Oregon State University OSU

Predicting Growth of Juvenile Chinook Salmon in Reservoirs

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FOREST SERVICE US DEPARTMENT OF AGRICULTURE

US Army Corps of Engineers®

Juvenile Chinook Salmon Reservoir Rearing

- Model to understand reservoir-specific factors driving growth rates
  - What conditions and management actions influence growth rates?
  - What depths do we expect them to use?

Pros and cons…

Stream Rearing
above Hills Creek Reservoir

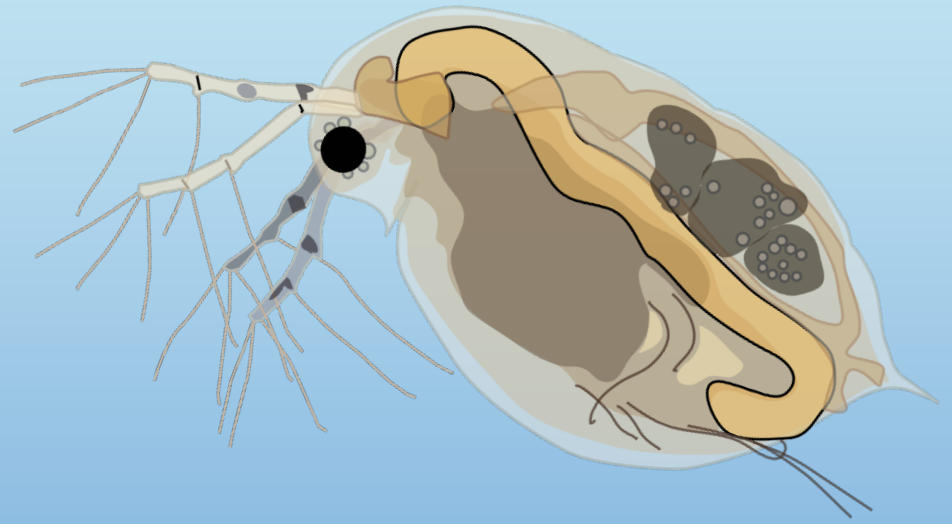
Reservoir Rearing
below Hills Creek Reservoir

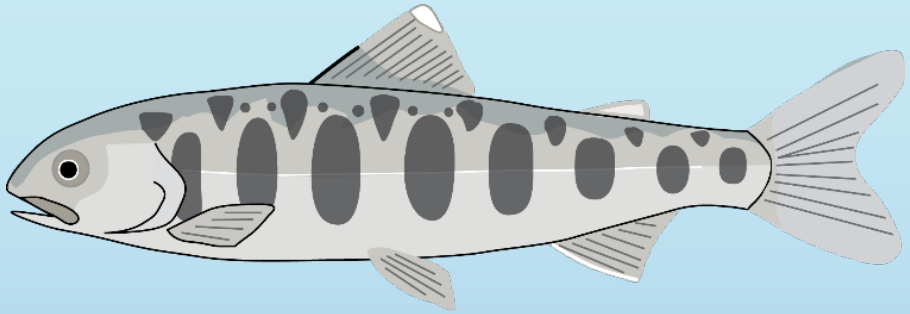
GrowChinook

- Mechanistic (equation-driven)
  - Linked Foraging-Bioenergetics model
- The visual foraging model uses light and prey availability to determine how much prey is available at a given depth
  - Beauchamp et al. 1999
- The bioenergetics model uses temperature and prey to determine the cost – benefit of foraging at a given depth
  - Hanson et al. 1997
- A fish can not eat more than its physiological maxima

Factors That Limit Growth

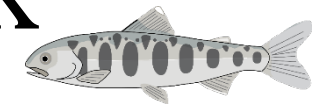
- Temperature
- Light
- Prey Quality
- Prey Availability
  - Timing of High Abundance of Daphnia
- Prey Size
  - Visual Encounter Rate and Prey Energetic Value
- Size of Juvenile Chinook
  - Swimming Speed and Metabolic Costs





Today, I'll be focusing on **model sensitivity** (assumptions about fish and reservoirs) and how that can inform our questions and understanding

GrowChinook



Current Graphic User Interface

Enter Values to GrowChinook

Please Select Year: 2015

Please Select Site: Fall Creek

Please Select Month: March

Use Default Values?

Yes
No

Fish Starting Mass (g): .2
Or Enter Value: .2

Daphnia Size (mm): 1.5
Or Enter Value: 1.5

Total Daphnia: 1000
Or Enter Value: 1000

Light Extinction Coefficient: 0.5
Or Enter Value: 0.5

Restrict Depth?

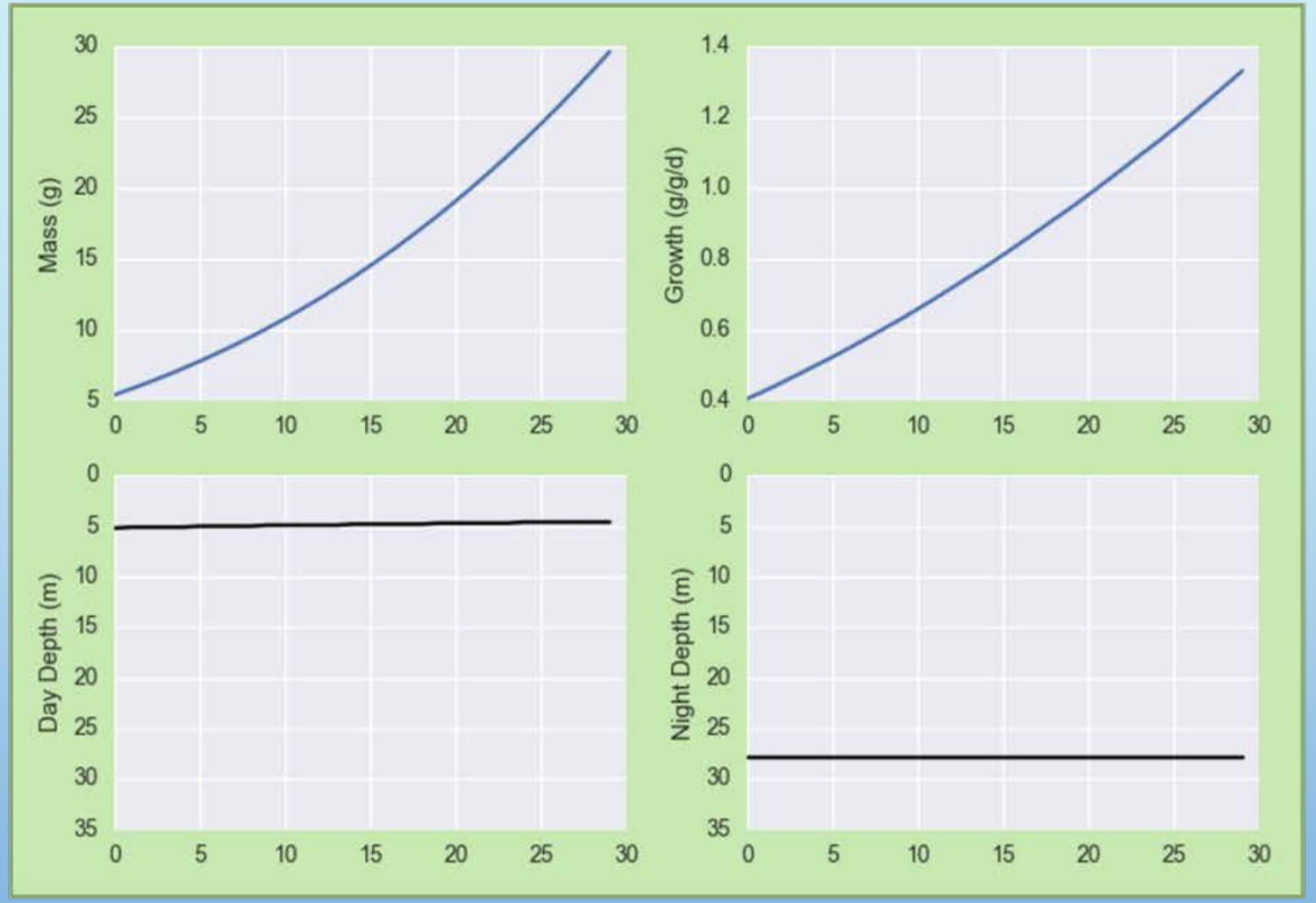
Yes
No

Maximum Depth: 15
Minimum Depth: 0
Or Restrict to a Single Depth:

Submit

Current Outputs

- Growth rate: g/g/day
- Depth use (m)
  - Day
  - Night
- Final mass (g)
- Daphnia consumed: #/day
- Condition (if lower than starting)

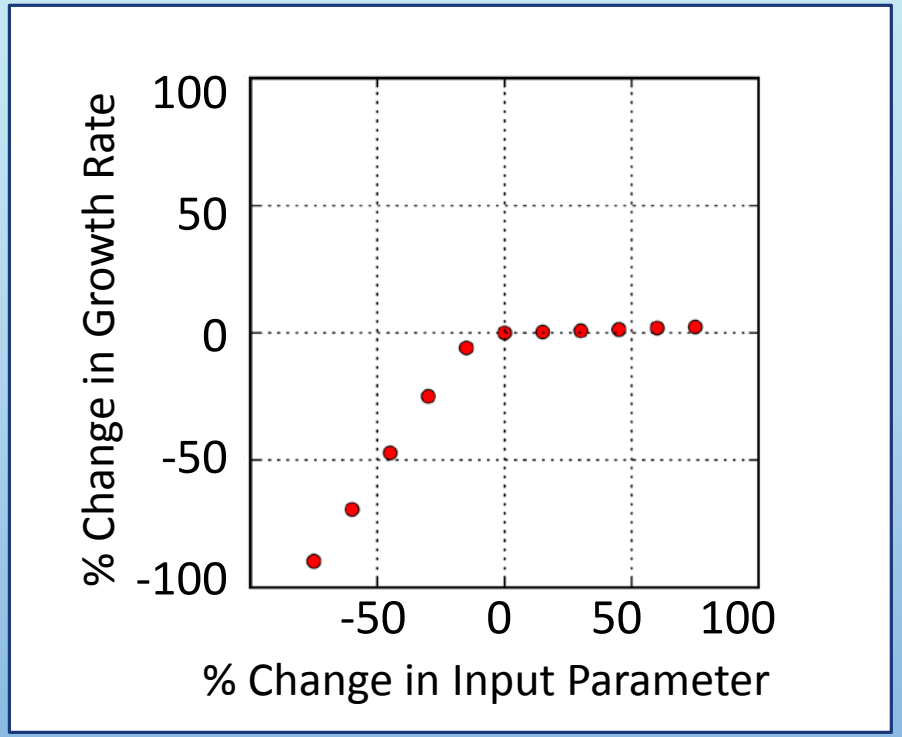


Fall Creek, 2015

Input Values:		Output Values:	
May Starting Mass:	5.0 g	May Final Mass:	29.6 g
May Total Daphnia:	1093	May Final Daily Growth:	1.3 g/g/day
May Daphnia Size:	1.14 mm	May Final Day Depth:	5 m
May Light Extinction Coefficient:	0.58	May Final Night Depth:	28 m
		May Total Daphnia Consumed:	12355

