Impact of Bridges and Culverts on Stream Fish Movement and Community Structure

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What a Little Mussel Can Do…

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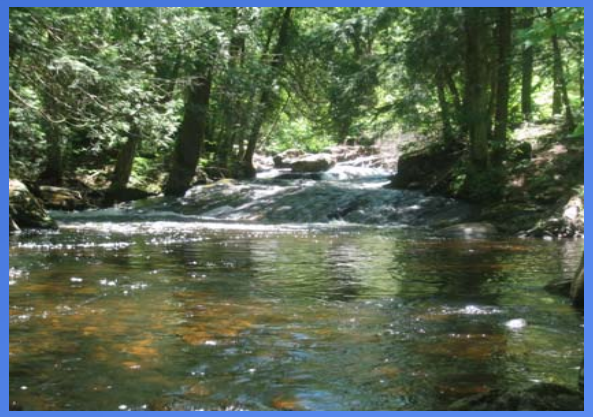

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- Filtration = Sediment Reduction = Water Clarity
- Indicators of stream health
- 50% endangered, threatened, or special concern

LIFE CYCLE OF EASTERN ELLIPTIO (Elliptio complanata)
Adult Elliptio complanata
Gravid Female
Glochidia
Fish Host
Juvenile
After Burch (1975) and Pennak (1978)

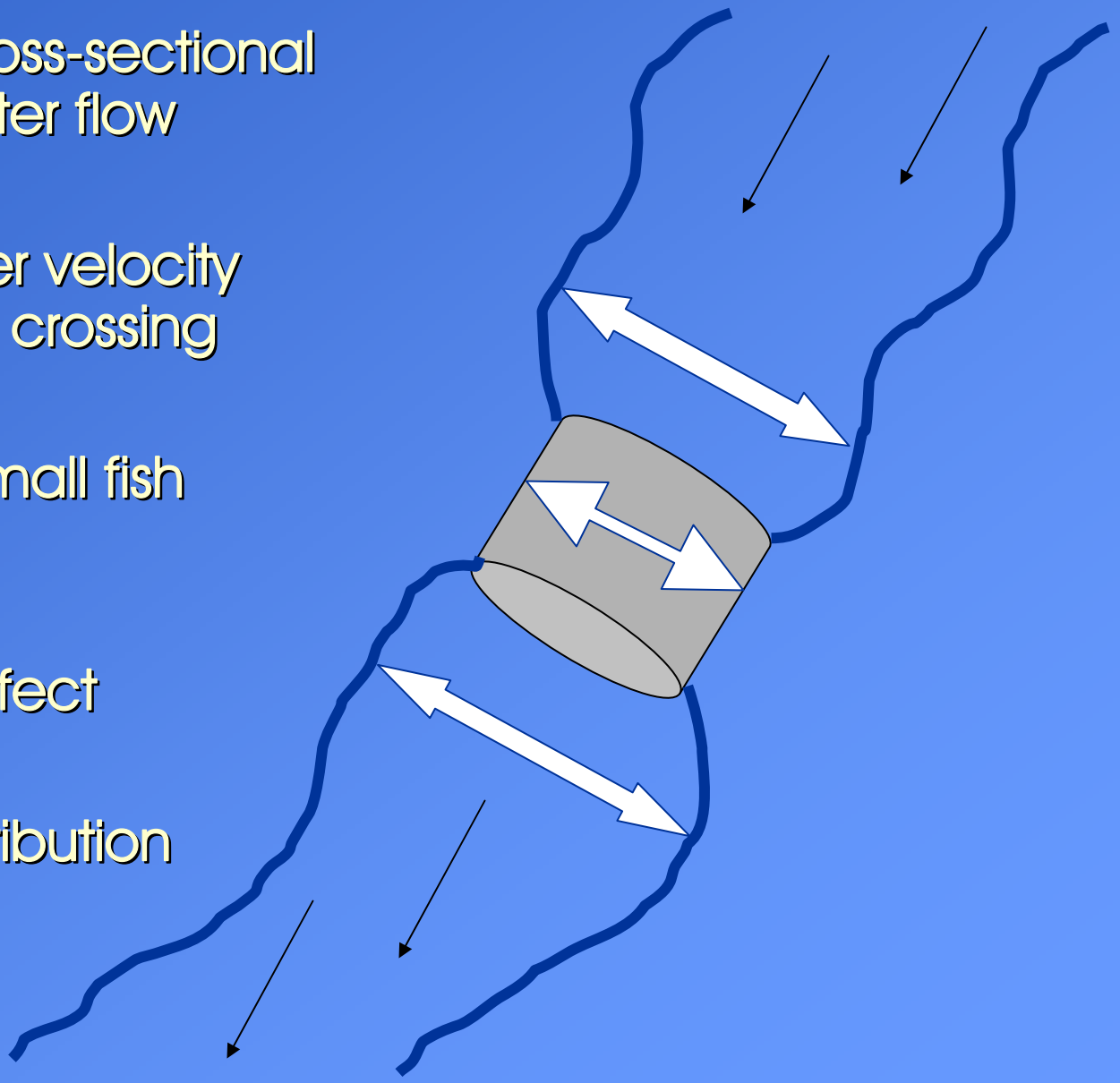
M. C. Barnhart 1998

Presentation Outline

- Introduction
- Study Objectives
- Hypotheses
- Methods: 2004
- Study sites
- Results
- Methods: 2005
- Results: PIT-tagging
- Conclusions
- Implications

Stream Velocity

- Reduction of cross-sectional area for water flow
- Increase in water velocity through the crossing
- Movement of small fish impeded
- Intense scour effect
- Sediment redistribution



Long Term Effects on Habitat

- Sediment deposited upstream of crossing
- Scouring habitat directly downstream
- Sediment deposited further downstream
- Cover fish spawning sites
- Habitat homogeneity
- Fish prefer heterogeneity for spawning

Culverts as Barriers to Movement

- Perching creates physical barrier to fish passage
- Dry conditions isolate reaches
- Smooth bottom replaces riffle habitat
- No refuge for fish to rest

