Rearing capacity of Detroit, Foster and Cougar Reservoirs for age-0 Chinook

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contracted to NWFSC

Introduction—juvenile life histories

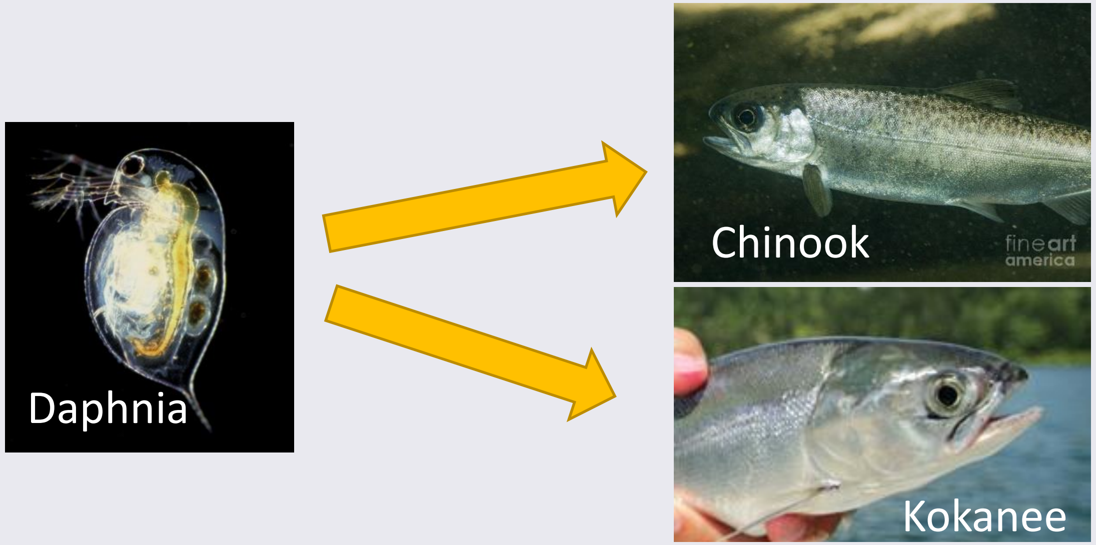
- A large proportion of fry spawned above dams disperse downstream in early spring and rear within reservoirs over summer

- Growth rates in reservoirs can be very high relative to in streams, but survival rates may be lower

- Many age-0 fish exit reservoirs in fall corresponding with drawdown, and overwinter below them

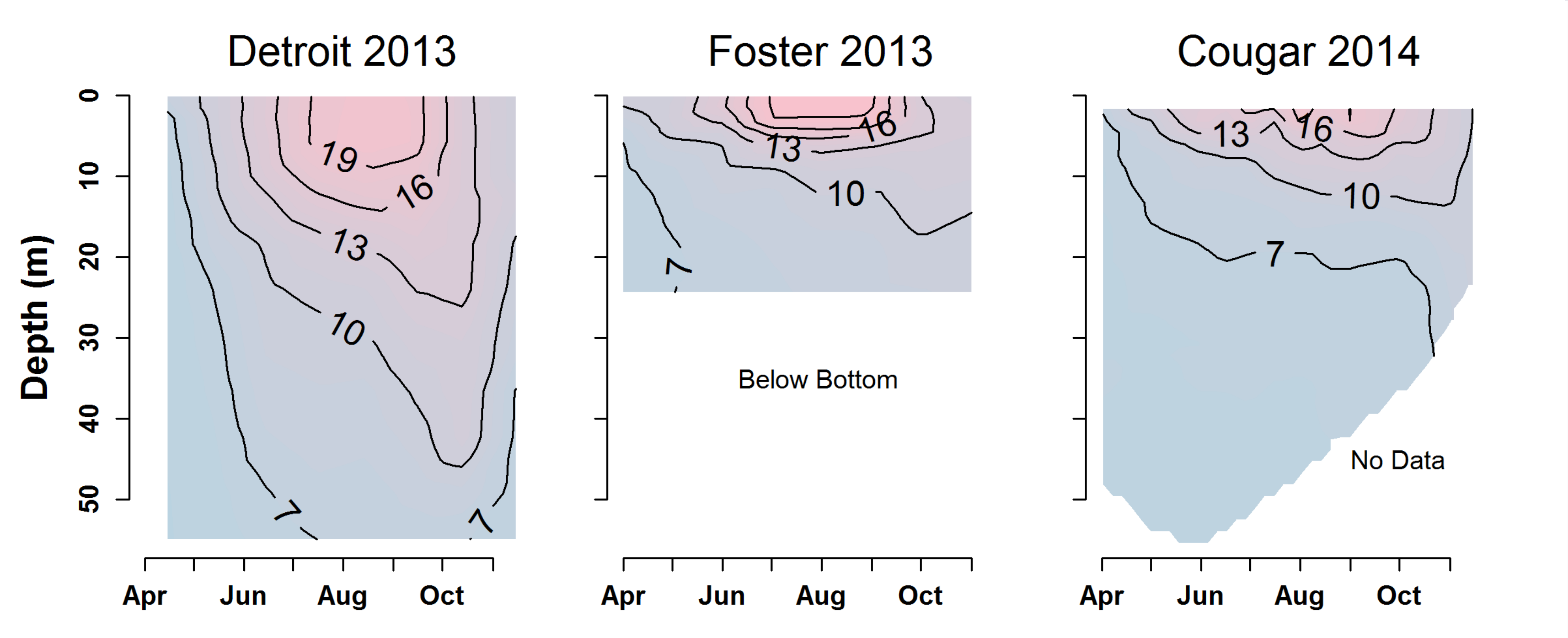
Introduction—reservoir rearing capacities

