Validation and Credibility

Validation: challenges

- population predictions not convincing unless the model's internal mechanisms have been tested successfully

- validation of models at specific sites requires extensive and accurate data from the study site, for both model input and comparison to results
    - Monitoring one undisturbed site generally not useful

- inSTREAM is complex but still a model: real trout populations can be affected by many processes and events that inSTREAM does not include
    - Unmodeled stuff that might be important: episodic predation by otters, angler harvest, variable immigration

Validation: opportunities

- The IBM predicts many things other than abundance
  - Examples:
    - Behavior
    - Individual variation in growth
    - Within-year patterns of growth

- Pattern Oriented Modeling during model formulation

- Patterns not used during model formulation

Validation via Pattern-Oriented Modeling (POM)

- Railsback and Harvey 2002
- Railsback et al. 2002
- Railsback et al. 2005
- Railsback et al. 2020

Pattern-Oriented Modeling (POM)
Railsback and Harvey 2002

- 1. Hierarchical feeding
- 2. Response to high flows: move to stream margins
- 3. Response to a larger competing species
- 4. Response to predatory fish
- 5. Variation in velocity preference with season
- 6. Changes in habitat use with food availability and energy reserves

(POM) Railsback et al. 2002

- 7. “Self-thinning”
- 8. Intense, density-dependent mortality in newly hatched trout.
- 9. Unstable population dynamics
- 10. Density dependent growth
- 11. Effects of pools on abundance of large adults

(POM) Railsback et al. 2005

- 12. Individual variation in diel activity
- 13. Nocturnal feeding in slower velocities
- 14. Higher local densities at night
- 15. Less nocturnal feeding at high temperature
- 16. Effects of life history stage on activity pattern
- 17. Competition increases daytime feeding
- 18. More daytime feeding when food availability or fish condition is low
- 19. Diel activity patterns depend on habitat

(POM for the latest model version)
Railsback et al. 2020

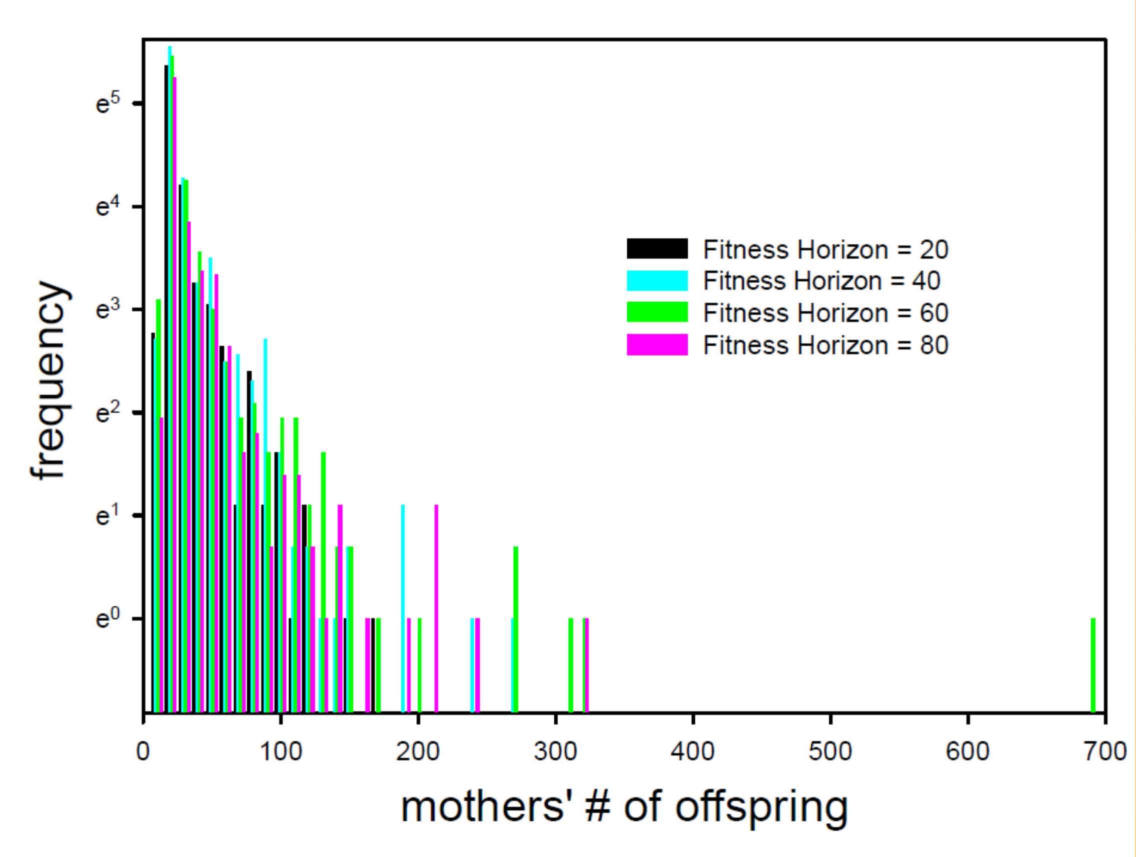
- 20. More daytime feeding when food availability or fish condition is low.
- 21. More daytime and crepuscular feeding at higher temperatures.
- 22. Feedbacks of competition on circadian foraging patterns: the percentage of trout feeding in each light phase varies with trout density.
- 23. Foraging patterns are affected by circadian cycles in food availability: if drift food becomes more available in, e.g., crepuscular phases, then feeding activity in those phases increases.
- 24. Less daytime foraging under higher predation risk.
- 25. Foraging patterns are affected by physical habitat conditions (e.g., flow regime).
- 26. Foraging patterns vary with day length.