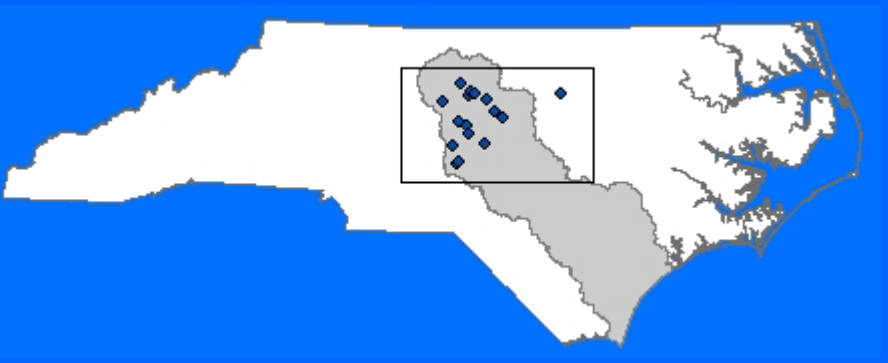
North Carolina Host Fish

Study Objectives

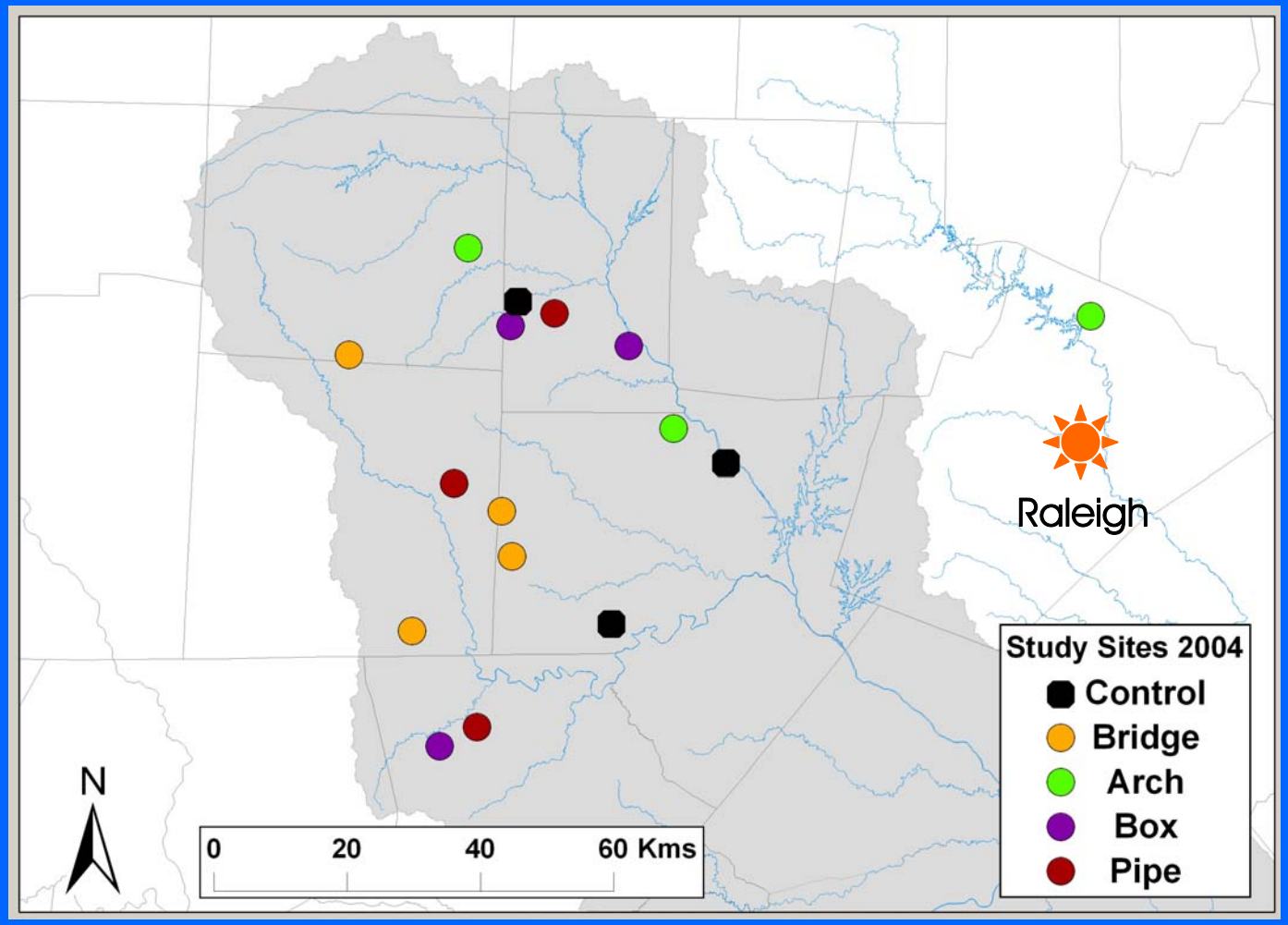
Quantify the impact of four common road crossings on:

1. Fish abundance & Diversity

2. Fish Movement



Study Sites 2004



Questions of Interest

1. Does the presence of a crossing affect fish community structure?

2. Does the presence of a crossing affect fish movement?

3. Do the effects on community structure and fish movement vary with crossing type?

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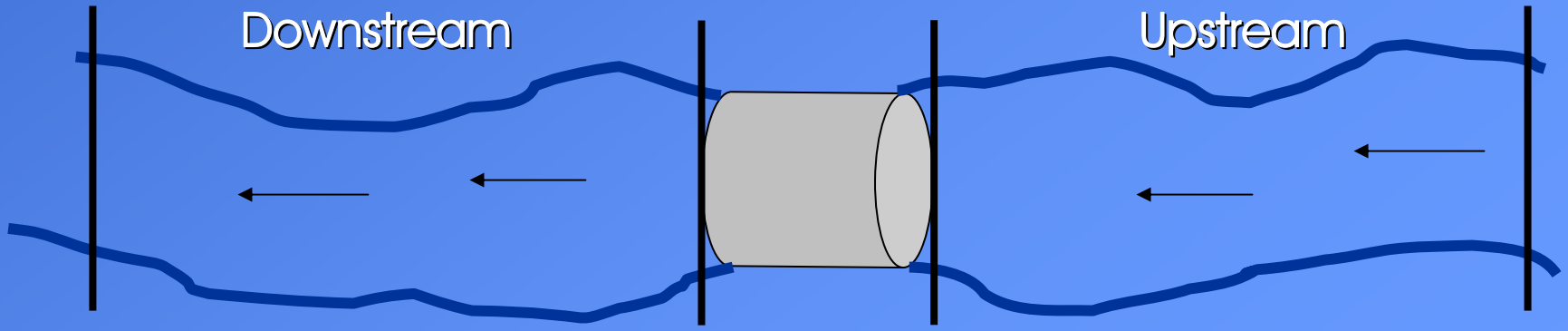
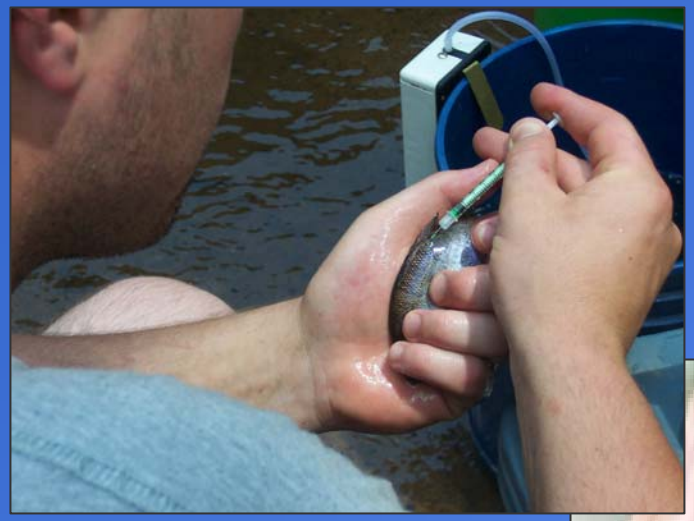
Methods: Mark & Recapture

