

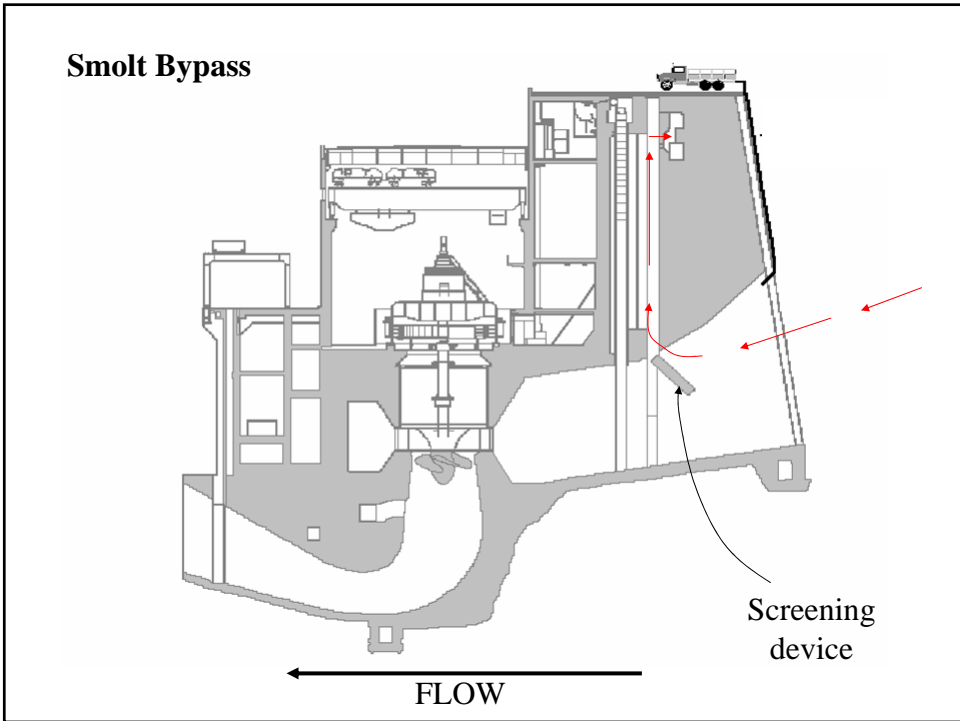
**THE BEHAVIOR OF SEAWARD MIGRATING JUVENILE PACIFIC  
SALMONIDS: IMPLICATIONS FOR ENHANCED FISH PASSAGE.**

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NATIONAL RESEARCH COUNCIL

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**Fish Guidance Efficiency (FGE)  
has been much lower than expected.**

The efficiency with which juveniles are guided away from the turbines to bypass systems:

Steelhead:	80-90%
Spring/summer chinook:	60-70%
Fall chinook:	30%

US Corp of Engineers  
Pacific Salmon Coordination Center

**Smolts are passive and neutrally buoyant migrants....**

Thorpe & Morgan (1978)	Atlantic salmon, Swimming ability < 2bl/s.
Smith (1982)	Pacific salmon smolts Decreased swimming performance is a necessary component of migration.

**... or smolts are capable of strong active migration**

Muir et al. (1994)	Spring chinook salmon Active Migrants.
Peake & McKinley (1998)	Atlantic salmon Strong swimming = 6-12 bl/s.

## Aim of Research

To investigate the behavior of smolt in response to accelerating flow and overhead cover.

