2015 In-reservoir Summer Conditions and Bioenergetics of Juvenile Chinook Growth

FALL CREEK, HILLS CREEK, LOOKOUT POINT

Christina A. Murphy, Sherri Johnson, Ivan Arismendi

Oregon State University

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

US Army Corps of Engineers®

Christina.Murphy@oregonstate.edu

Many Thanks to Many Folks!

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*
Brendan Coffin
Brent Johnson
Margaret Whitmore
Kailan Mackereth
Tim Glidden
Chelsea Duke
Margaret McCormick

*Committee

You know who you are…

The entire **RME Team**

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

Image credits:
ndow.org
maine.gov
texas.gov
fishweb.com
idaho.gov
imgbuddy.com
fpc.org

What are the effects of changes in water management on habitat and potential growth of juvenile Chinook Salmon in Willamette Basin reservoirs?

Background

Juvenile Chinook Salmon grow larger in upper Willamette Reservoirs

Management activities:

- Summer drawdown for repairs
- Fall drawdown to stream bed to aid passage

In streams

Leaving reservoir

Timing and magnitude of droughts

Models using observed data can be useful for evaluating alternative scenarios

RESERVOIR CONDITIONS

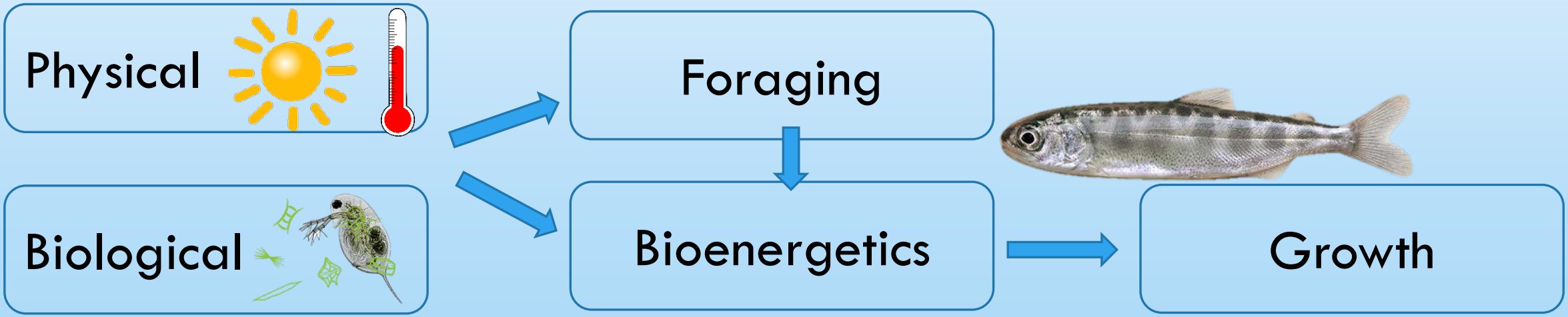


Photo from fishbio.com

Foraging

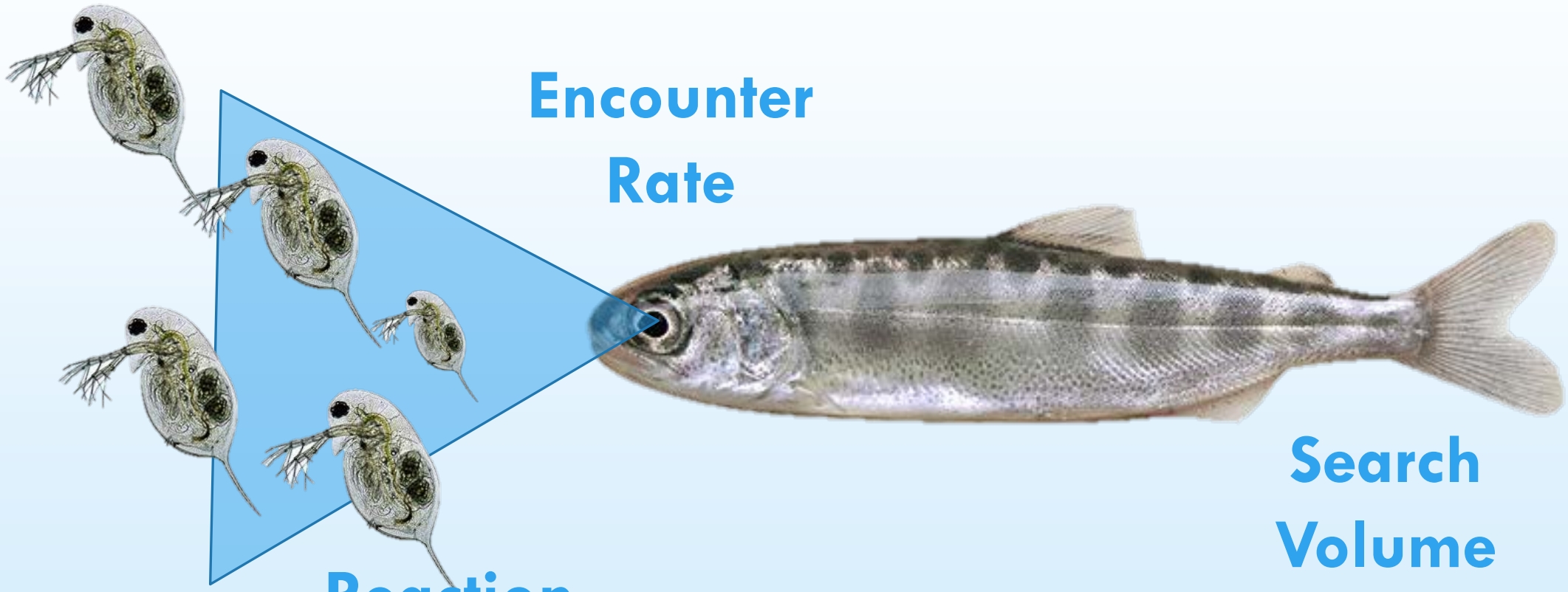


Photo from fishbio.com

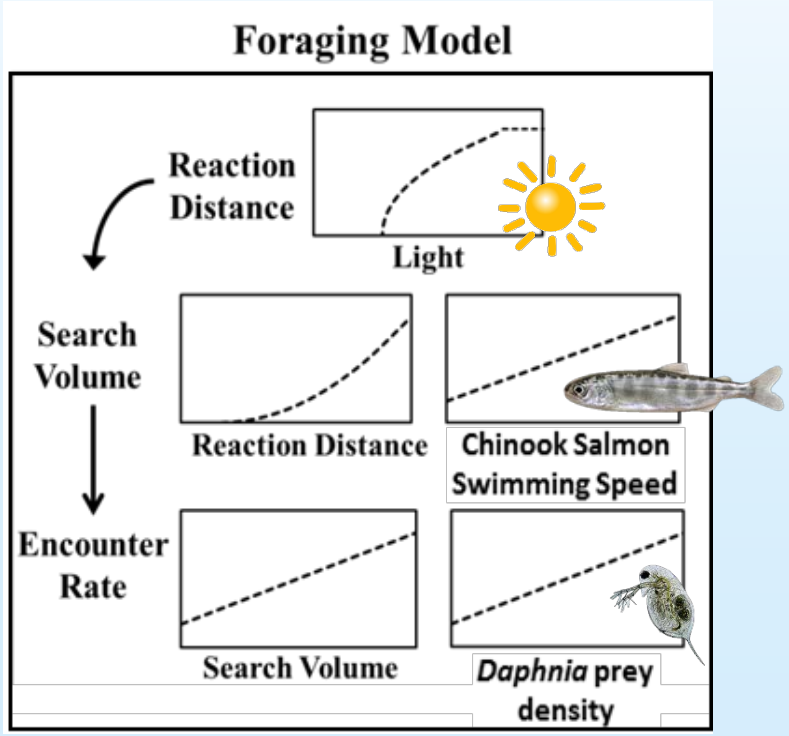
see Beauchamp et al. CJAFS 1999

Foraging

Visual foraging depends on:

Reaction Distance

- Visual acuity
- Target size
- Light conditions



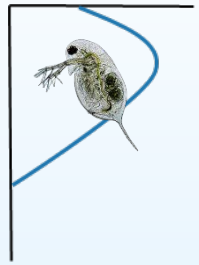
Encounter rate

- Swimming speed
- Density of targets

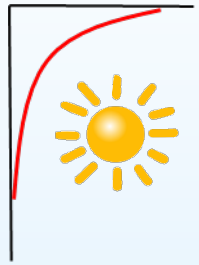
Foraging

Computations:

Daphnia density by depth



Available light by depth

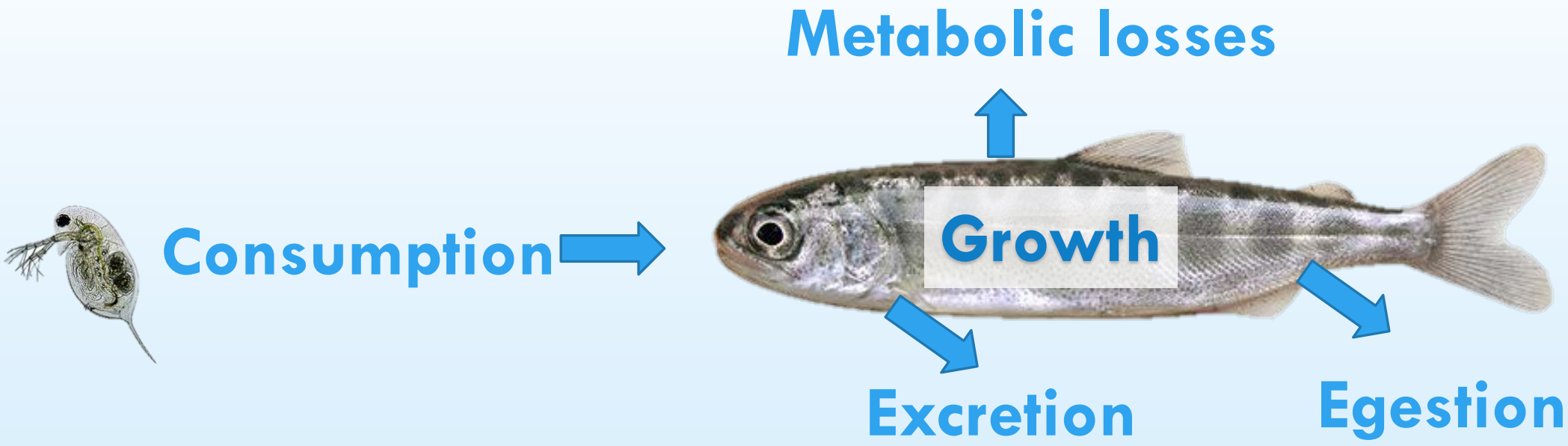


Reaction distance RD = 3.8 * (light^0.47) * (daphnia size^0.95)

Search volume SV = π * RD^2 * swimming speed

Encounter rate ER = SV * daphnia density * daphnia weight / weight

Bioenergetics



see Hanson et al. 1997 Wisconsin Bioenergetics Model 3.0

Bioenergetics are influenced by:

Energy budgets =

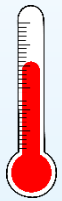
respiration

+ active metabolism

+ specific dynamic action

+ egestion

+ excretion

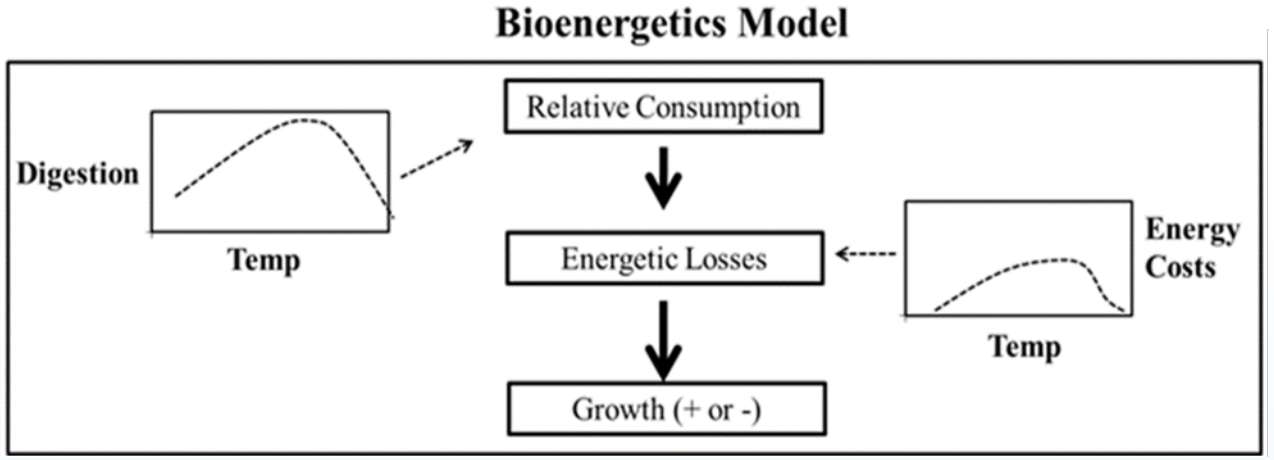


Temperature

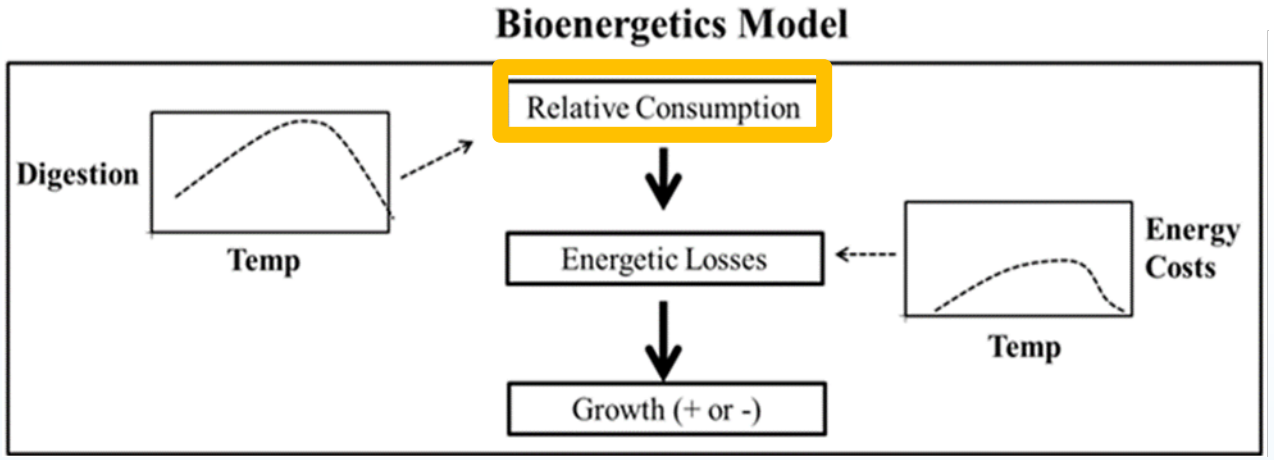
- Each of these parameters has a temperature dependent specific rate

Fish size

- Parameters are also mass dependent

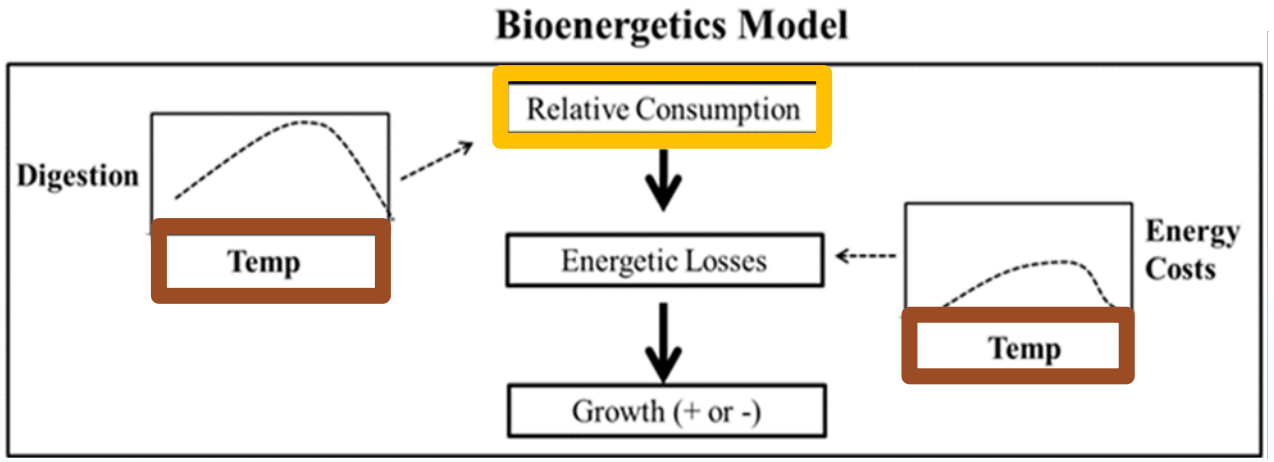


Computations for Bioenergetics Model:



Computations for Bioenergetics Model

Consumption = metabolism + wastes + growth

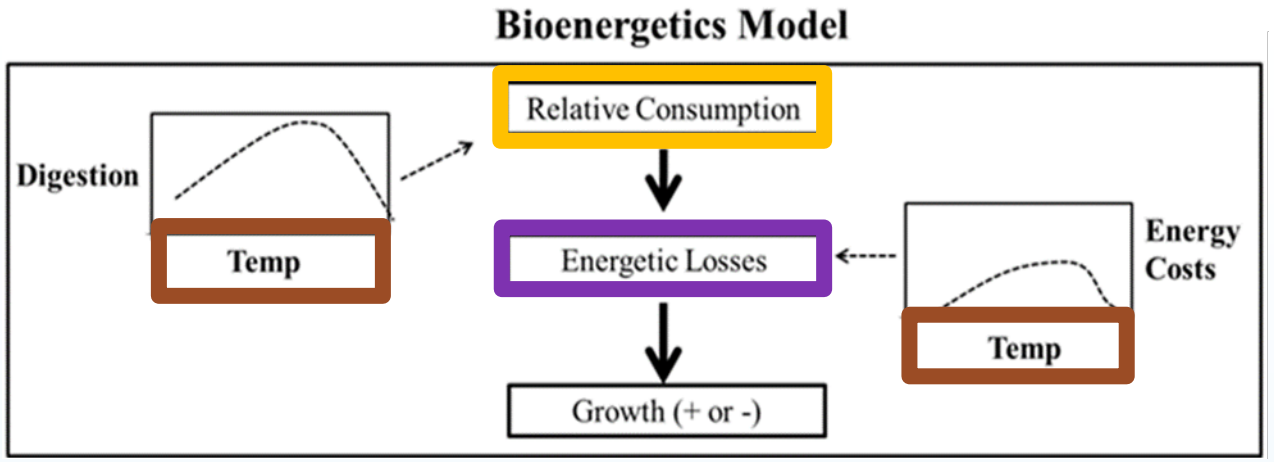


Computations for Bioenergetics Model:

Consumption = metabolism + wastes + growth

Temperature dependence (f(T)) = SSPs and temperature

SSPs = Species-specific parameters



Computations for Bioenergetics Model:

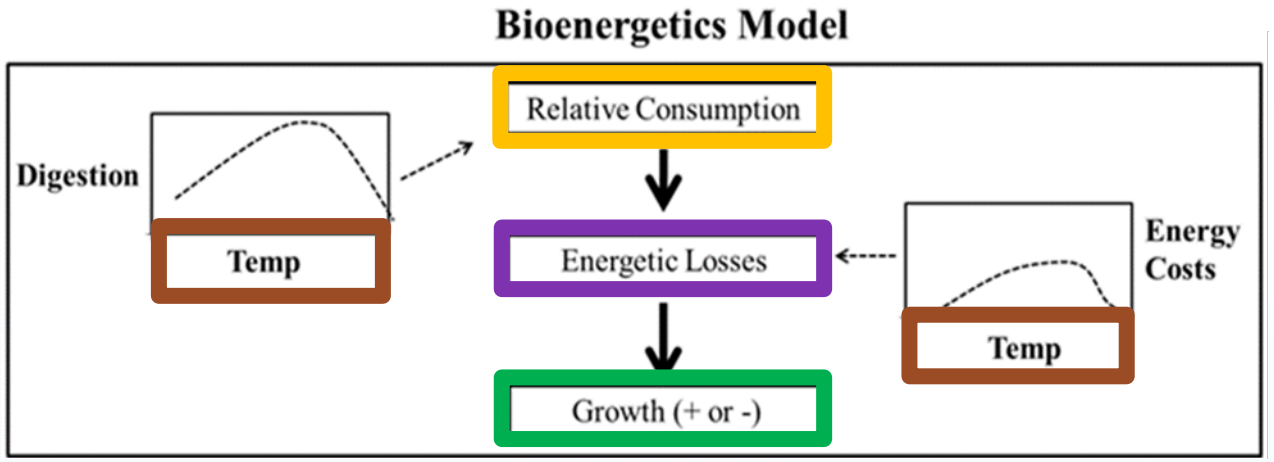
Consumption = metabolism + wastes + growth

Temperature dependence (f(T)) = SSPs and temperature

Waste = SSPs, consumption, temperature and prey digestibility

Respiration = SSPs, mass, temperature, egestion and consumption

SSPs = Species-specific parameters



Computations for Bioenergetics Model:

Consumption = metabolism + wastes + growth

Temperature dependence (f(T)) = SSPs and temperature

Waste = SSPs, consumption, temperature and prey digestibility

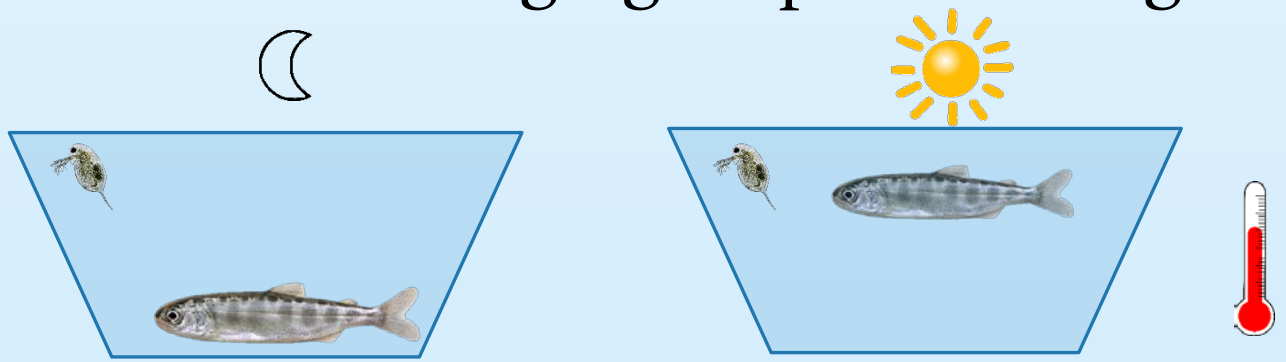
Respiration = SSPs, mass, temperature, egestion and consumption

Growth = Consumption, prey energy, egestion, excretion, specific dynamic action, respiration, predator energy, mass

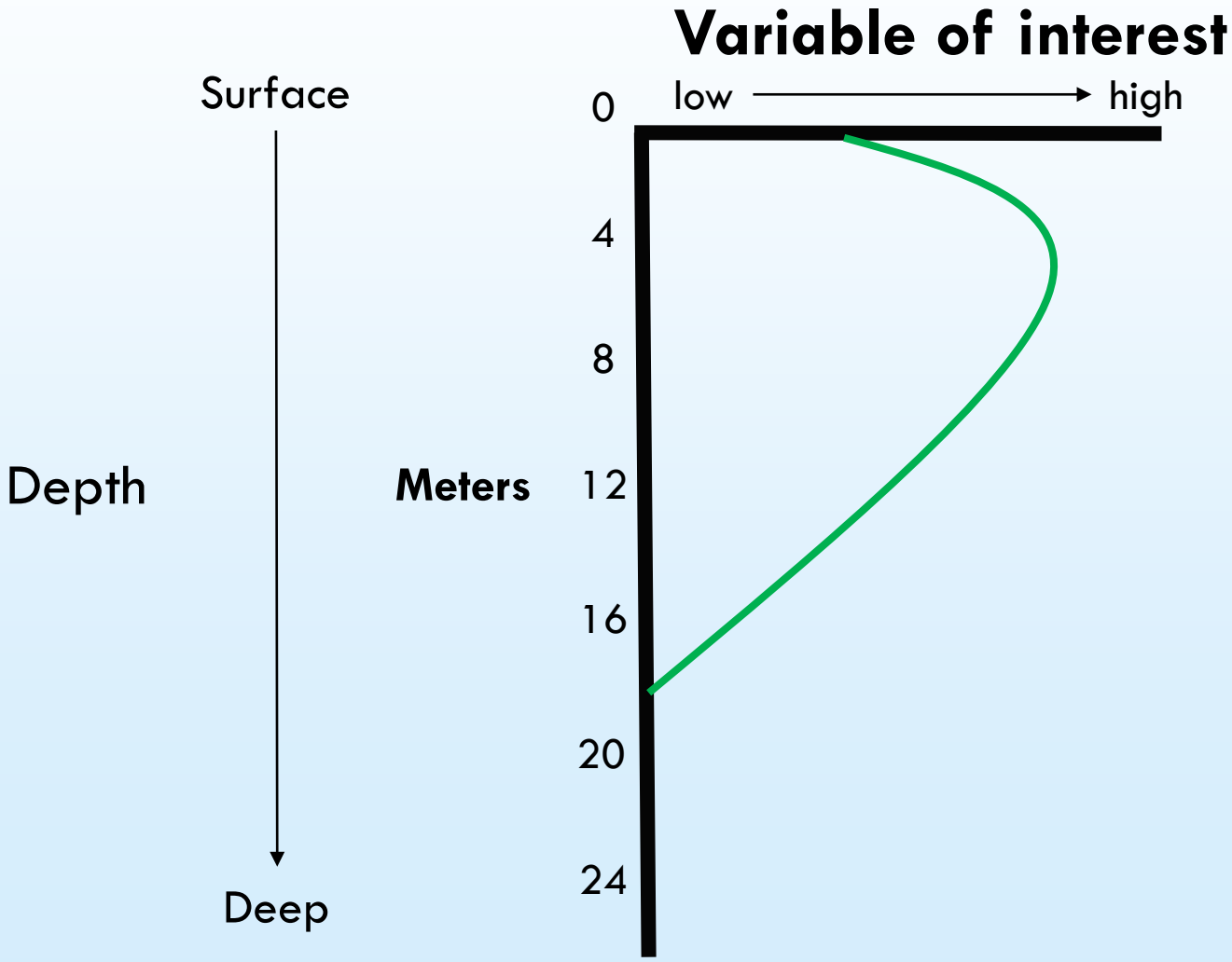
Combining Foraging and Bioenergetics Models