Unplanned Pattern Matching I

Life history above barriers (Harvey and Railsback 2012): higher survival of juveniles, fewer and smaller adults

Unplanned Pattern Matching II

Variation in reproductive success

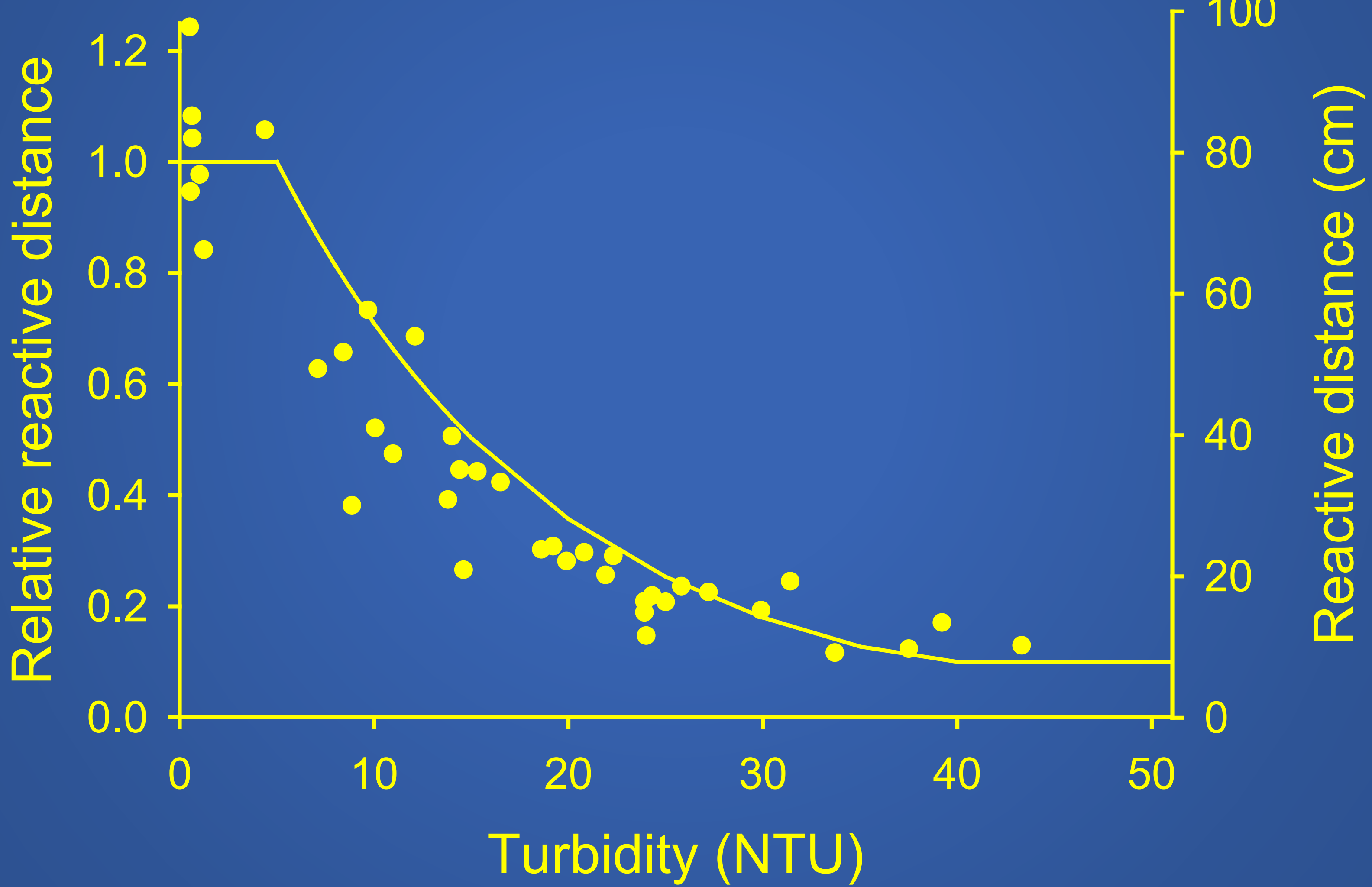


Invalidation, a useful concept:

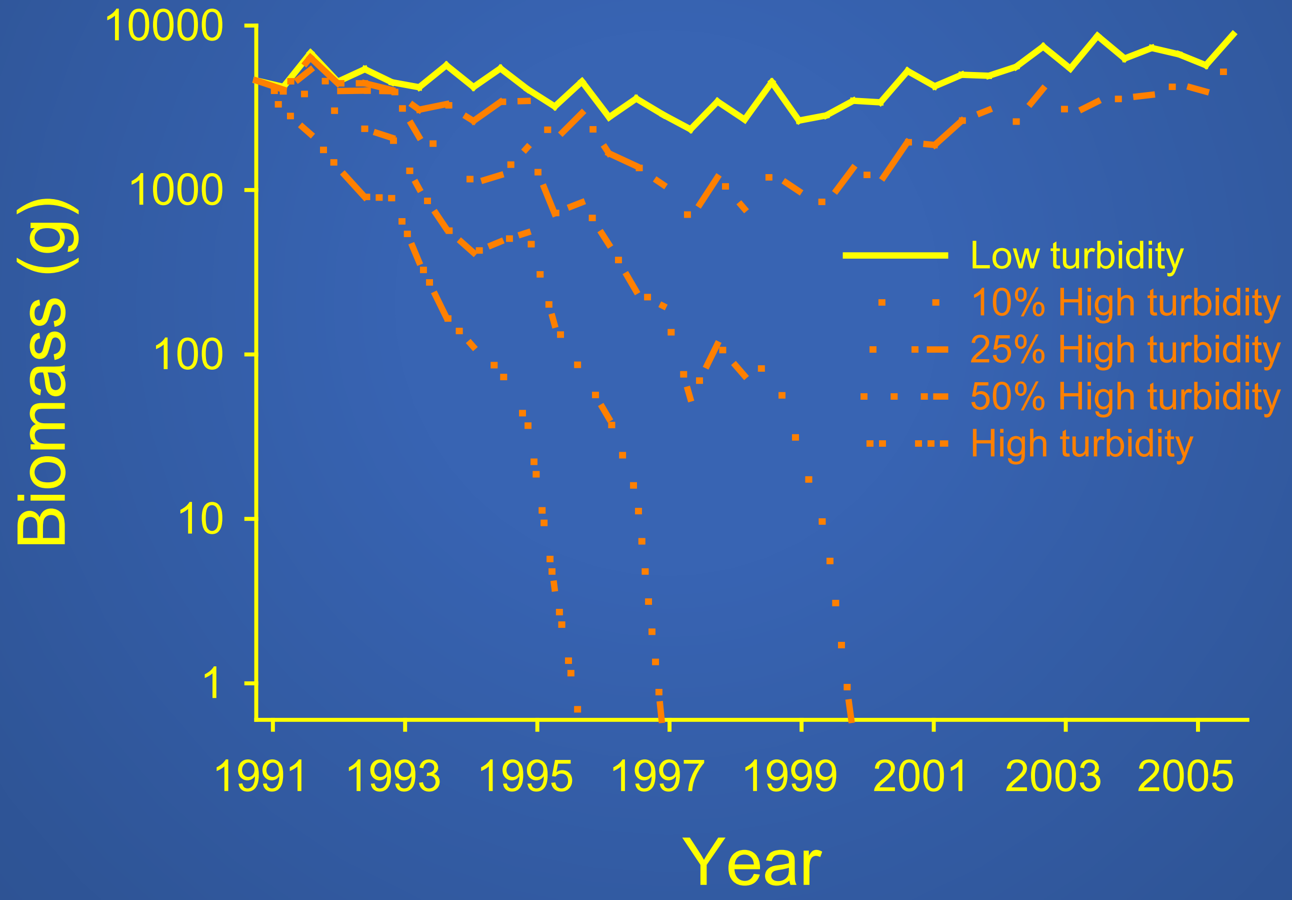
1. Survival of…

2. Victory from defeat

Victory from defeat:
