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ARTICLE

Estimation of salmonid habitat growth potential through measurements of invertebrate food abundance and temperature

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Abstract: Criteria used to characterize lotic salmonid habitat suitability are often based on correlations between physical habitat characteristics and salmonid abundance. Focusing on physical habitat features ignores other habitat components, such as an adequate food supply, that limit the amount of energy available for growth and survival. We tested the degree that food availability and temperature influence lotic salmonid consumption and growth rates and outline an approach for assessing habitat quality based on measurements of these features. We collected benthic and drifting invertebrate abundances, stream temperatures, and juvenile steelhead – rainbow trout (*Onchorhynchus mykiss gairdneri*) summer growth rates among nine stream segments in central Oregon. Stream temperatures and growth rates were used in bioenergetics model simulations to estimate *O. mykiss* consumption rates. The variation in *O. mykiss* consumption rates was explained by measurements of total drift biomass along a type II predator response curve ($R^2 = 0.71$). This simplified foraging relationship between food abundance and consumption is then used to estimate the consumption component of the bioenergetics model to allow estimation of salmonid growth potential. Validation of the growth potential model produced reasonably accurate estimates of fish growth rates at reaches within the study area and precise but biased estimates in novel systems. While additional reach-level habitat information may be required to make the model more generalizable, the assessment of invertebrate food availability offers a simple yet powerful approach for describing the growth potential of stream habitat.

Résumé : Les critères utilisés pour caractériser la qualité des habitats de salmonidés lotiques reposent souvent sur des corréla-

Salmonid Habitat Assessment

Abiotic

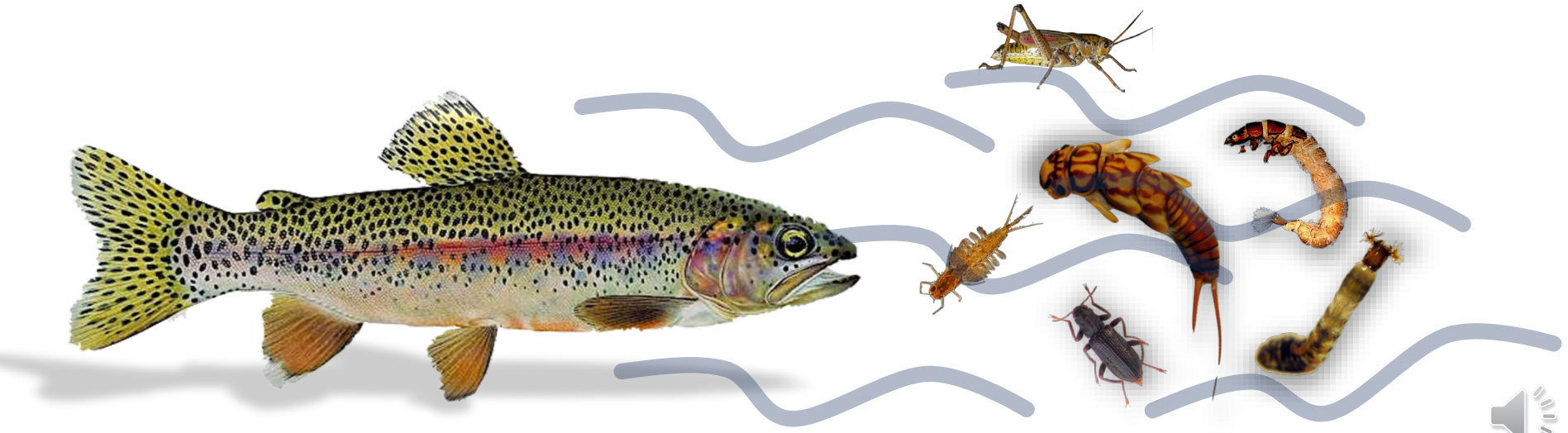
- Flow regime/magnitude
- Channel morphology
- Channel complexity
- Stream temperature

Biotic

- Predation
- Competition
- Food abundance

Food as Salmonid Habitat

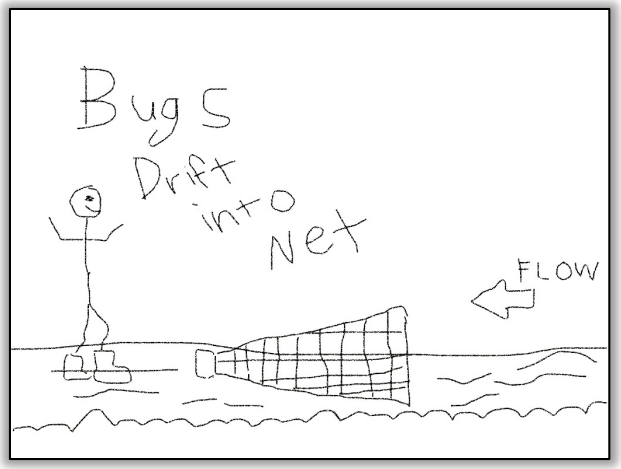
- Aquatic and terrestrial macroinvertebrates
- Focus on drifting invertebrates
- Set physiological limitations on growth
  → Survival