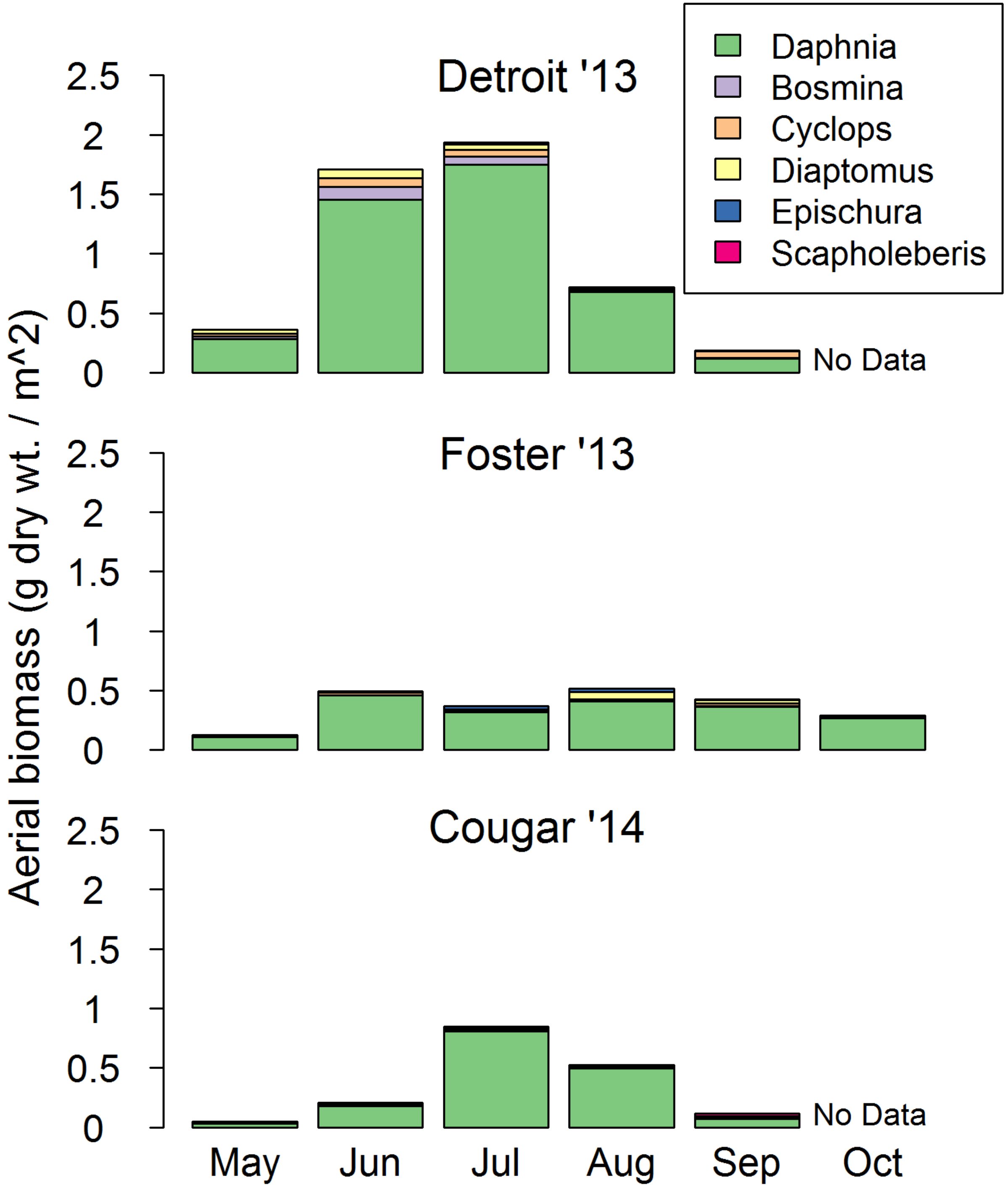
- The *number* of fish that can be produced in reservoirs will have a significant impact on population responses to reintroduction
- *Objective:* Evaluate “bottom-up” prey limitations on reservoir rearing to help calibrate expectations for reintroduced population productivity



Reservoir characteristics

- *Morphometry:* Detroit has ~3x the surface area of Foster or Cougar
- *Thermal regime:* All thermally stratified in summer
- *Food web:* Detroit has significant kokanee population; Foster has significant piscivore population; Cougar has fewer resident fish



