Re-connecting Rivers through Step-pool Nature-like Fishways (NLFs)

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What are NLFs?

- The concept of NLFs is to design a structure that mimics the natural riverine ecosystem and enables the passage and inhabitation of diverse aquatic organisms in the most efficient manner
- NLFs are nature-based solutions for re-connecting rivers and restoring freshwater eco-systems.
- NLF utilizes natural boulders, cobbles, gravel and sand. A wide range of substrates and varying flow conditions in step-pools facilitate the inhabitation, migration, and dispersal of diverse aquatic species.

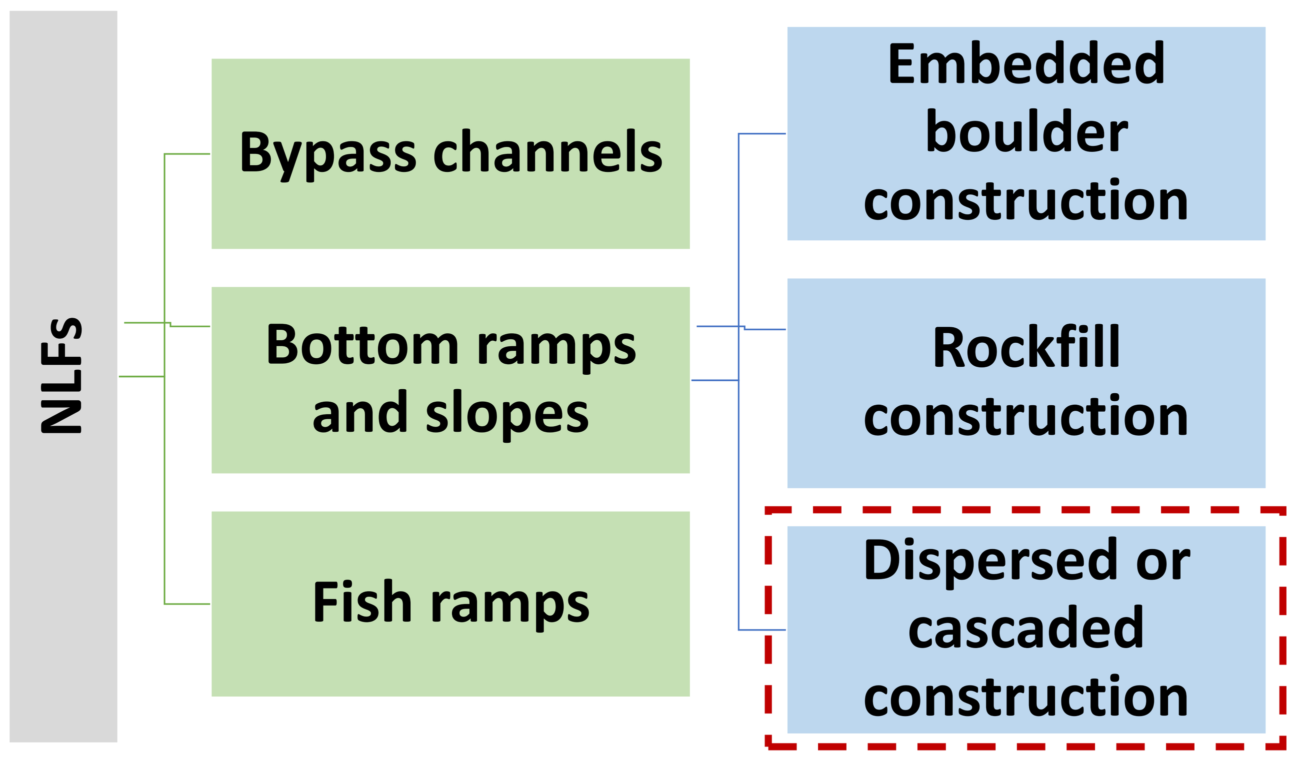

Fig. 1. Classification of NLFs. Step-pool NLFs fall under the dispersed or cascaded construction of bottom ramps NLFs.

Design criteria: Step-pool NLFs

- There are limited guidelines available for the design of step-pool NLFs.
  - A. Min. dimensions[1] →
  - B. Bed slope[2] – b/w 1:20 & 1:30
  - C. Max. velocity[2] - 2 m/s
  - D. Max. drop per pool[2] - 0.20 m
- However, it is imperative to design the fishway for optimum levels of turbulence kinetic energy and energy dissipation factor that are indicators of the local and global turbulence in the fishway respectively.

