

Insights From Population Modeling on the Cause of Brown Trout Decline

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Objectives

- To quantify the decline of the brown trout population in standard demographic terms
- To identify stages in the brown trout life cycle where excessive mortality or diminished reproductive output lead to population decline.
- To translate competing hypotheses accounting for the decline from verbal to mathematical form, and then to measure the support for each hypothesis statistically.
- To contrast the brown trout population in the Batten Kill with the brook trout population in the same stream, and to make comparisons between the Kill and other Vermont trout streams.
- To use information from the early stages of analysis to inform further field work; in particular, we set out
 - to measure survival rates of mid-size brown trout,
 - to estimate abundance of Common Mergansers, a trout predator,
 - to characterize the diet of Common Mergansers.

Modeling Framework:

Life Cycle Diagram & Demographic Model

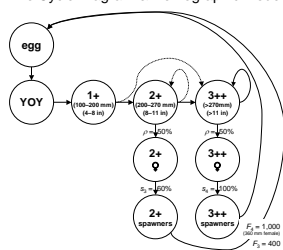


Figure 1. Life cycle diagram depicting the stages and transitions in the life of a brown trout (we used a slightly simpler model for brook trout with only three stages). Stages are identified in circles while arrows connecting circles represent transitions from one stage to another. Thus young-of-the-year (YOY) trout, if they survive, become yearlings (1+), which subsequently become adults. Dotted lines indicate that some trout may actually skip ahead or linger in a size class longer than a year. Each transition that is represented by an arrow in the diagram, above, also is represented as a parameter in the demographic model. Some of those parameters are well established in the scientific literature, as indicated by the values filled in for the reproductive parameters. We used statistical methods to determine the values of the remaining parameters, which are annual survival rates, given the data shown in Fig. 2.

Summary of Model Fitting

- Estimated annual survival for brown trout in the Batten Kill is approximately 30%.
- The estimate for brook trout is slightly lower, approximately 25%.
- Population growth (or decline) is the result of a balance between births and deaths, so those numbers do not imply that the brown trout population should not be declining while the brook trout population remains steady. Rather, brook trout reproduce at an earlier age and a smaller size than brown trout, and their population can apparently sustain 75% annual mortality.
- For brown trout, if we estimate survival probabilities separately for each size class, estimated survival for the middle size class (6-10") is generally lower than for young-of-year or larger trout.
- Also only for brown trout, if we estimate the trend in survival probability over the period of the surveys, and if we ask which size class shows the strongest signal of such a trend, the data best support declining survival of brown trout in the middle size class (6-10").
- Based on demographic analysis of the brown trout model, we determined that overall population growth (or decline) will respond more strongly to slight changes in survival of mid-size trout than to slight changes in any of the other parameters.

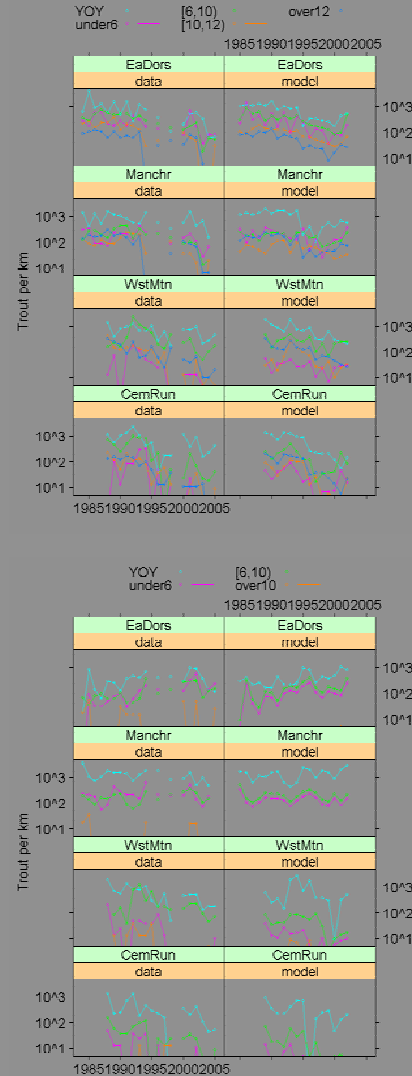


Figure 2. Time series plots of estimated brown trout (top) and brook trout (bottom) density, 1984-2002, at four stations from East Dorset (near the headwaters) to West Arlington (near the state line). Panels on the left show actual estimates from electrofishing surveys, while panels on the right show predictions from demographic models fit to the data. (Data were collected by Ken Cox and his crew.)