Example: fish feeding in dirty water

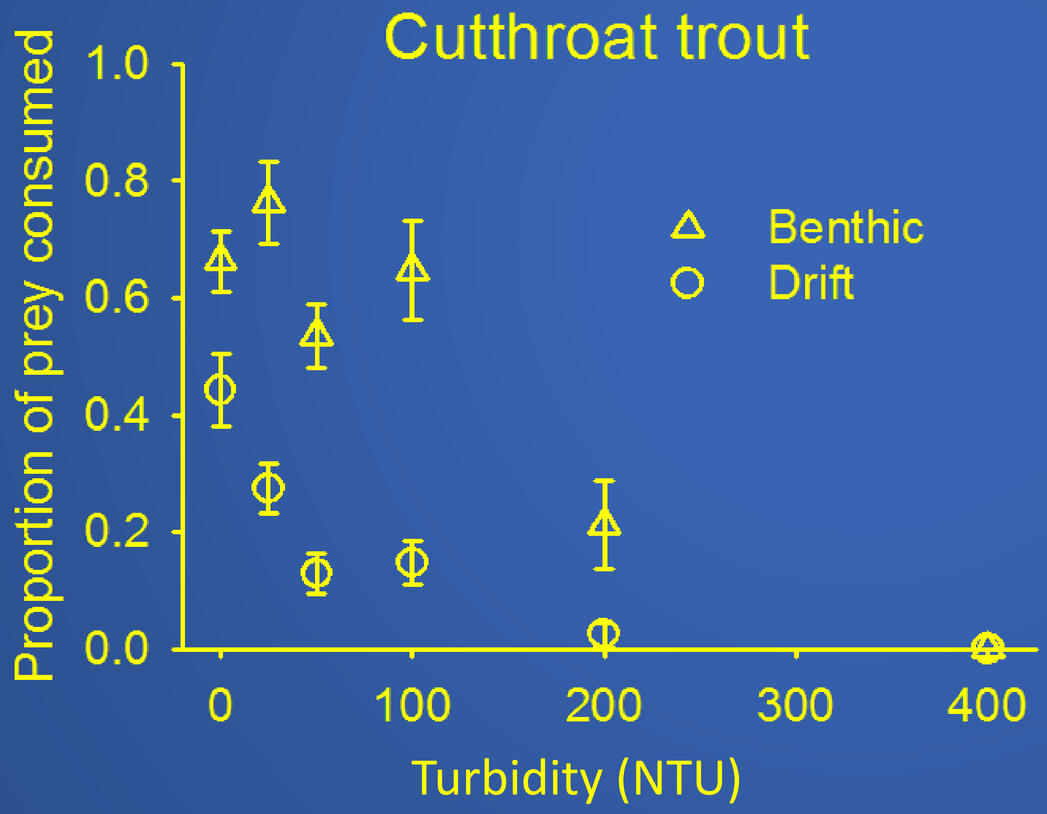


Population-level IBM results




Reality bites. . .