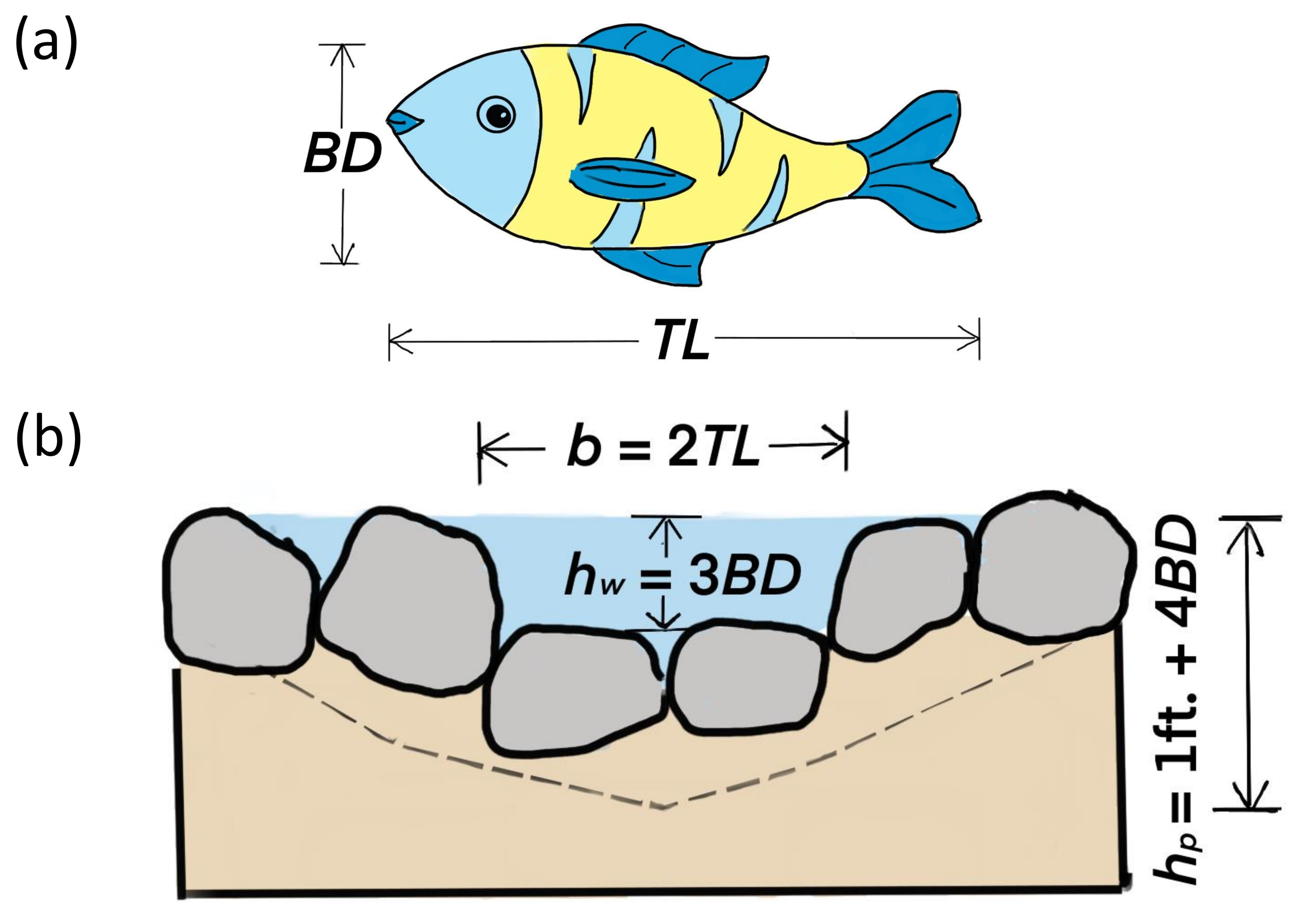

Fig. 2. (a) Body measurements of the largest target species, (b) Weir section of step-pool NLF, where b = weir opening width, h_w = weir opening depth, h_p = pool depth

References

1. Turek, J., Haro, A. & Towler, B. (2016). Federal Interagency Naturelike Fishway Passage Design Guidelines for Atlantic Coast Diadromous Fishes. Interagency Technical Memorandum, US.
2. FAO, DVWK (2002). Fish passes -Design, dimensions and monitoring, Food and Agriculture Organization of the United Nations (FAO) in arrangement with Deutscher Verband für Wasserwirtschaft und Kulturbau e.V. (DVWK) (German Association for Water Resources and Land Improvement), Rome.
3. Indra, T. J. and Raghunathan, M. B. (2007). Ichthyofauna of Indira Gandhi Wildlife Sanctuary, Tamil Nadu. Records of the Zoological Survey of India Occasional Papers, 277, pgs. 58.

