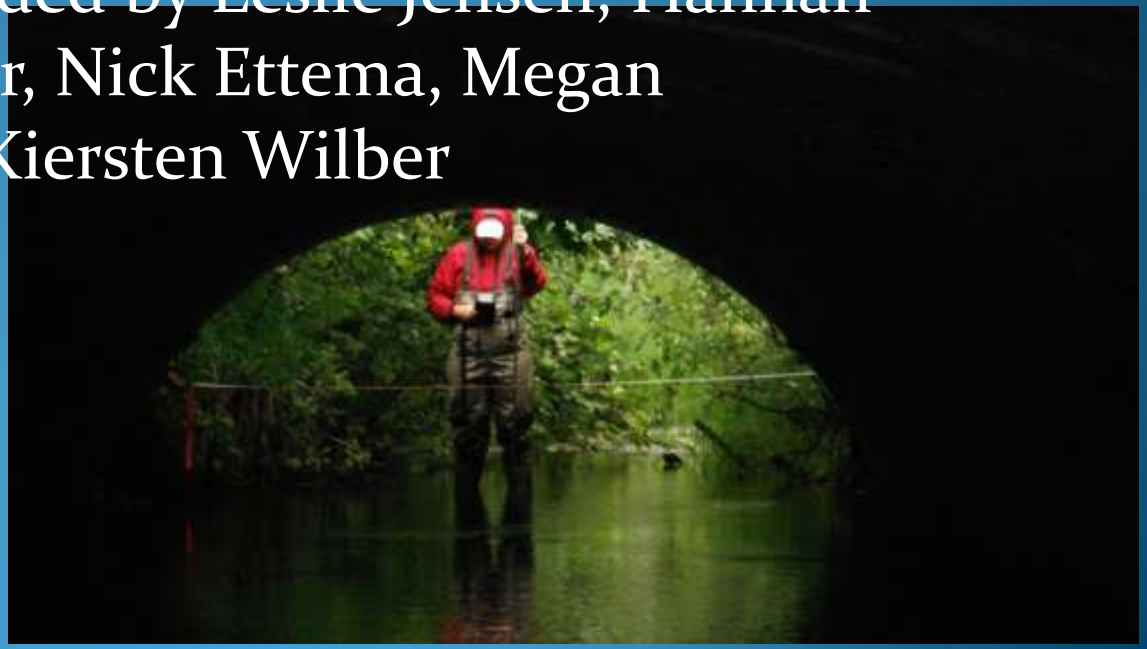
The Assessment of Road Crossing Barriers to Juvenile Pacific Salmon

ARRI
Aquatic Restoration & Research Institute

Acknowledgements

- Partial project funding provided by Alaska Sustainable Salmon Fund, USFWS Fish Passage Program, The Nature Conservancy
- Field support provided by Leslie Jensen, Hannah Ramage, Erin Miller, Nick Ettema, Megan Cookingham, and Kiersten Wilber



Background

- Belke et al. (1991) DOT and ADFG Mac McLean
- 1990 to 2000—Steve Albert ADFG Division of Habitat and Restoration with B. Gubernick, USFS.
- Initial Road Surveys on the Kenai Peninsula , Mat-Su Borough, Tongass (Flanders and Cariello 2000)
- DOT MOU
- DOT Fish Passage Assessment (Karle, K. 2005)
- ADFG Road Conditions Surveys/Database (see summary in O'Doherty 2010)

Current Assessments

- Models (FishXing, Fish Pass)
- ADFG Level 1. Red/Gray/Green
  - Red= Bottomless or Embedded—CW:SW < 0.5
    CMP not Embedded—CW:SW < 0.5, OR
    Culvert Slope > 2% or Perch Height > 4”
  - Green= Culvert Slope – Stream Slope ± 1%
    CW:SW ≥ 0.75 or Backwatered
    CMP not Embedded—Slope < 1%
    Not Perched, CW/SW ≥ 0.75

Current Assessments

- Washington State Assessment Methods (Price et al. 2010)
  - Red = Perch Height > 0.24 m
    Culvert not Countersunk 20% and
    Slope > 1%
  - Green = Perch Height < 0.24 m
    Countersunk >20%
    CW:SW > 0.75

Information Need

- Assessment of “Gray” Culverts
  - Models—Fish Xing, Fish Pass
  - Refine Existing Criteria
- Restoration Prioritization
- Evaluation of Restoration Projects
  - Implementation and Effectiveness
- Quantifying Biotic Effects

Project Objectives

- Determine the Culvert and Stream Parameters (Slope, Constriction Ration, Substrate etc.) that Influence Culvert Velocities
- Determine the Parameter Values that Resulted in Water Velocities Exceeding the Sustained and Burst Swimming Speeds of Juvenile Coho Salmon
- Test for Differences in Culvert and Stream Parameters among Barriers based on Biotic Assessments