Linkage and special considerations:

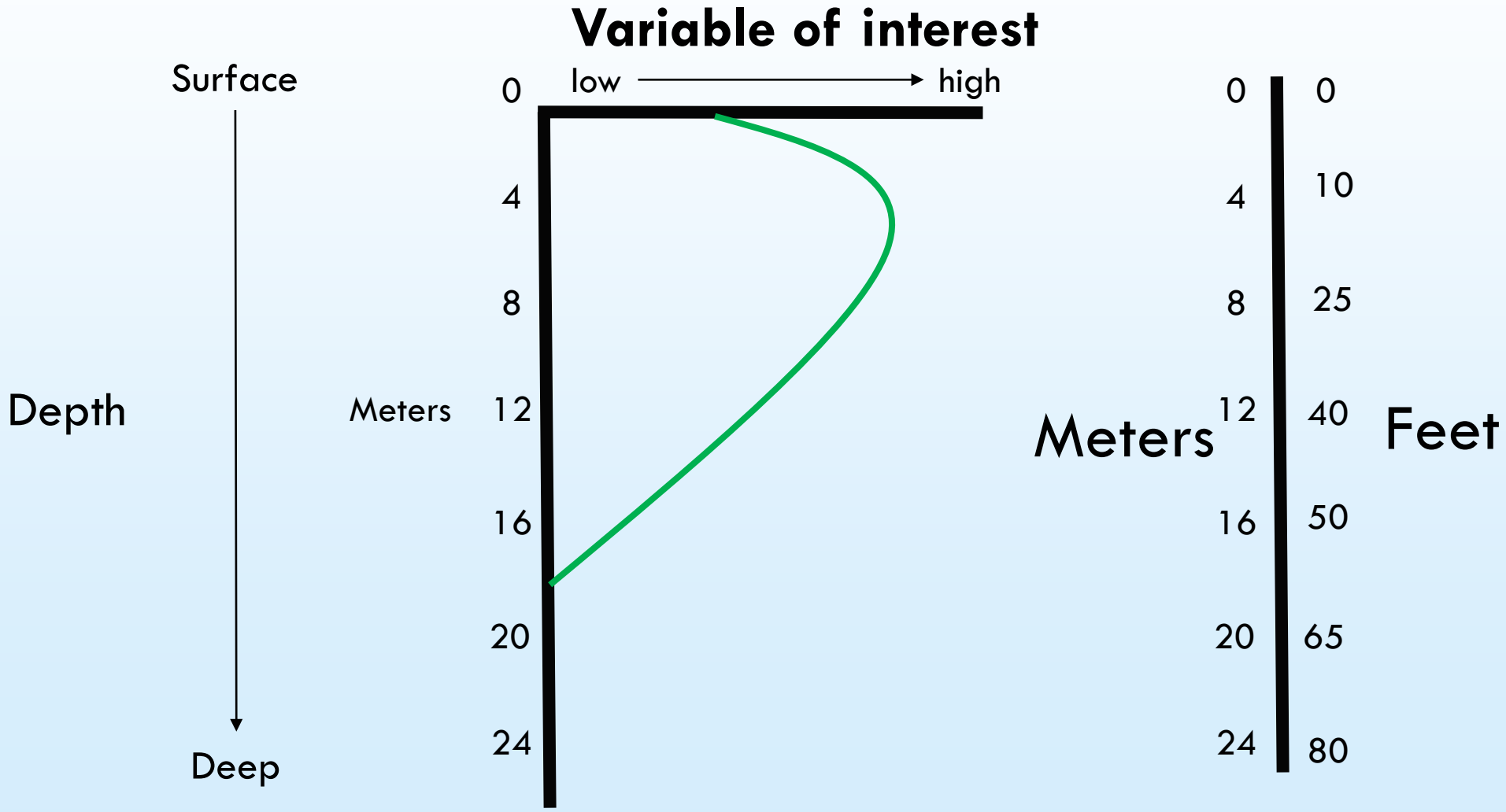
1. Consumption efficiency (P) is constrained by **physiology** and **foraging**
2. Combined models, using hourly time-steps and designation of day or night, accommodates foraging responses to light and diel vertical migration