Hydraulic performance evaluation

- Target species – Ichthyofauna of Indira Gandhi Wildlife Sanctuary, Western Ghats, India[3].
- The step-pool NLF was designed based on the body measurements of the largest fish in the target population (*Ompok bimaculatus*, 474 mm SL).
- The fishway hydraulics varies with discharge (Q) and the ratio of the weir opening width (b) to the width of the channel (B).
- Experimental and Numerical Study with variables b/B and Q.

Fig. 3. Physical model of step-pool NLF. A model scale of 1: 4 was chosen. The step-weir arches in the upstream direction. Experiments are conducted at the Hydraulics Laboratory of IIT Madras

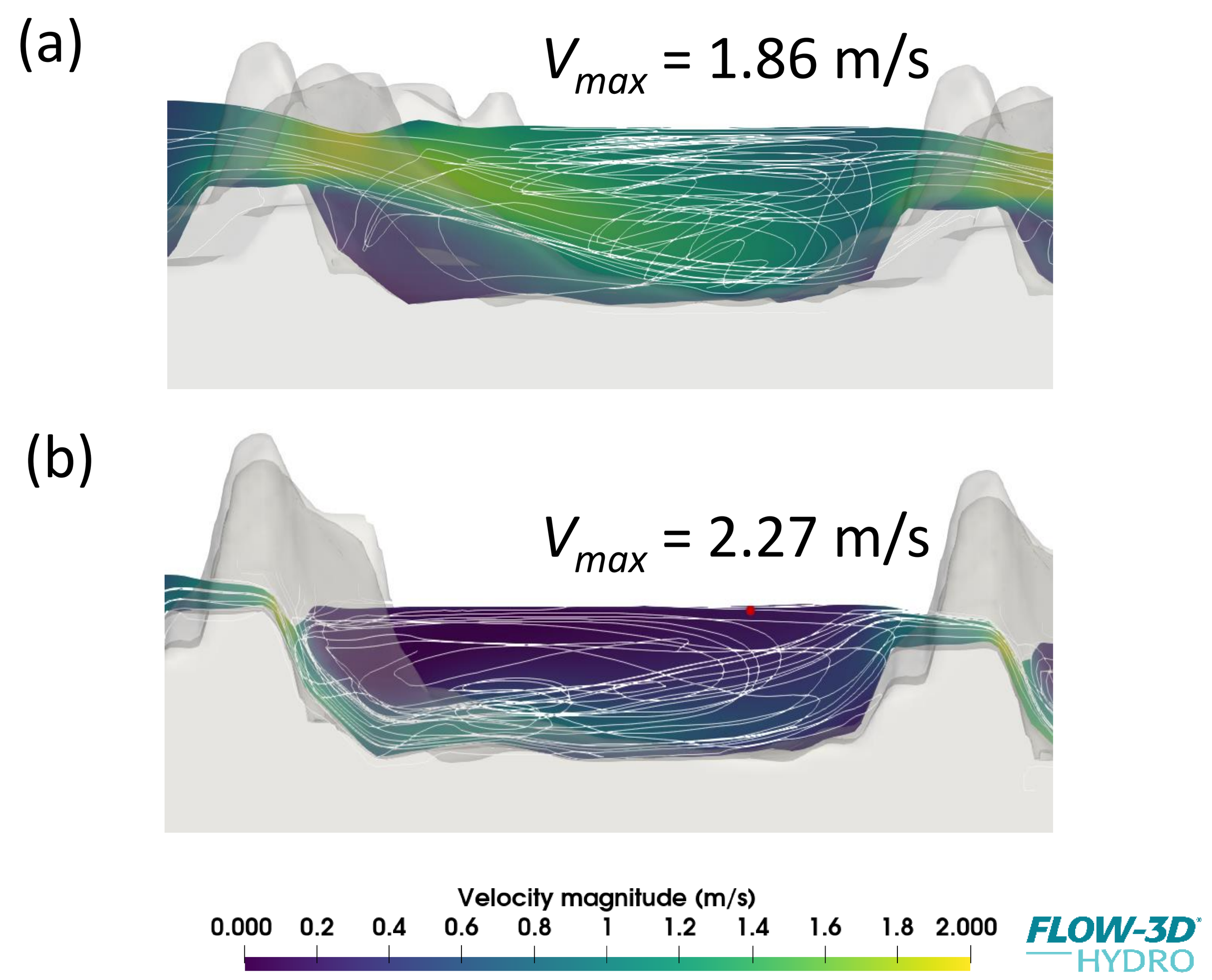

Fig. 4. The contour of velocity magnitude along the centreline of step-pool NLF at Q = 0.5 m^3/s for b/B: (a) 0.30, and (b) 0.70. The former provides sufficient flow depth and acceptable velocity ranges.