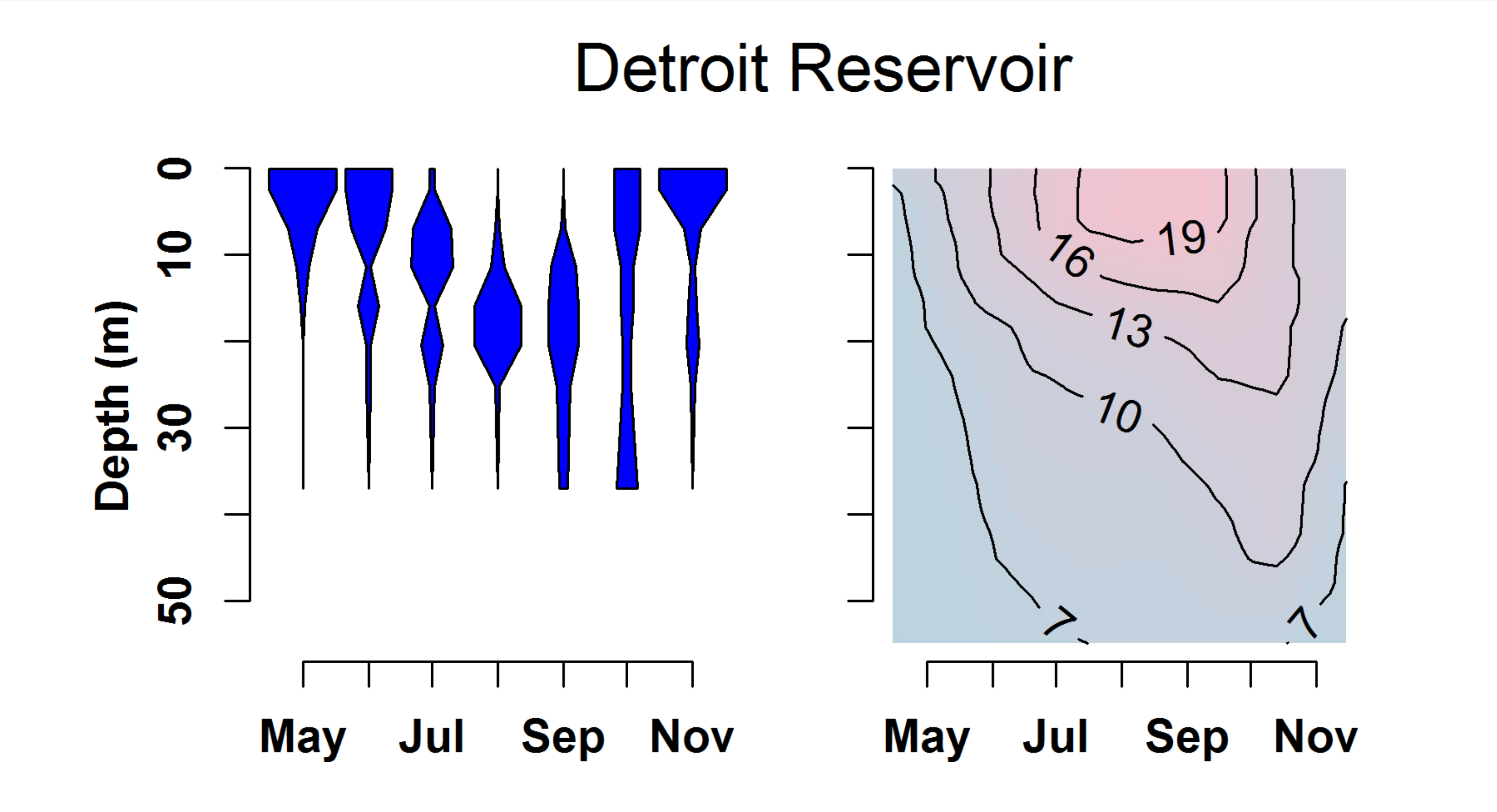


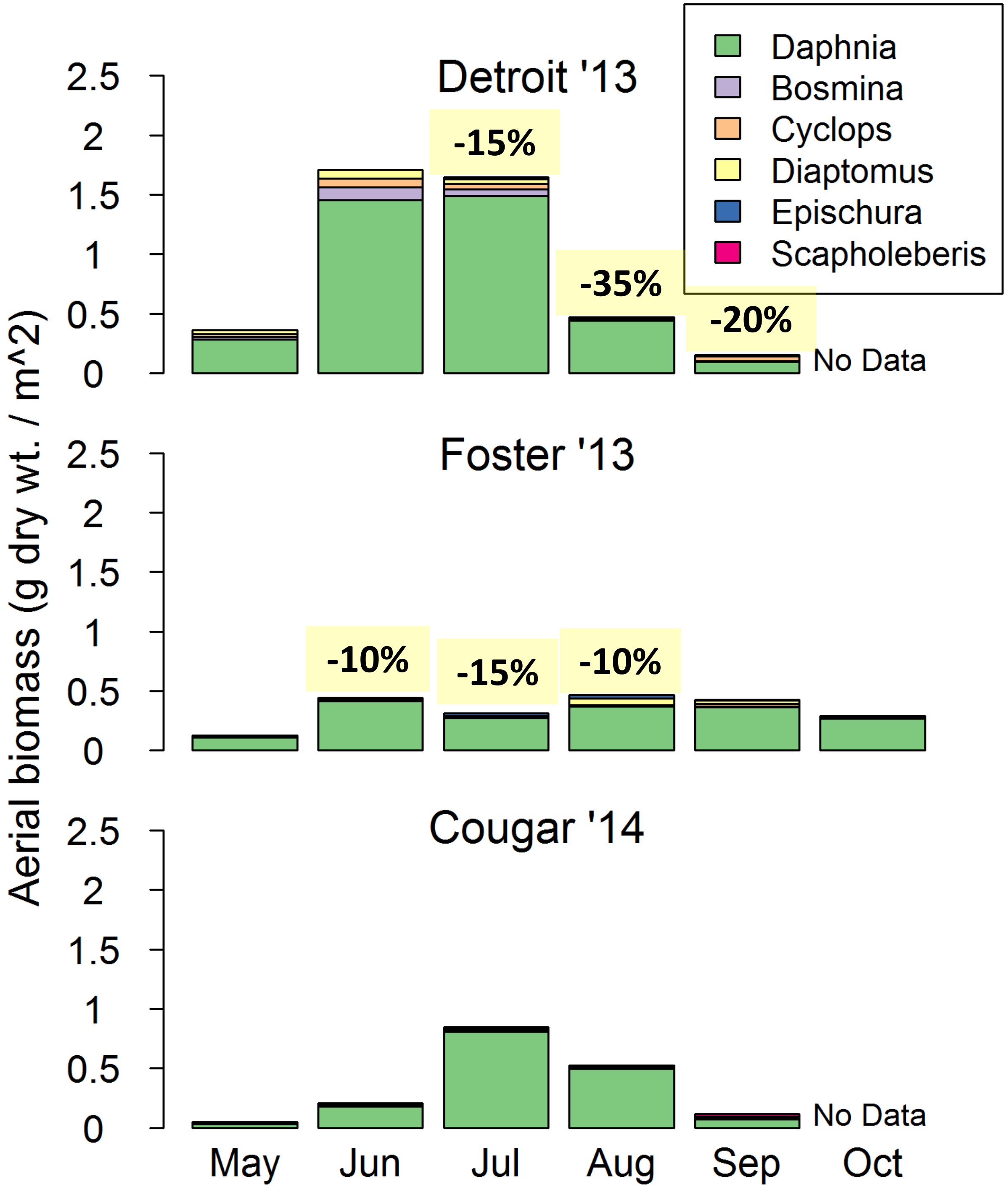
Zooplankton

- Zooplankton densities in upper 6 m measured by ACOE (K. Tackley)
- We assumed zooplankton lengths and distributions loosely based on nearby reservoirs to estimate aerial biomass

Thermal exclusion of Chinook from prey