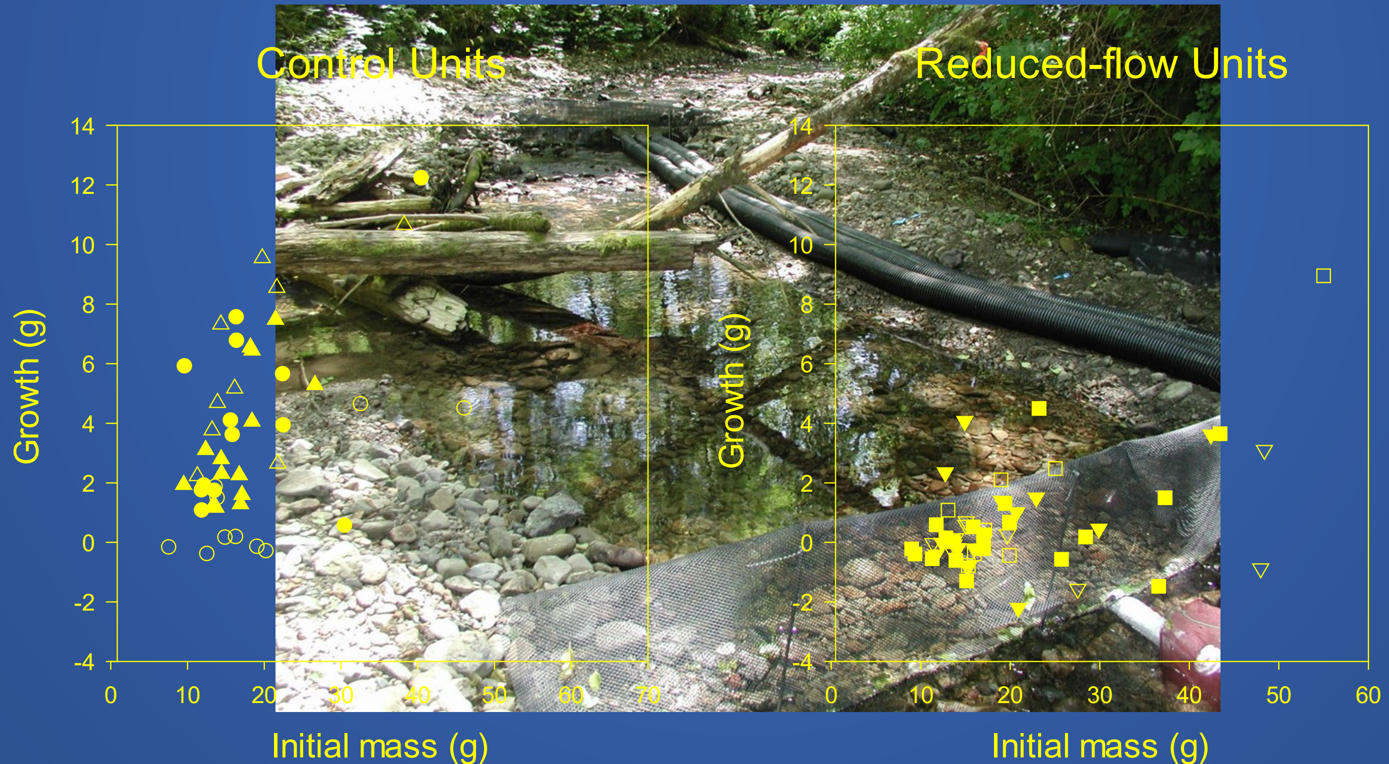
Model results motivated empirical research: reactive distance*turbidity relationship does not always control feeding success



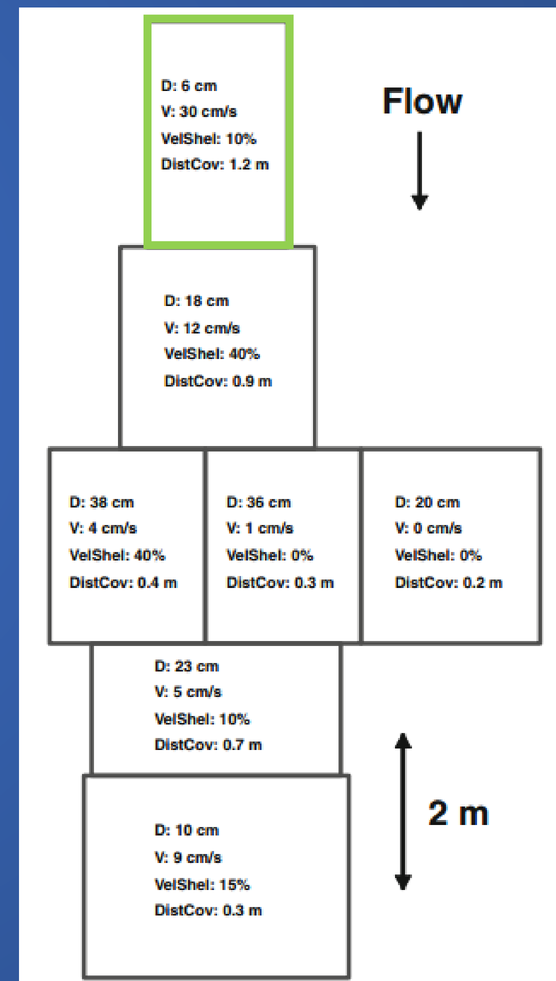
The original model formulation could easily address this result...

