Restoring flow in the Beebe River: Implications for Eastern brook trout

Tyson Morrill

M.S. Program in Biological Sciences

Dr. Brigid O'Donnell (Biological Sciences) & Dr. Amy Villamagna (ES&P)

Plymouth State University, NH

Introduction

The Beebe River watershed (Campton & Sandwich, NH) is home to wild, headwater populations of Eastern brook trout (*Salvelinus fontinalis*). Of the seven tributaries, five are impacted by undersized road crossings (NHFGD 2014).

- Brook trout require cool, clean water and their presence often suggests good water quality (Kanno et al. 2014)
- Movement upstream occurs when water temperature exceeds thermal tolerance (20°C) and during spawning (Curry et al. 2002; Davis et al. 2015)
- Temperature and/or physical barriers can impact movement and genetic diversity may be reduced resulting in subpopulations at risk of extirpation (Warren Jr. & Pardew 1998; Kondratieff & Myrick 2006; Poplar-Jeffers et al. 2009)
- In small populations, genetic impacts may be amplified when subpopulations become isolated and chances of inbreeding increase (Hudy et al. 2010; Kanno et al. 2014)
- Little data exists as to the genetic impacts of stream-crossing structures, like culverts, on brook trout (Hebert et al. 2000; Torterotot et al. 2014; Kelson et al. 2015)

Research Objectives

1) Assess population demographics of brook trout

2) Track brook trout movement over time and space

3) Document impact of human and natural barriers on population genetics of brook trout

Methods

Population demographics

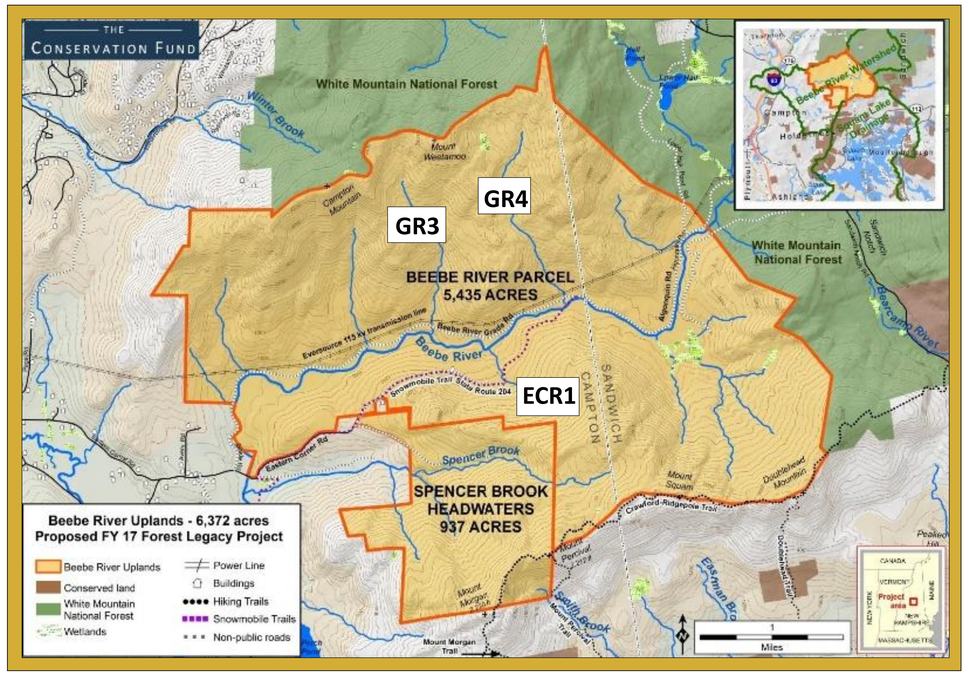
- Length, mass, scale samples:
  a) Scale samples used to age fish
  b) Growth calculated by mark-recapture length/mass change (7/23, 8/5 - 10/7/2016)

Fish movement

- Implanted PIT tags for:
  a) Mark and recapture via e-fishing
  b) Stationary antennae detections
  c) Mean movement calculated by mark-recapture (7/23, 8/5 - 10/7/2016)

Fish genetics

- Fin clips:
  a) Sequence 12 microsatellites identified by King et al. (2012)
  b) Will be sequenced & analyzed in summer 2017



Map of the Beebe River Uplands property (Sandwich/Campton, NH), owned by The Conservation Fund. GR3, GR4 and ECR1 are the three study streams.