Sensitivity of the Model Outputs to Model Inputs

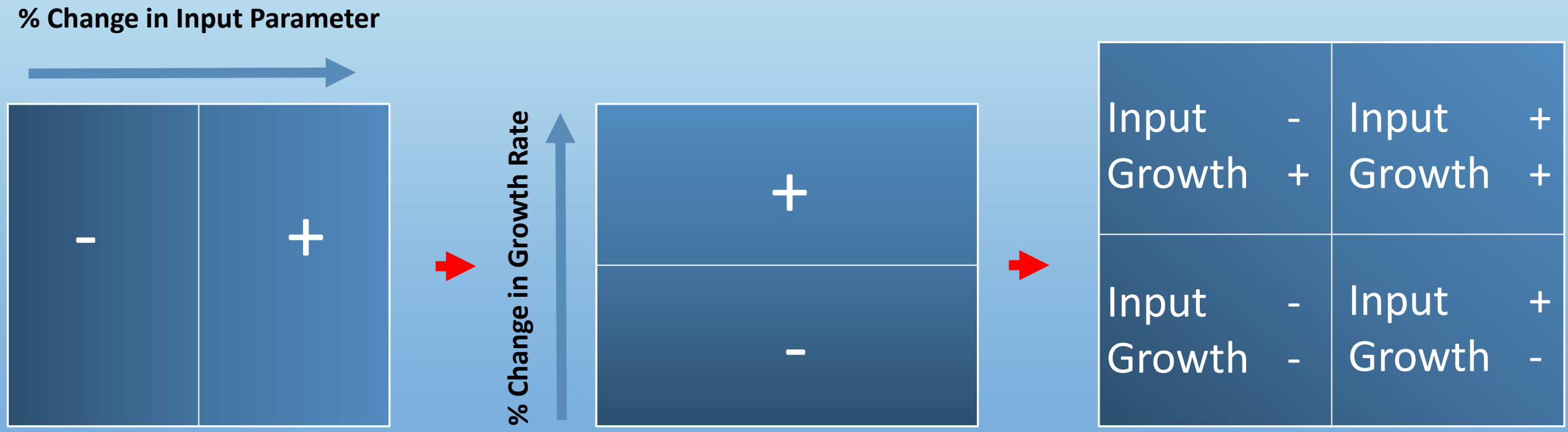
- Testable hypotheses
  - Outputs of models
  - Model sensitivities



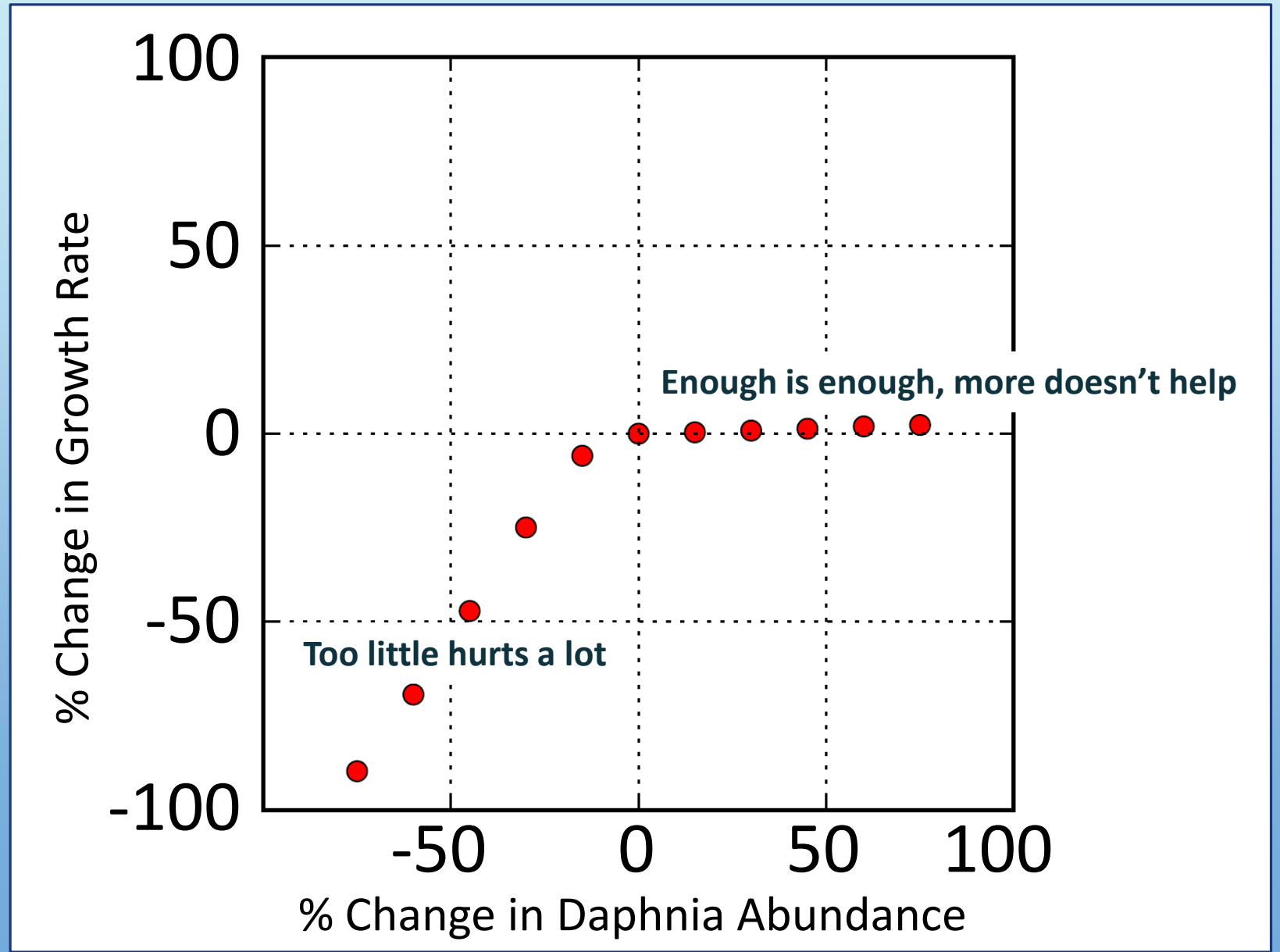
% change in input results in % change in output.

- These patterns tell us about how the model works, but also about predicted relationships and feedback.