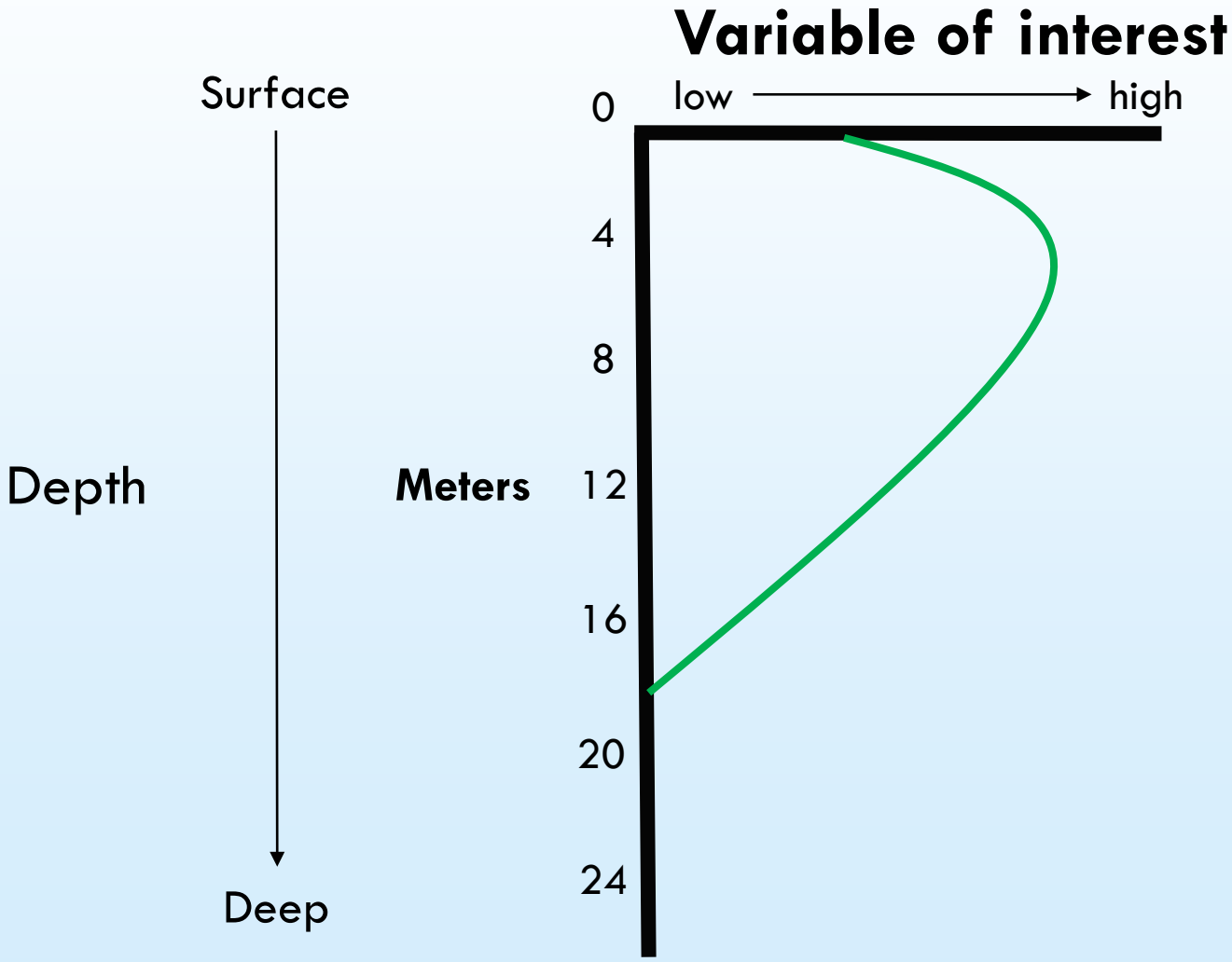
Model Inputs: 2015 Empirical Data

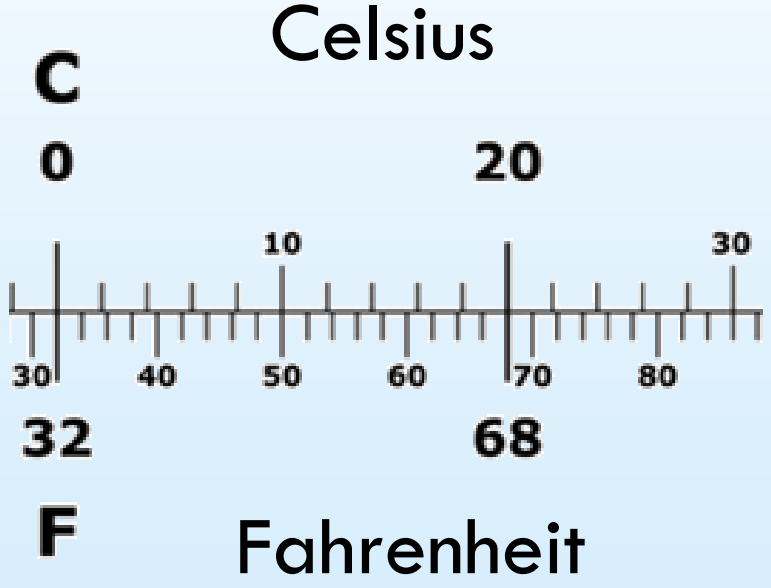


Model Inputs: 2015 Empirical Data

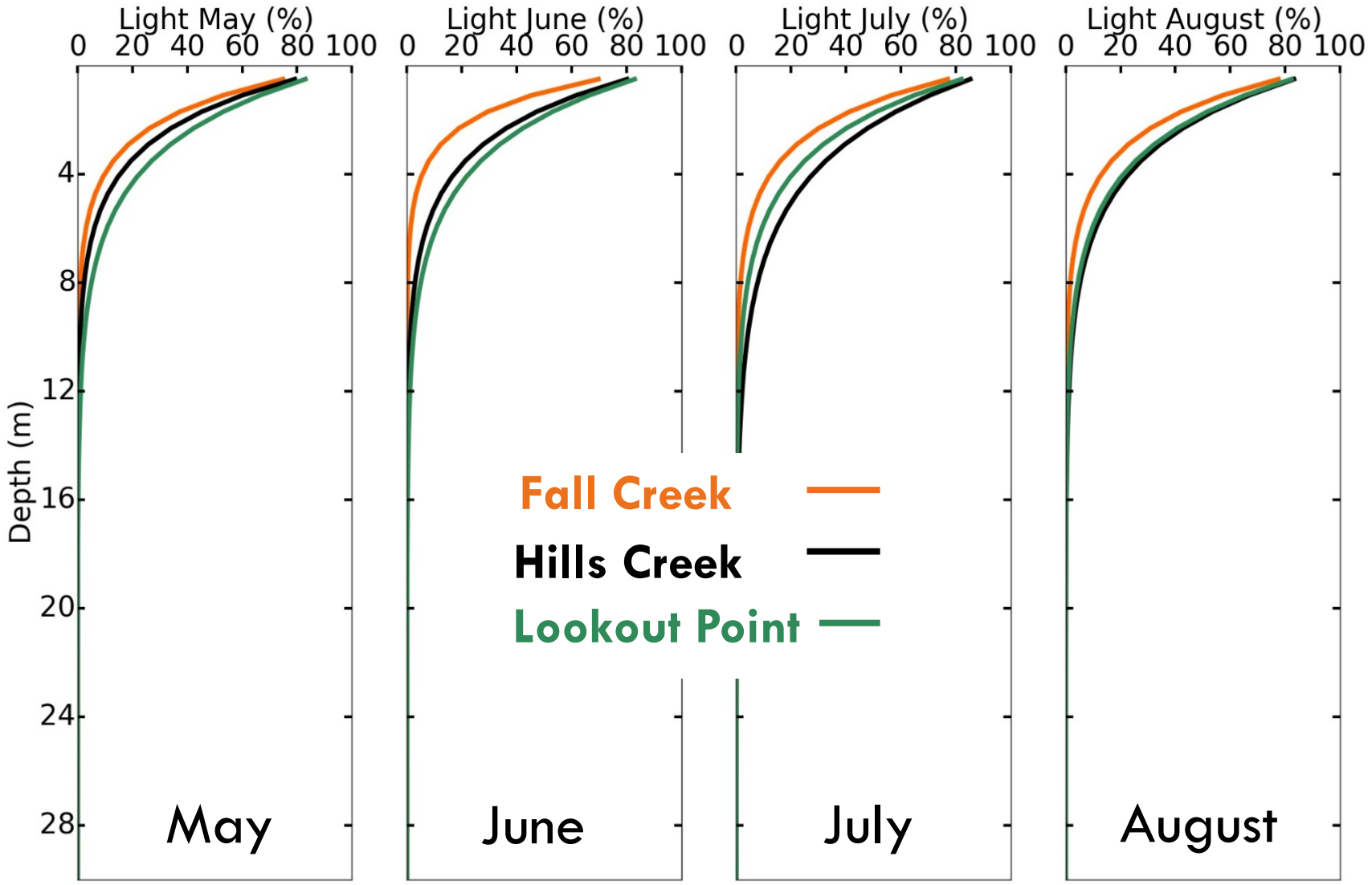


Model Inputs: 2015 Empirical Data