Tributary 1 (ECR1)

No barrier

Tributary 2 (GR4)

Fully passable

Tributary 3 (GR3)

Impassable barrier

Results

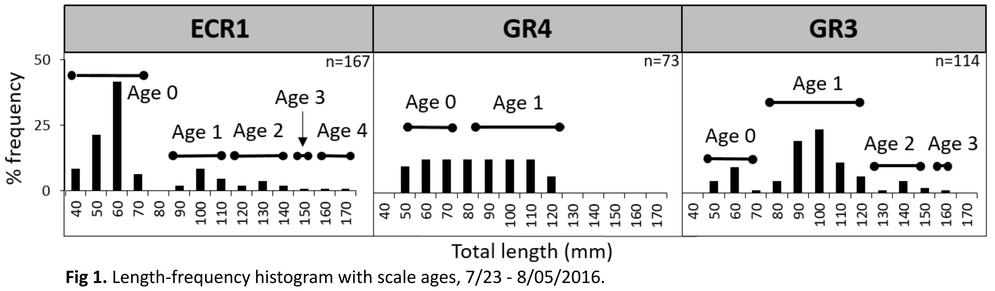


Fig 1. Length-frequency histogram with scale ages, 7/23 - 8/05/2016.

Population demographics

Age structure **(Figure 1)**

- Age distribution GR3 & GR4 (with human impacts) differs from ECR1 (without)
- Highest fish abundance in the non-impacted stream, Tributary 1- ECR1 (N = 167)

Results

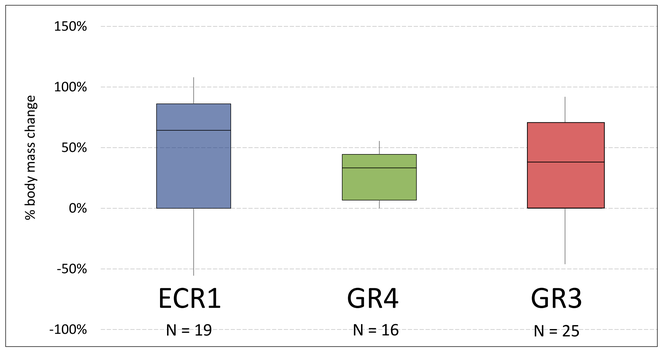


Fig 2. Box-whisker plot of percent body mass change, 7/23, 8/5 – 10/07/2016 (single factor ANOVA, Bonferroni correction p = 0.0006).

Seasonal Growth **(Figure 2)**

- Mean body mass increased in all three streams, highest median increase in ECR1
- Brook trout in GR3 significantly increased body mass when compared to GR4

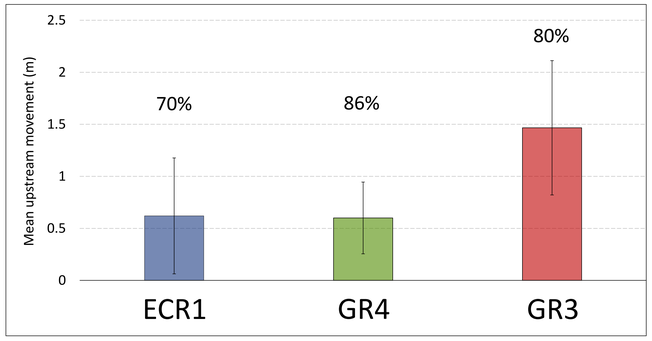


Fig 3. Mean and standard error for upstream movement, same mark-recapture period and sample size as Fig 2 (p = 0.41)