Macroinvertebrate Assessment

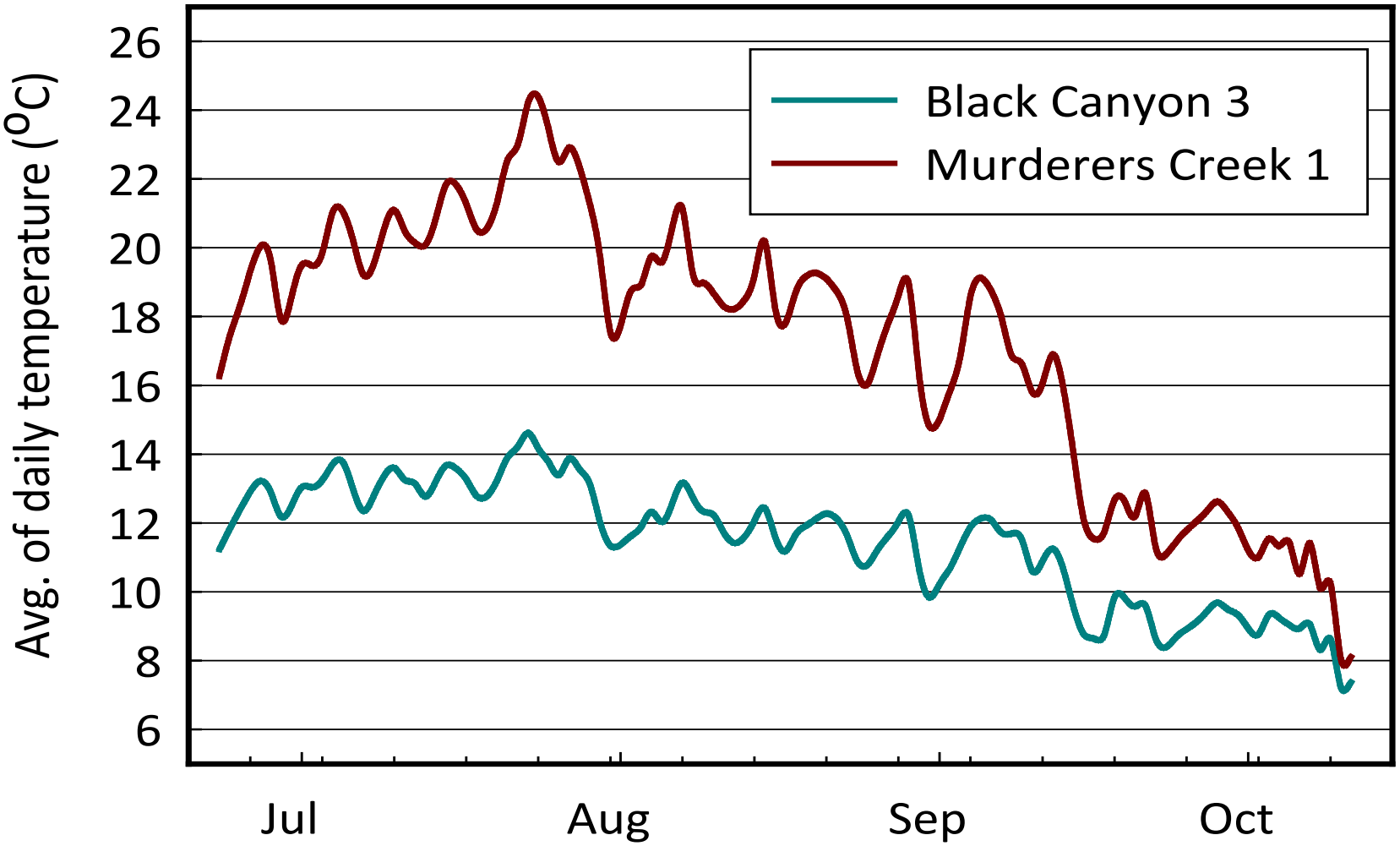
Benthic Sampling

- Most Common
- Diversity Indices
- Water Quality



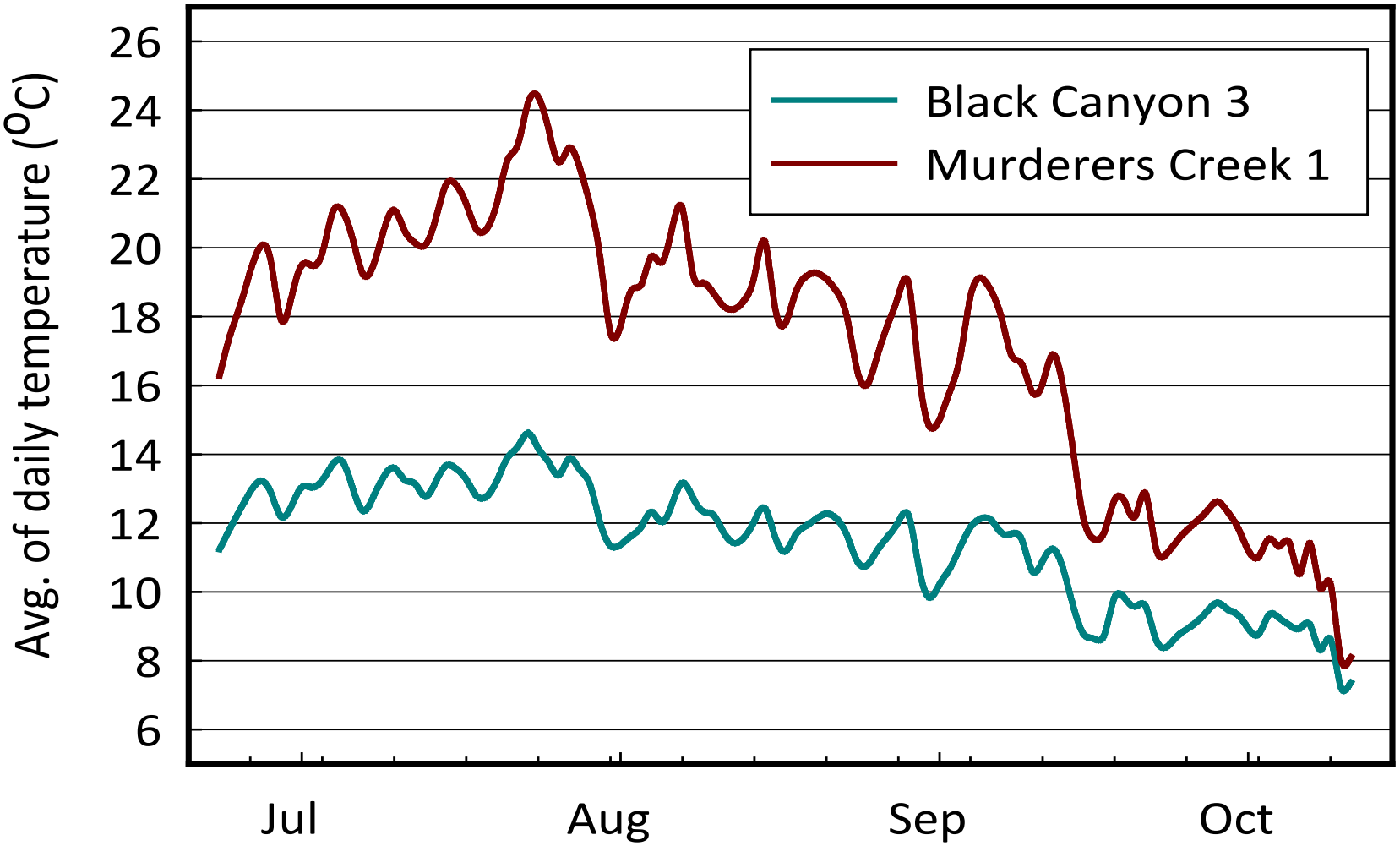
Drift Sampling

- Descriptive of Food Availability
- Seldom Collected



Hypothesis:

- Temperature Explain Juvenile Steelhead Summer Growth



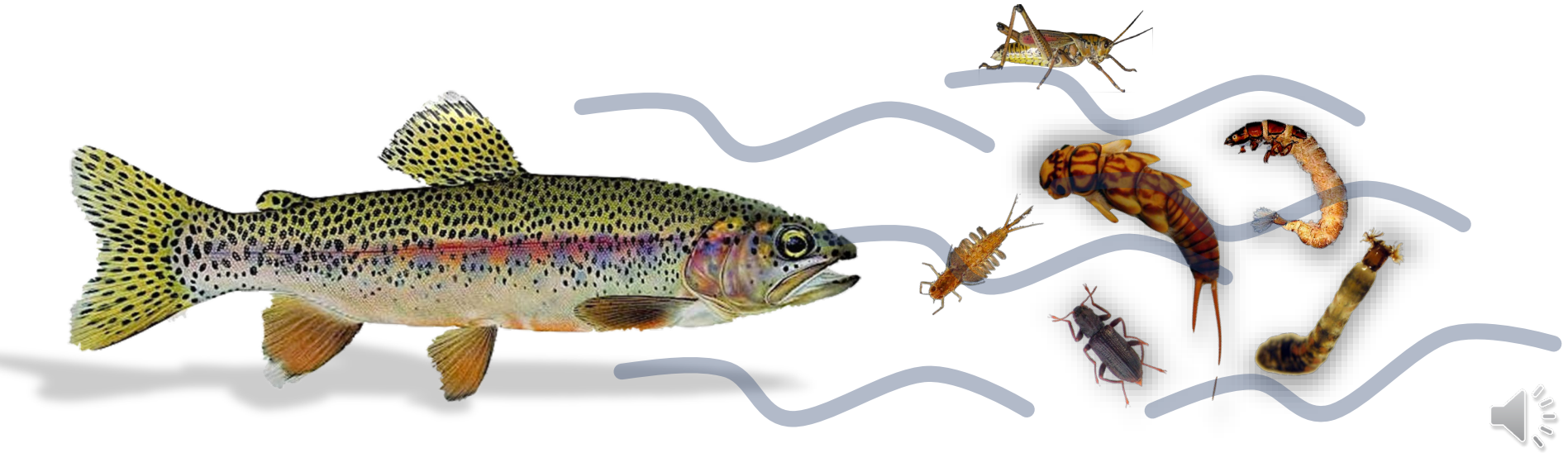
Hypothesis:

- Temperature Explain Juvenile Steelhead Summer Growth
- Food can help explain Summer Growth?

Development of a Salmonid Food-Availability Monitoring Protocol

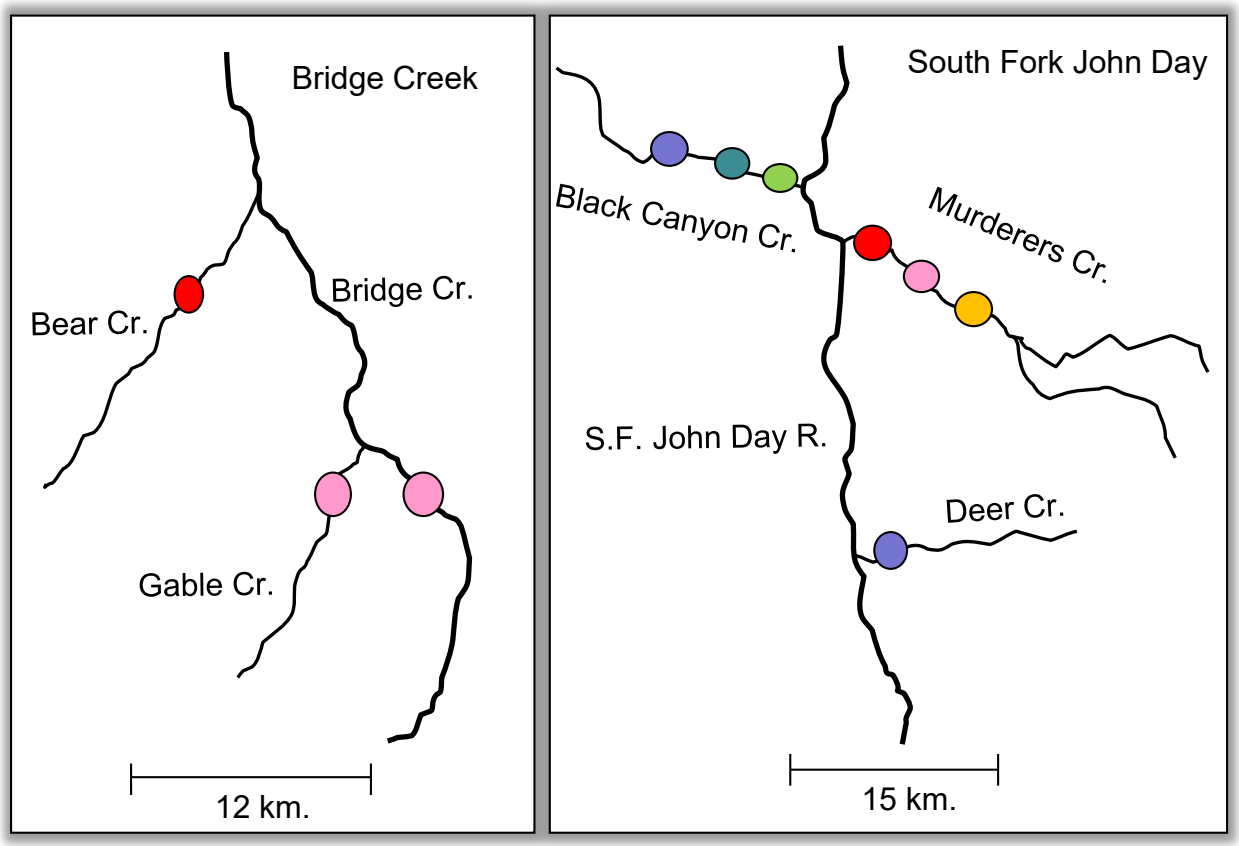
1) Describe how food abundance affects salmonid consumption and growth

2) Develop approaches for sampling food availability



At each study sites:

- juvenile steelhead summer growth rates
- Drift and benthic invertebrate samples
- Summer stream temperatures



Juvenile Steelhead Growth

Reach Specific Growth Rates:

- Capture during mid-June and late September
- Fish tagged with PIT-tags
  - identify captures of individuals over time
  - growth = change in weight over summer

Densities:

- Lincoln-Peterson mark-recapture
- no./m

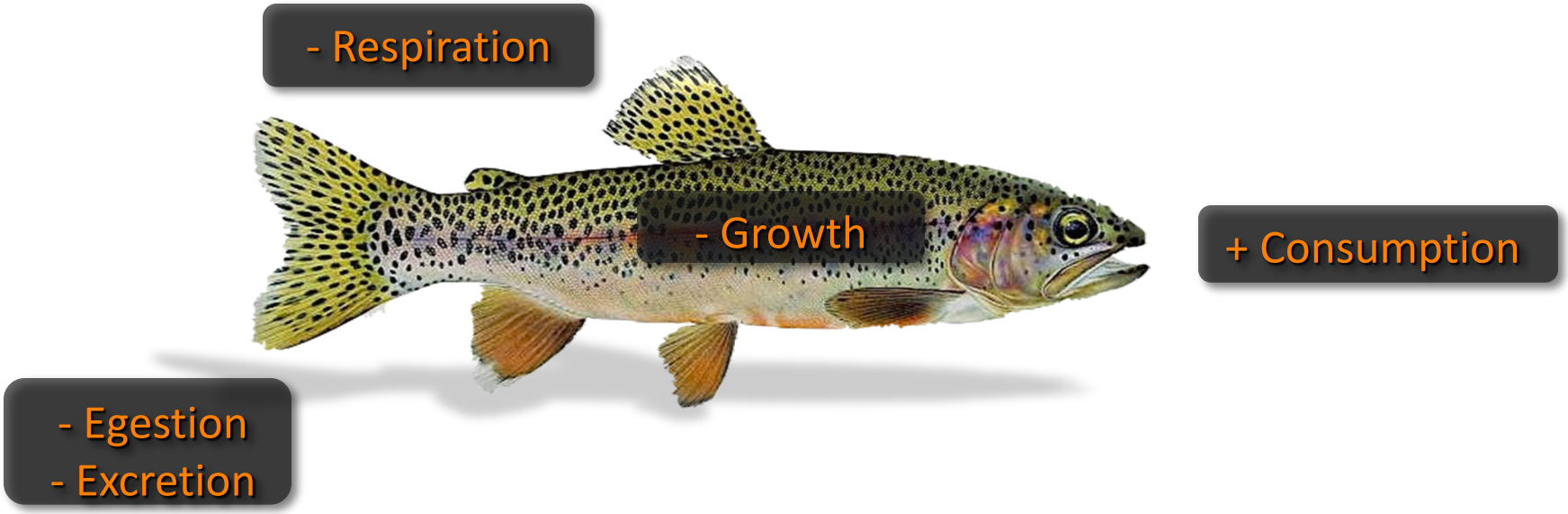
Isolating Consumption on Growth

Bioenergetics Model

Consumption = Growth + Respiration + Egestion + Excretion

Field Measurements

Function of Temperature



Bioenergetic Estimates of Consumption:

- Proportion of Maximum Consumption → %Cmax

%Cmax: Response to Food Availability

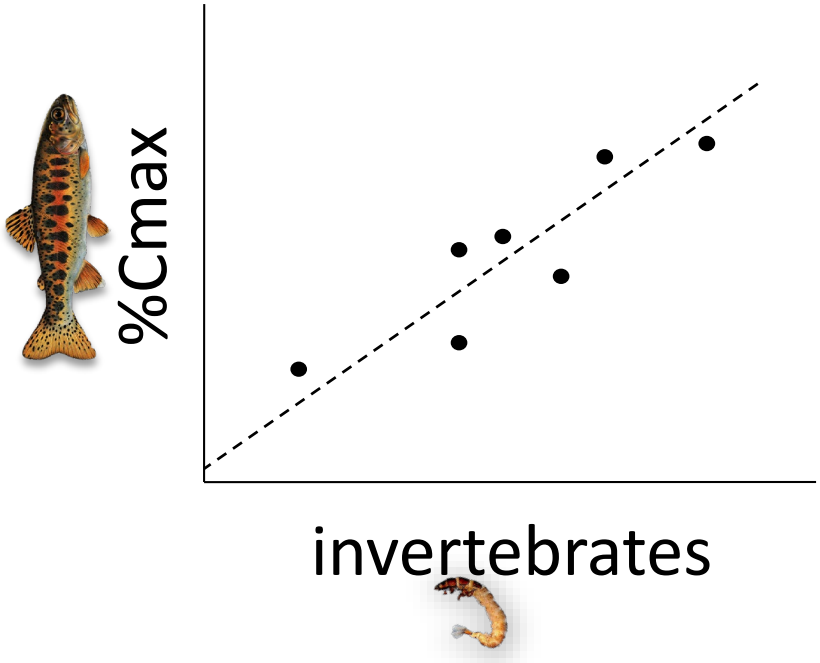
- Comparable Among
  - Different Temperature Regimes
  - Fish of Unequal Sizes

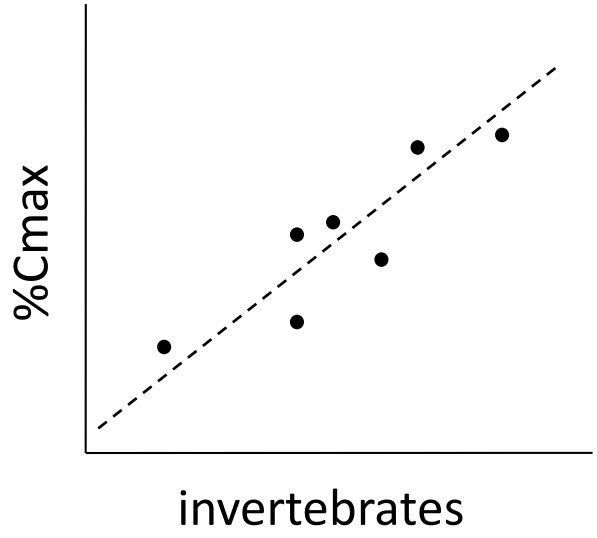
If Food is Limiting growth:

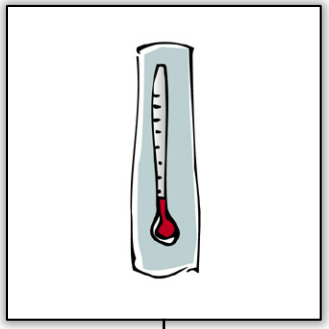
- Consumption and invertebrates highly correlated

Best description of food availability?

- invertebrate metric explaining consumption

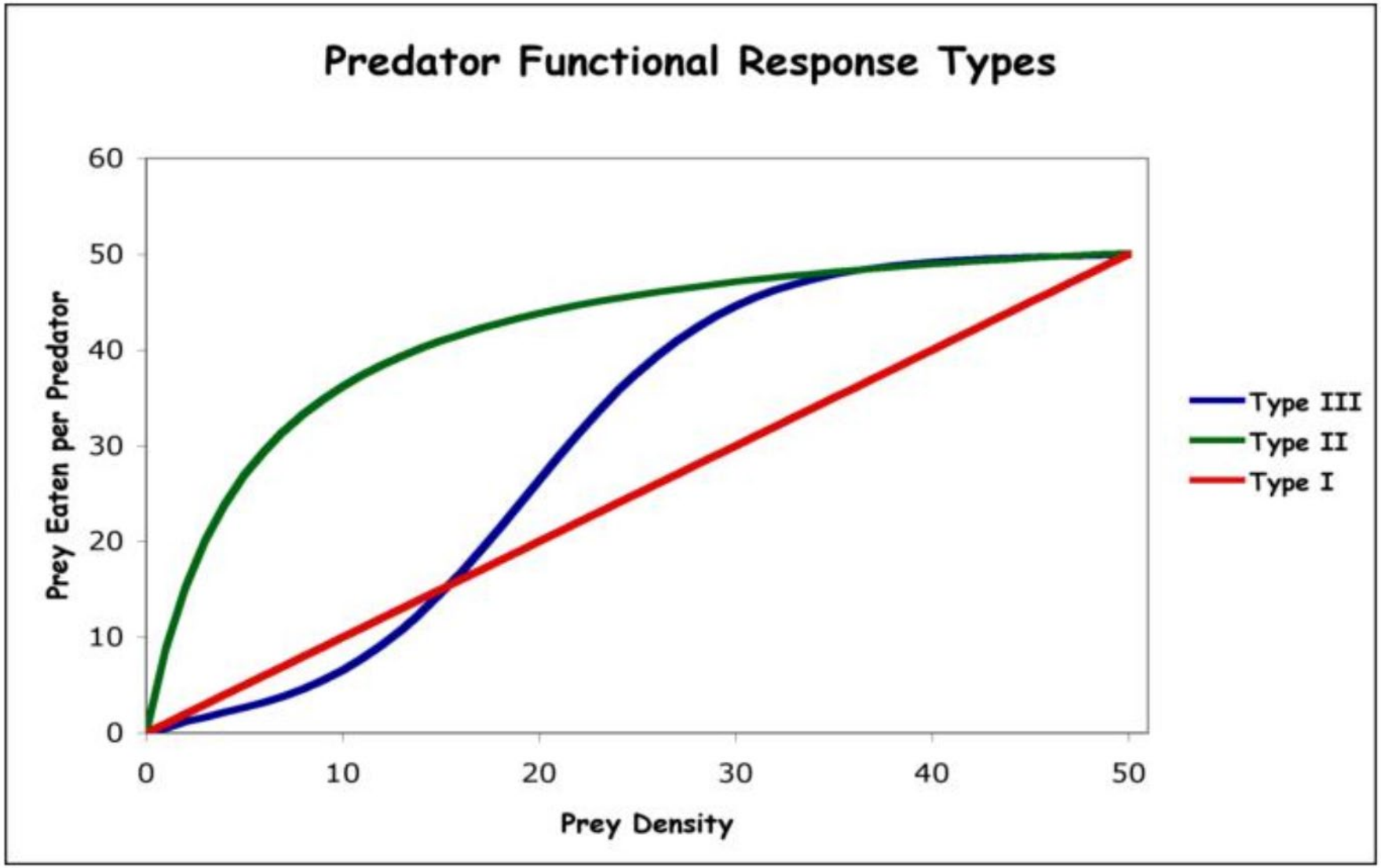






Consumption -
(Respiration + Egestion + Excretion)