More credibility: Field evaluations of feeding and growth sub-models

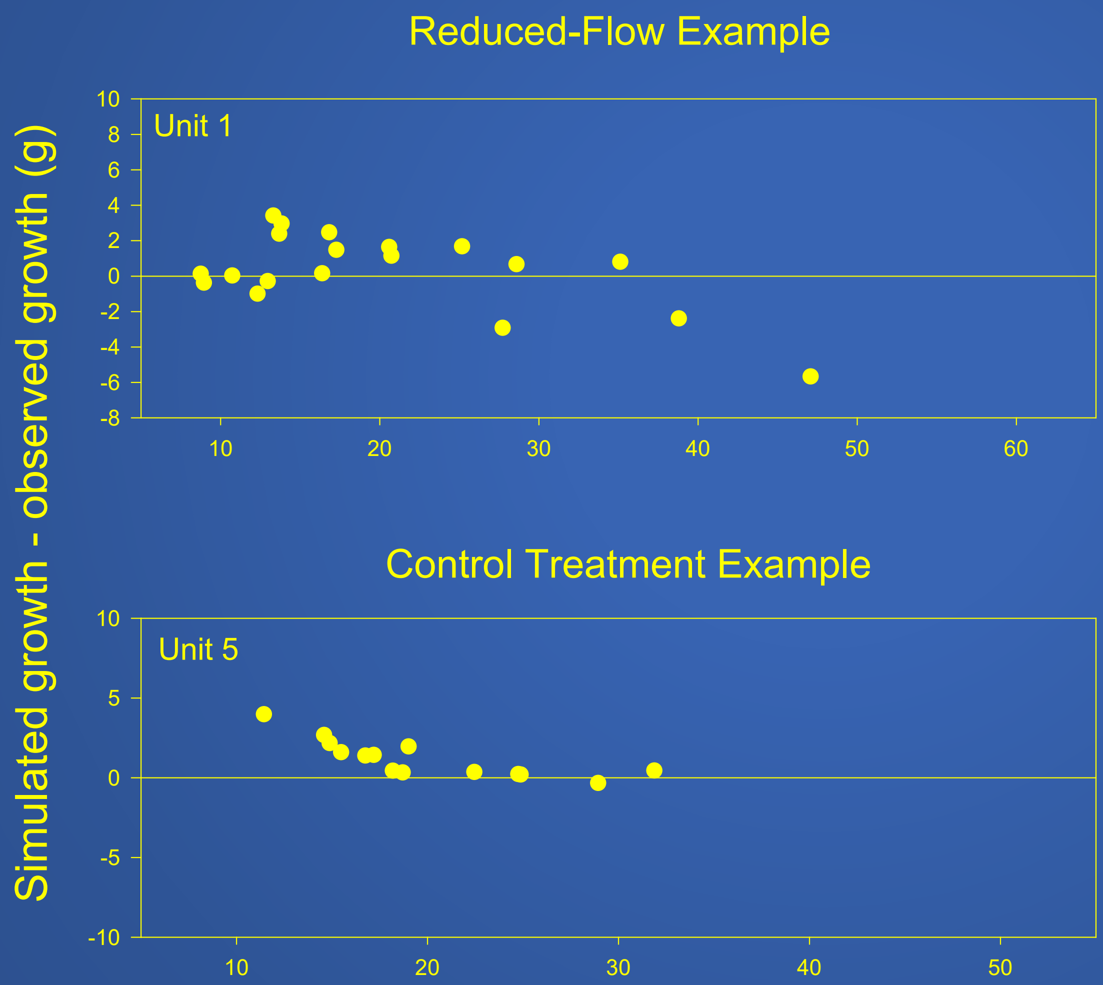
Feeding and growth sub-models: Importance of search feeding, reasonableness of food calibration



3. Evaluation of calibration parameters
Example continued



3. *Example continued:* Simulation results



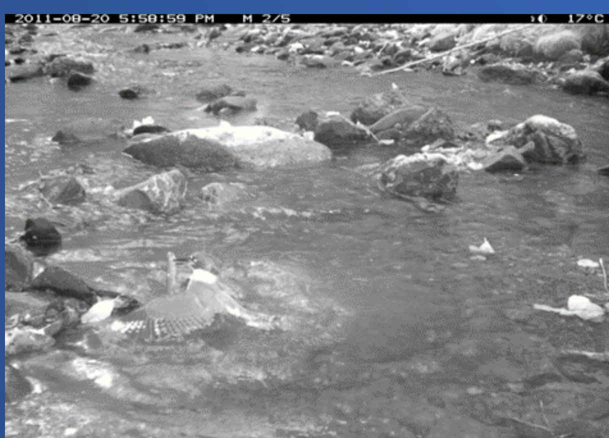
Calibration results matched empirical measurements of food availability