Mark & Recapture

- May of 2004 began study
- Enclosed 50m reaches above & below crossing
- Seine and backpack electrofishing
- Triple Pass Depletion
- Identified and measured each fish
- Resampled June, July, and August
- Emigration sampling



Tag: Visible Implant Elastomer (VIE)



Variables of Interest

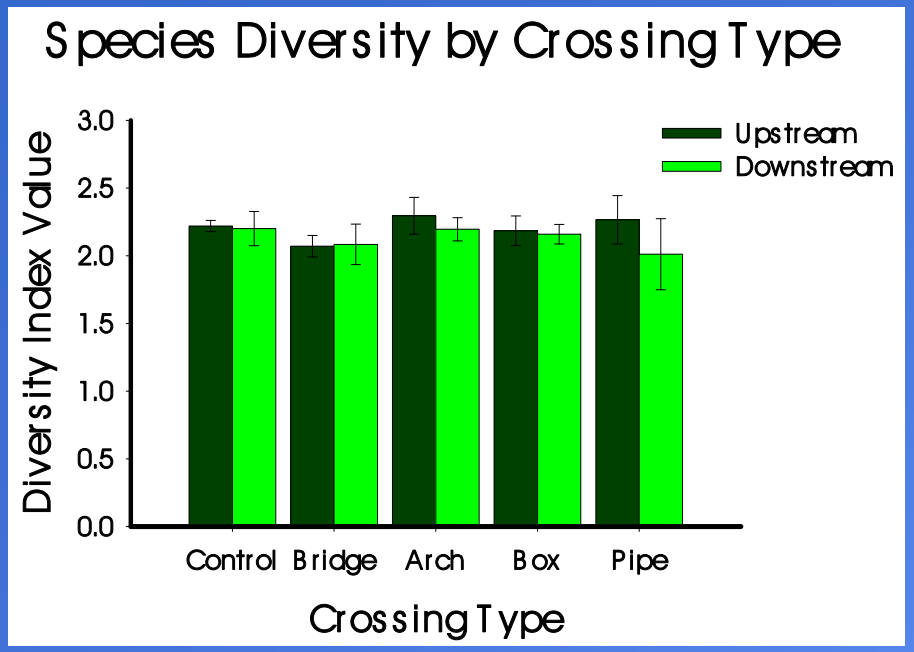
Independent

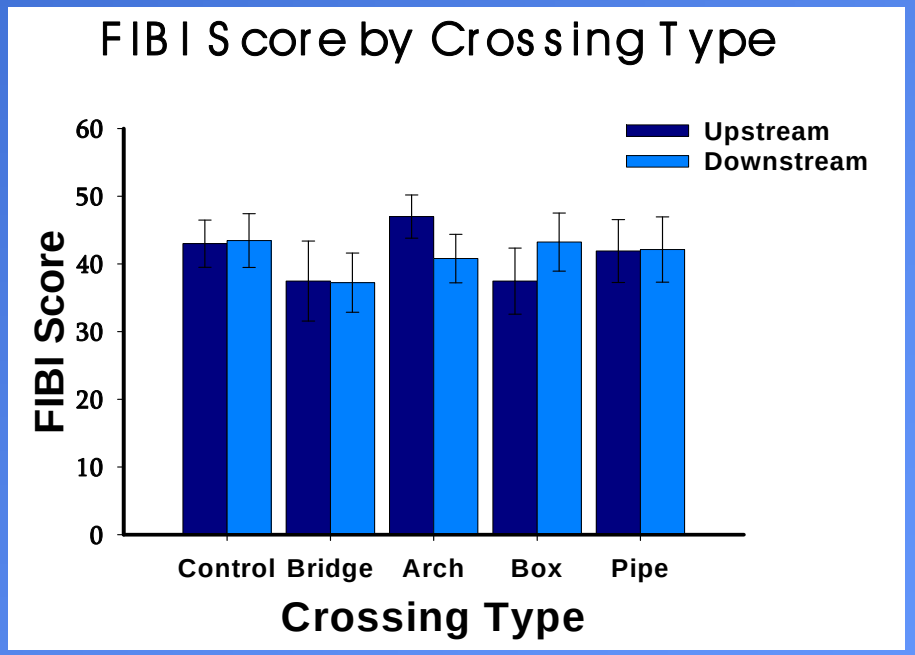
- Habitat Characteristics:
  - % riffle, run, pool
  - Stream Volume (m^3)
  - Flow (cm/sec)
- Crossing Type:
  - Culverts: arch, box, pipe
  - Bridge
  - Control
- Position:
  - Upstream of crossing
  - Downstream of crossing

Dependent

- Community Structure:
  - Species Richness/m^3
  - Diversity Index
  - Fish Index Biotic Integrity
  - Population Estimates
- Movement:
  - Conditional Percent Movement

Results: Community Structure





~~H_a: Species diversity indices and FIBI scores will be higher for control streams than streams with crossings.~~

~~H_a: Both community structure measurements will vary along a decreasing gradient scale:~~