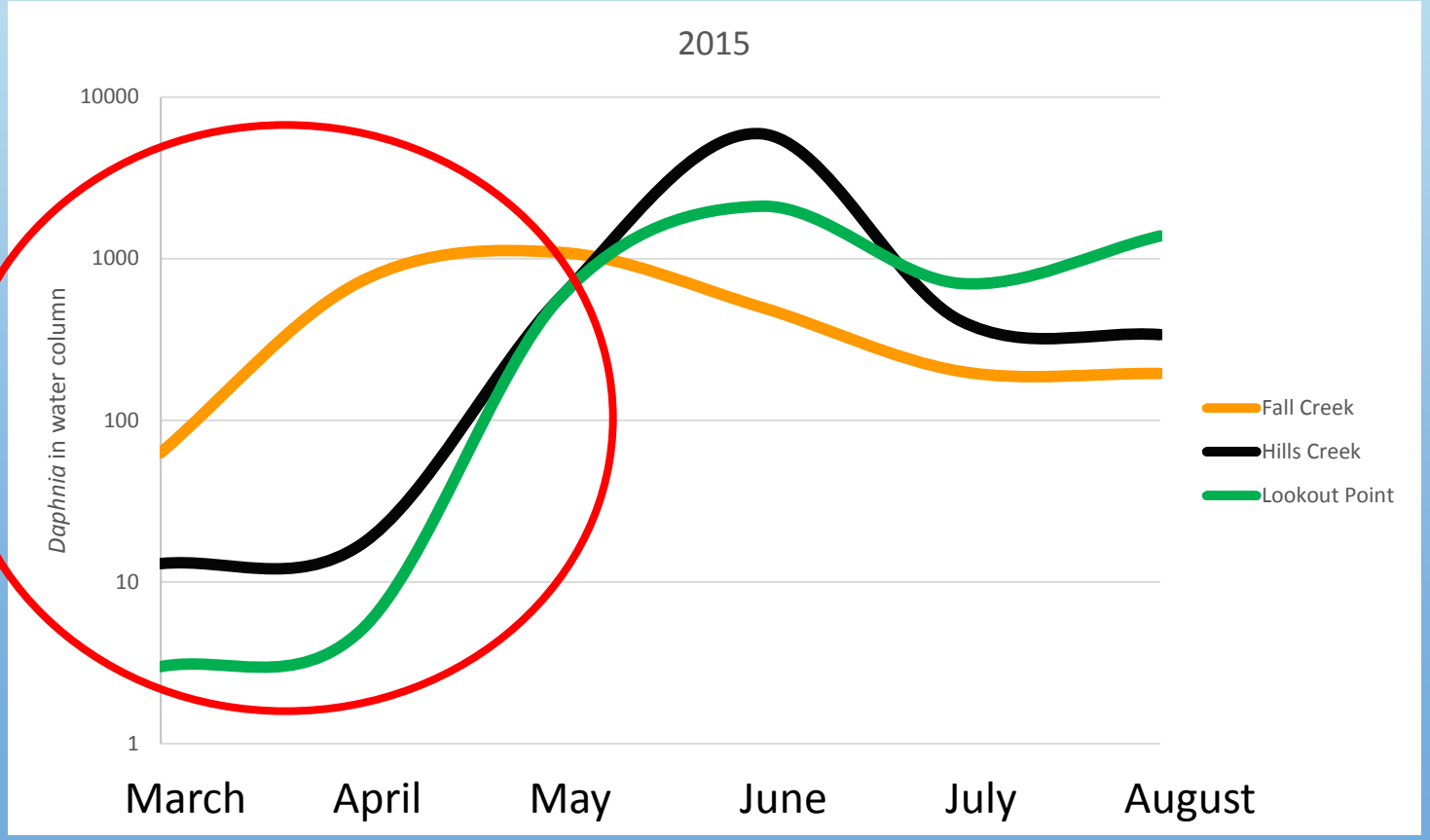
Sensitivity Plots



Daphnia Abundance

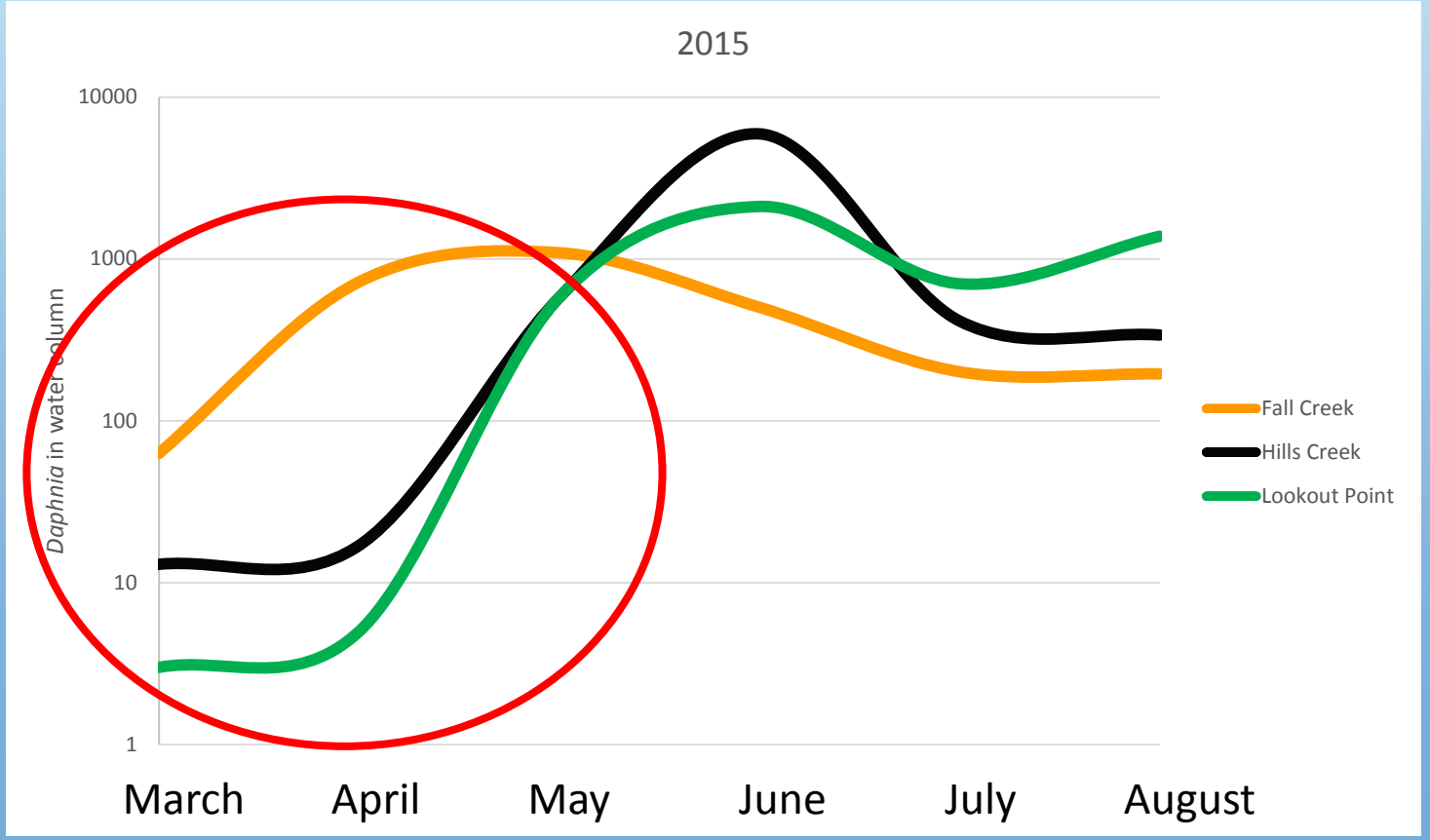


Strong Seasonal Differences in Daphnia Across Reservoirs

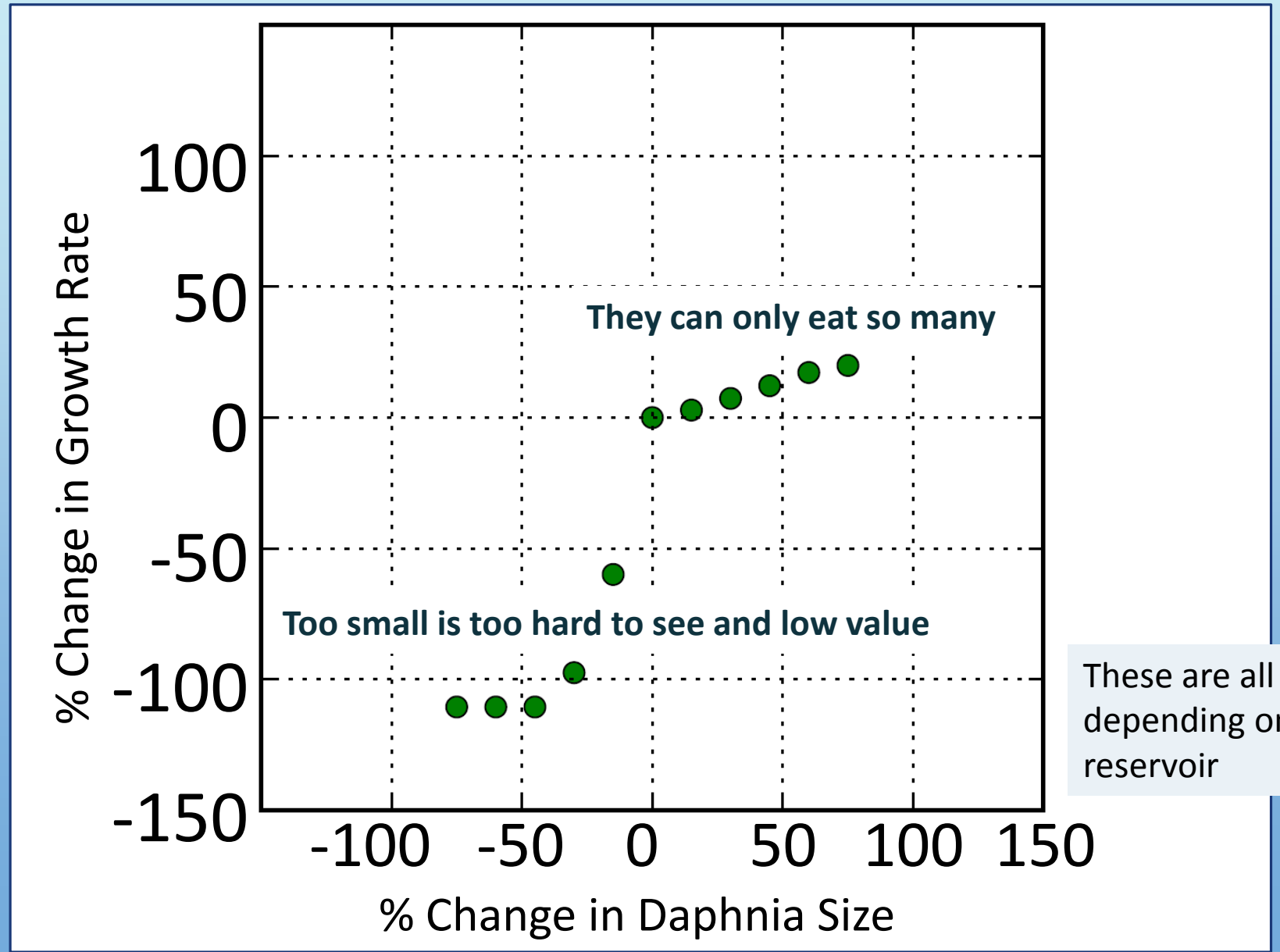


Why are Fall Creek juvenile Chinook Salmon so large?

- Model can walk through month by month to identify constraints.
- They have a head start in prey availability:



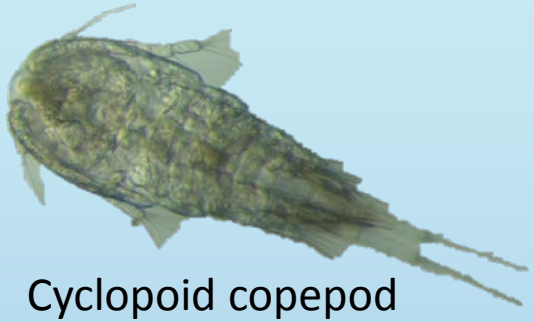
Daphnia Size



These are all realistic sizes, depending on month and reservoir

Why do juvenile Chinook Salmon eat Daphnia?

Bosminid
0.3 mm

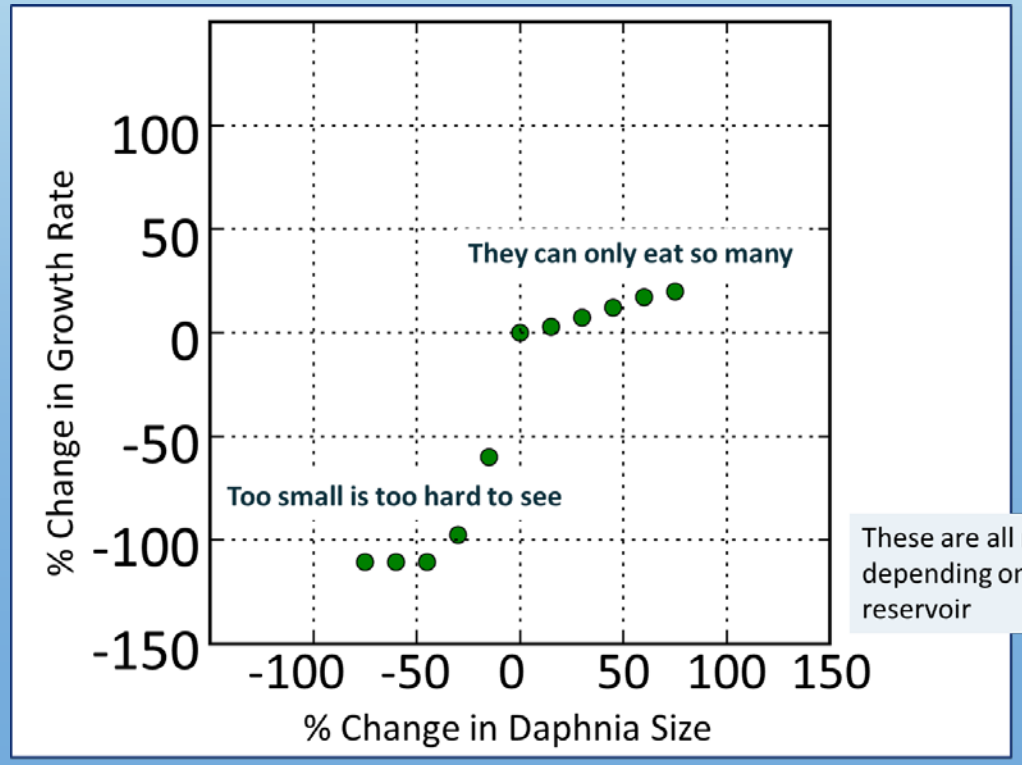


Cyclopoid copepod
1.1 mm

Daphnia mendotae
1.3 mm

Daphnia pulex
1.5 mm

Calanoid copepod
1.7 mm



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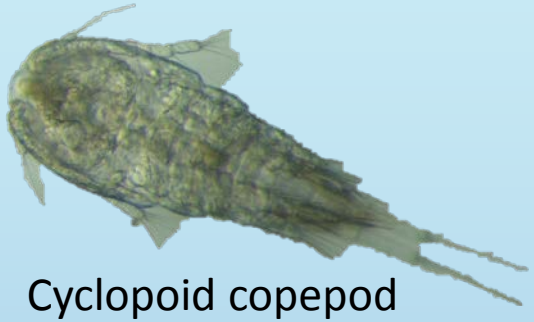