- Based on Monzyk et al. 2014, Chinook appear to avoid warm epilimnion during peak stratification

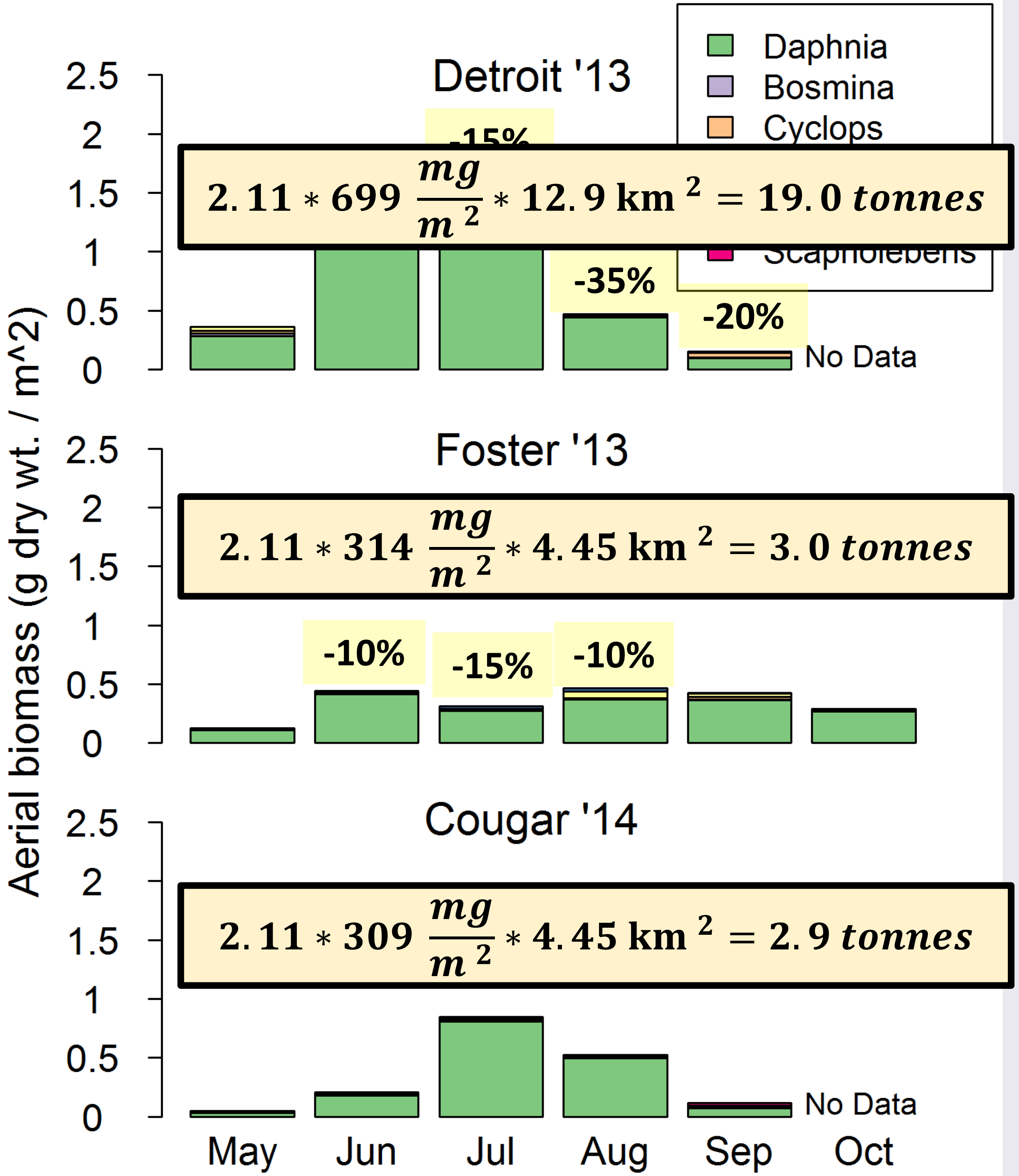




Zooplankton

- Zooplankton density in upper 6 m measured by Corps (K. Tackley)
- Converted to biomass and extrapolated across depths based on measurement in Lewis River
- Adjusted available biomass to account for thermal exclusion of salmon from warm shallow water