~~Bridge → Arch → Box → Pipe~~

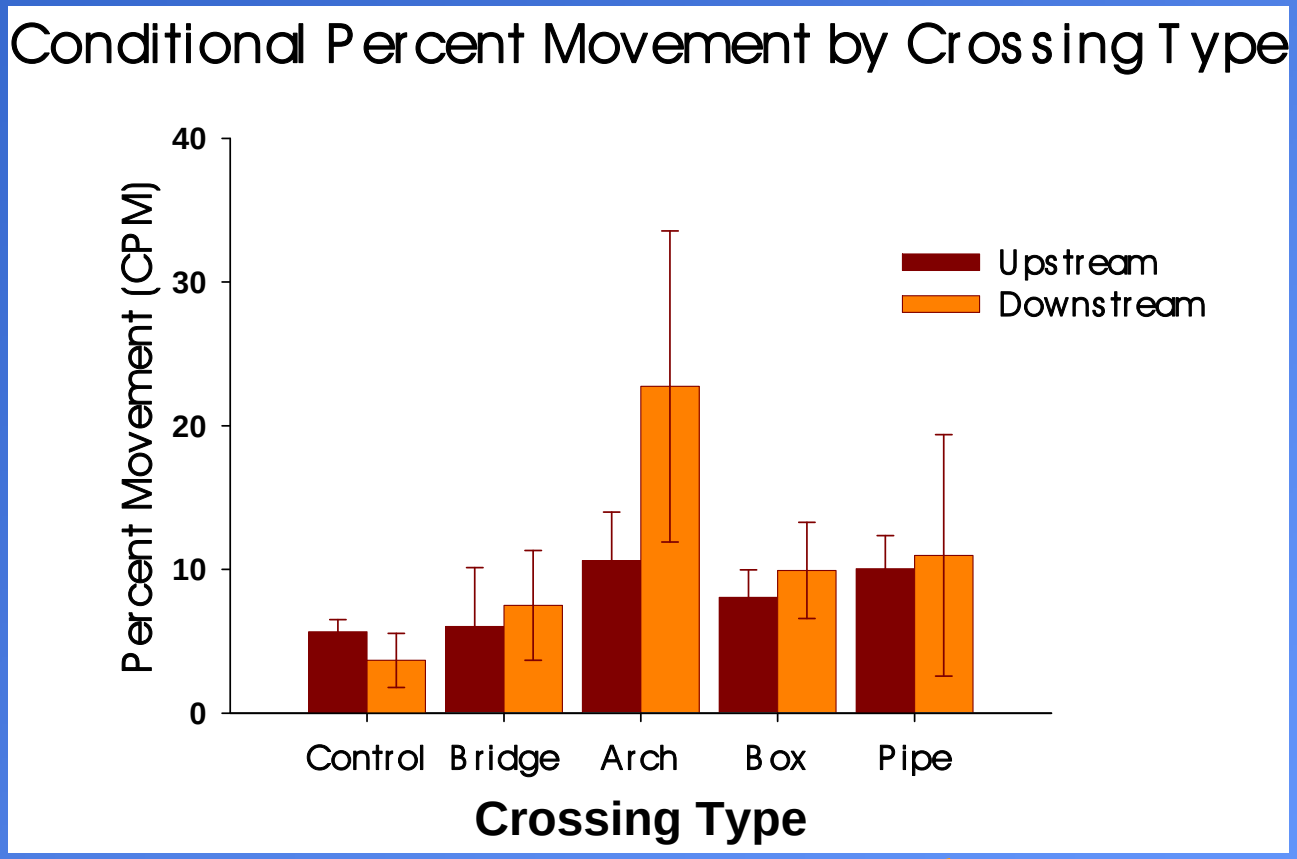
Measurement of Movement

Conditional Percent Movement (CPM)

$$\text{CPM downstream of crossing} = \frac{M_D}{M_D + R_U}$$

This number represents the percent of the recaptured fishes which moved through the crossing.