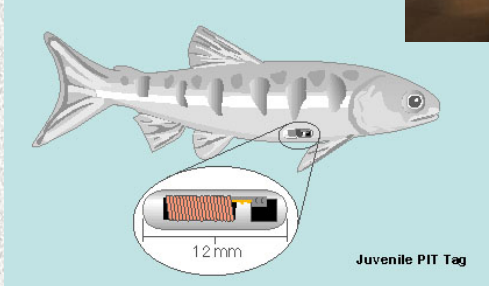


Culvert Restoration: Studies to assess success of upstream movement of juveniles. PIT tag technology

**Study fish from  
a distance using  
tagging technology**

**Macro-scale**

**PIT tagging**



**Radio-tracking**

**Fine Resolution (micro-scale) Flume Studies**



## Consideration of Scale

- Studies are conducted over different scales
  - Micro-scale: meters
  - Meso-scale: e.g. River Reach
  - Macro-scale: e.g. catchment, regional, global
- Reliance on one approach leads to “scale inconsistencies”
- Integration across scales is required for better understanding of reality

## Hydraulic Studies



### Experiment 1: Flow acceleration

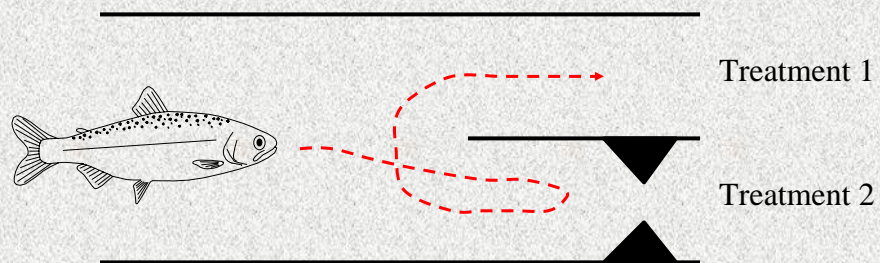


Treatment 1 = Open Channel      70% Q  
Constant velocity

Treatment 2 = Constricted Channel      30% Q  
Accelerating flow

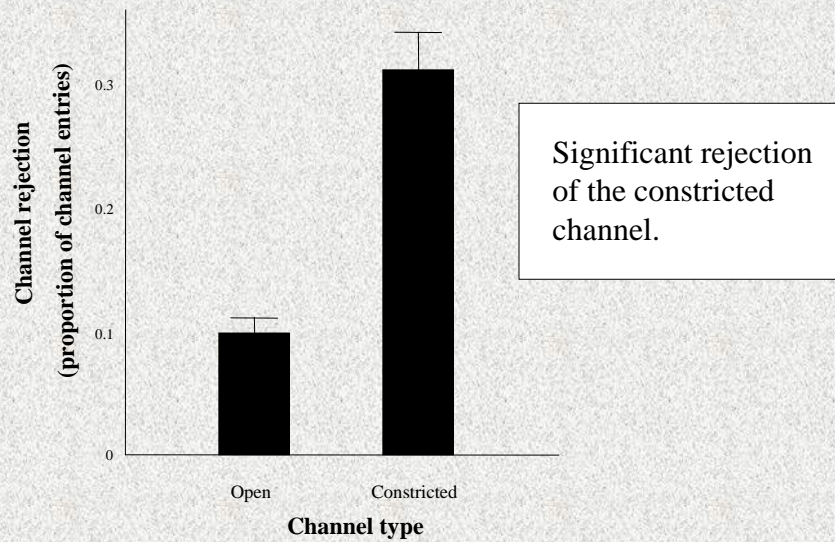
Smolts encounter a choice of constricted (low flow but high acceleration) or open (high and constant flow) passage route.

### Experiment 1: Results

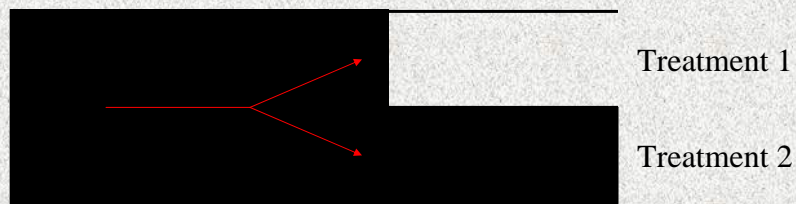


1. Initially higher preference for the constricted channel.
2. But on reaching zone of acceleration, high rejection of constricted channel.