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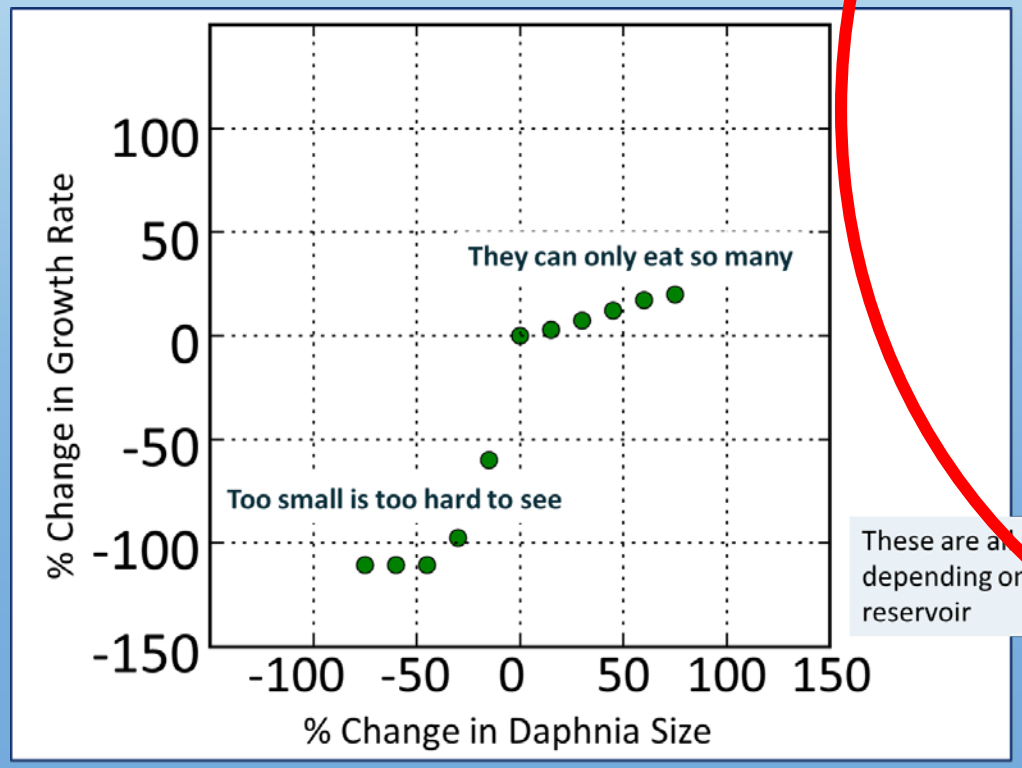

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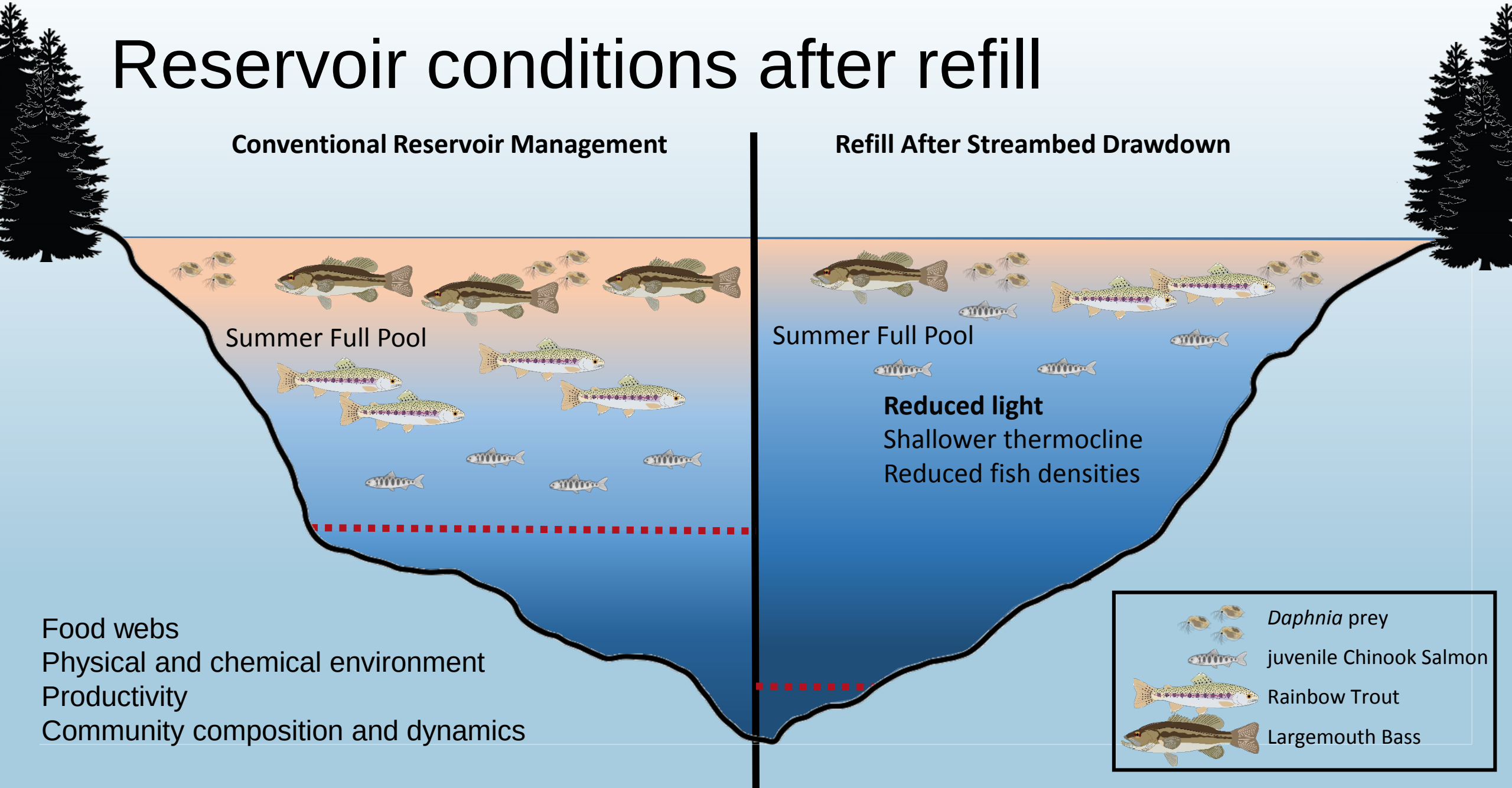
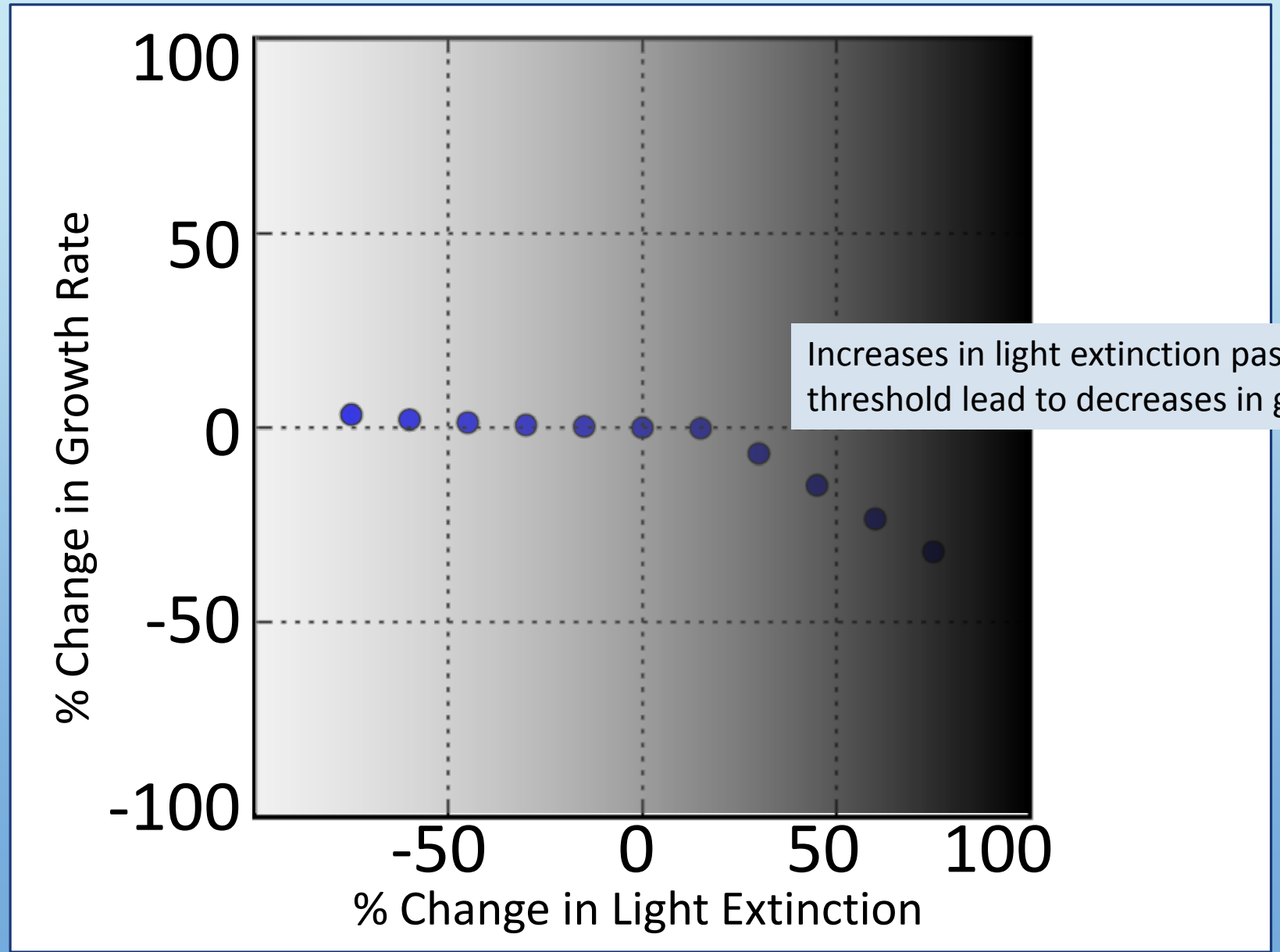
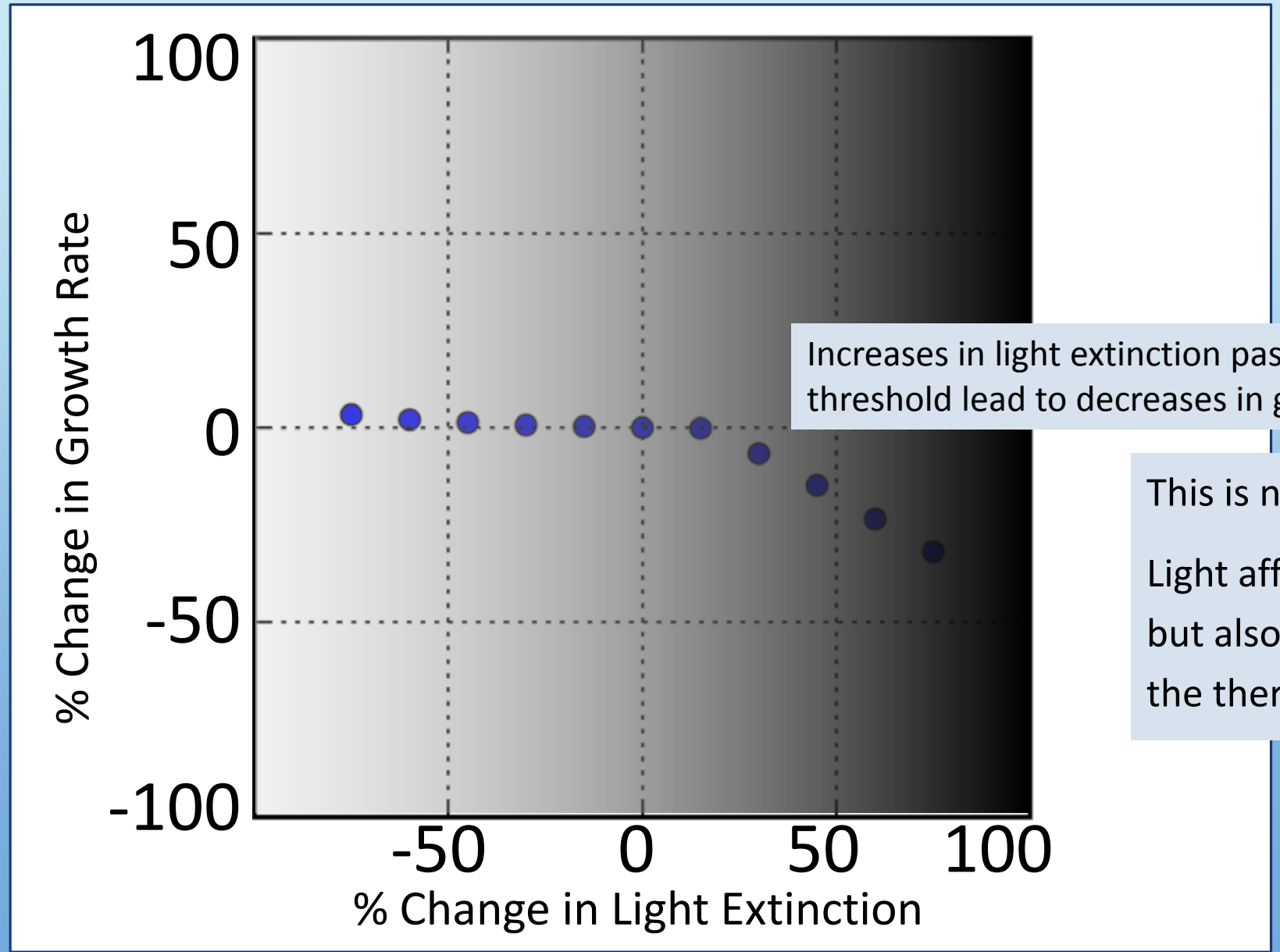
Reservoir conditions after refill