Zooplankton → Fish



$$2.11 * 699\,\frac{mg}{m^2} * 12.9\ \mathrm{km}^2 = 19.0\ tonnes$$

$$2.11 * 314\,\frac{mg}{m^2} * 4.45\ \mathrm{km}^2 = 3.0\ tonnes$$

$$2.11 * 309\,\frac{mg}{m^2} * 4.45\ \mathrm{km}^2 = 2.9\ tonnes$$

- Zooplankton density in upper 6 m measured by Corps (K. Tackley)
- Converted to biomass and extrapolated across depths based on measurement in Lewis River
- Adjusted available biomass to account for thermal exclusion of salmon from warm shallow water
- I estimated rearing capacities with the Koehnings and Kyle (1997) regression:

Capacity (fish biomass [kg/km^2]) = 2.11 * mean growing season zooplankton biomass (mg/m^2)

Fish growth and *preliminary* capacity

- I subtracted annual kokanee production from the rearing capacity of Detroit
  - A range of possible kokanee production was estimated based on size-at-age and hypothetical population abundances and age structures
- Individual Chinook parr sizes were the 2012–2014 averages in Oct. (Monzyk et al.)
- I divided capacity in biomass by individual masses to estimate numerical capacity

	Detroit	Foster	Cougar
Rearing capacity (tonnes)	19.0	3.0	2.9
Kokanee production (tonnes)	3.5 - 10	-	-
Average fall parr mass (g)	64	76	25
Chinook parr capacity	140,000 - 240,000*	40,000	120,000

*In addition to kokanee

Density-dependent growth considerations

- If increasing fry densities leads to reduced growth *without* severely decreasing survival, then capacities could be increased

	Detroit	Foster	Cougar
Rearing capacity (tonnes)	19.0	3.0	2.9
Kokanee production (tonnes)	3.5 - 10	-	-
Average fall parr mass (g)	**28**	**28**	25
Chinook parr capacity	**330,000 - 560,000***	**110,000**	120,000

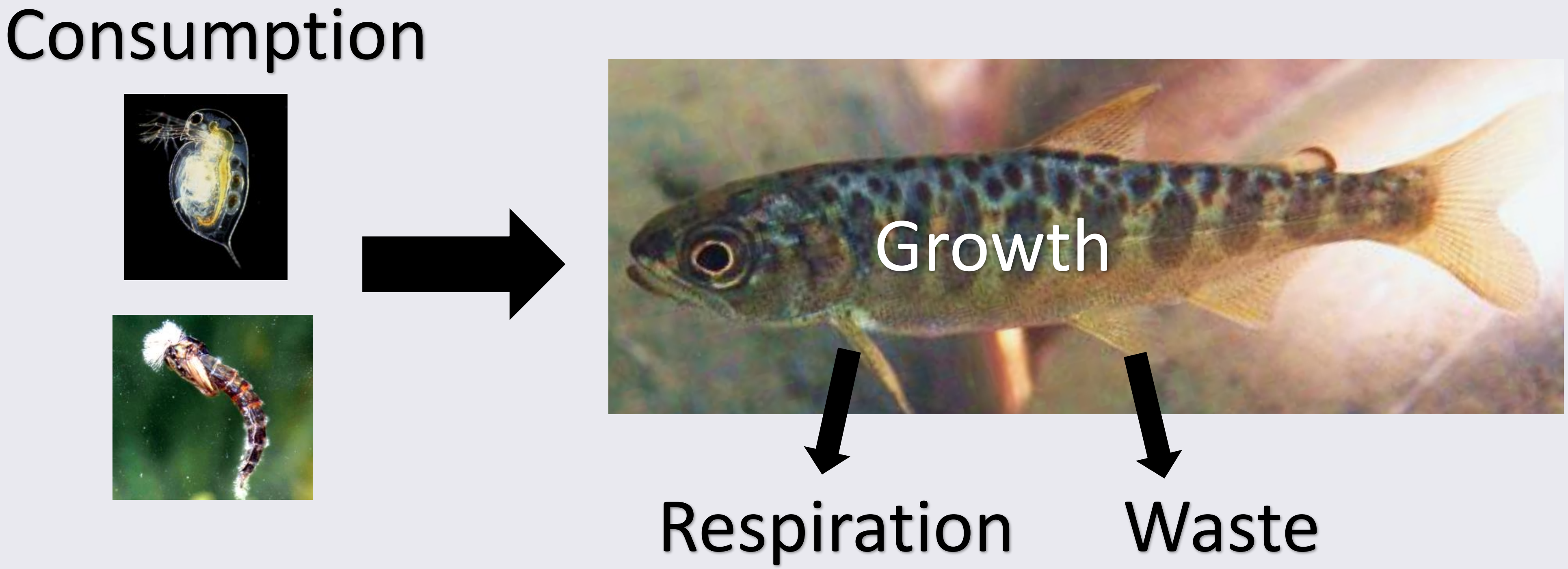
*In addition to kokanee

Prey Supply vs. Consumption Demand

a different perspective

Exploitable prey ÷ Consumption demand = Rearing capacity

Wisconsin bioenergetics model



- We estimated the biomass of prey required to produce observed growth with the Wisconsin bioenergetics model
- The relationship between consumption and growth is affected by a fish's thermal experience