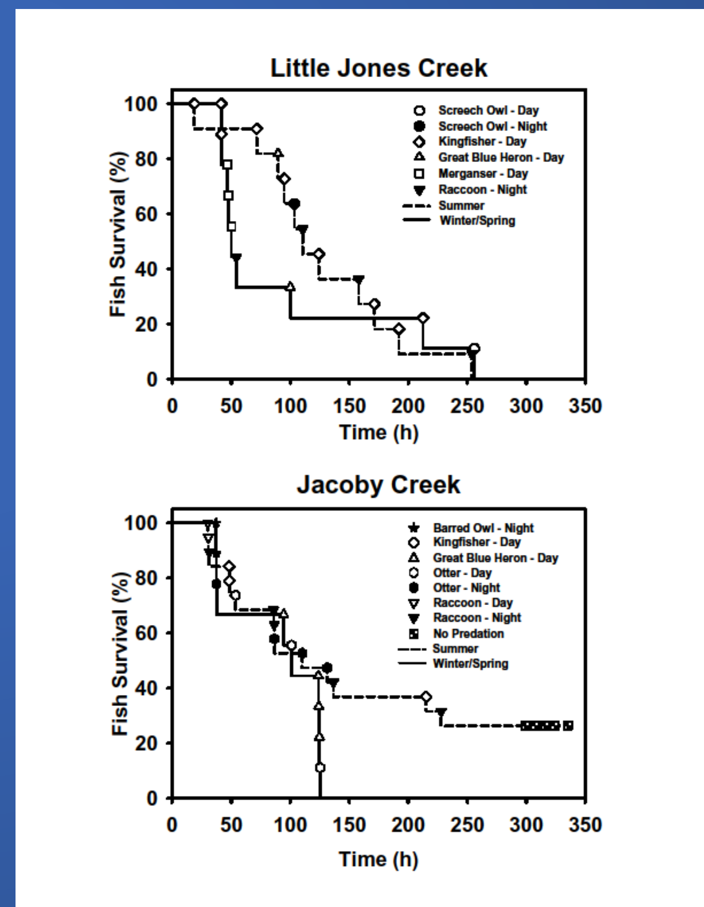
Harvey and Railsback 2014

More credibility: field evaluation of baseline predation risk

- Trout model formulation uses a baseline daily survival probability for the riskiest habitat
- Habitat features can increase survival (e.g. water depth)
- Harvey and Nakamoto (2013)

Baseline predation risk (continued)





Credibility from paired modeling and empirical studies

Example: a site-specific study of streamflow diversion effects on a fish population

Historic diversion of interest to resource managers

Compared an upstream control to a downstream reach

Fish monitoring: 4 y of sampling at the beginning and end of the dry season

IBM simulation of both reaches

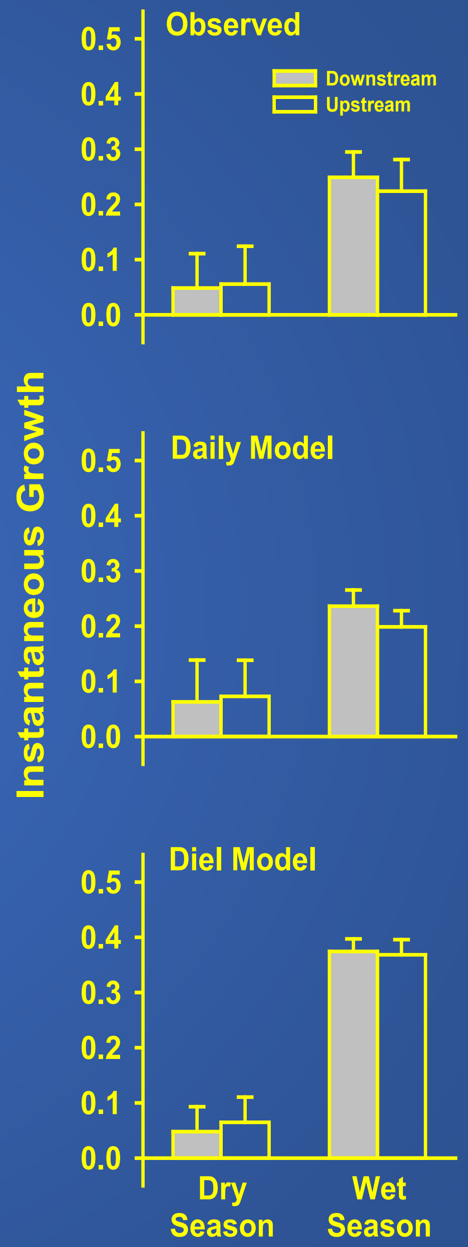
IBMs can mitigate common limitations of case studies, may gain credibility from site-specific data