Light Extinction Coefficient



Should we worry about visibility?

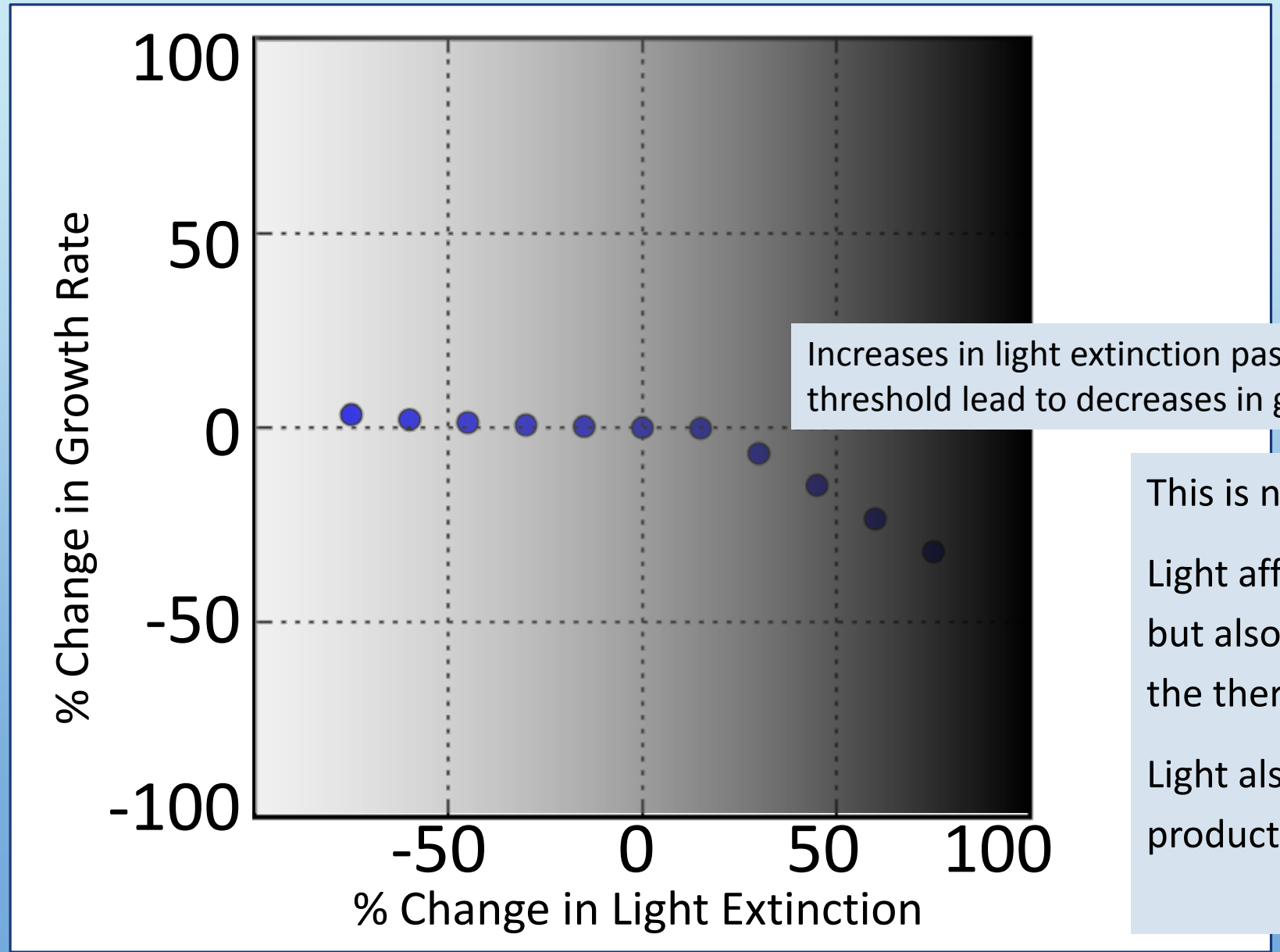


Increases in light extinction past threshold lead to decreases in growth

This is not all!

Light affects foraging, but also the depth of the thermocline

Should we worry about visibility?



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This is not all!

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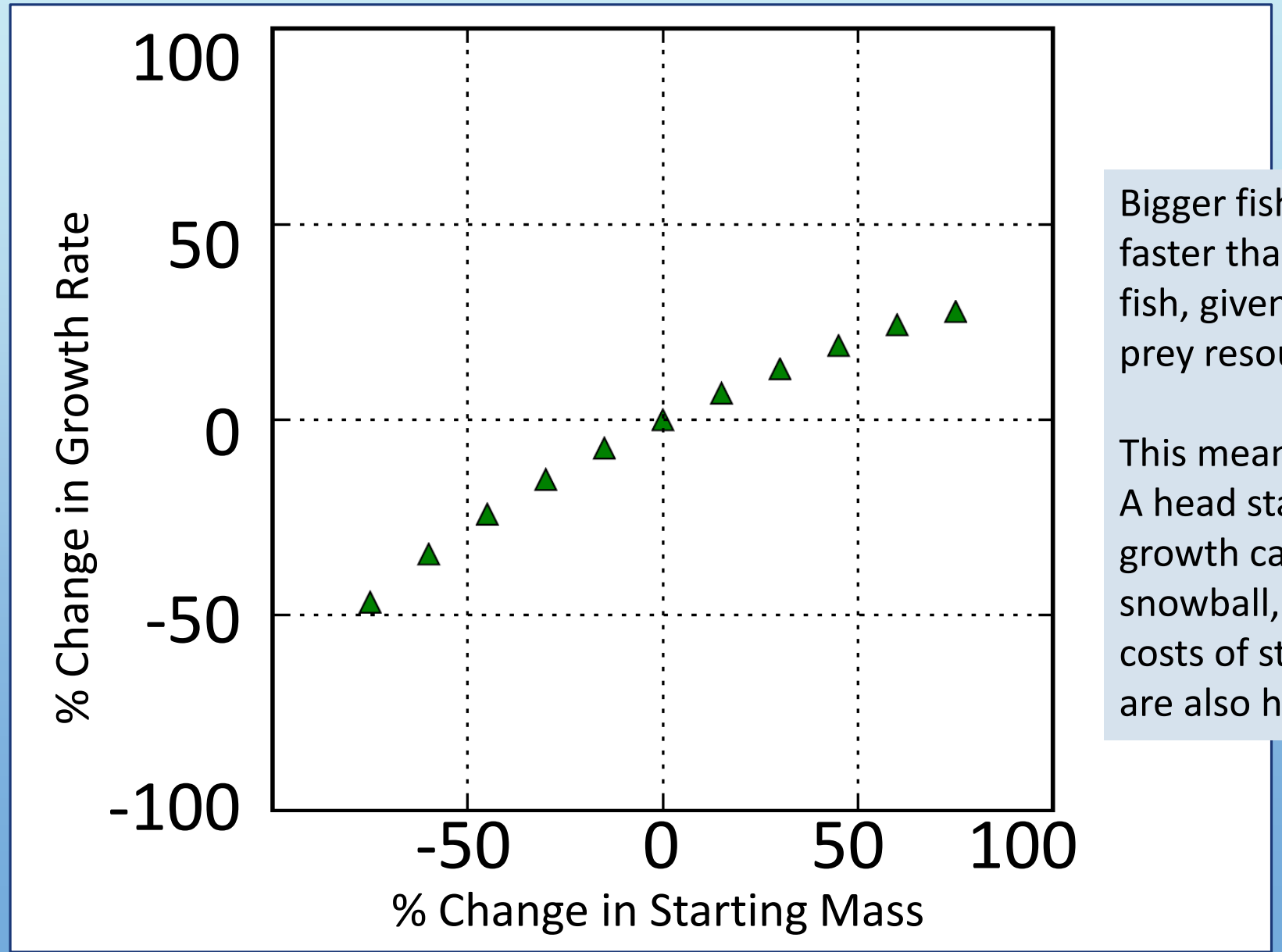
Light also affects productivity patterns

