Size-selective mortality and bioenergetic limitations of juvenile steelhead under different freshwater environmental constraints in the Skagit River, Washington

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Size-selective mortality and bioenergetic limitations of juvenile steelhead under different freshwater environmental constraints in the Skagit River, Washington

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Early growth influences survival of steelhead

Embryo/alevin → Freshwater

Juveniles

Smolts

Marine

Adults
Constraints on growth in freshwater

- Sampled: Food Ration
- Estimated: Feeding Rate
- Sampled: Water Temperature
- Substrate: Structure/Refuge
- LFD: Structure/Refuge
- Predator Presence
- Less-Optimal Foraging/Refuge
- Optimal Foraging/Refuge
- Flow
Energy In = Energy Out

**Model Inputs**
- Thermal experience
- Temporal diet composition
- Consumer growth (G)
- Predator energy density
- Prey energy density

**The Bioenergetics Model**

Energy Out: Metabolism + Waste + Growth

**Model Outputs**

Estimated Energy In (given observed Growth & other input values)

Estimated as...
- Feeding Rate (\%C_{max})
- Consumption (g of prey/day)
Growth

Juveniles (2011-2012)
Smolts (2012)
Adults (2008-2012)

Food Ration

Thermal Experience

Rain Zone

Lower Skagit River

Baker Lake

Lake Shannon

Bacon Creek

Illabot Creek

Drift net
Data collection: Growth (FL-to-weight)

Juveniles

Smolts

Adults
Adult sample: 25% $C_{\text{max}}$
Smolt sample: 24% $C_{\text{max}}$
Juvenile sample: 23% $C_{\text{max}}$

53% of annual growth

56% of annual growth

Adult sample: 27% $C_{\text{max}}$
Smolt sample: 25% $C_{\text{max}}$
No Juvenile sample

POOR DIET
65% of annual growth

73% annual growth

Adult sample: 24% $C_{\text{max}}$
Smolt sample: 24% $C_{\text{max}}$
Juvenile sample: 22% $C_{\text{max}}$

Adult sample: 26% $C_{\text{max}}$
Smolt sample: 26% $C_{\text{max}}$
Juvenile sample: 26% $C_{\text{max}}$
49% of annual growth

43% of annual growth

HOT

COLD

GREAT DIET

LIMITED ACCESS TO QUALITY FEEDING HABITAT?

WIDE DISPARITY

Adult sample: 25% $C_{\text{max}}$
Smolt sample: 22% $C_{\text{max}}$
Juvenile sample: 21% $C_{\text{max}}$

Adult sample: 28% $C_{\text{max}}$
Smolt sample: 25% $C_{\text{max}}$
Juvenile sample: 23% $C_{\text{max}}$

Finney Creek

10 g Steelhead Smolt
5107 J/g

30% $C_{\text{max}}$
25% $C_{\text{max}}$
20% $C_{\text{max}}$

Finney Creek

30 g Steelhead Smolt
5107 J/g

30% $C_{\text{max}}$
28% $C_{\text{max}}$
25% $C_{\text{max}}$
Conclusions

1) Early growth influences survival during later life stages

2) Water temperature, consumption, feeding rate, and prey energy density affect growth differently according to the local environment

3) **Usefulness**: If freshwater SSM is significant, evaluating and improving growth in freshwater habitats could be a useful tool for recovery

4) **Usefulness**: Bioenergetics modeling can help identify the main factors inhibiting growth
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