Evaluation of Volitional Entry and Passage of Adult Pacific Salmonids through a Novel Fish Passage Technology

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Overview

- Publication in Review: *Garavelli, L.J., T.J. Linley, B.J. Bellgraph, B.M. Rhode, J.M. Janak, and A.H. Colotelo. In Review. Evaluation of Volitional Entry and Passage of Adult Pacific Salmonids Through a Novel Fish Passage Technology. Submitted to Fisheries Research.*
- Introduction
  - Background and Objectives
- Methods
  - Study Site Setup
  - Experimental Procedure
  - Fish Assessment
  - Analysis
- Results
- Discussion, Caveats, Next Steps

Introduction

- Problem(s):
  1. U.S. Department of Energy (DOE) mission to improve sustainability of energy generation while reducing environmental effects – e.g., improve fish passage to reduce effects of hydropower
  2. Whooshh Innovations goal to advance understanding of their technology to meet NMFS experimental fish passage approval process

- Solution:
  - Through DOE's Small Business Voucher Program, Whooshh won grant to advance commercialization of their newest volitional entry system and work toward DOE's energy/environmental mission by evaluating newest version of the WFTS.

- Publication Study Objectives:
  1. Investigate the feasibility of volitional entry and passage of adult Chinook salmon and steelhead
  2. Assess its effects on fish during their passage through the system

Study Site

- Ringold Springs Rearing Facility (Columbia River – Hanford Reach)
  - Fall Chinook salmon and steelhead return to hatchery via Ringold Springs
  - Swim 200 m upstream to a V-trap weir, then trapped within a collection pool

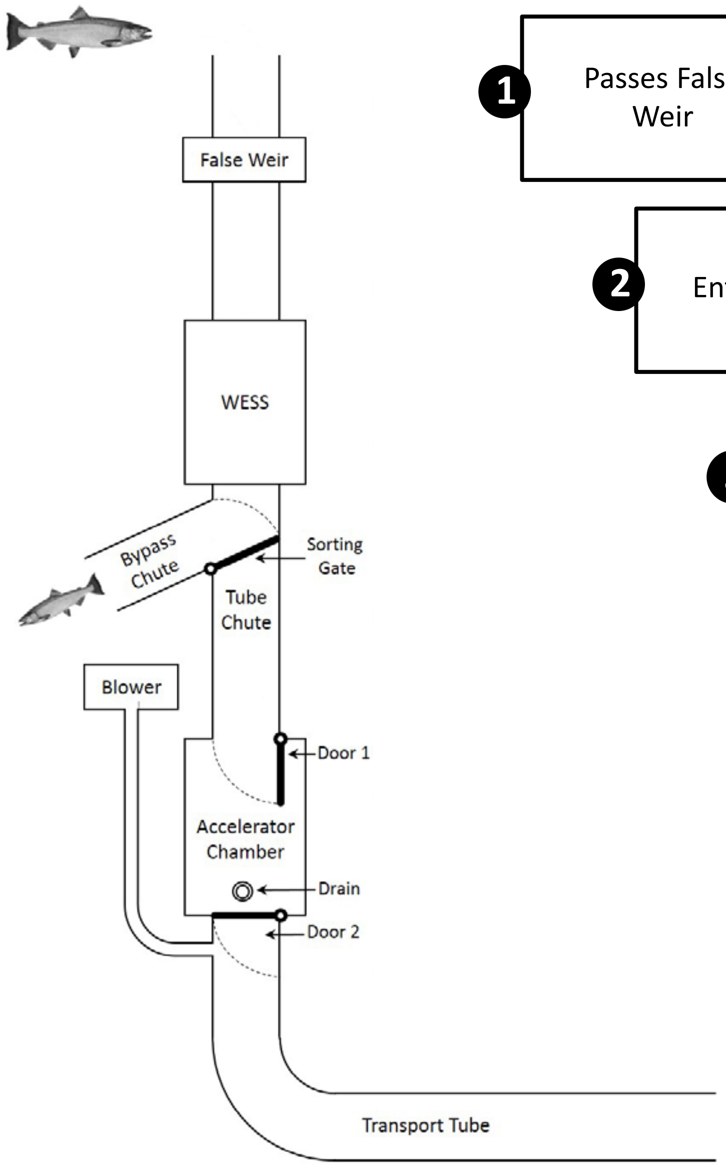
WFTS Setup

- Enter an Alaskan steeppass fishway volitionally
- Pass through a ‘flow box’ and false weir into camera chamber (Whooshh-Ellips Sorting System, WESS)
- Either diverted back to collection pool via bypass, or transported to an exit pool via Whooshh tube