Fish Movement **(Figure 3)**

- Mean movement occurred upstream between peak summer water temperatures and spawning (Fig 4)(NHFGD)
- Furthest mean movement occurred in the most impacted stream with an impassable crossing (GR3)

Discussion

- Differences in age distributions = threat of subpopulation extirpation in GR3 and GR4 (Fig 1)(Öhlund et al. 2008).
- Greatest % body mass increase occurred in the least impacted stream, suggesting most food availability/least stress (Fig 2)
- Greatest movement trend occurring in the most impacted tributary, suggesting unfavorable conditions (Fig 3)
- We predict culvert removal will increase fish movement into and within tributaries, providing enhanced access to thermal refuge and spawning habitat, resulting in increased genetic variation

Acknowledgements

The Conservation Fund, NH Fish & Game Dept., PSU SRAC and PSU Biology Dept. for funding and Trout Unlimited: Pemigewasset Chapter for volunteer hours on the project.

Literature Cited

1. Curry, R. A., Sparks, D. & Van de Sande, J. 2002. Spatial and Temporal Movements of a Riverine Brook Trout Population. *Transactions of the American Fisheries Society.* 131:551-560
2. Davis, L. A., Wagner, T. & Bartron, M. L. 2015. Spatial and temporal movement dynamics of brook *Salvelinus fontinalis* and brown trout *Salmo trutta*. *Environmental Biology of Fishes.* 98(10):2049-2065
3. Hebert, C., Danzman, R. G., Jones, M. W. & Bernatchez, L. 2000. Hydrography and population genetic structure in brook charr (*Salvelinus fontinalis*, Mitchill) from eastern Canada. *Molecular Ecology.* 9:971-982
4. Hudy, M., Coombs, J. A., Nislow, K. H. & Letcher, B. H. 2010. Dispersal and Within-Stream Spatial Population Structure of Brook Trout Revealed by Pedigree Reconstruction Analysis. *Transactions of the American Fisheries Society.* 139:1276-1287
5. Kanno, Y., Letcher, B. H., Coombs, J. A., Nislow, K. H. & Whiteley, A. H. 2014. Linking movement and reproductive history of brook trout to assess habitat connectivity in a heterogeneous stream network. *Freshwater Biology.* 59:142-154
6. King, T. L., Lubinski, B. A., Burnham-Curtis, M. K., Stott, W. & Morgan II, R. P. 2012. Tools for the management and conservation of genetic diversity in brook trout (*Salvelinus fontinalis*): tri-and tetranucleotide microsatellite markers for the assessment of genetic diversity, phylogeography, and historical demographics. *Conservation Genetics Resources.* 4:539-543
7. Kondratieff, M. C. & Myrick, C. A. 2006. How High Can Brook Trout Jump? A Laboratory Evaluation of Brook Trout Jumping Performance. *Transactions of the American Fisheries Society.* 135:361-370
8. Öhlund, G., Nordwall, F., Degerman, E. & Eriksson, T. 2008. Life history and large-scale habitat use of brown trout (*Salmo trutta*) and brook trout (*Salvelinus fontinalis*) – Implications for species replacement patterns. *Canadian Journal of Fisheries and Aquatic Sciences.* 65:633–644
9. Poplar-Jeffers, I. O., Petty, J. T., Anderson, J. T., Kite, S. J., Strager, M. P. & Fortney, R. H. 2008. Culvert replacement and Stream habitat Restoration: Implications from Brook Trout Management in an Appalachian Watershed, U.S.A. *Restoration Ecology.* 17(3):404-413
10. Torterotot, J-B., Perrier, C., Bergeron, N. E. & Bernatchez, L. 2014. Influence of Forest Road Culverts and Waterfalls on the Fine-Scale Distribution of Brook Trout Genetic Diversity in a Boreal Watershed. *Transactions of the American Fisheries Society.* 143(6):1577-1591
11. Warren Jr., M. L. & Pardew, M. G. 1998. Road Crossings as Barriers to Small-Stream Fish Movement. *Transactions of the American Fisheries Society.* 127:637-644