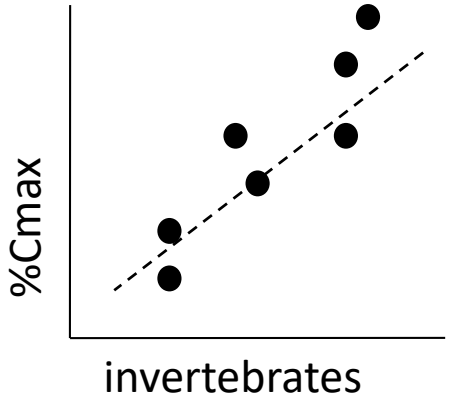
=


Predator Functional Response Types
Prey Eaten per Predator
0
10
20
30
40
50
60
Prey Density
0
10
20
30
40
50
Type III
Type II
Type I

Explaining Variation in Salmonid Consumption

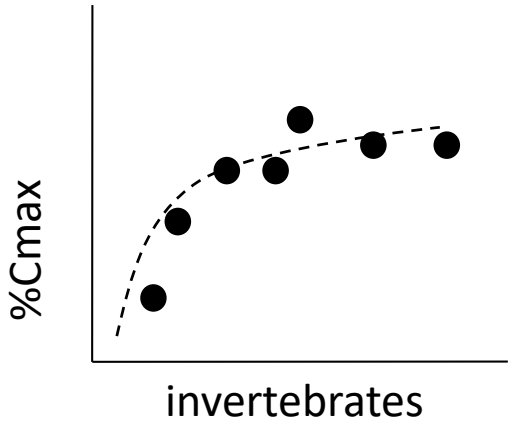
Type I Feeding Response

- Constant proportion of food availability



Type II Feeding Response

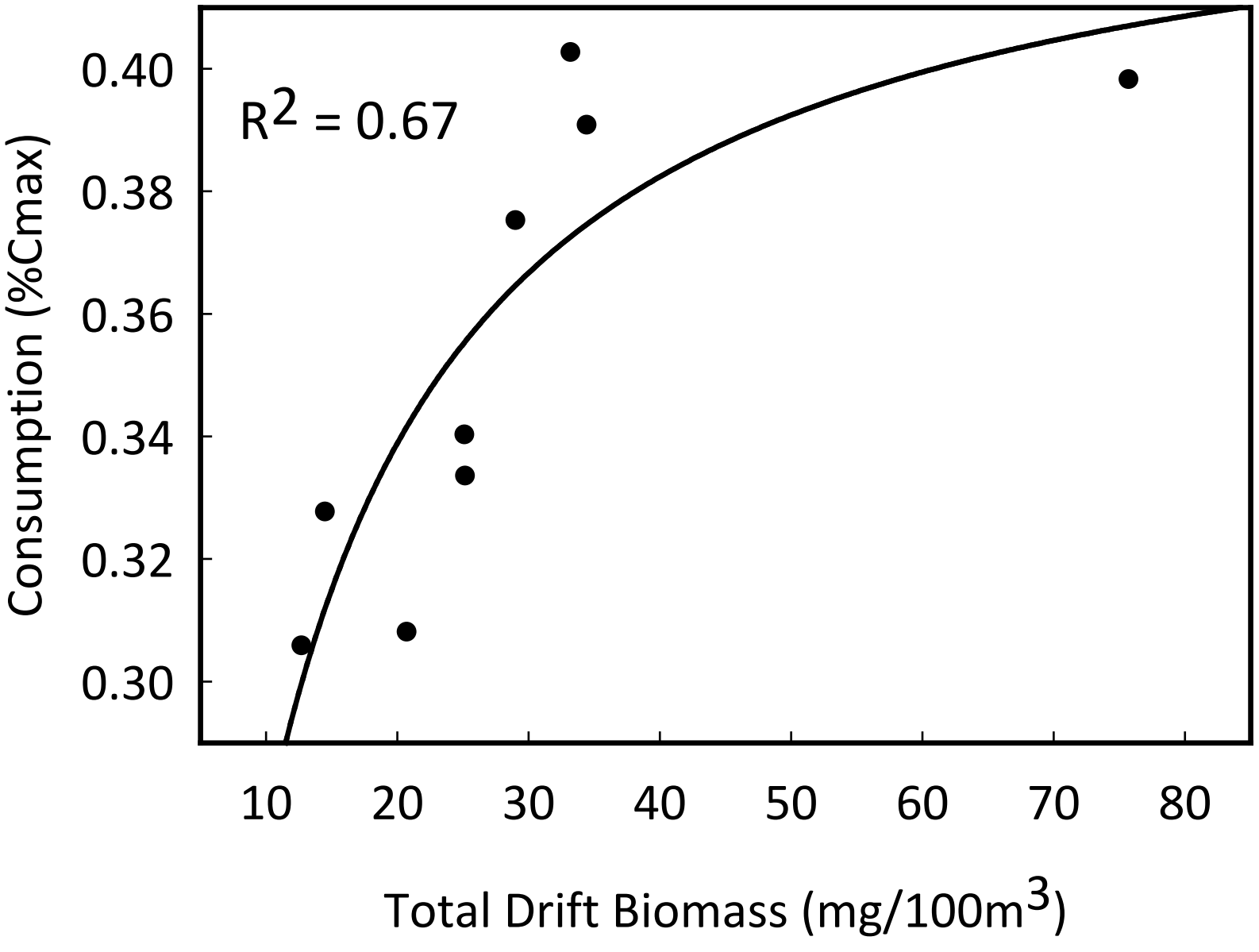
- Consumption reaches a maximum rate
- Satiation or handling time



Predictors:

- Drift and Benthic - Density and Biomass
- Fish Density: Competitive interactions

