Arctic Grayling and Denil Fishways: A Study to Determine How Water Depth Affects Passage Success

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Arctic Grayling and Denil Fishways: A Study to Determine How Water Depth Affects Passage Success

Denil in Field

Denil in Lab

- Erin Ryan, BFTC-USFWS
- Matt Blank, WTI-MSU
- Kevin Kappenman, BFTC-USFWS
- Owen Dudley, MSU
Arctic Grayling and Denil Fishways
Thanks to Funders, Partners and Key People

Key Agencies and Partners
• AGRP
• USFWS
• BFTC
• MSU, Civil Engineering Department
• MSU, Ecology Department
• MSU, Western Transportation Institute
• Montana FWP
• Montana DNRC
• NRCS
• Private Landowners
• Others

Key People
• Emma Cayer
• Jim Magee
• Mike Roberts
• Jacqueline Knutson
• Kale Gullet
• Steve Becker
• Bob Muth
• Bill Rice
• Matt Toner
• Jason Ilgen
• Buddy Drake
Study Purpose and Background
Arctic Grayling and Denil Fishways

Purpose

The purpose for this study was to determine the optimum water depth or depth range for passage of Arctic grayling through Denil fishways.

Knowing what depths provide the “best” passage will help manage the operation of the fishways - especially during water limited periods.
Arctic Grayling and Denil Fishways

Background

- Present field installations use either 6-foot or 12-foot long ladders set with a 1-foot vertical drop.
- There are 63 installed in Big Hole, with plans for more.
- The Denils are a type of “Simple” Denil.
Methods
Arctic Grayling and Denil Fishways

Methods

- **Target for each length (6- and 12 foot):**
  - 18 treatments per ladder
  - 3 different water depths at approach (6, 12, and 18 inches)
  - 6 depths at first notch for each approach depth (1.5, 2.5, 4, 6, 10 and 14 inches)
  - One control without ladder

*Arrow is flow direction.*
Arctic Grayling and Denil Fishways Methods

Section A – A’

6 inch approach depth

1.5 inch entrance depth
Arctic Grayling and Denil Fishways
Methods

Section A – A’

6 inch approach depth

2.5 inch entrance depth
Arctic Grayling and Denil Fishways

Methods

Section A – A’

6 inch approach depth

4.0 inch entrance depth
Arctic Grayling and Denil Fishways Methods

Section A – A’

6 inch approach depth

6.0 inch entrance depth
Arctic Grayling and Denil Fishways

Methods

Section A – A’

6 inch approach depth

10 inch entrance depth
Arctic Grayling and Denil Fishways

Methods

Section A – A’

6 inch approach depth

14 inch entrance depth
Arctic Grayling and Denil Fishways
Methods

- Grayling were raised at BFTC. Fish were same size class, ~12 inches.
- Fish movements recorded by PIT array and video cameras. Ten fish per treatment.
- 2 hours per treatment. Time based on pilot studies and volitional study (2015).
- All treatments done at ~12 C (optimum temperature for grayling).
Arctic Grayling and Denil Fishways

Methods

- Characterized hydraulic environment by collecting water depths, velocities, and stage heights.
- Monitored flow and temperature continuously.

*Arrow is flow direction.*
Arctic Grayling and Denil Fishways Analysis

- Characterized flow environment using hydraulic computations and modeling
- Evaluated data using basic statistics
- Developed logistic regression models
Arctic Grayling and Denil Fishways Analysis

- Analysis focused on exploring relationships between passage success and:
  - Water depth
  - Water depth ratios
  - Velocities
  - Flow
Results
Arctic Grayling and Denil Fishways

Results

In the 6-foot Denil

- 130 grayling attempted passage
- 71 passed (55%)
- 59 failed (45%)
Arctic Grayling and Denil Fishways Results

WATER DEPTH AT NOTCH (IN)

% PASS

6-Foot Long Denil

- 6-inch Approach Depth
- 12-inch Approach Depth
- 18-inch Approach Depth
Arctic Grayling and Denil Fishways Results

6-foot Denil

Water Depth (in)

Depth_Fail

Depth_Pass

P=0.5785
Arctic Grayling and Denil Fishways Results

Velocity (ft/s)

6-foot Denil

Velocity_Fail

Velocity_Pass

P < 0.001
Arctic Grayling and Denil Fishways

Results

6-foot Denil

Flow (gpm)

Flow Fail

Flow Pass

P<0.001
Arctic Grayling and Denil Fishways Results

6-foot Denil

Depth Ratio (ft/ft)

Depth Ratio_Fail

Depth Ratio_Pass

P < 0.001
Arctic Grayling and Denil Fishways Results

![Graph showing passage probability vs. depth ratio for 6-foot Denil fishway. The graph indicates that the model correctly predicts passage success with 95% accuracy and incorrectly predicts passage success with 5%.]
Arctic Grayling and Denil Fishways Results

In the 12-foot Denil

- 138 grayling attempted passage
- 82 passed (59%)
- 56 failed (41%)
Arctic Grayling and Denil Fishways Results

12-Foot Long Denil

% PASS

WATER DEPTH AT NOTCH (IN)

- 6-inch Approach Depth
- 12-inch Approach Depth
- 18-inch Approach Depth
Arctic Grayling and Denil Fishways Results

Water Depth (in)

12-foot Denil

Depth_Fail

Depth_Pass

P=0.8871
Arctic Grayling and Denil Fishways

Results

12-Foot Denil

Velocity (ft/s)

Velocity_Fail

Velocity_Pass

P < 0.0015
Arctic Grayling and Denil Fishways

Results

12-Foot Denil

Flow (gpm)

Flow_Fail Flow_Pass

P < 0.0001
Arctic Grayling and Denil Fishways Results

12-foot Denil

P<0.0001
Arctic Grayling and Denil Fishways
Results

- Model correctly predicted passage success: 86%
- Incorrectly predicted passage success: 14%
Summary and Implications
Arctic Grayling and Denil Fishways
Summary and Implications

- Velocity, flow and depth ratio were significantly different between pass and fail to pass for both size structures.
- Best model for passage success was ratio of entrance depth and approach depth.
- Plunging flows should be avoided, best passage was during streaming flows.

Diagram showing the approach depth and entrance depth with a section labeled A - A'.
Plunging flows should be avoided, best passage was during streaming flows.
Arctic Grayling and Denil Fishways
Summary and Implications
Arctic Grayling and Denil Fishways
Summary and Implications

![Graph showing passage probability and depth ratio for 6-foot and 12-foot Denil fishways. The graph illustrates the relationship between passage probability and depth ratio, with curves for 12-foot and 6-foot Denil fishways. The passage probability increases as the depth ratio increases, with the 12-foot fishway having a higher passage probability than the 6-foot fishway at the same depth ratio.](Image)
Future Research: Two New Studies
The Team:
- USFWS, MSU, MFWP
- DNRC, NRCS, Land Owners
  - Katey Plymesser, PI
  - Tyler Blue, Grad Student
  - Matt Blank
  - Kevin Kappenman
  - Erin Ryan
  - Joel Cahoon

The Question:
- Do flow control devices affect passage success?

The Lab Study:
- Evaluate four different flow control devices
Denil Projects (2017-2019)

Landscape Level Study of Denils: Big Hole Watershed

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Denil Projects (2017-2019)
Landscape Level Study of Denils: Big Hole Watershed

This study will evaluate 63 Denil structures in the field to determine conditions that prevent, limit or allow passage.
Thanks!