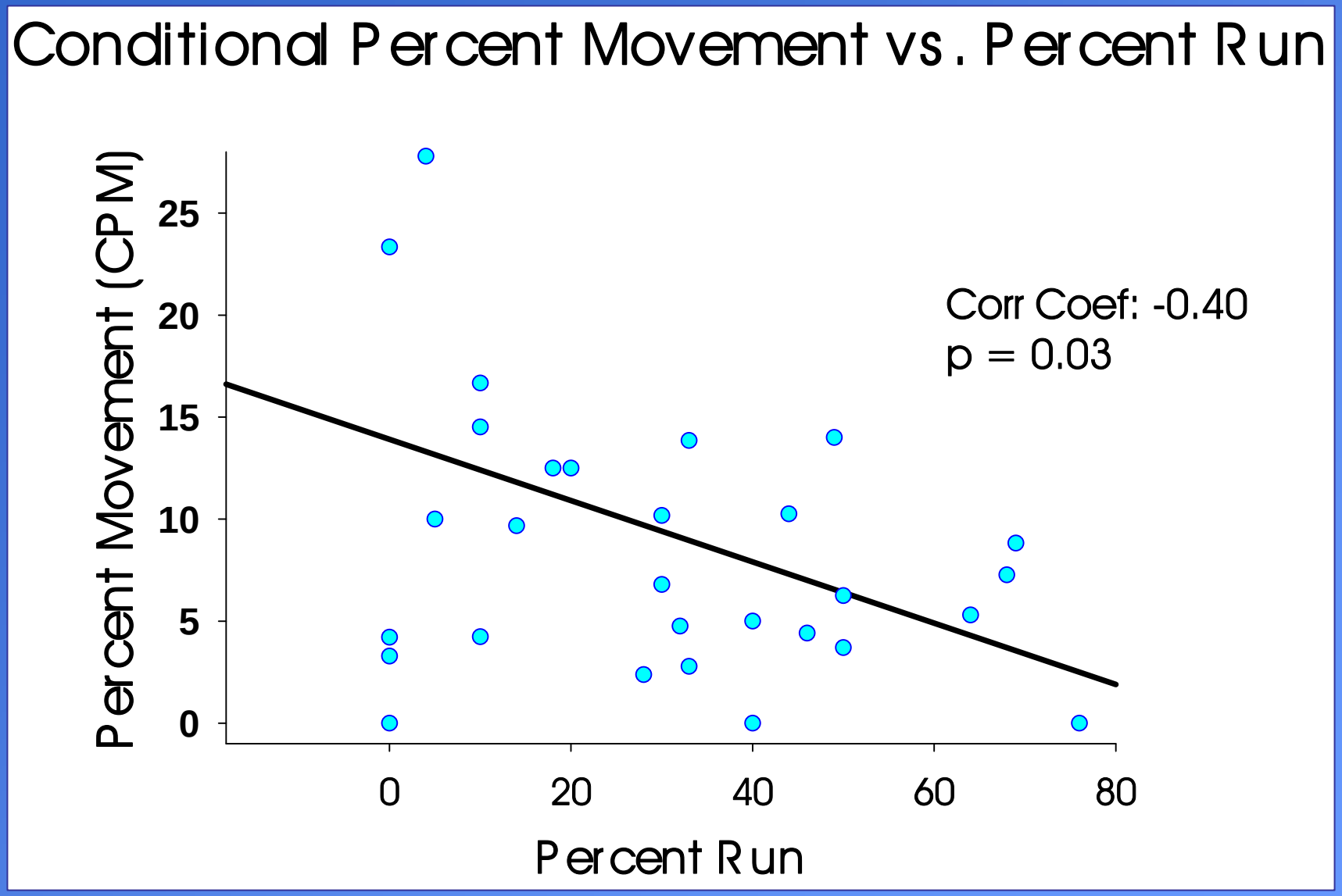
Results: Movement



~~Ha: More fish movement in Control Streams~~

~~Ha: Fish Response will vary on a gradient~~

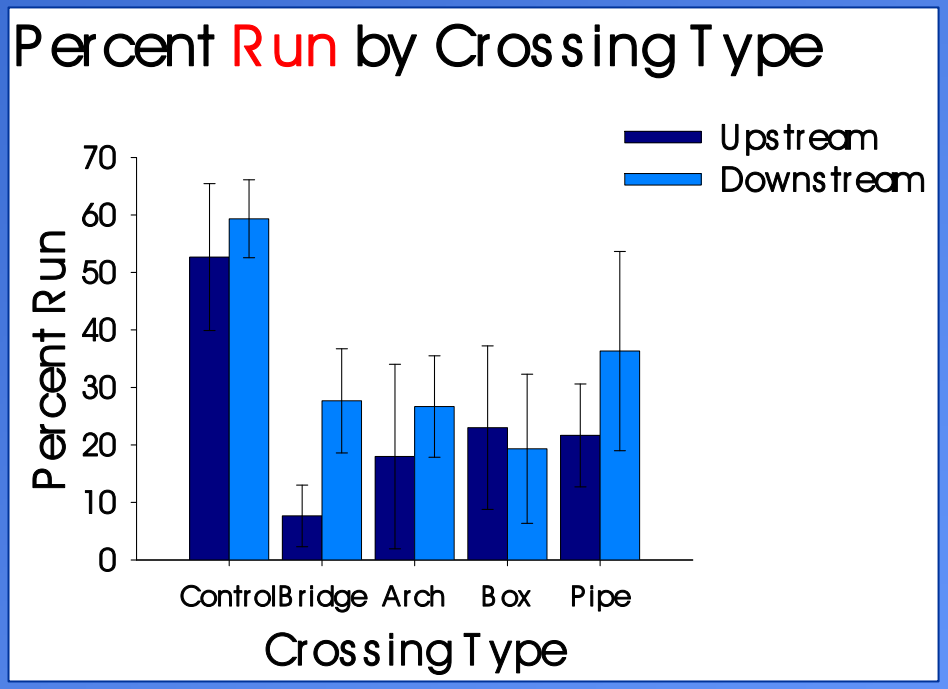
Bridge → Arch → Box → Pipe

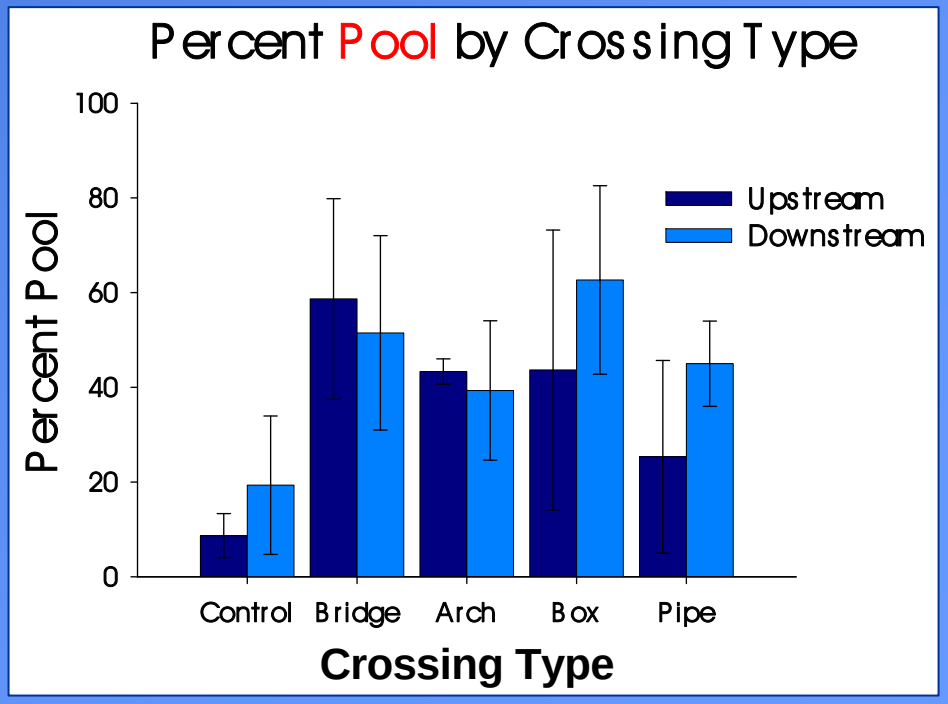


- Movement increases as percent run decreases

Habitat Variables

- % Riffle, Pool, & Run
- What is ecological significance of correlation?
- More fish associated with run & pool





Conclusions: What does no response mean?

- 7500 m stream reach sampled
- 15,000 fish sampled
- 9,594 fish marked: 43 species, 12 families

No difference in movement of fish in these streams with or without crossings or according to crossing type

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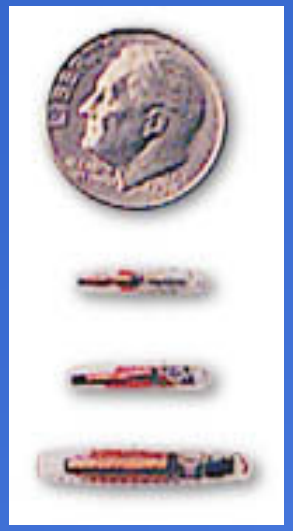
Low Number of Movers (102 moved, 1.06%)