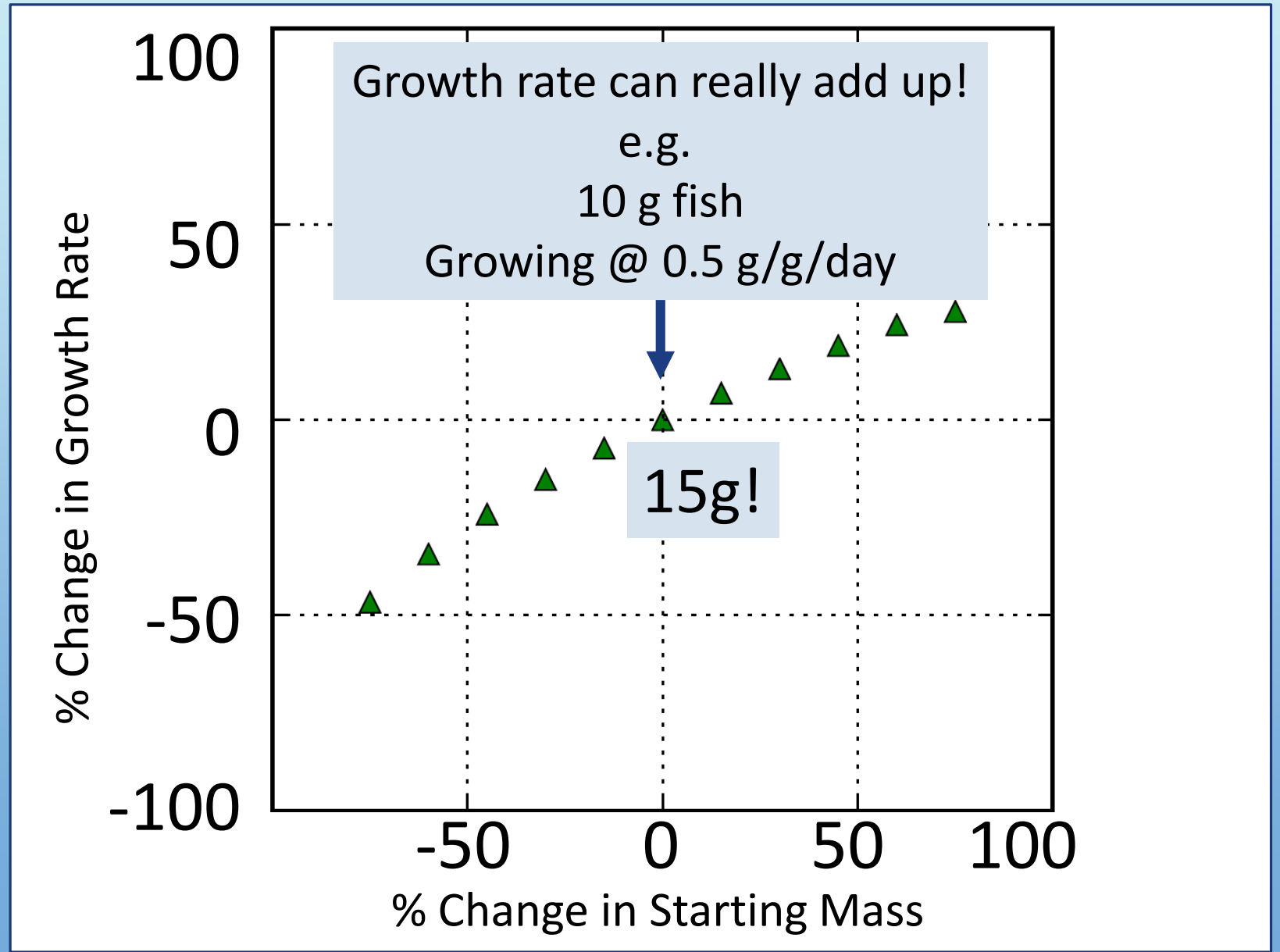
Starting Mass (g)



Bigger fish can grow faster than smaller fish, given sufficient prey resources

This means:
A head start on growth can snowball, but the costs of starvation are also higher

Starting Mass (g)



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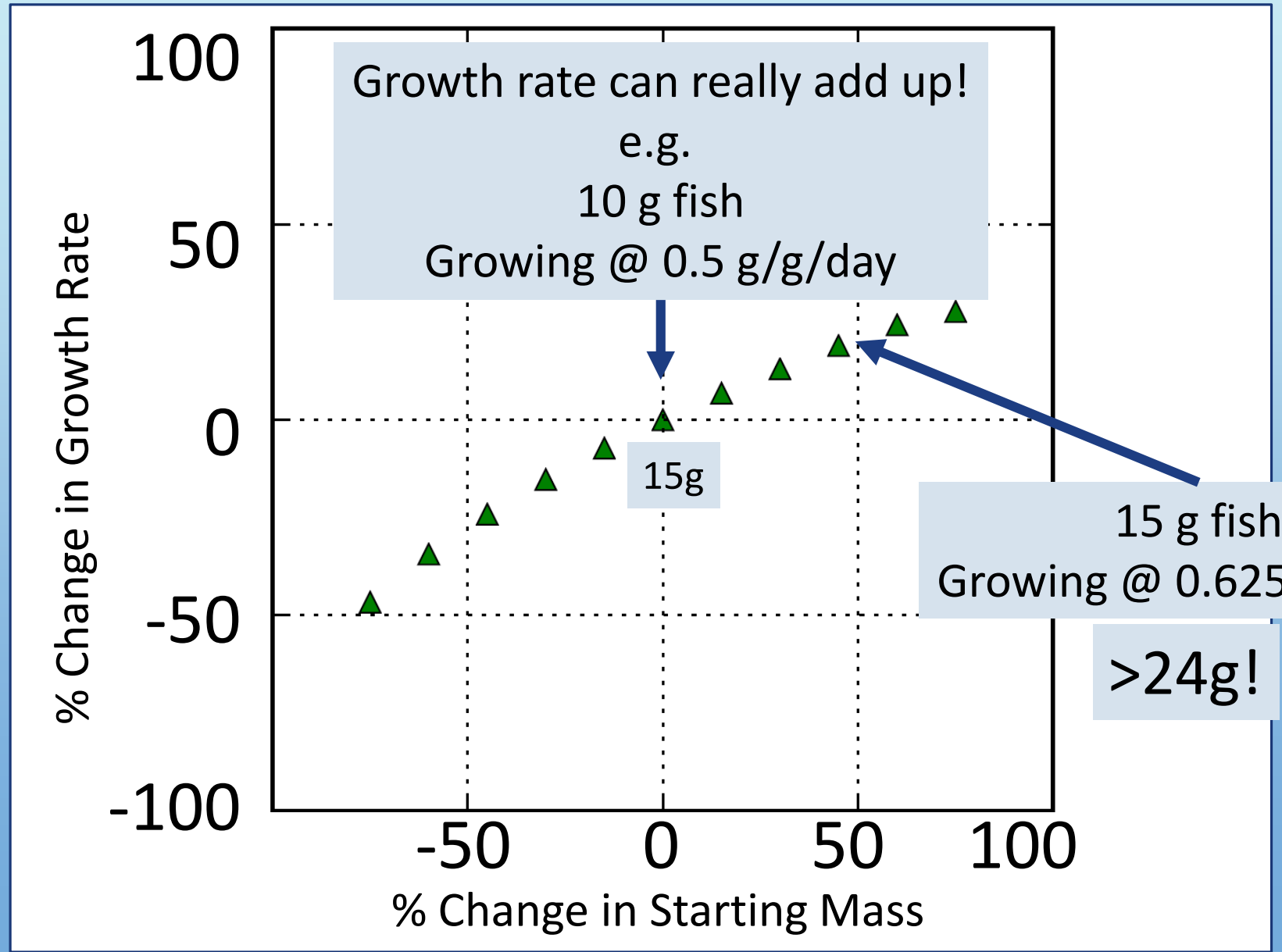