Explaining Variation in Salmonid Consumption



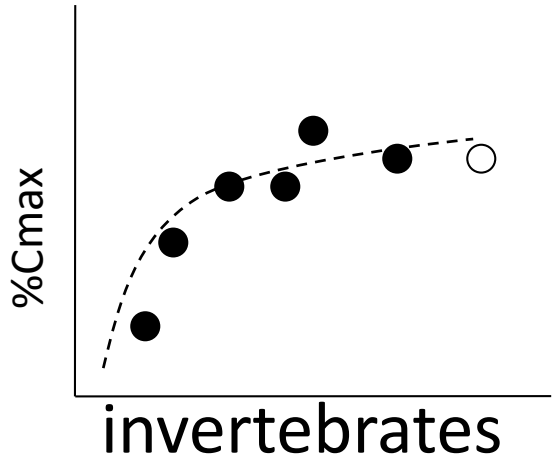
Consumption Model Validation

“Jackknifing” – data resampling

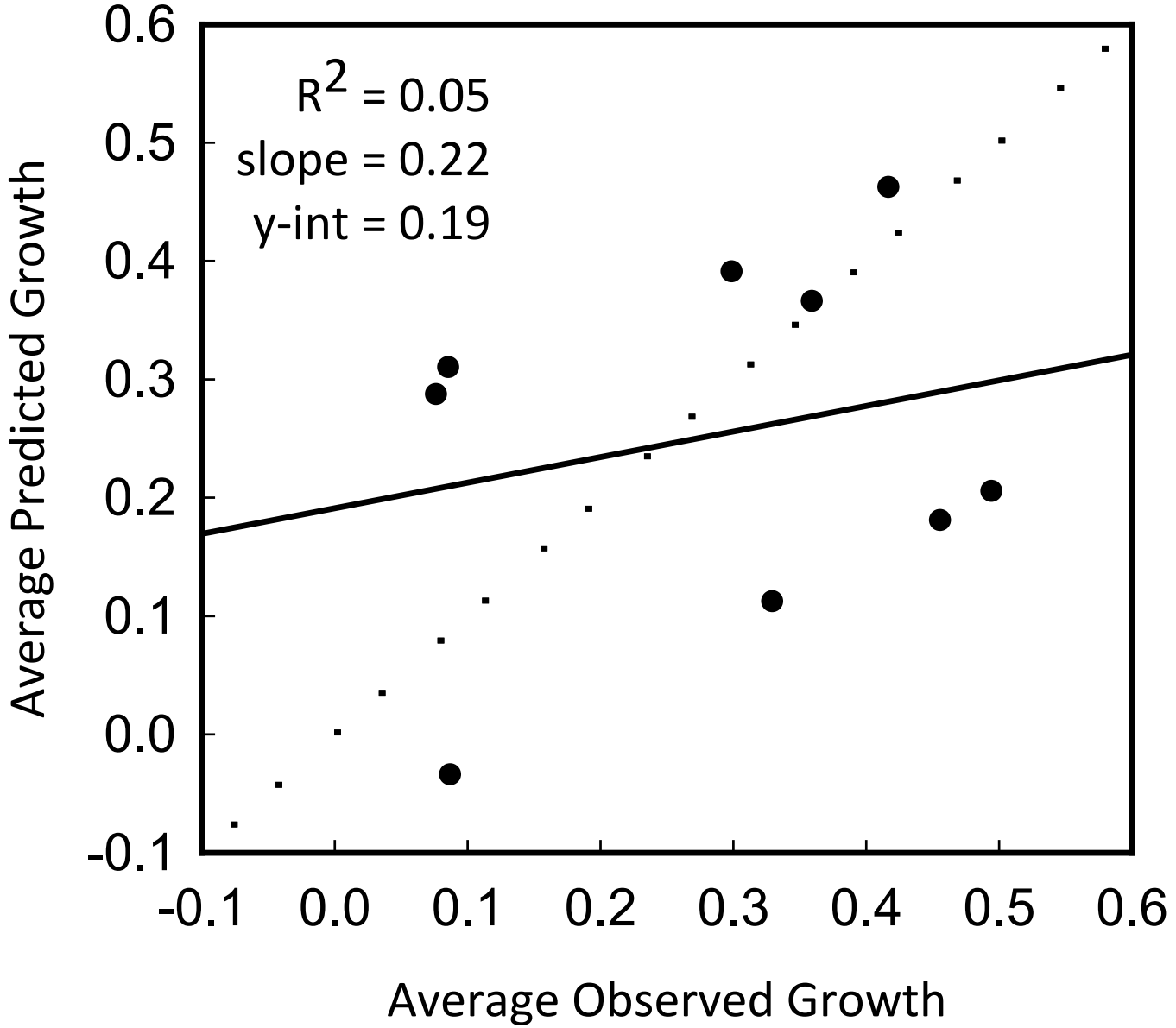
- Novel set of growth predictions
- Compare observed to predicted growth

Conducted for top model containing:

- Fish density + Invertebrates
- Only invertebrates



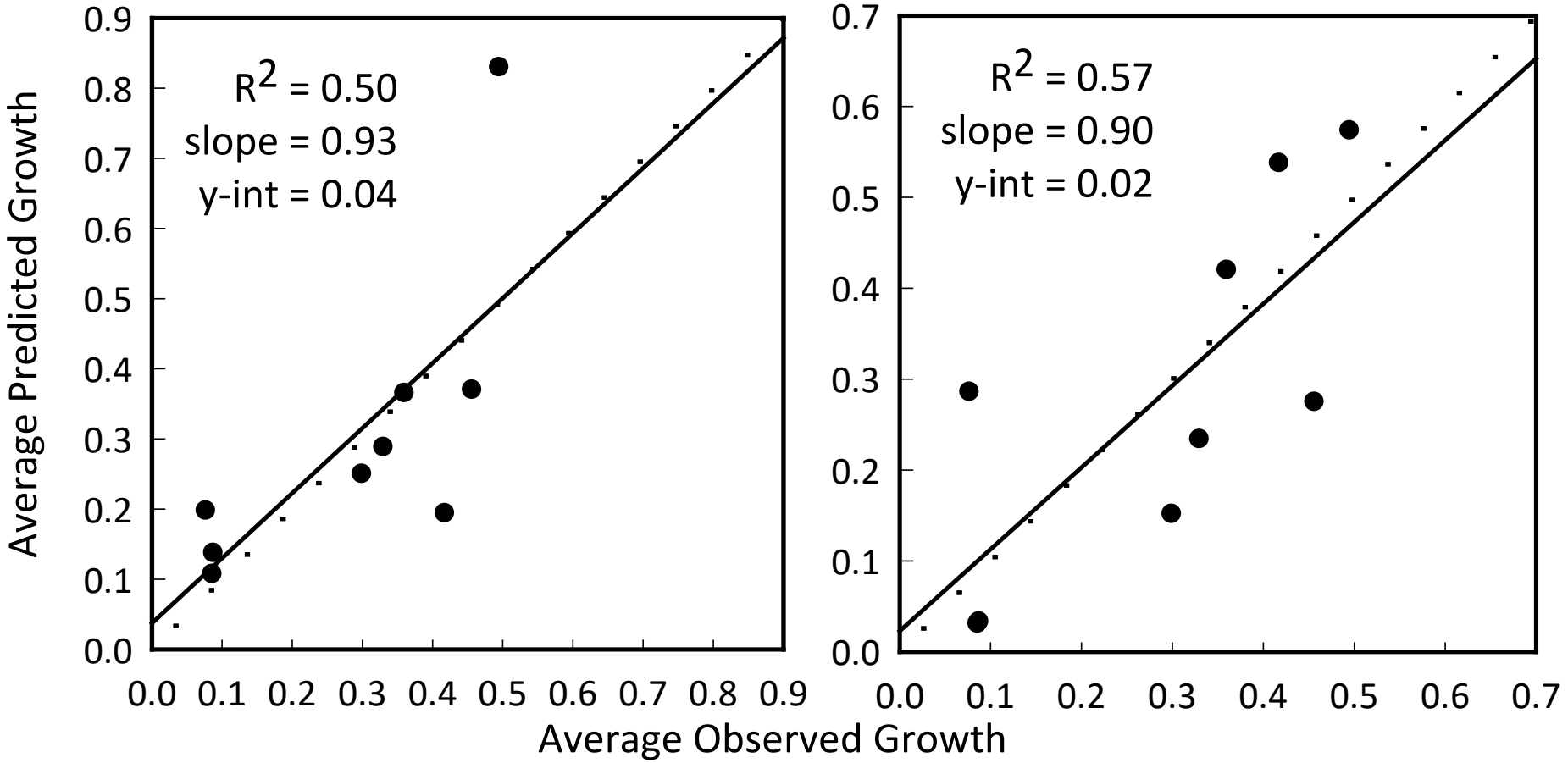
Temperature Predicted Growth



Consumption Model Validation

Type I model:
Fish Density + Drift Biomass

Type II model:
Drift Biomass



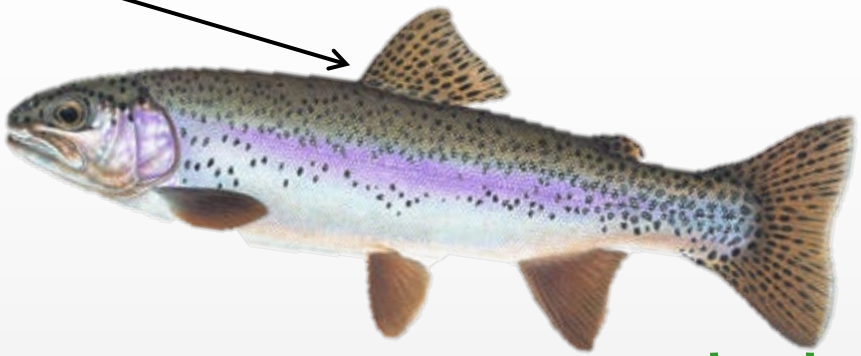
Bioenergetics

Drift

temperature

IN

Consumption



OUT

Metabolism

Waste

Growth

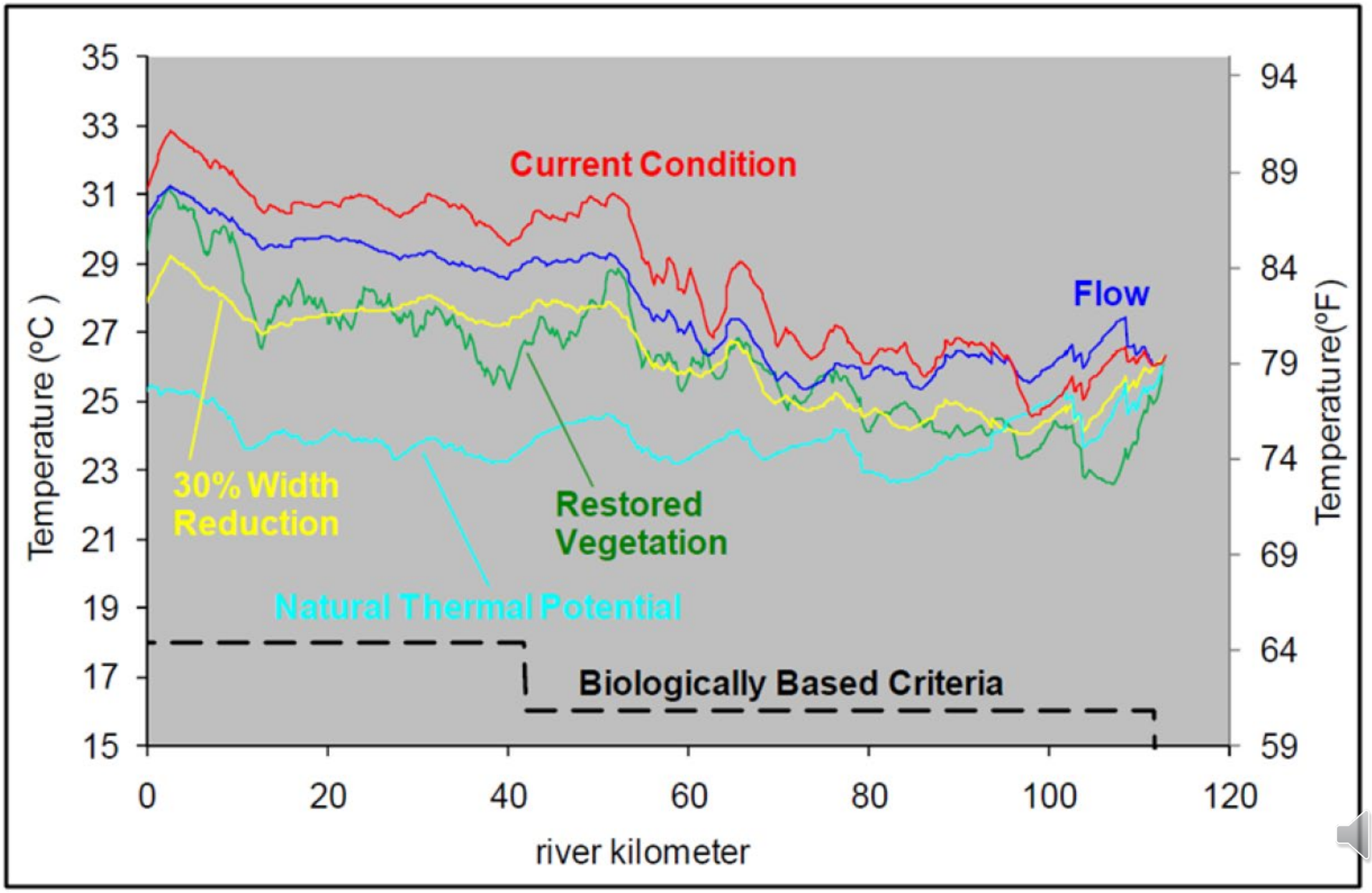
Growth = Consumption – (Metabolism + Waste)