Scale of Study: Stream Reach Size, Low N

Scale of Study: Time Between Recapture Events

Sampling Scheme Inadequate: Reevaluate Methods

Small Scale PIT Tag Study

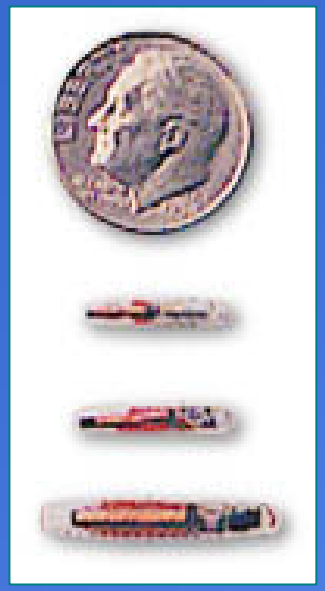


Passive Integrated Transponder Tag

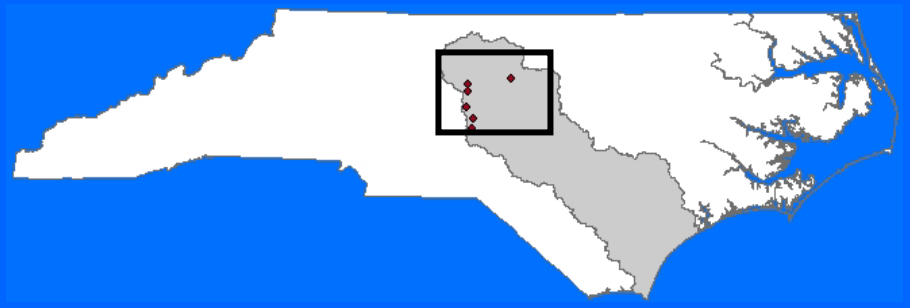
- Increased recapture rates from continuous monitoring and 95-100% detection efficiency
- Reduced sampling effort
- Reduced sampling bias from fright response
- Reduced recording error
- Reduced handling time of fish—reduced mortality

Study Objective: 2005

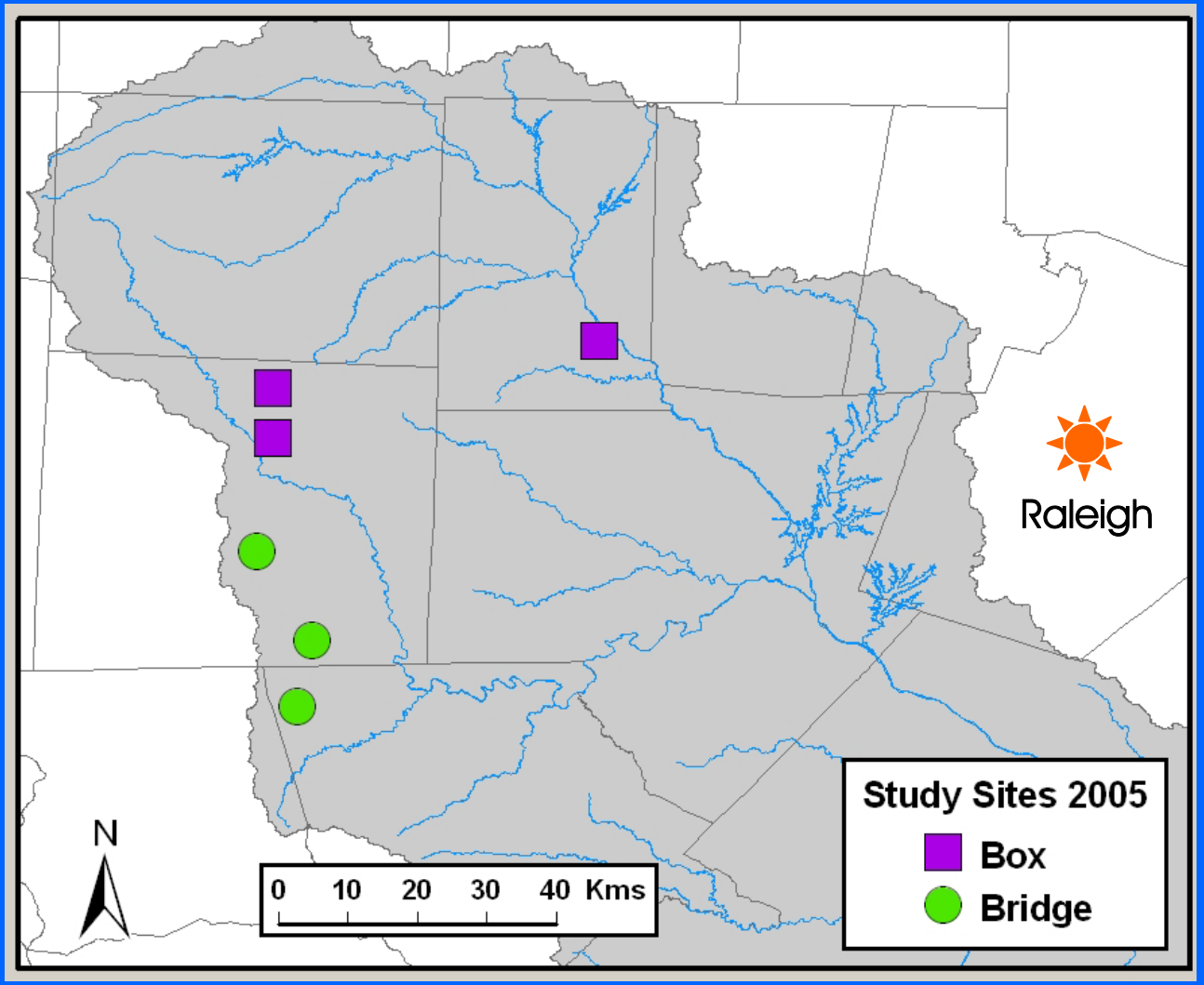
Assess unidirectional stream fish movement through two types of road crossings, box culverts and bridges, using PIT tags and remote antenna arrays.