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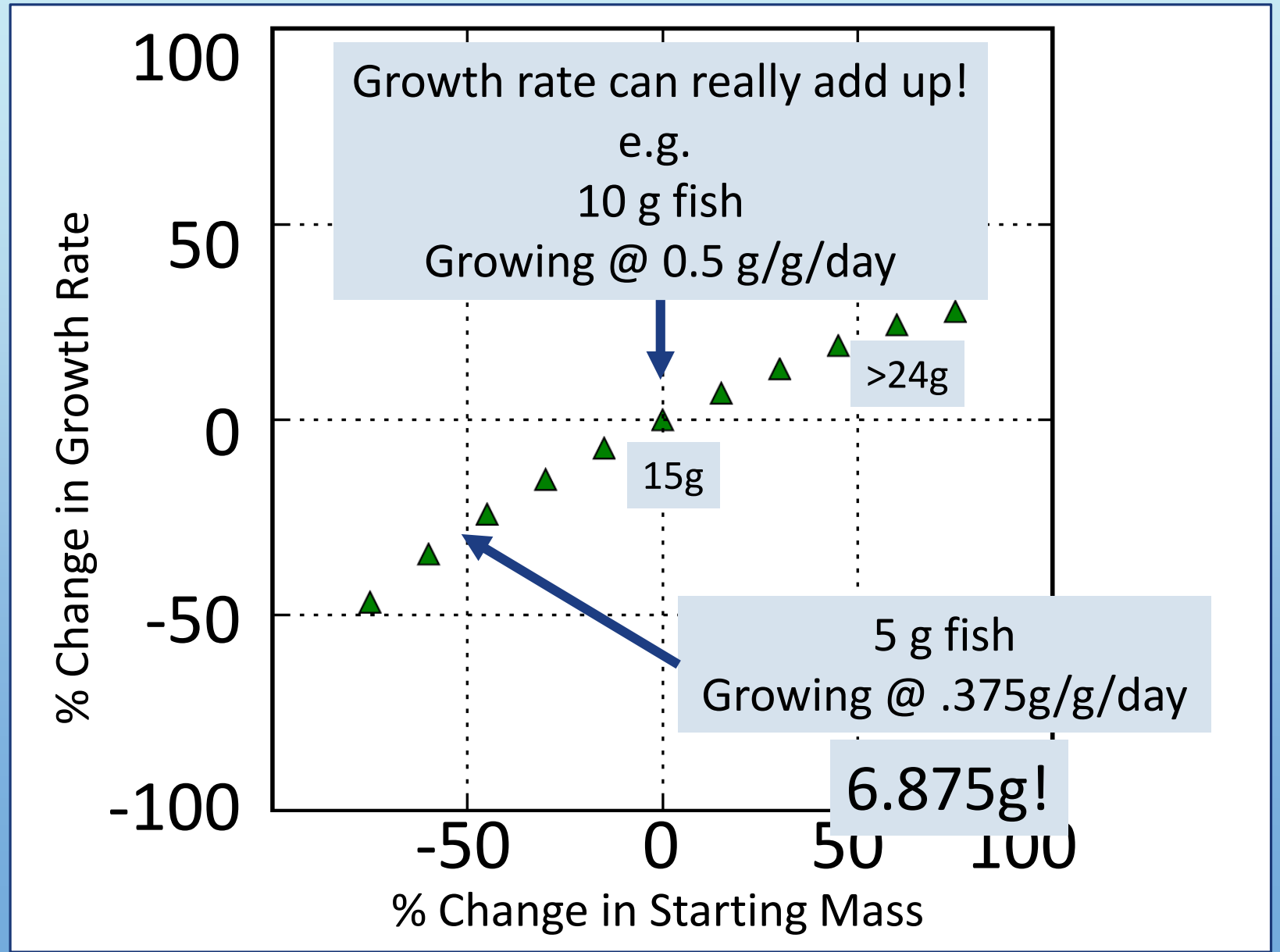
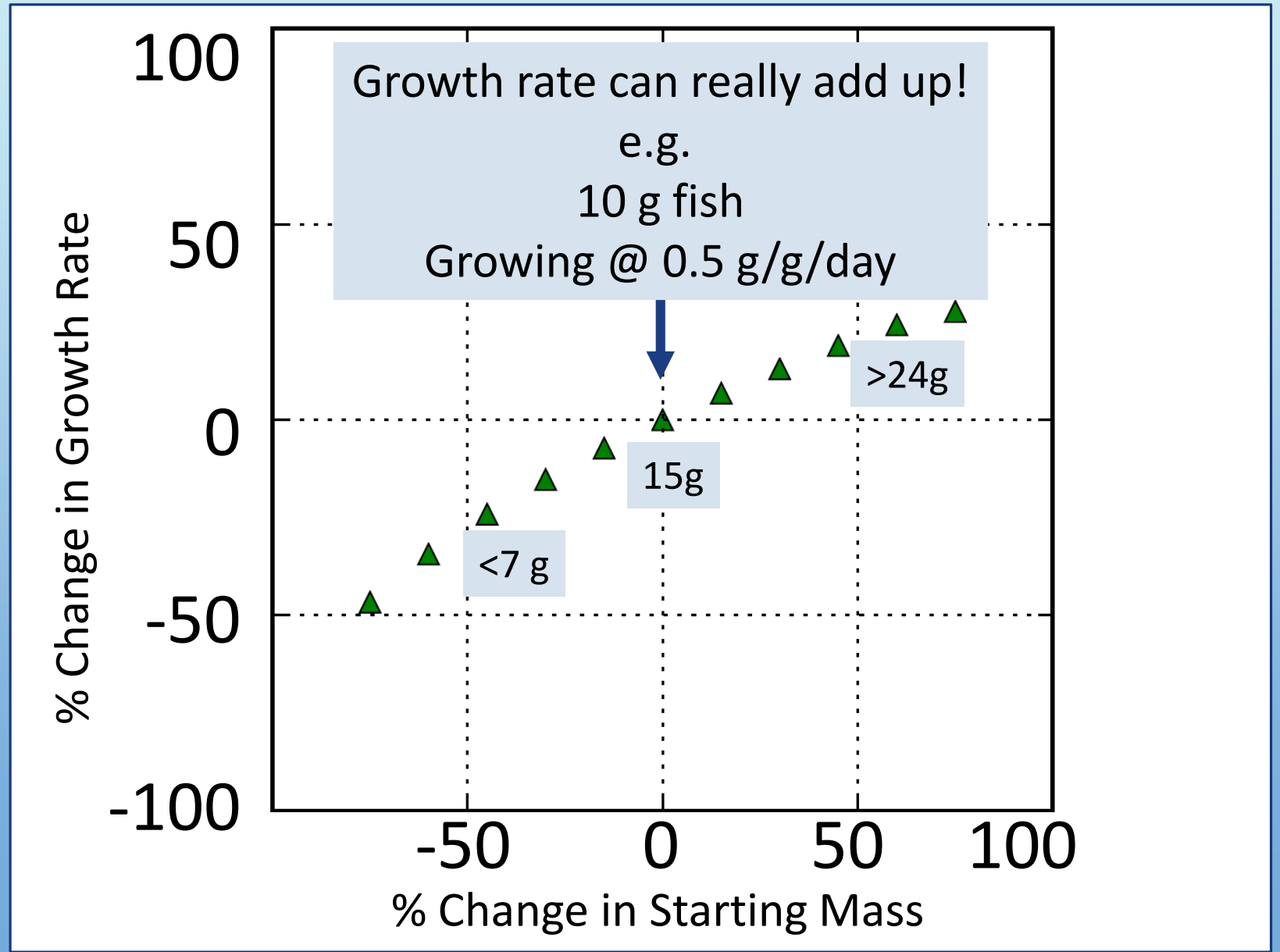
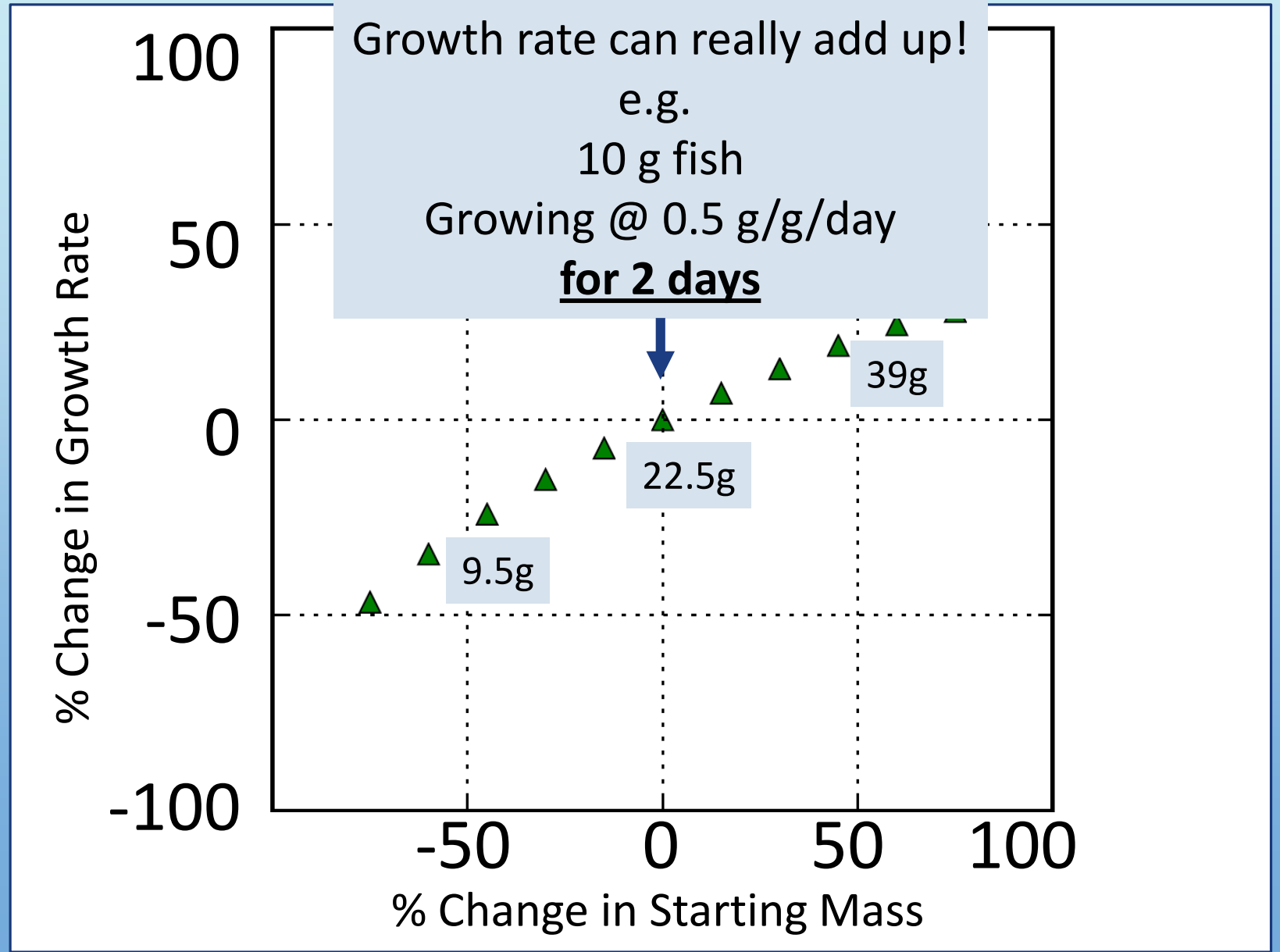


Starting Mass (g)

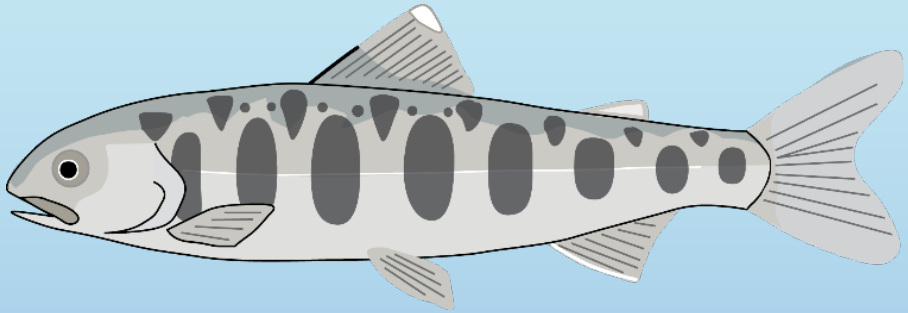


Starting Mass (g)