Prey Supply vs. Consumption Demand

a different perspective

Growth
-Monthly net sampling

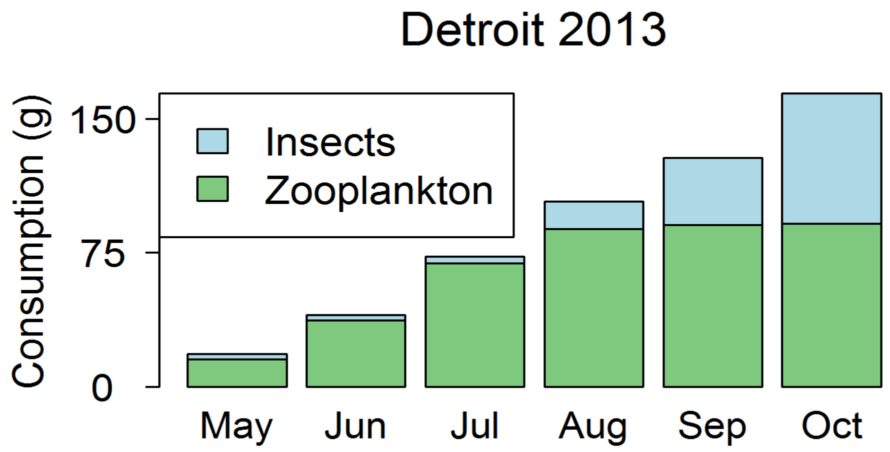
Thermal Experience
-Temperature logger strings
-Depth-specific catch rates

Diet
-From Lewis and Clackamas
-Zooplankton availability

Bioenergetics model

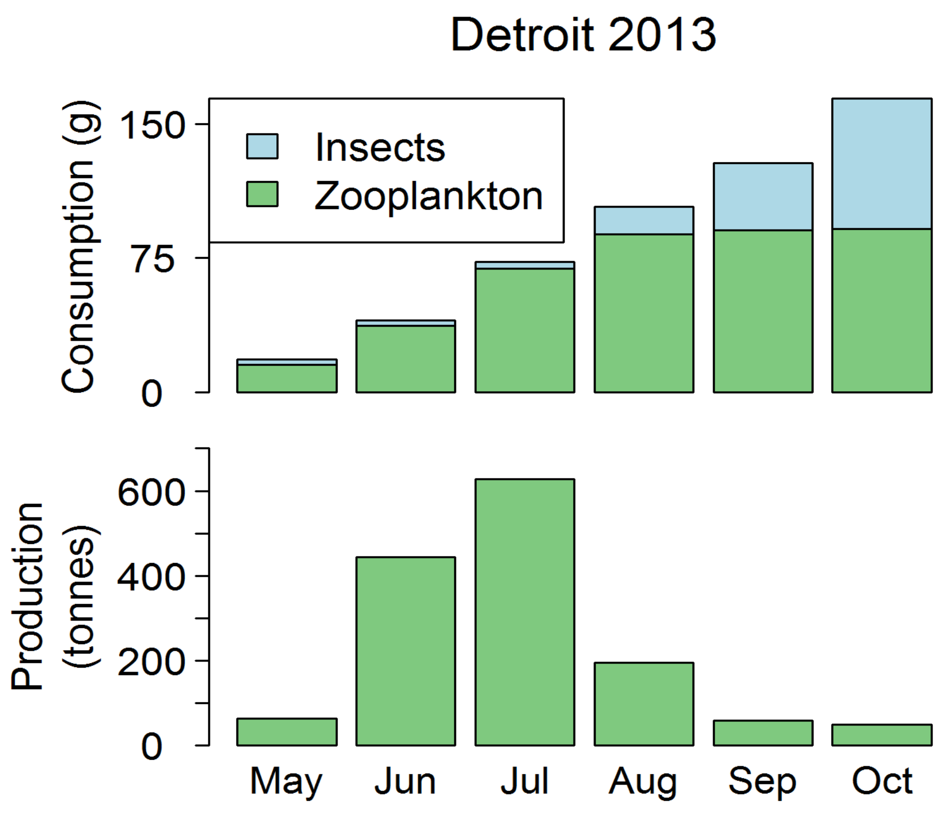
Exploitable prey ÷ **Consumption demand** = **Rearing capacity**

Prey Supply vs. Consumption Demand



- Consumption demand of each Chinook increases as they increase in size
- Thermal experience remains within the range of high metabolic rates through October
- Production appears to decline in Fall
- Increased consumption demand and decreased prey production combined to reduce rearing capacities in Fall