Culvert and Stream Characteristics

- Upstream and Downstream Slopes
- Upstream and Downstream Channel Widths
- Substrate Size Distribution
- Culvert Slope
- Culvert Width and calcu[illegible]n of (CW:SW)
- Culvert Substrate (Embedded)
- Perch Height
- Culvert Inlet and Outlet Velocities (IOV)
- Culvert and Stream Flow Time of Dissolved Solutes (FTV)

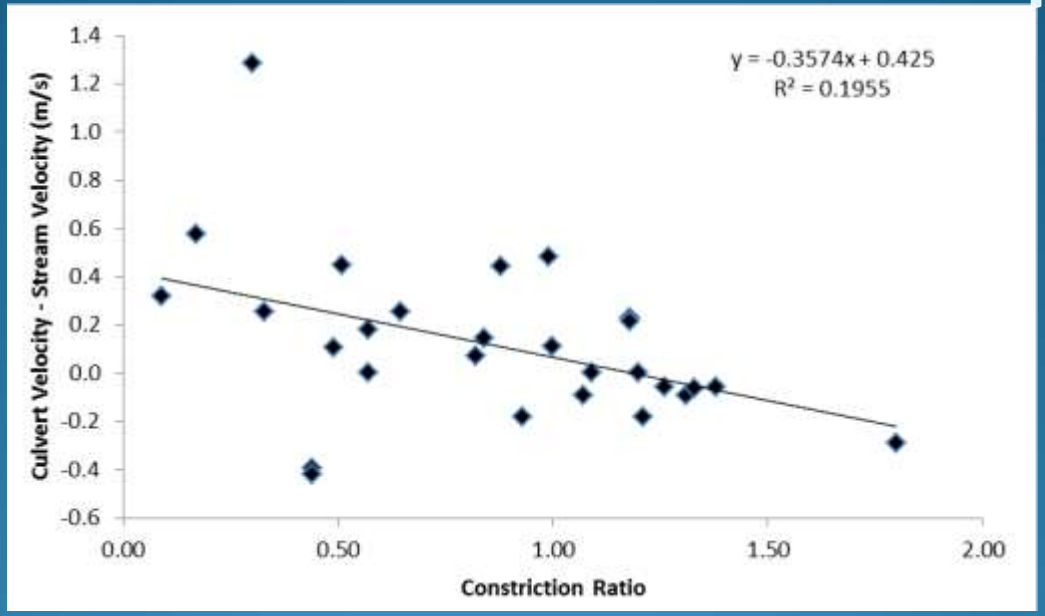
Approaches to Biotic Assessment

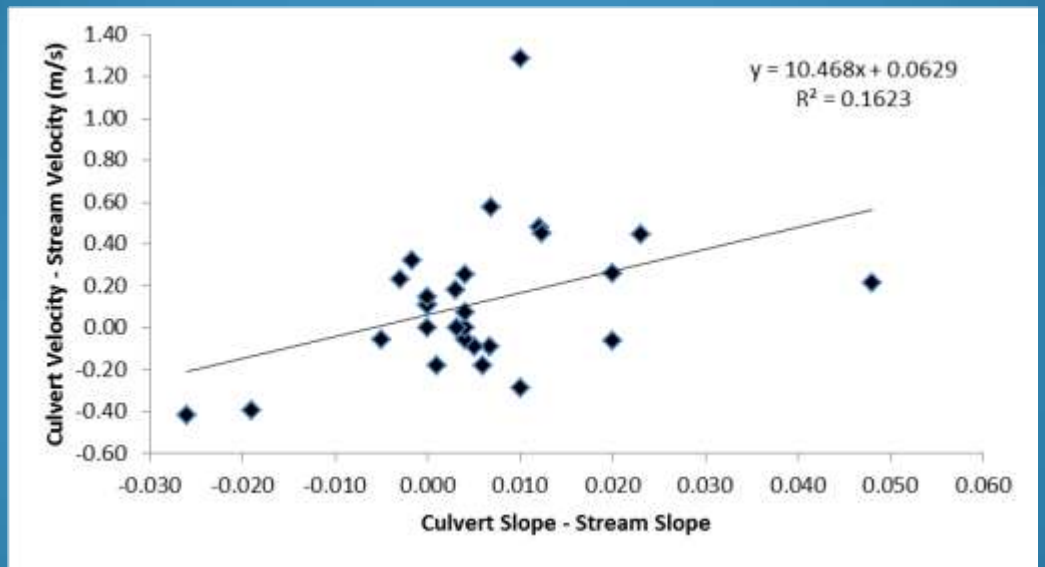
- Biotic Evaluation of Fish Passage
  - PIT Tagging—King, M., ADFG, J. Gerken, USFWS
    - Cost/Effort, Size Selective
  - False Culvert—Coffman, 2005; Robertson et al., (USFS) 2011
    - Recapture Efficiency, Sample Timing and Fish Movement
  - Relative Abundance—Bedford and Gould 1989, Davis and Davis 2011
    - Influenced by other factors