Survival Bottleneck?

During the summer of 2003, we set out to perform a mark-recapture study of brown trout survival hoping to contrast the survival rate across a range of sizes. The problem with that study as we originally conceived it was that there were too few fish in the 200-300 mm range — perhaps an indication right from the start that there is a bottleneck for brown trout trying to advance into their second year. Although we could not make the usual mark-recapture estimates, Fig. 2 illustrates a way of viewing the changing size distribution over the course of the season that supports the hypothesis that yearlings (120-150 mm) had a lower survival probability than older fish.

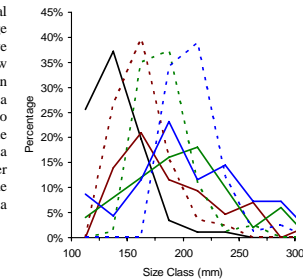


Figure 3. Size distribution of brown trout at the West Mountain station, four survey dates during 2003. Solid lines are actual distributions; dashed lines show the expected distributions based on the 20 June survey if survival was uniform among size classes, i.e., if the distribution changed only because fish grew.

Common Mergansers

The Common Merganser is a species of fish-eating duck that is native to our region and is likely an important predator of trout. In other parts of the world, particularly northern coastal regions, salmonids are known to make up a significant proportion of merganser diet. We studied geographic trends in Common Merganser abundance, compared density of mergansers (and other avian fish predators) between the Batten Kill and other Vermont streams, and collected a sample of mergansers for diet analysis.



Figure 4. Map showing rate of increase of probability that Common Mergansers were detected in Breeding Bird Survey routes, 1966-2004, by state/province. Intensity of red reflects magnitude of logistic parameter (steepness of increase).

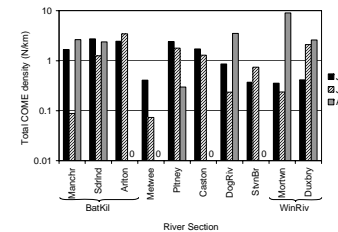


Figure 5. Density of Common Mergansers on three ~10km segments of the Kill and seven other comparable stream sections elsewhere in Vermont, summer 2004.

Common Merganser Diet

- Twenty-six Common Mergansers collected from the Batten Kill and the Dog River in Berlin
- Thirteen (½) had fish or fish parts in their stomachs
- 5 of the 13 had eaten trout (38%)
- Higher proportion than in community
- Fish in both hatch-year and after-hatch-year ducks
- 3 trout in 6-8" size class, both brown & brook

Conclusions

- We estimated the annual survival rate for brown trout in the Batten Kill to be approximately 30%. Coupled with other demographic parameters, that corresponds to a rate of decline of 15-25% per year.
- Brook trout have not been declining despite having lower annual survival, probably because they reach reproductive maturity at an earlier age.
- Data *do not* indicate any problems with recruitment or survival in the early life stages, as would be associated with problems of pollution, siltation, or many diseases.
- Data *do* indicate a problem with survival through the yearling size class, as may be associated with predation and lack of cover beneath which trout can take refuge.
- Common Merganser, a native duck, is a likely predator that may contribute to mortality of mid-size trout.
 - They have been increasing across the southern tier of their range.
 - They are common on the Kill and other Vermont streams.
 - They appear to preferentially prey on trout.



Figure 6. Ken Cox injects a PIT tag into a Batten Kill brown trout while Pete Meier records data.

Acknowledgements

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