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Session A2- Simple drag force and energy calculations for fish passage through a model a steeppass

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Simple Drag Force and Energy Calculations for Fish Passage Through a Model A Steeppass

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Photo Credit: USFWS
Model “A” Steeppass Design

- designed by Ziemer in 1962 to pass salmonids
- baffle (Denil) type fishway
- prefabricated 27-inch high, 18-inch wide, 10 foot long sections
- highly portable and inexpensive
- suited to small streams and low head dams

Photo Credit: USFWS
Model “A” Steeppass Design

Each unit consists of:
- Six top straps
- One left side panel
- One right side panel
- One bottom panel
- Three joint plates

Rivets, bolts and welding

G. L. Ziemer, P.E.
Alaska Department of Fish and Game
Division of Engineering and Services
April 27, 1962

Plan

Elevation

Steeppass Model A

Figure 2
Recommended Operating Range

- Head – 13” to 24”
- Slope – 1:10 to 1:3

Results in….
- Bulk Velocity ~1.5 to 4 ft/s
- Discharge ~1.5 to 8 cfs
- Capacity~750 migrants per hour

Photo Credit: USFWS
Steeppass Model A Velocity vs. Head for Standard Slopes

*Data complied from Ziemer (1962) and Odeh (1993).*
Steeppass Research

• 1D hydraulic characteristics
  – head and velocity relationships
  – centerline velocity profiles
• Passage rates
  – good for salmonids
  – not good (or unknown) for other species, i.e. American Shad, Blueback Herring
Simple Drag Force Calculation

\[ R_{L_{fish}} = \frac{V_{fw} \times L}{v} \]

\[ C_D = 1.2 \times (0.455/(\log R_L)^{2.58}) \]

\[ D = C_D \times \rho \times S \times \frac{V_{fw}^2}{2} \]
Drag Force on Blueback Herring vs. Head for Standard Slopes

![Graph showing drag force on blueback herring vs. head for different slopes.](image)
Energy (Work) Calculation

\[ F = D + W \sin \theta \]

\[ P_{wr} = F \times V_{fw} \]

\[ E = F \times L \]
Energetic Costs for Blueback herring Ascending 10-foot Model A Section at Standard Slopes
Energy Example

• 1:8 Slope
• 5.0 cfs
• 2.5 f/s
• 2.82 ft-lbf

• 1:4 Slope
• 1.5 cfs
• 2.5 f/s
• 3.35 ft-lbf

Nearly a 20% increase in energy required for the same bulk velocity.

Photo Credit: http://www.chesapeakebay.net
Major Assumptions

- Due to 1D approximation, passage pathway is not accounted for.
- Constant swimming speed is assumed due to lack of data for fish swimming in Steeppass.
- Model neglects effects of turbulence and air entrainment.

Photo Credit: USFWS
Future Work

• Computational Fluid Dynamics (CFD) model of Steeppass fishway
• Steeppass swimming study required to define swimming pathways for target specie
• Fish swimming cost in turbulence for target specie
CFD Model
(preliminary results)
Research Challenges

• Cost of swimming in turbulence unknown for most species

• High air entrainment makes observations of fish swimming and measurement of velocities difficult

Photo Credit: http://luirig.altervista.org
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