Prey Supply vs. Consumption Demand



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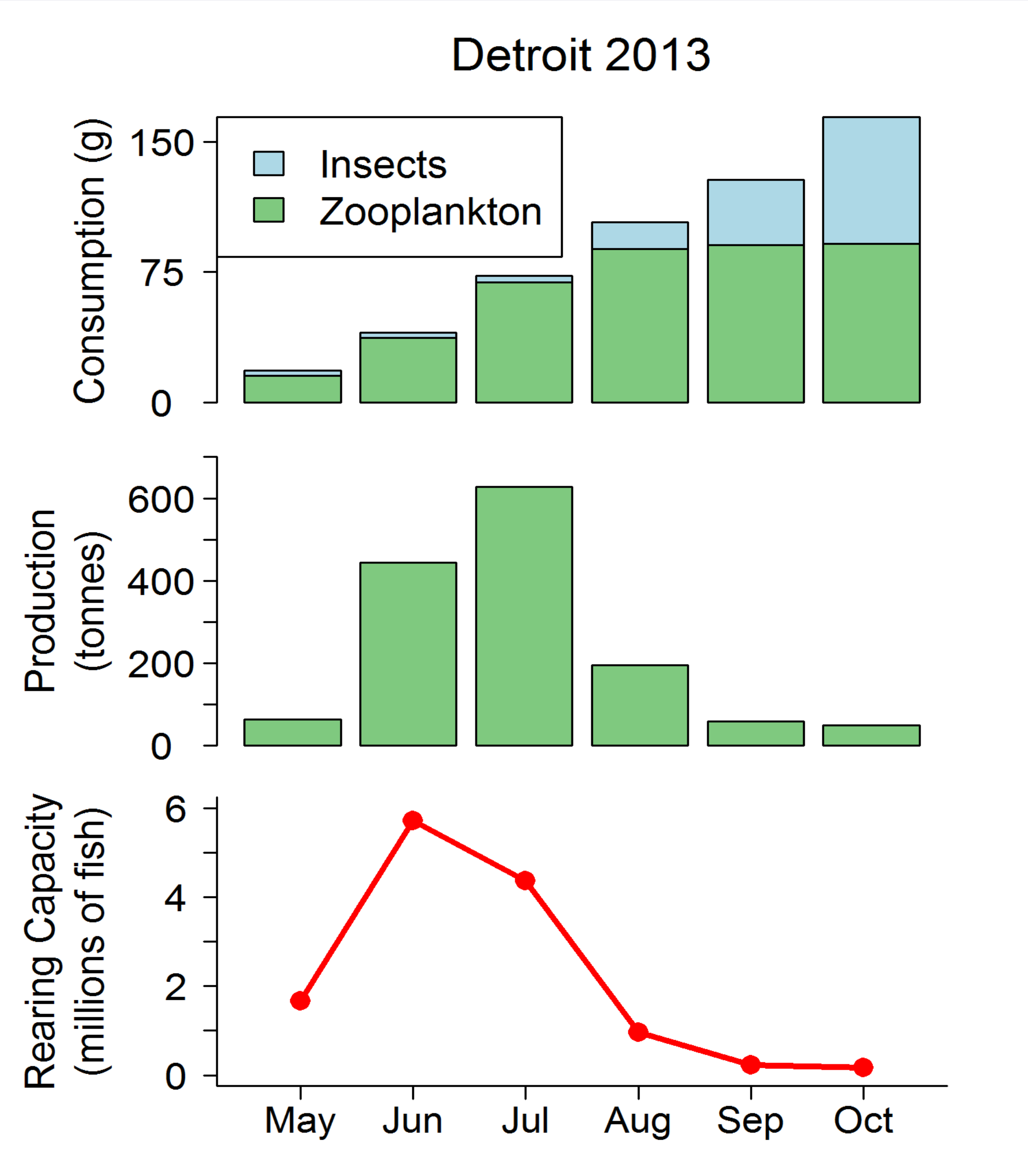