## Experiment 1: Results



## Experiment 2: Overhead cover



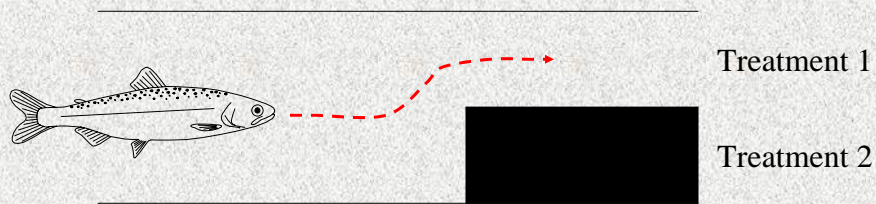
Treatment 1 = Uncovered Channel (50% Q)

Treatment 2 = Covered Channel (50% Q)

Smolts encounter a choice of covered or uncovered passage route after prior covered or uncovered passage.

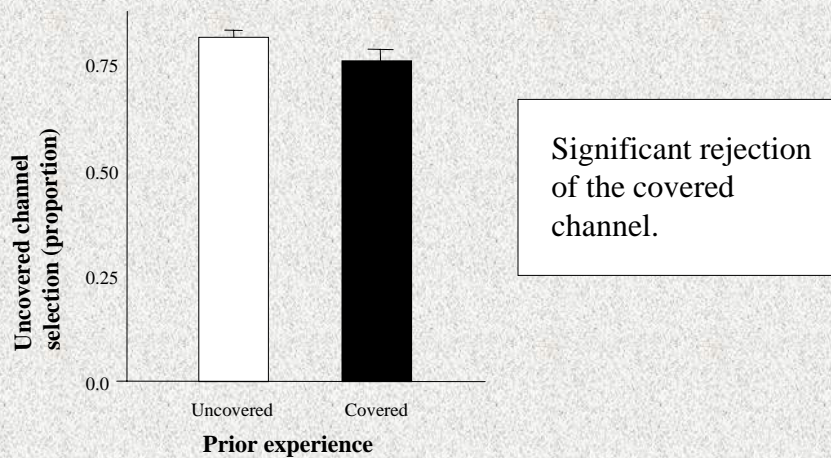


## Experiment 2: Results

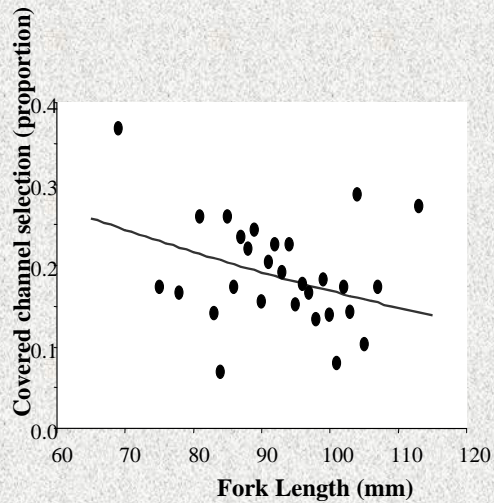


> 75% of smolts rejected the covered route independent of prior experience.

## Experiment 2: Results



## Experiment 2: Results



Those fish that selected the covered channel were significantly smaller than those that did not.

## Conclusions

- At the micro-scale, migratory smolts are not passive migrants, but show active preference / avoidance of environmental variables
  - Flow acceleration
  - Overhead cover
- Response to environmental variables is influenced by size of fish.
- Behavioral response varies between species.
- At the Macro-scale, smolts do use river transport and therefore do active passively.
- Need to integrate information across scales to get the most accurate picture.

## Management Implications

Screening devices- Reduce rate of hydraulic transition  
may increase FGE

Overhead cover - Culverts  
Riparian development  
Barrier to entry of off-take channels

Effects of delayed migration - Energetic costs  
Predatory costs