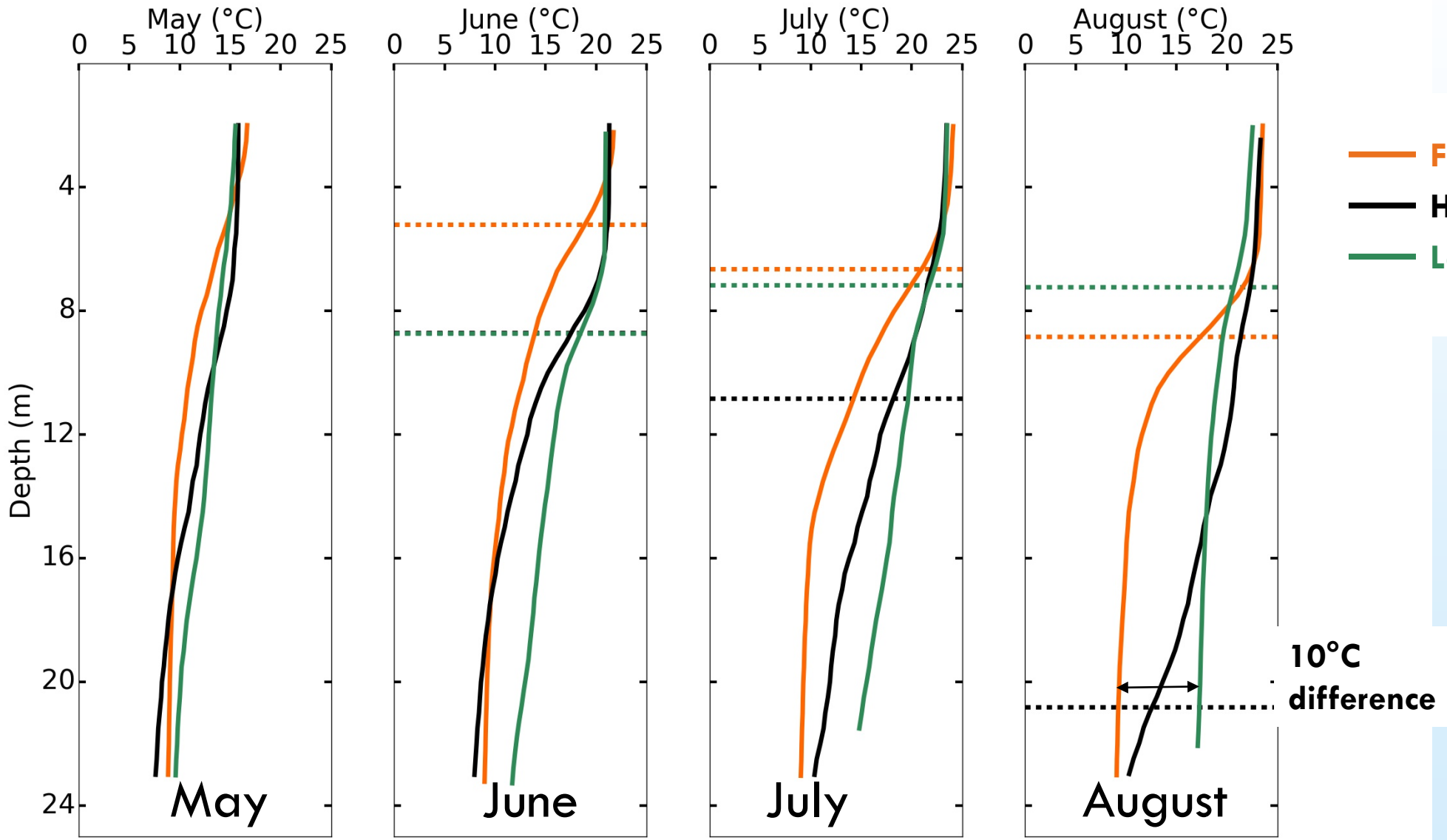
2015 light by depth



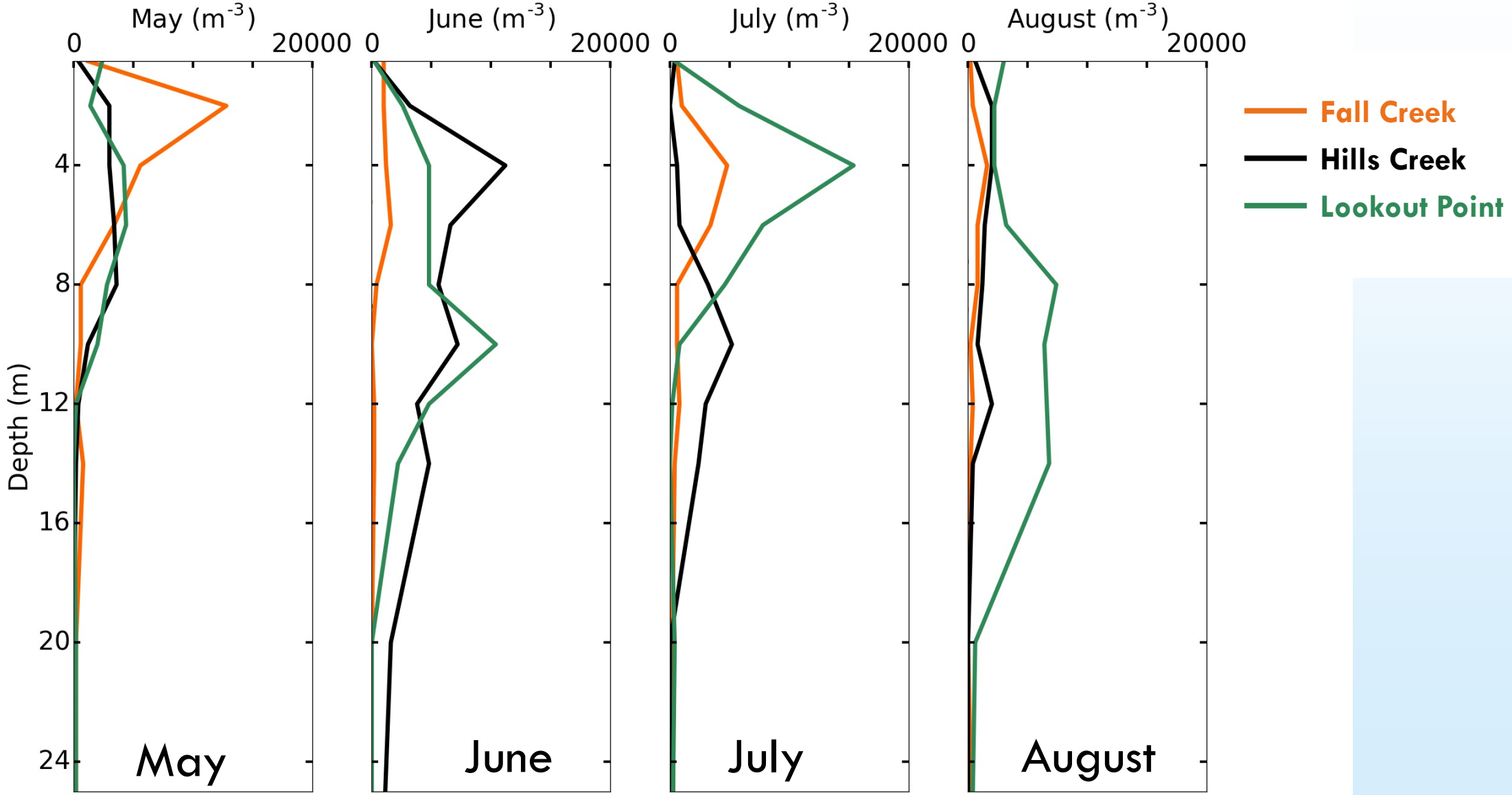
Differences in percent light at 4m depth

	May	June	July	August
Fall Creek	10	6	12	13
Hills Creek	15	17	28	23
Lookout Point	22	22	21	21