Within Stream Relationships

- Correlation among Stream and Culvert Parameters, and difference between culvert and stream flow time velocities (N = 28)
  - Culvert Width: Stream Width—Negative Correlation with Difference in Maximum Flow Time Velocity
  - Upstream and Downstream Channel Slope—Negative Correlation with Differences in Maximum Flow Time Velocity (Steeper Sloped Streams = Lower Culvert Effect)
  - Culvert Slope-Stream Slope—Positive Correlation with Differences in Maximum Flow Time Velocity

Within Stream Relationships





Relationships Among Streams

- No Significant Correlations between CW:SW, Stream Slope, Culvert Slope-Stream Slope and IOV or FTV (N=58)
- No Significant Correlations for Culverts in Streams with Slopes > or < 1.0% Slope
- Exception, in Streams with >1.0% Slope, Perch Height Positively Related to Stream Slope. Based on 12 Perched Culverts Ranging from 0.06 to 1.33 m.

Sustained and Burst Swimming Speeds

- Sustained Speed 0.39 m/s: Burst 0.63 m/s (equations in Fish Xing)
  - Constriction Ratio
    - No significant difference between sites with Ave FTV > or < 0.39 m/s
    - No significant difference between sites with IOV > or < 0.63 m/s
    - No significant difference between sites with Max FTV > or < 0.63 m/s
  - Culvert Slope and Culvert Slope-Stream Slope
    - Significant difference between sites with IOV > or < 0.63 m/s
    - No significant difference between sites with Ave or Max FTV

Substrate

- Significant Differences in IOV, and Max, Min, and Ave FTV between sites with (34) and without (22) substrate.

If velocity exceeds sustained and burst swimming speeds, what percent of those sites are with or without substrate?

	With Substrate	Without Substrate
IOV > 0.62 m/s	32%	77%
Max FTV > 0.62 m/s	32%	68%
Ave FTV > 0.39 m/s	44%	73%
Min FTV > 0.39 m/s	3%	18%

Biotic Assessment

- 18 Sites with Significant Differences in Total Juvenile Coho Salmon
  - 6 of the 18 were Significant for Coho ≥ 55 mm
  - 18 of the 18 were Significant for Coho < 55 mm
- 6 of the 18 Sites with Perched Culverts
  - Perch Heights from 0.12 to 1.33 m
  - Coho > 55 mm significantly different at 4 of the 6 sites, velocities at the remaining 2 sites over 1.5 m/s
- Max FLV only Parameter Significantly Different between Sites that were Migration Barriers

Assessment of Migration Barriers

- Culvert Slope (Ave 2.4 to 2.9%) Indicator of Velocity > Sustained and Burst Swimming speeds, but did not identify barriers based on Biotic Assessments
- Lack of Substrate an Indicator of High Velocity but did not identify barriers based on Biotic Assessments
- Perch Heights > 0.18 m = Migration Barrier
- Max FTV only Parameter that Identified barriers based on Biotic Assessment . Max FTV > 0.55 m/s identified 11 of 12 Barriers

Assessment of Migration Barriers

- Why haven't field measures of velocity been used previously?
  - Measure is not independent of flow. Does this matter?
  - Assessment parameters (CW:SW, Slope Difference) must be good at one flow to be representative of all flows.
  - Methods to measure flow time velocity.
- Why not Inlet/Outlet Velocities?
- Why not a velocity near sustained swimming speed and length of culvert?

Literature Cited

Behlke, C., D. Kane, R. F. McLean, and M. D. Travis. 1991. Fundamentals of culvert design for passage of weak-swimming fish. FHWA-AK-RD-90-10:1-203. Alaska Department of Transportation and Public Facilities, Fairbanks, Alaska. (Available from: Alaska Department of Transportation and Public Facilities, 2301 Peger Road, Fairbanks, Fairbanks, Alaska 99709 USA.).

Coffman, J. S. 2005. Evaluation of a predictive model for upstream fish passage through road stream crossings. James Madison University, Harrisonburg, Virginia. Masters Thesis.

Davis, J.C. and G.A. Davis. 2011. The influence of stream-crossing structures on the distribution of rearing juvenile Pacific salmon. North American Benthological Society 30(4):1117-1128.

Flanders, L. S., and J. Cariello. 2000. Tongass road condition survey report. Technical Report 00-7. Alaska Department of Fish and Game, Fairbanks, Alaska.

Karle, K. F. 2005. Analysis of an efficient fish barrier assessment protocol for highway culverts. FHWA-AK-RD-05-02. Statewide Research Office, Alaska Department of Transportation. Hydraulic Mapping and Modeling, Statewide Research Office, Denali Park, Alaska. (Available from: Alaska Department of Transportation, 3132 Channel Drive, Juneau, AK, 99801-7898).

O'Doherty, G. O. 2010. ADF&G Fish Passage Program: Summary of existing inventory and assessment data and gap analysis, September 2009. Alaska Department of Fish and Game, Special Publication No. 10-17. Anchorage.

Price, D. M., T. Quinn, and R. J. Barnard. 2010. Fish passage effectiveness of recently constructed road crossing culverts in the Puget Sound Region of Washington State. North American Journal of Fisheries Management 30:1110–1125.