Experimental Overview

- Treatments: 1) Control, 2) Scan/Sort to Bypass or WFTS tube
  - Reduced from 3 treatments due to low fish numbers
- 8 sampling days from 2 Oct – 7 Nov 2017
  - Low density required crowding fish to encourage passage
- Study analysis performed relative to manually measured gir
  - 85% body occlusion for WFTS transport (i.e., ~400 mm girth)
    - Based on length, width, height, girth
  - Girth > 400 mm → WFTS tube
  - Girth < 400 mm → Bypass
  - If < 0.5 seconds between fish, default to Bypass
- Exit pools:
  - WFTS tube: 5 m long, 2.5 m wide, 1 m deep
  - Bypass: 1.3 m long, 0.6 m wide, 0.8 m deep
- Visual Assessment of both Treatments

Experimental Schematic



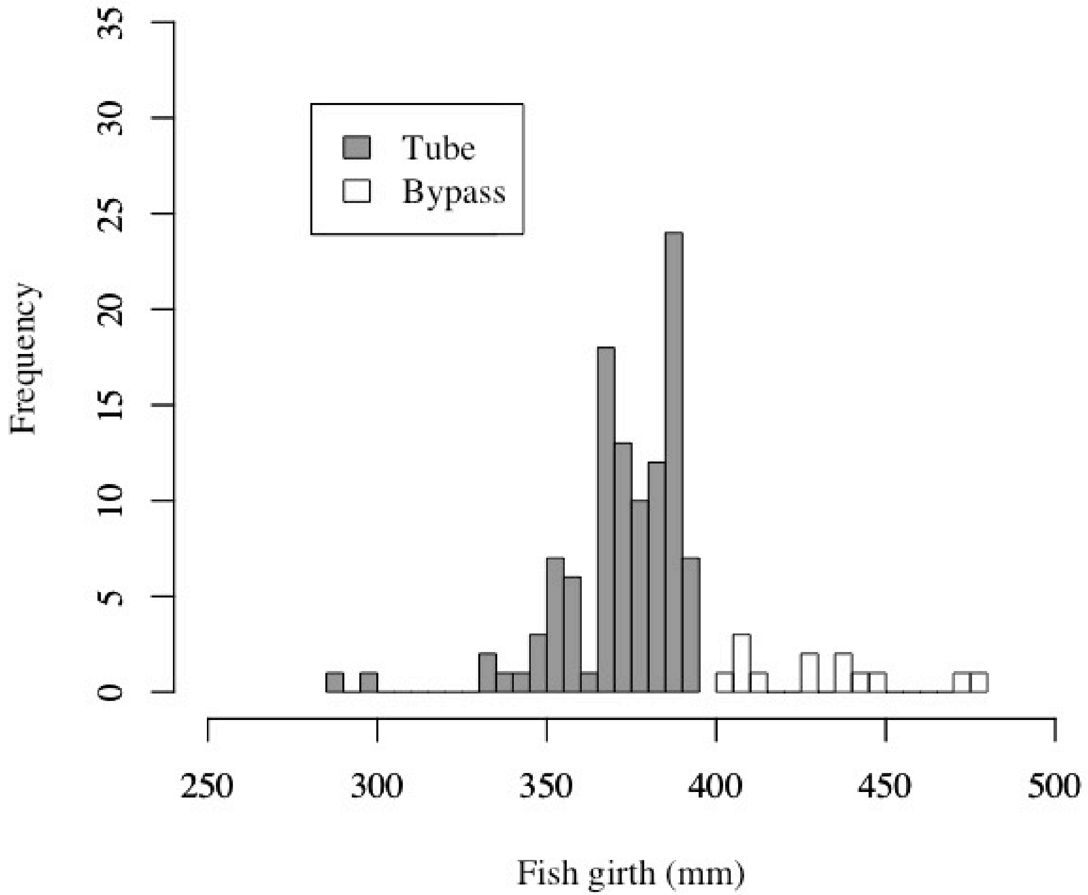
1. **Passes False Weir**
   - Sensor triggered
   - Scanner LED Relay turns ON
2. **Enters WESS**
   - Images captured and relayed to processing software where measurements are estimated
3. **Passes through Sorting Gate**
   - If conditions met, Sorting Gate opens to Tube Chute
   - If not, fish sent to Bypass Chute
4. **Enters Accelerator Chamber**
   - Door 1 and drain close
   - Blower turns on
   - Door 2 opens
5. **Accelerates through Transport Tube**
   - Fish pushed through lubricated tube by air pressure differential
6. **Exits Transport Tube**
   - Blower turns off after all fish have been transported
7. **Fish Assessment**
   - Length, girth, mass, sex, fungus coverage, overall external condition assessed
8. **Fish Released Post-Assessment**
   - Chinook salmon to hatchery
   - Steelhead to holding tank, then Columbia River