2015 Temperature Profiles

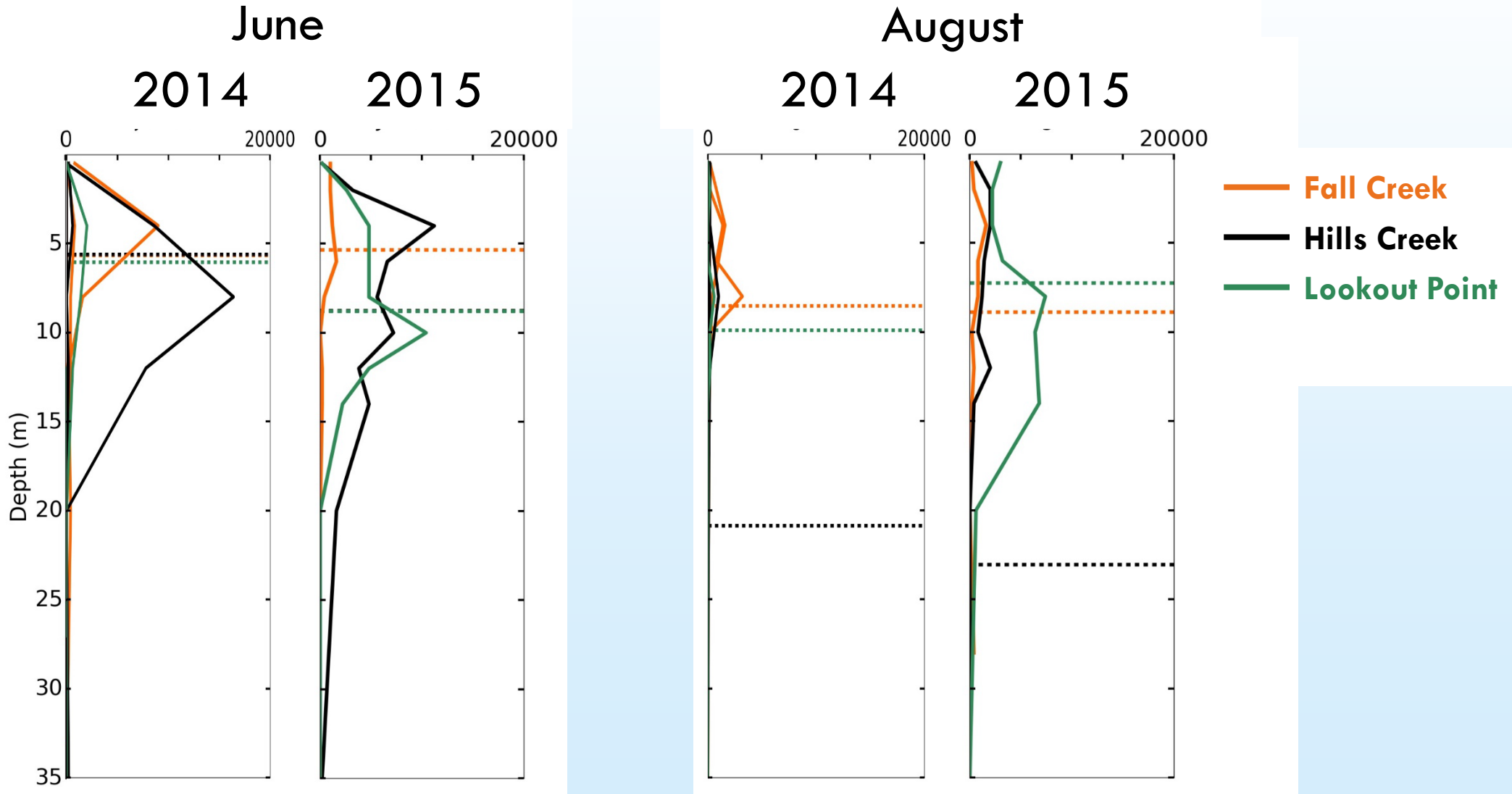


2015 In-Reservoir Food Availability



Differences between years

Daphnia abundance and distribution



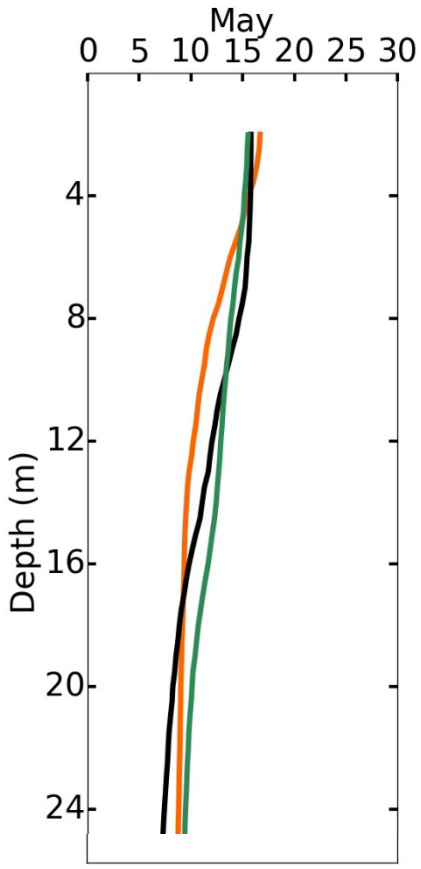
Model scenarios

- Identify **processes** that drive growth to determine **management** opportunities
- Current **scenarios**
  - Fixed starting size each month with real data on light, temp and food
  - Diel vertical migration to defined temperatures
  - Output format presented % maximum for that month across reservoirs
    - Purple = high growth, Blue = no/little growth
- **Behavior** in one reservoir may not be ideal in another

Modelled growth May 2015

60 mm fish (4.5 g), 1.1 mm Daphnia, excluding depths >25m (82 ft)

Temperature		Fall Creek	Hills Creek	Lookout Point
Day	Night	*Provisional findings*		
18°C	18°C			
18°C	15°C			
18°C	12°C			
15°C	18°C			
15°C	15°C	97%	68%	98%
15°C	12°C	**98%**	**70%**	**100%**
12°C	18°C			
12°C	15°C	39%	38%	38%
12°C	12°C	41%	39%	39%



Modelled growth June 2015

100 mm fish (8.0 g), 1.1 mm Daphnia, excluding depths >25m (82 ft)

Temperature		Fall Creek	Hills Creek	Lookout Point
Day	Night	*Provisional findings*		
18°C	18°C	56%	74%	96%
18°C	15°C	58%	76%	98%
18°C	12°C	**59%**	**78%**	**100%**
15°C	18°C	53%	68%	55%
15°C	15°C	55%	70%	57%
15°C	12°C	56%	72%	58%
12°C	18°C	54%	57%	54%
12°C	15°C	56%	59%	56%
12°C	12°C	58%	61%	58%

Modelled growth July 2015

125 mm fish (13.2 g), 1.1 mm Daphnia, excluding depths >25m (82 ft)

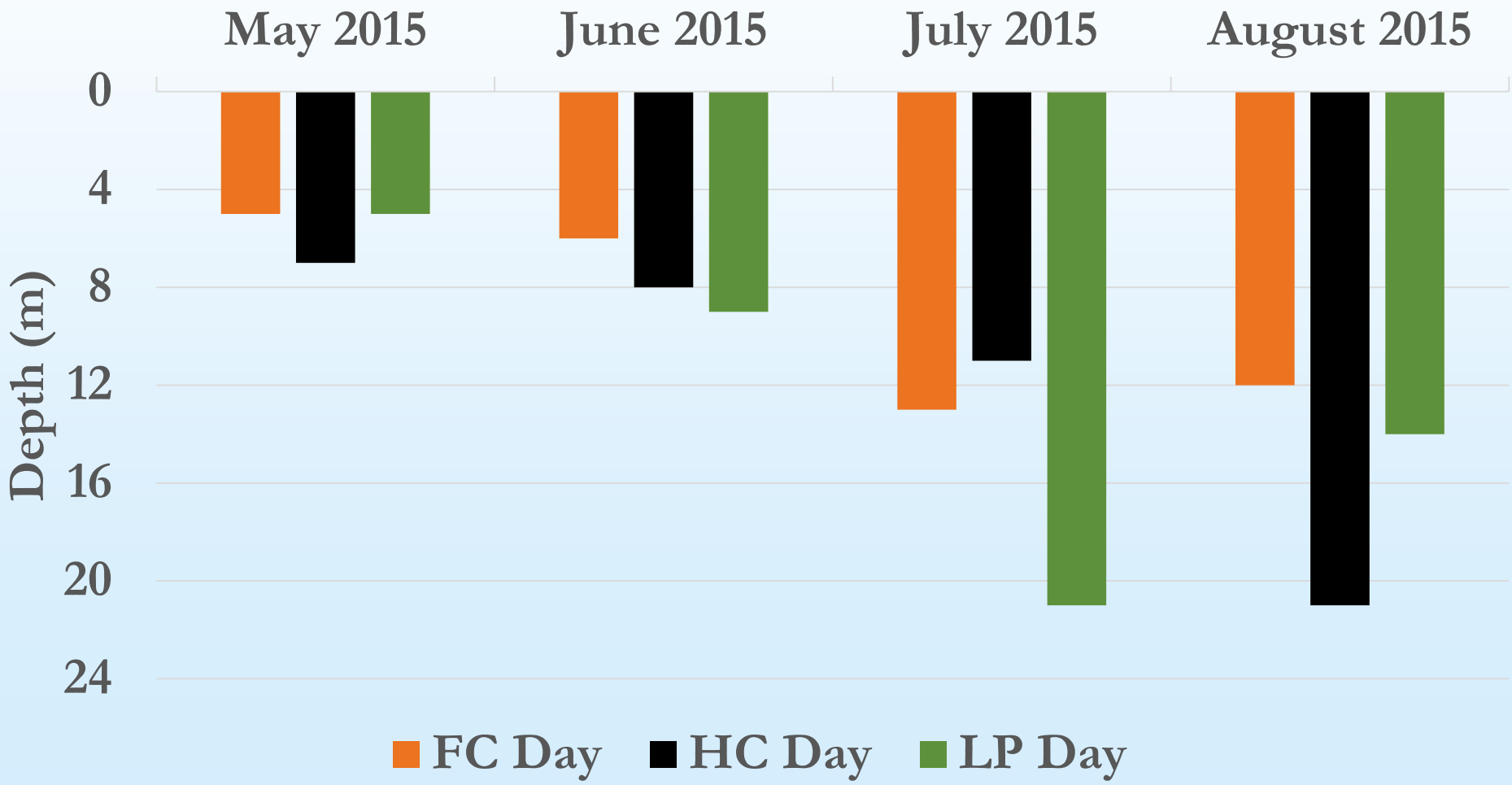
Temperature		Fall Creek	Hills Creek	Lookout Point
Day	Night	*Provisional findings*		
18°C	18°C	67%	96%	64%
18°C	15°C	69%	98%	66%
18°C	12°C	70%	**100%**	
15°C	18°C	69%	74%	68%
15°C	15°C	71%	76%	**70%**
15°C	12°C	72%	78%	
12°C	18°C	70%	70%	
12°C	15°C	73%	72%	
12°C	12°C	**74%**	74%	