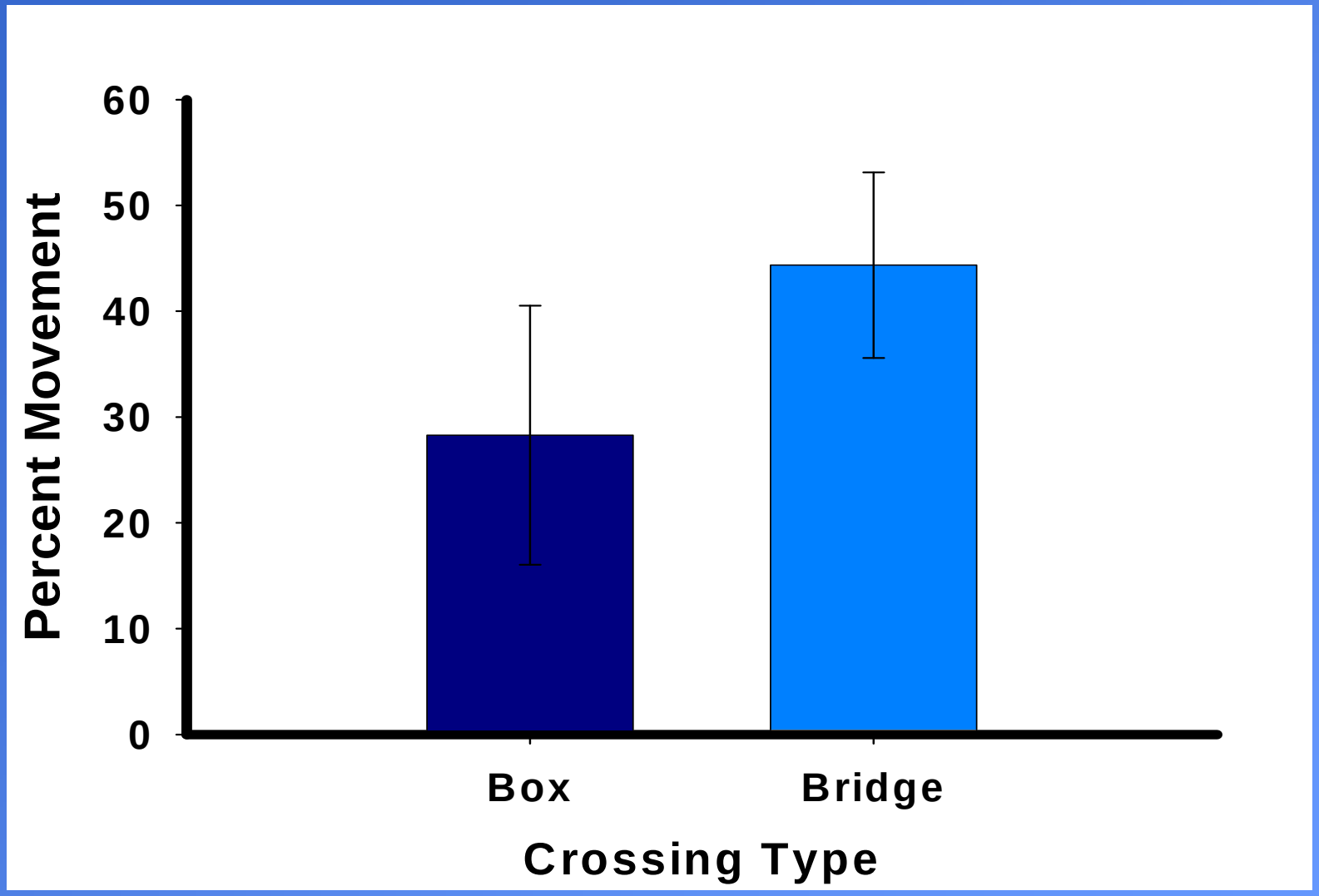
- Smaller study of 6 streams: Compare Bridges vs. Box Culverts, N=3
- Limited by fish size : must be ≥ 60 mm
- Increase study reach to 150 m above & below
- Two-pass depletion
- Constant monitoring for 30 days by remote antenna array