Fish Assessment and Analysis

- Assessment:
  - Sedated with 15 ppm Aqui-S 20E until Stage 4 anesthesia (about 2-3 minutes)
  - For Chinook: length, girth, mass, sex, fungus cover, and overall external body condition
  - For Steelhead: girth, condition, and sex
  - Chinook transferred to hatchery raceway; Steelhead back to Columbia River
- Unexpected Events:
  - Backward transport
  - Temporary stalling
  - Other
- Analysis:
  - Differences in girth, length, and mass between WFTS tube, Bypass, and Control using Kruskal-Wallis ranks
  - Pairwise comparisons using Dwass-Steel-Critchlow-Flinger test with alpha = 0.05

Results

- Scanned & Sorted: 298 Chinook, 85 Steelhead
  - 75% (n=225) of Chinook Tube-transported
  - 93% (n=79) of Steelhead Bypassed
- Control: 69 Chinook; no steelhead due to WDFW regulation
- Sorting:
  - Girth, length, and mass all significantly greater for transported fish compared to bypassed fish ($W \geq 60.8$, $p < 0.001$) and control fish ($W \geq 58.2$, $p < 0.001$)
  - Length and mass differed significantly between bypassed and control Chinook ($W \geq 6.7$, $p < 0.001$); girth did not ($W \geq 1.3$, $p = 0.62$)
  - 400 mm girth-defined criteria:
    - < 400 mm: 127 Tube-transported (1 Steelhead)
    - > 400 mm: 12 Bypassed (all Chinook)



Results

- Injury Assessment:
  - Chinook: only hemorrhaging of fins and eyes (*n* = 11)
  - Hemorrhaging in 6 of 225 Tube-transported (2.7%), 1 of 73 Bypassed (1.4%) , and 4 of 69 Controls (5.8%)
  - Only one mortality
- 47 Unexpected Events:
  - 35 backwards transport
  - 8 temporarily stalled
  - 3 backwards and temporarily stalled
  - 1 error setup of Tube

Discussion

- Sorting generally distinguished fish size
  - 400 mm not a ‘hard’ criteria
  - Default to Bypass safety mechanism
  - Most (n = 118) Tube-transported Chinook < 400 mm passed normally; 8 temporarily stalled
- No injury difference vs. Controls
  - Minor and observed less than Control group
  - Suggests long-term or population effects likely minimal
- Unexpected Events are manageable:
  - Low for both Chinook salmon and steelhead
  - Higher rate observed when 2 or more fish entered the system in close proximity

Caveats and Next Steps

- Volitional entry facilitated by addition of steeppass, which required a series of behavioral events (i.e., detection, entry, ascent) to occur prior to fish encountering the WESS-WFTS
- Study limited to single tube
- Next Steps:
  - Ideal Study: Directly compare performance of WESS-WFTS to conventional fishway
  - In-progress: Address factors that lead to unexpected events
    - Sensing stalls and autonomously adjusting blower settings to address the stall)
    - Reduce backwards transport

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Questions?