Modelled growth August 2015

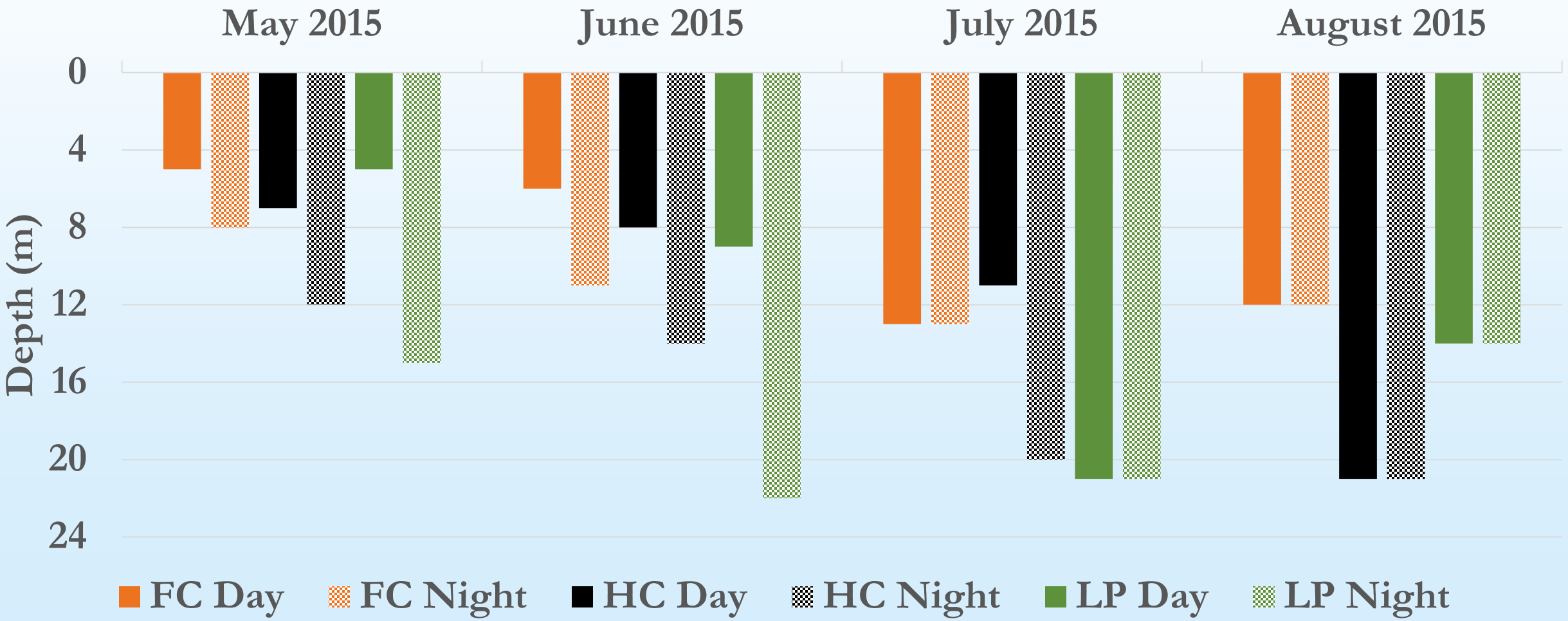
175 mm fish (13.2 g), 1.1 mm Daphnia, excluding depths >25m (82 ft)

Temperature		Fall Creek	Hills Creek	Lookout Point
Day	Night	*Provisional findings*		
18°C	18°C	89%	88%	**91%**
18°C	15°C	92%	91%	
18°C	12°C	94%	93%	
15°C	18°C	92%	91%	
15°C	15°C	95%	94%	
15°C	12°C	97%	97%	
12°C	18°C	95%	94%	
12°C	15°C	98%	97%	
12°C	12°C	**100%**	**99%**	

Daytime depth of predicted optima for juvenile Chinook Salmon



Predicted diel vertical migration for juvenile Chinook Salmon

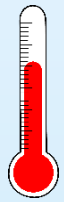


Summary of foraging and bioenergetics models

- Early season conditions appeared more conducive to growth than late season conditions across all three reservoirs.

- Optimal depths shallower at Fall Creek, likely function of shallower thermocline and less light at depth.

- Coldwater refugia were less available late in the summer in Lookout Point than Hills Creek or Fall Creek Reservoirs. At similar depths, Juvenile Chinook Salmon in Lookout Point occupied 18°C versus 12°C in Fall Creek.



Future model scenarios

- Additional years and comparison of conditions

  Low densities of Daphnia in Fall Creek in 2015, esp late summer, likely led to less growth in 2015 models than likely for 2014.

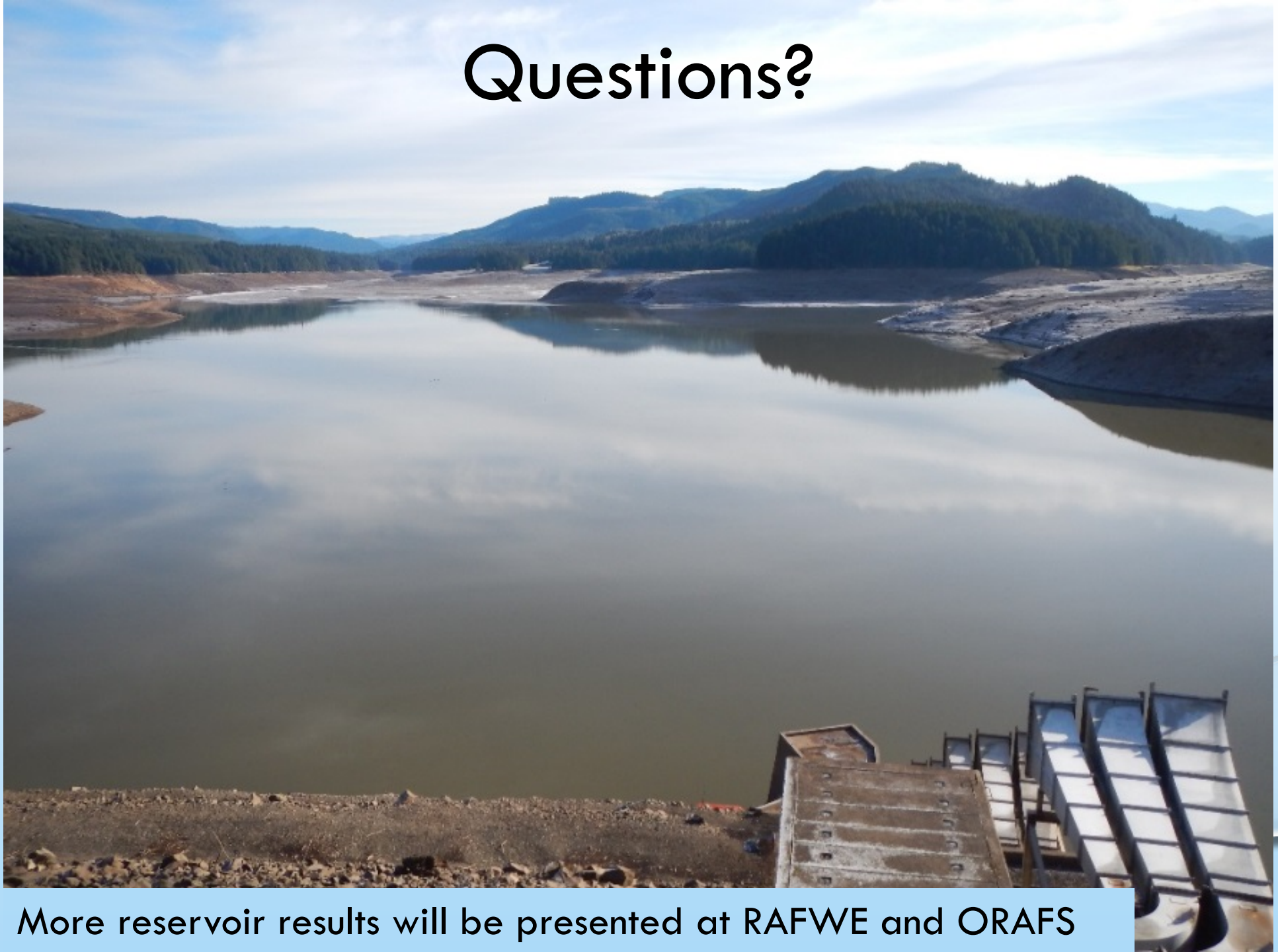
- Discussions with managers and stakeholders to explore scenarios including:

  Predator exposure / depth exclusion

  Management decisions which alter

  depth, temperature, light, zooplankton

Questions?



More reservoir results will be presented at RAFWE and ORAFS