$$C = \frac{0.44D}{5.89 + D}$$

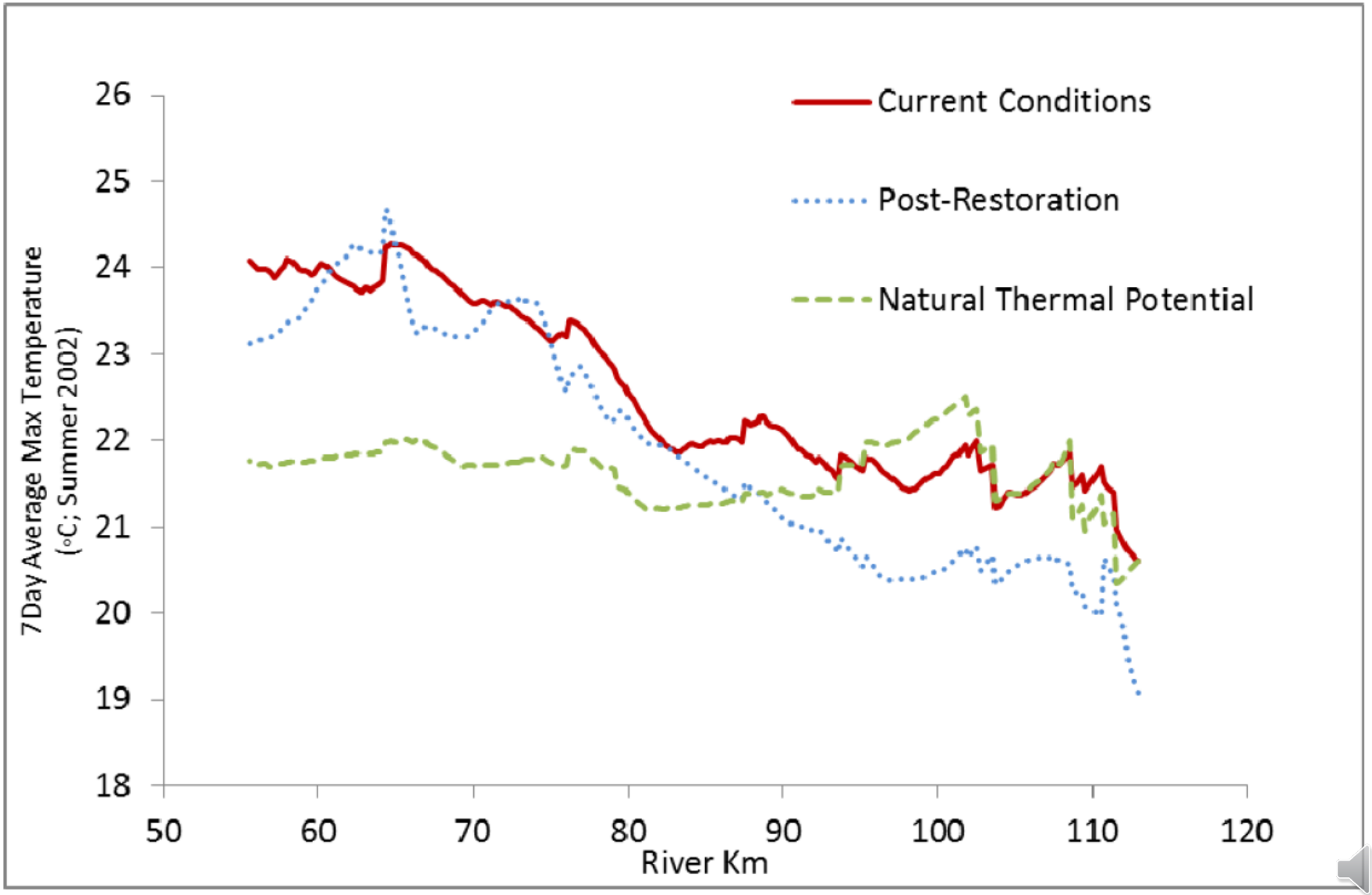
Measured in the field

Measured in the lab

Temperature under different restoration scenarios



Temperature under proposed scenario

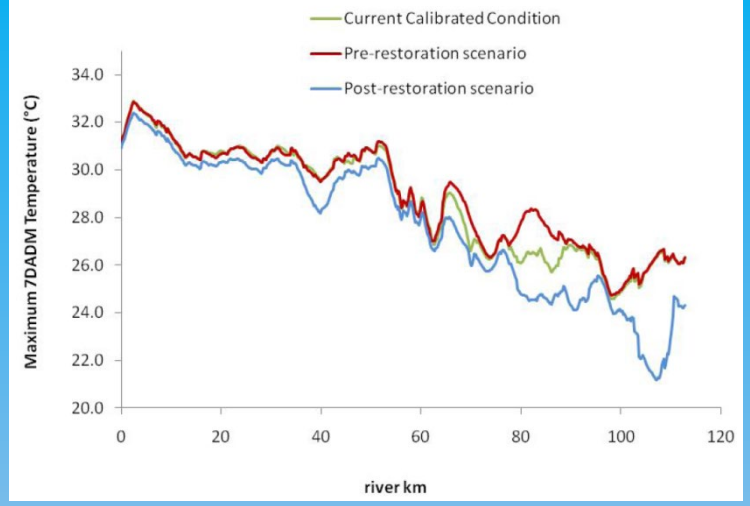


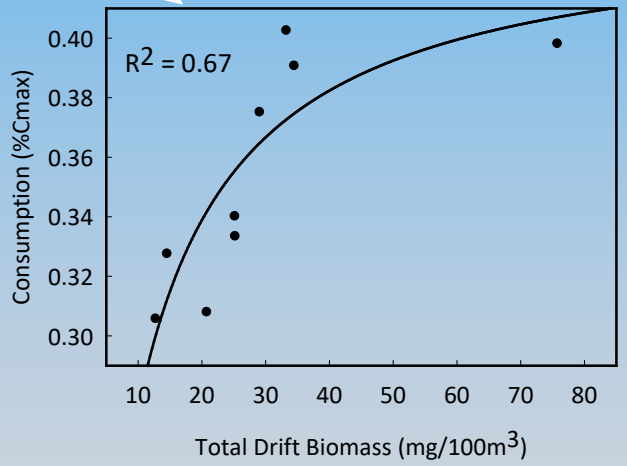
Heat Source calculates longitudinal profiles of temperature under different scenarios

CHaMP Surveys

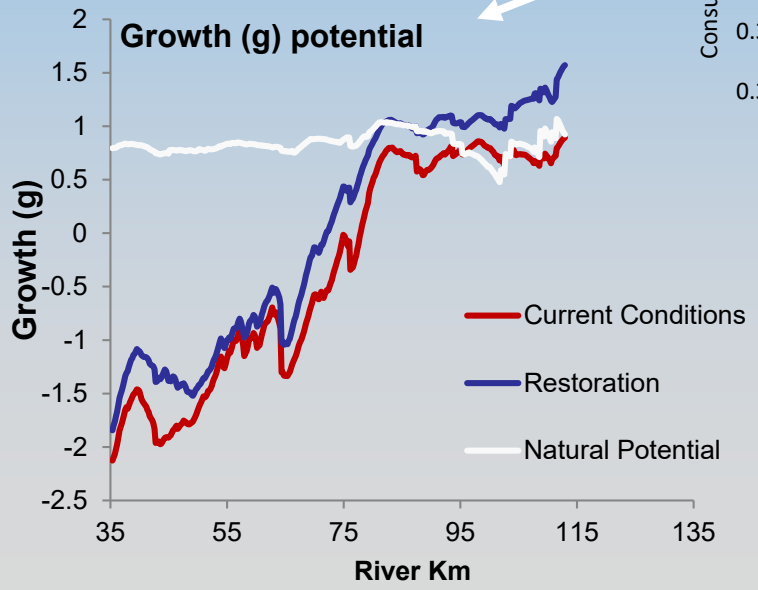
Thermal experience
Drift biomass

Habitat surveys used to calibrate Heat Source and estimate drift biomass





Bioenergetics model translates drift and temperature into growth



Model growth potential profiles under different scenarios

Growth under proposed scenarios