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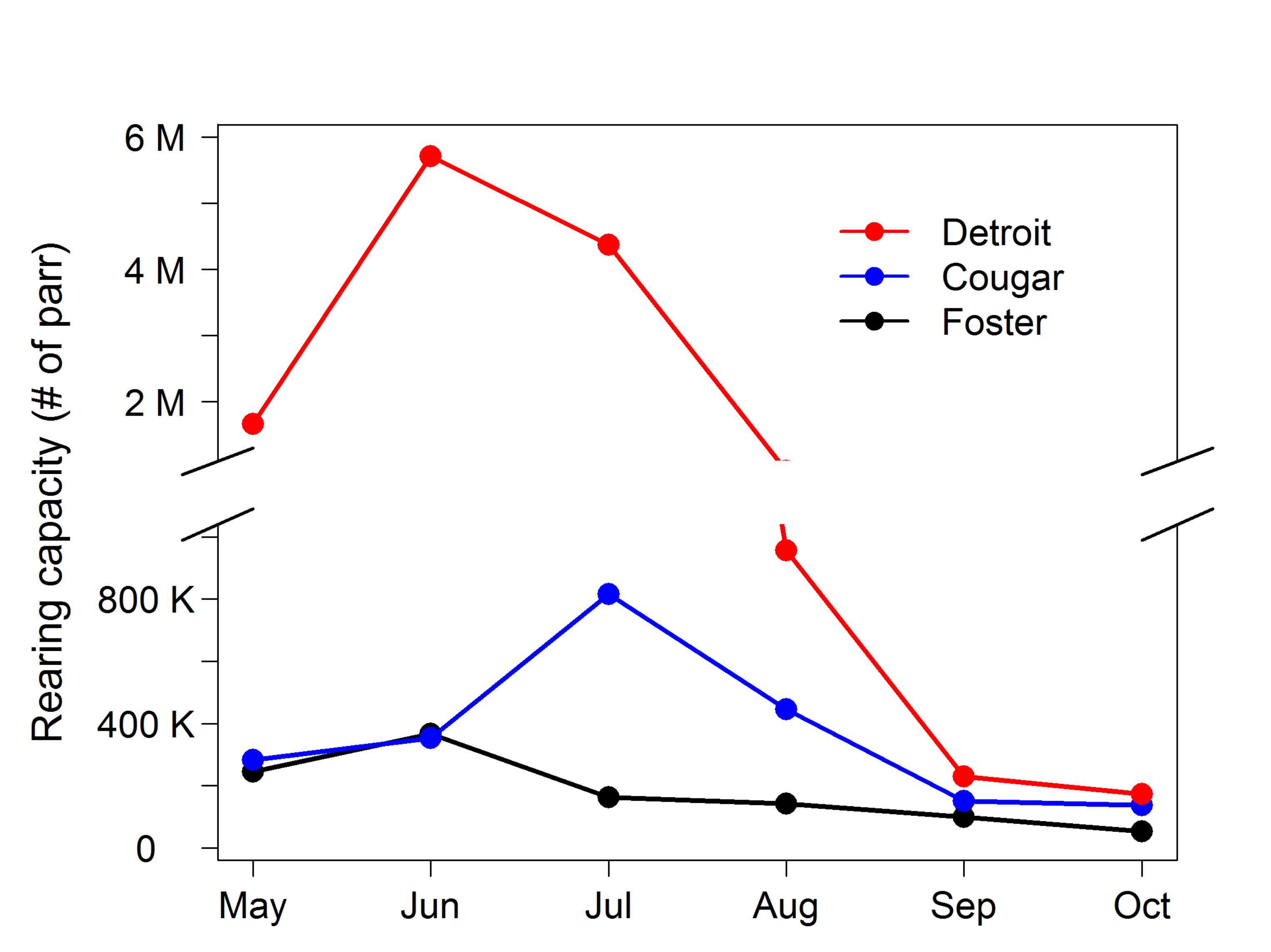
Preliminary monthly rearing capacities

- Highest capacities in late spring/early summer capable of supporting incoming fry pulses
- Capacity declined from summer to fall
- Minimum monthly capacities in October similar to regression estimates

	Detroit	Foster	Cougar
October capacity	130,000–220,000	50,000	140,000

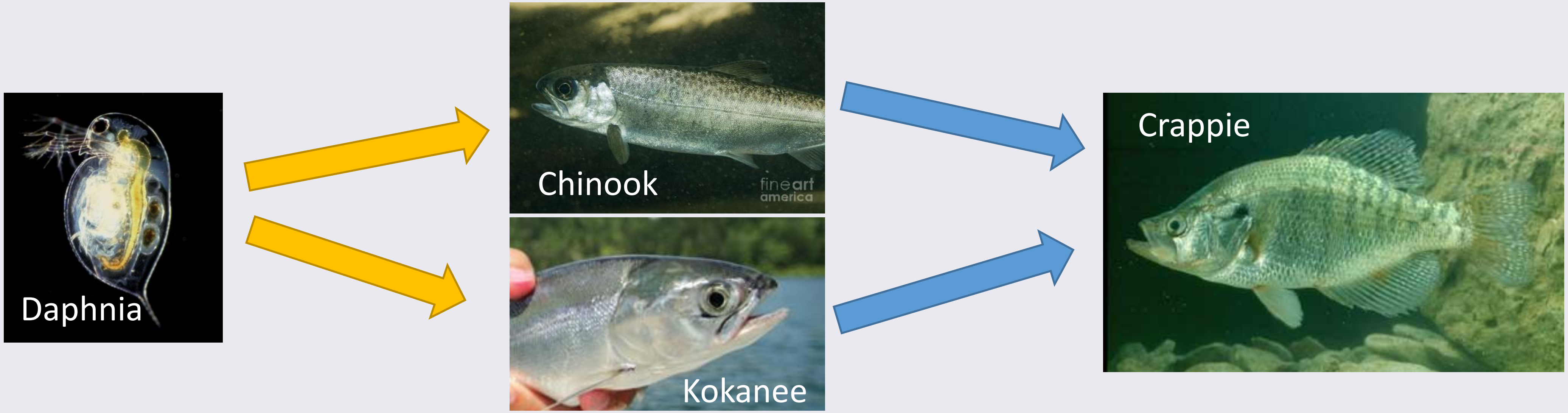


Discussion

- These estimates provide rough bounds on the number of fish that each reservoir may produce
- Capacities would be higher in Detroit and Foster if fish grew slower
  - Uncertain whether density-dependent growth would occur and how survival would be impacted
- Existing zooplankton data suggests that fall may be a period when zooplankton availability is limiting

Discussion

- Survival rates uncertain: How many fry needed to achieve rearing capacities in fall?
  - Predation rates likely higher in Foster due to piscivore populations



Next Steps

- Further investigate prey supply and predation rates to refine capacity estimates
- Use hydrodynamics models to evaluate the effects of environmental variability and water operations on prey production and rearing capacities
- We will be integrating rearing capacities into life-cycle models to evaluate effects of reintroduction on population viability

Acknowledgements

- Zooplankton and temperature data
  - ACOE: Kathryn Tackley et al.
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  - ODFW: Elise Kelley