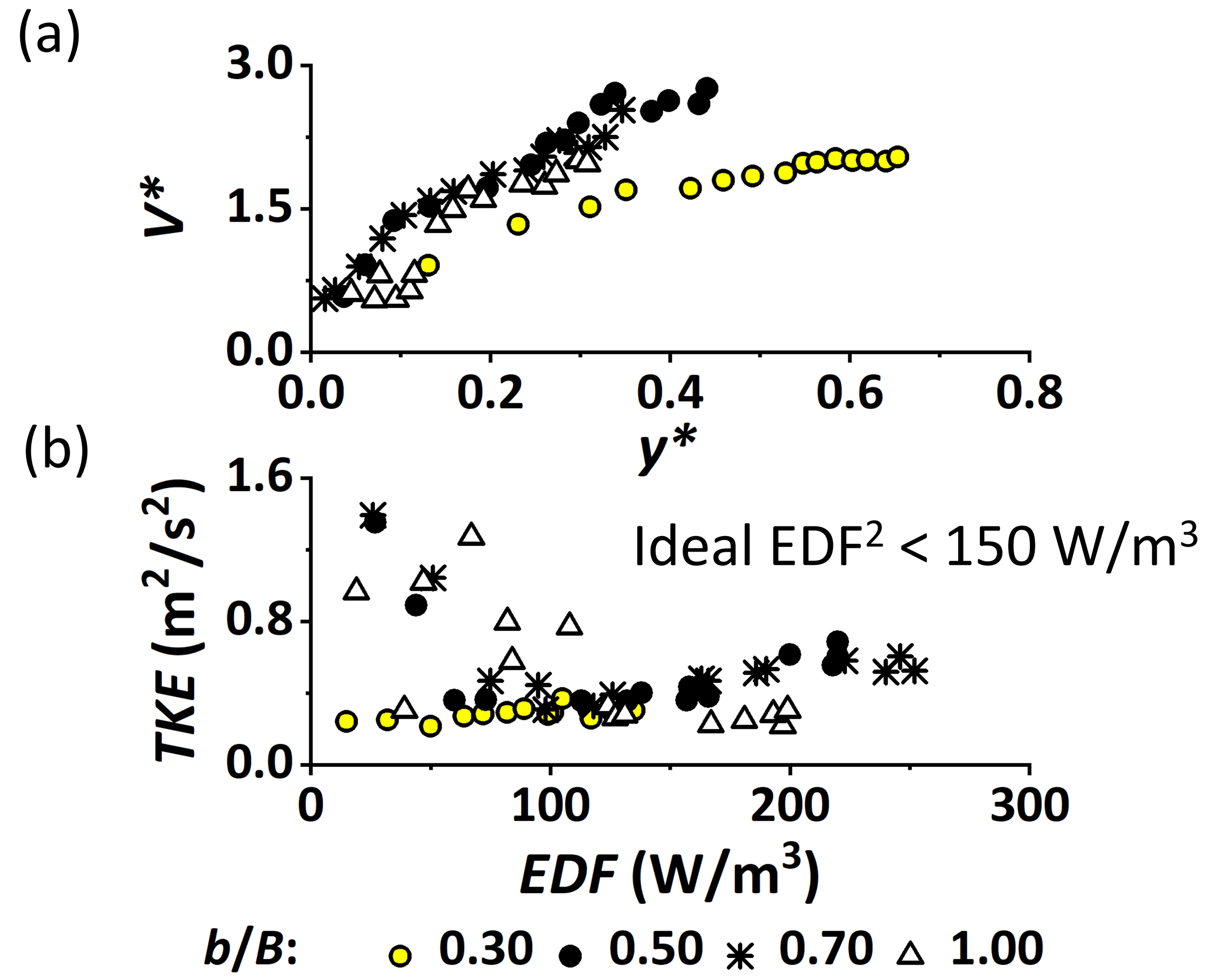

Fig. 5. Variation of (a) V^* with y^*, and (b) TKE with EDF. The dimensionless depth, dimensionless velocity, turbulent kinetic energy and energy dissipation factor are calculated as $y^* = y/b$, $V^* = V/(gbS_0)^{0.5}$, $TKE = 0.5(u_i'^2+u_j'^2+u_k'^2)$ and $EDF = \gamma Q \Delta H/\forall$, where y, V, S_0, u', ΔH, and $\forall$ are the flow depth above weir crest, velocity of flow over crest, bed slope, fluctuating velocity component, drop per pool and volume of pool, respectively.

Conclusions

Minimum levels of turbulent kinetic energy and energy dissipation factors provide suitable hydraulic conditions for efficient fish passage. In the present study, the optimal conditions were obtained for the step-pool NLF with a weir opening width to channel width ratio of 0.30.