- No replication
- No observations before/after impact
- Small perturbation
- Few biological observations covering significant timespans

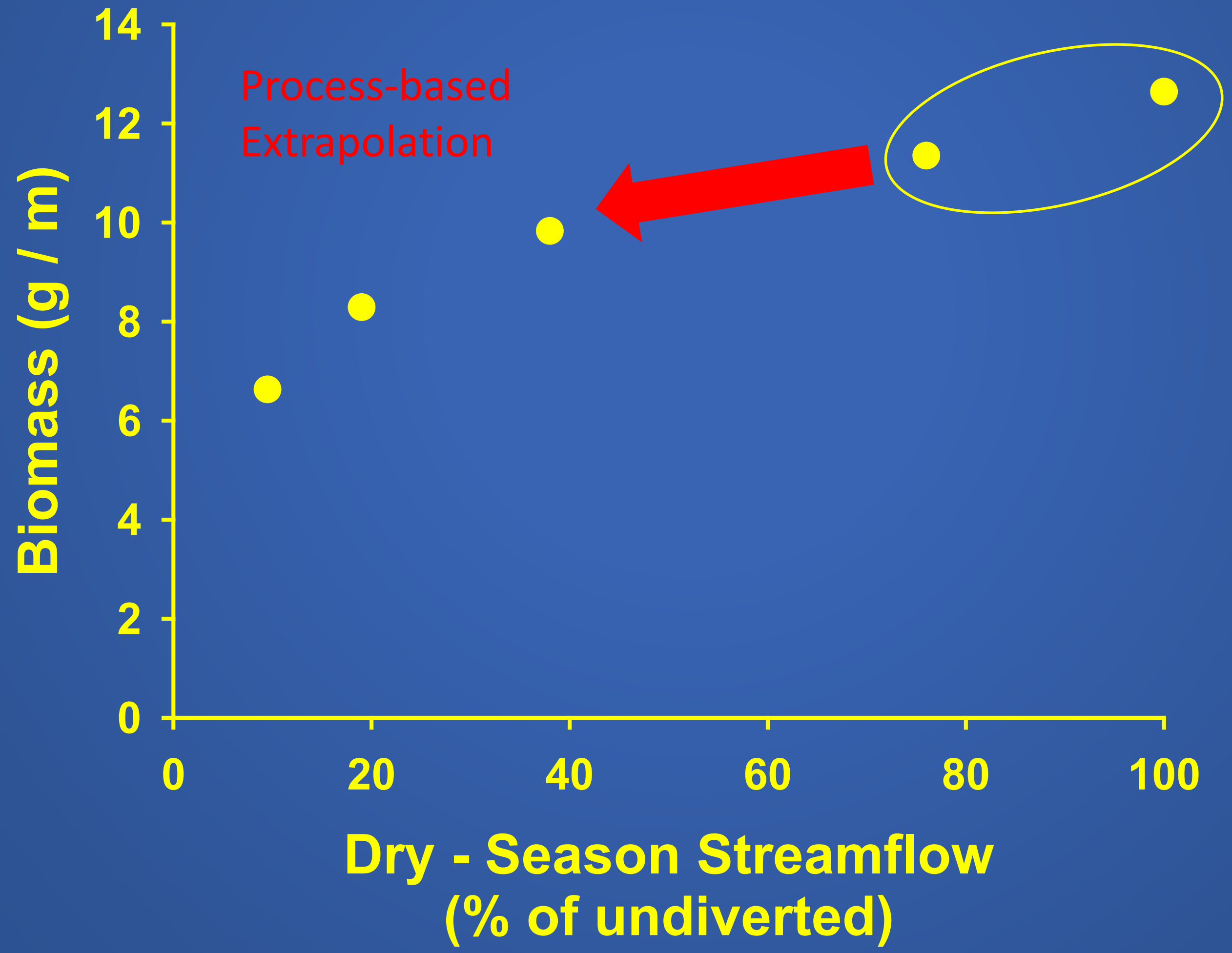
- *The site-specific field data create excellent IBM invalidation opportunities*

The IBMs reproduced key patterns in the empirical data, including:

- Seasonality of fish growth
- Distribution of individual growth rates
- Biomass differences between reaches



Leaving us in position to predict the consequences of additional environmental change:



Validation bottomline

- Many different kinds of results have demonstrated InStream’s reasonableness (including its survival of many opportunities to be invalidated)
- More extensive and site-specific validation will always be useful
- “Classic” validation for many important applications will be very difficult to achieve (e.g. population-level validation in large rivers)