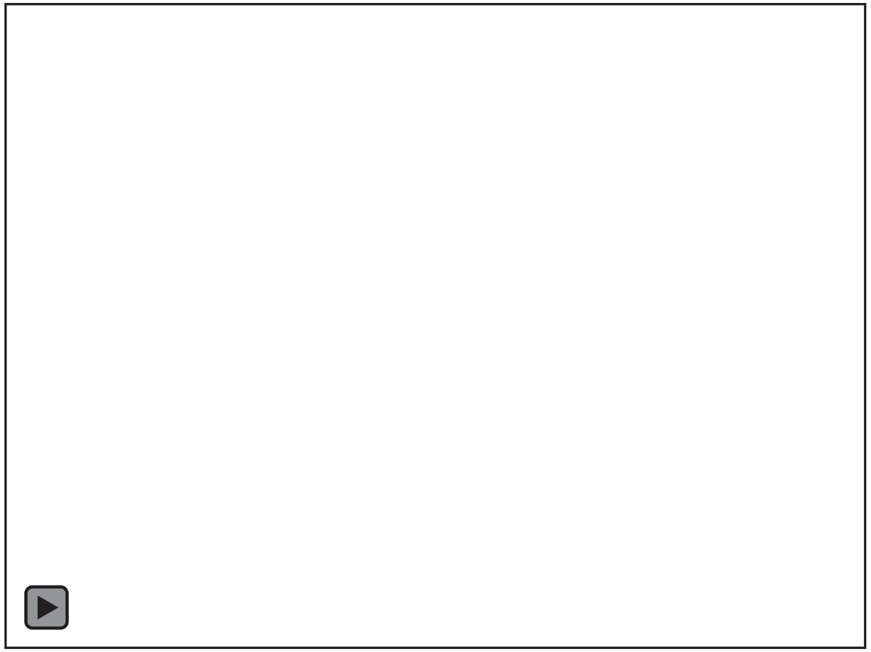


	Figure 5a	Figure 5b	Figure 5c	Figure 5d
Tail-beat frequency (Hz)	12	8	11	30
Fish velocity (m/s)	0.2	1	0.7	0.25
Tail-beat amplitude (m)	0.026	0.005	0.008	0.017
Strouhal number	1.56	0.04	0.13	2.10



Summary

- The brush fish pass represents a good option for fishways in small river basins. In a high-gradient channel with a bed slope of 10%, the maximum measured velocity of 1.5 m/s is 30% less than that of vertical-slot and pool-weir fishways.
- Behind the brush blocks, fish are not subject to considerable turbulent shear forces, and those regions are thought to be resting areas for fish.
- Diagonal fish pass provides several migration corridors which are suitable for multiple fish species with different preferences.
- The cleverness of the fish is used to seek the convenient corridors (S flow, horizontal momentum exchange) and to avoid zones not suitable for their migration preferences.
- Fish energy expenditure (i.e. fish tail beat frequency) and fish behavior is crucial in order to evaluate fish pass structures.