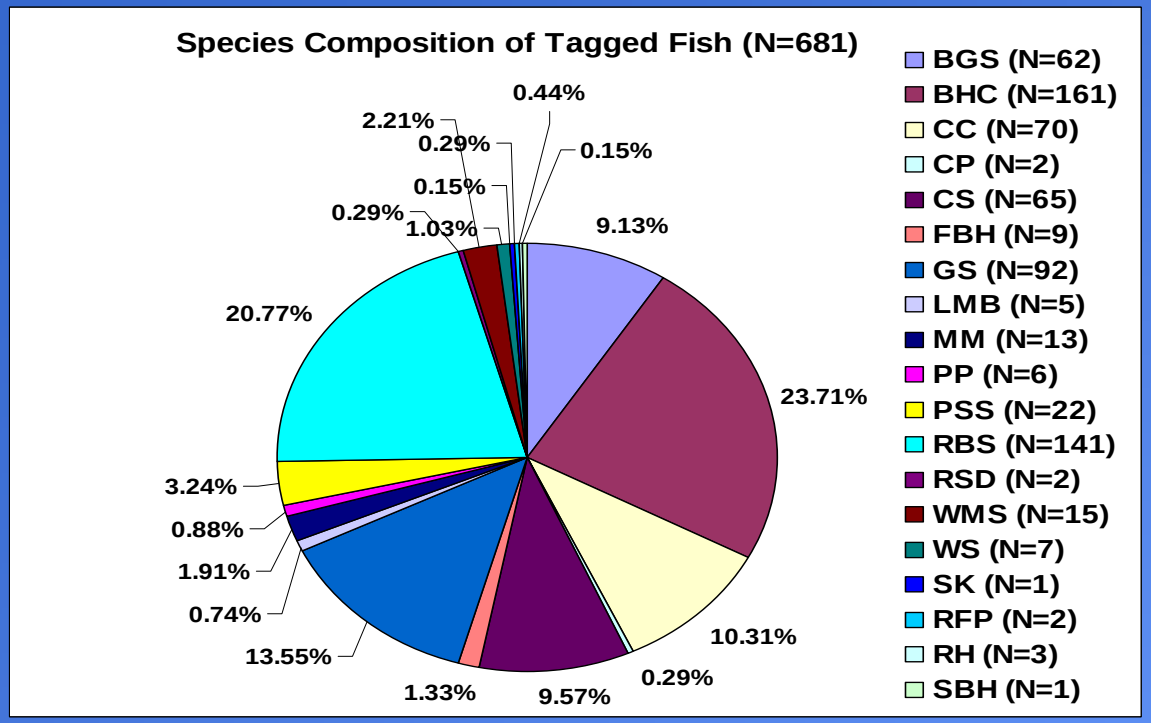
Study Sites 2005

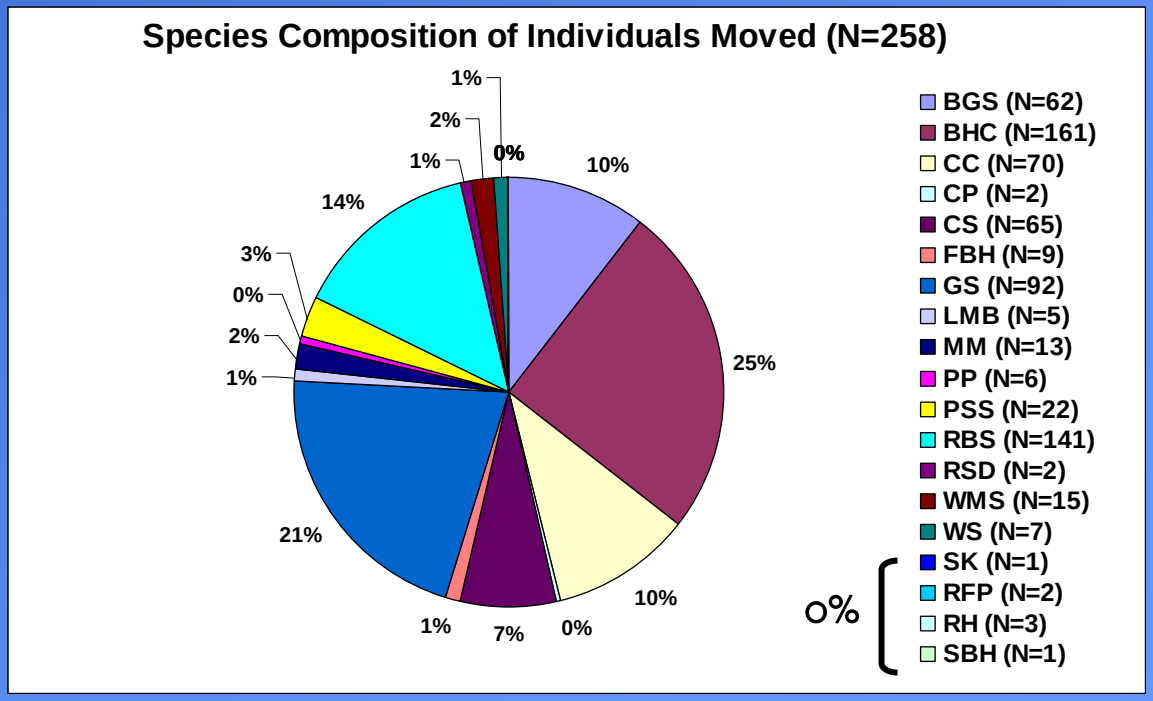


Results: PIT-tagging



- Percent tagged fish moved did not vary with crossing type
- Trend apparent, possible low sample size N = 3


Species Composition of Tagged Fish (N=681)
0.44%
2.21%
0.29%
0.15%
0.15%
0.29%
1.03%
9.13%
20.77%
23.71%
3.24%
0.88%
1.91%
0.74%
13.55%
10.31%
1.33%
9.57%
0.29%
BGS (N=62)
BHC (N=161)
CC (N=70)
CP (N=2)
CS (N=65)
FBH (N=9)
GS (N=92)
LMB (N=5)
MM (N=13)
PP (N=6)
PSS (N=22)
RBS (N=141)
RSD (N=2)
WMS (N=15)
WS (N=7)
SK (N=1)
RFP (N=2)
RH (N=3)
SBH (N=1)


Species Composition of Individuals Moved (N=258)
1%
2%
0%
1%
10%
14%
3%
0%
2%
1%
25%
21%
10%
1%
7%
0%
0%
BGS (N=62)
BHC (N=161)
CC (N=70)
CP (N=2)
CS (N=65)
FBH (N=9)
GS (N=92)
LMB (N=5)
MM (N=13)
PP (N=6)
PSS (N=22)
RBS (N=141)
RSD (N=2)
WMS (N=15)
WS (N=7)
SK (N=1)
RFP (N=2)
RH (N=3)
SBH (N=1)

Effectiveness of Movement Methods

Field Season	Fish Tagged	Fish Moved	% Moved	Streams Sampled	Days **	Hours worked	Cost
2004	9594	102	1.06	16	120	2560	$23,000
2005	681	258	37.89	6	30	300	$26,330

** 2004 – four sampling periods per stream

2005 – one sampling period per stream

Conclusions: PIT-tagging

- Fish movement through bridges and box culverts did not vary significantly
- PIT tags and remote antenna arrays effective methods to monitor fish movement
- Re-evaluate traditional mark-recapture methods for movement studies

Summary and Overall Conclusions

No difference in fish movement or community structure in streams with or without crossings or according to crossing type

Spatial Scale vs. Frequency of Recapture

Power Issues, Low N

Sampling a Mobile Fish Community 30 years Later

BACI Design to Assess Short Term Impacts of Crossings

Implications of Work

No apparent impact of crossings on current stream fish communities

- Fish not a sensitive indicator to impacts
- After 30 years, baselines have shifted

Current mussel dispersal is not impeded

Re-evaluation of methods is important

PIT tags and antenna array capture movement more effectively

Acknowledgements

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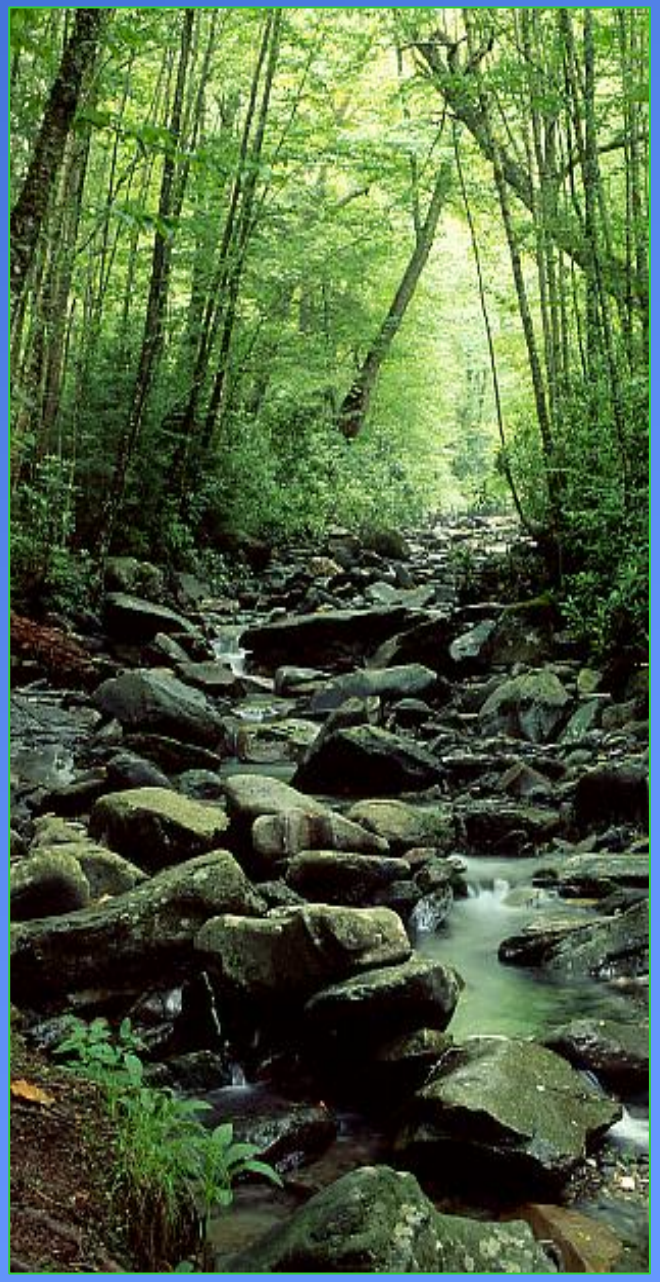
Residents of NC Piedmont

Various Quicky Marts of the Piedmont



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