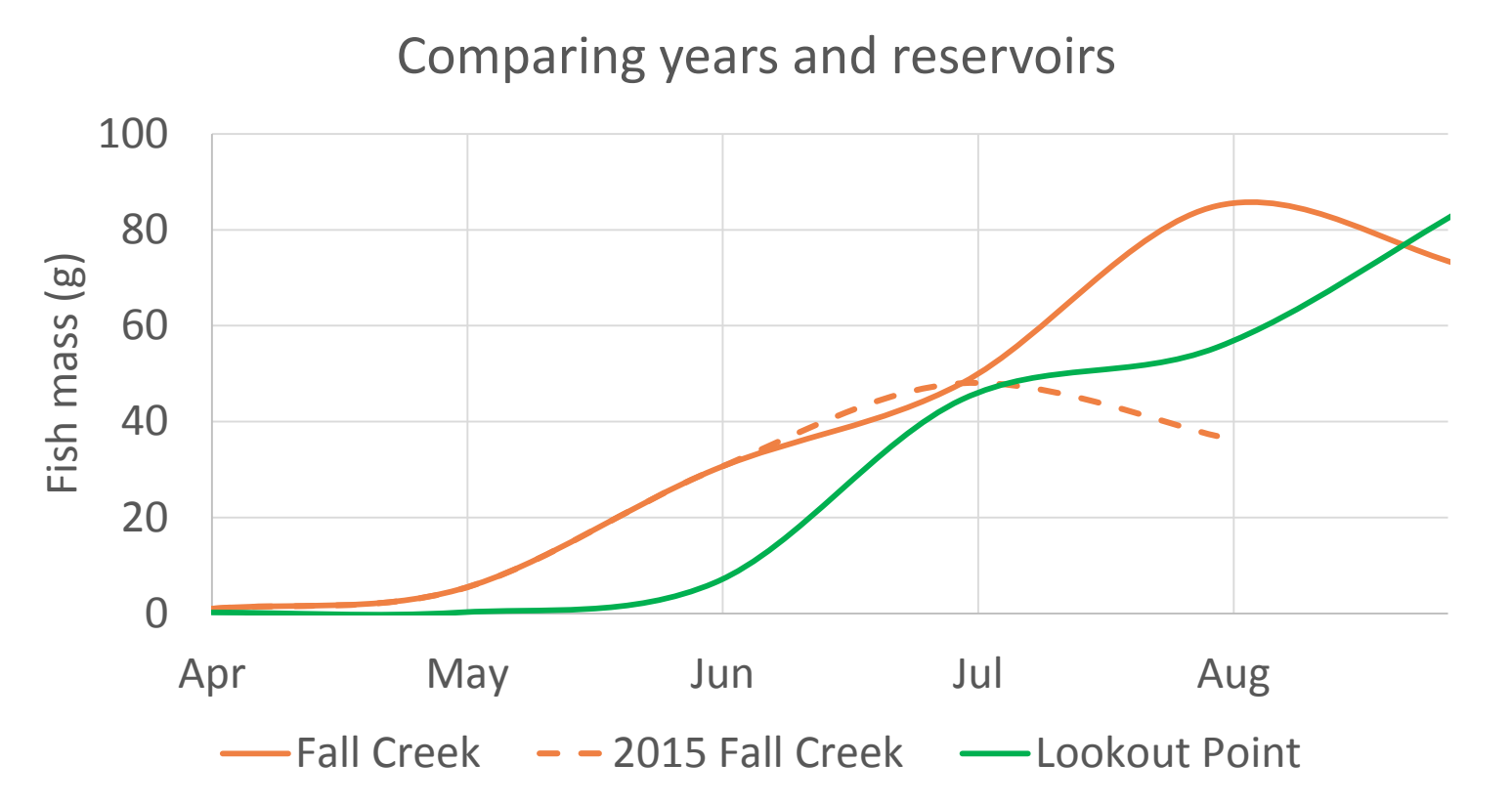
Interested in scenario building or beta-testing?

- Contact Us!



- Today, I focused on **model sensitivity** (assumptions about how the system works) and how that can inform our questions and understanding

Example model output (not sensitivity): Fall Creek / Lookout Point Projected Weights 2015 drought



Outputs also include predicted depth use

Thanks!

USACE

Lookout Point

Greg Taylor
Katie Rayfield
Terri Berling
Ben Cram
Todd Pierce

Portland

Cindy Studebaker
Bob Wertheimer
Kathryn Tackley
Dan Turner

OSU

Jason Dunham*
Angela Strecker (PSU)*
Steve Arnold*
Kailan Mackereth
Tim Glidden
Chelsea Duke
Margaret McCormick

NOAA

Kim Hatfield

ODFW

Michelle Weaver
Dan Peck

Springfield

Jeff Ziller
Kelly Reis
Shannon Richardson

Reservoir Dogs

Tom Friesen
Fred Monzyk
Jeremy Romer
Ryan Emig
Khoury Hickman
Meghan Horne-Brine
Andrew Nordick
Matt Price
Ryan Flaherty

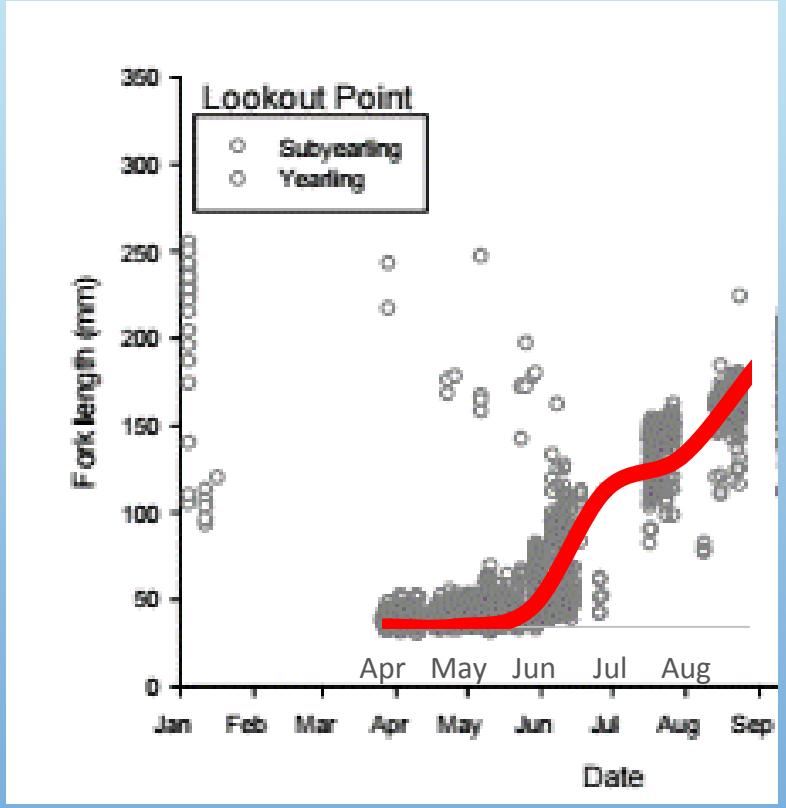
*Committee

Questions?

- Current plan is spring model release
- Beta-test model as educational tool in OSU Limnology Spring 2017
  - Graduate / Undergraduate split

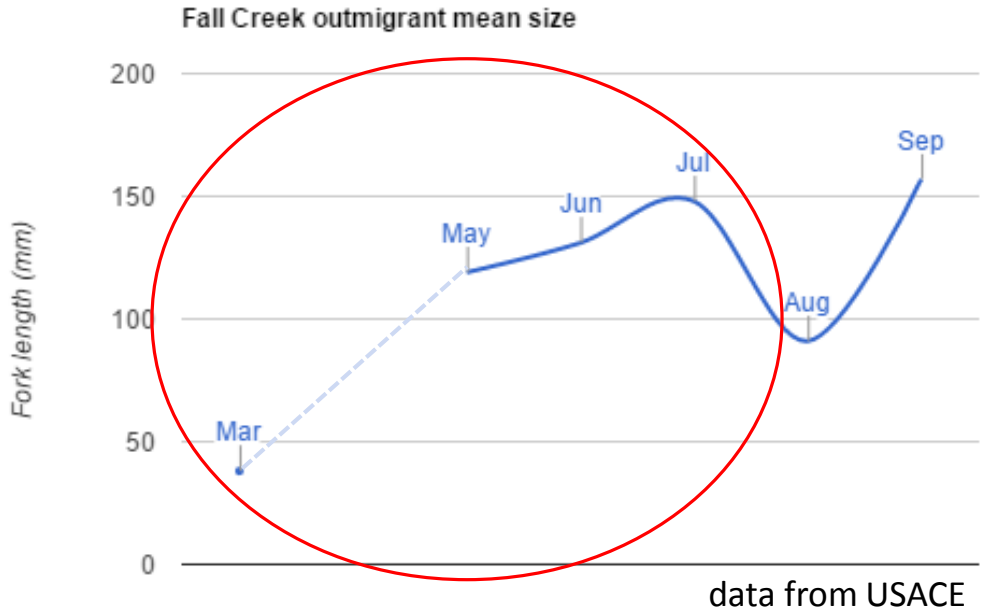
- Christina.Murphy@oregonstate.edu

Projected weight vs. observed length patterns
Lookout Point Example

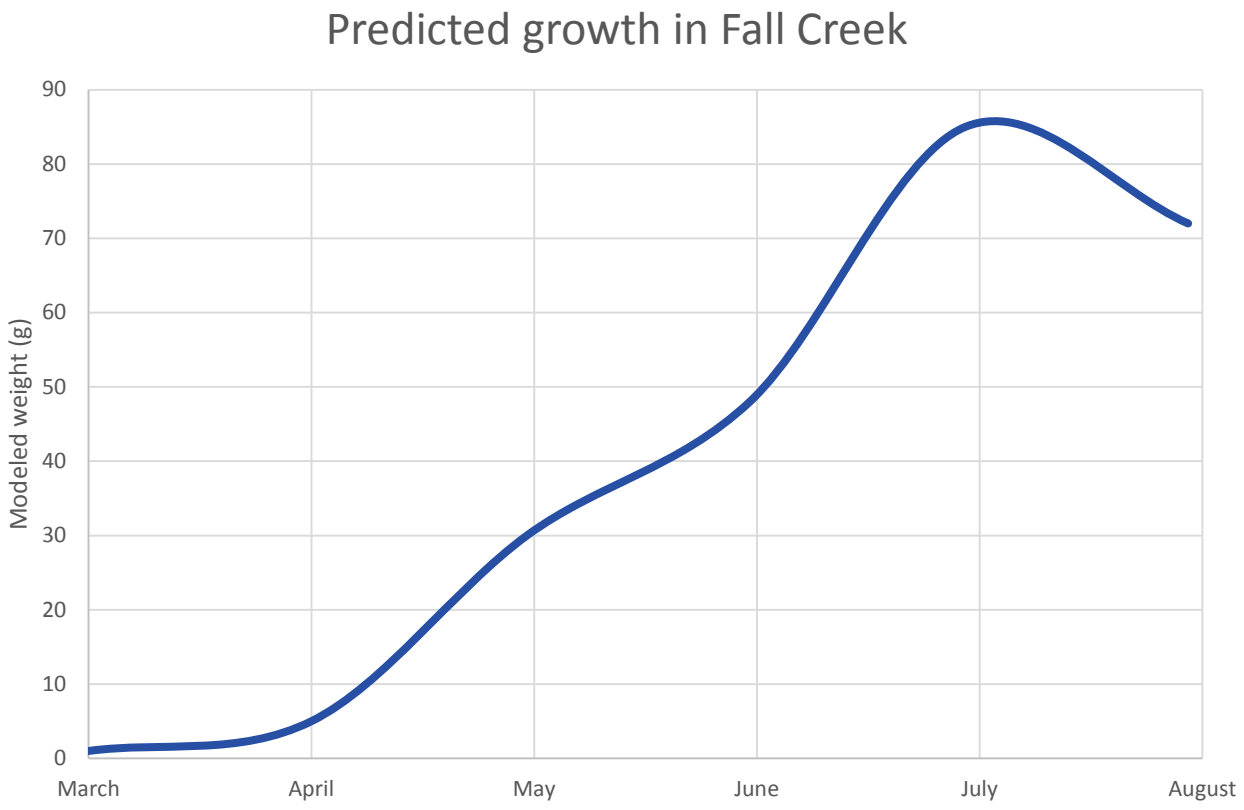


Monzyk et al. 2012

Fall Creek Example



data from USACE



Change to put months in middle