Factors Limiting Growth of Juvenile Anadromous and Resident *Oncorhynchus mykiss* in the Duckabush and Hamma Hamma Rivers, WA.

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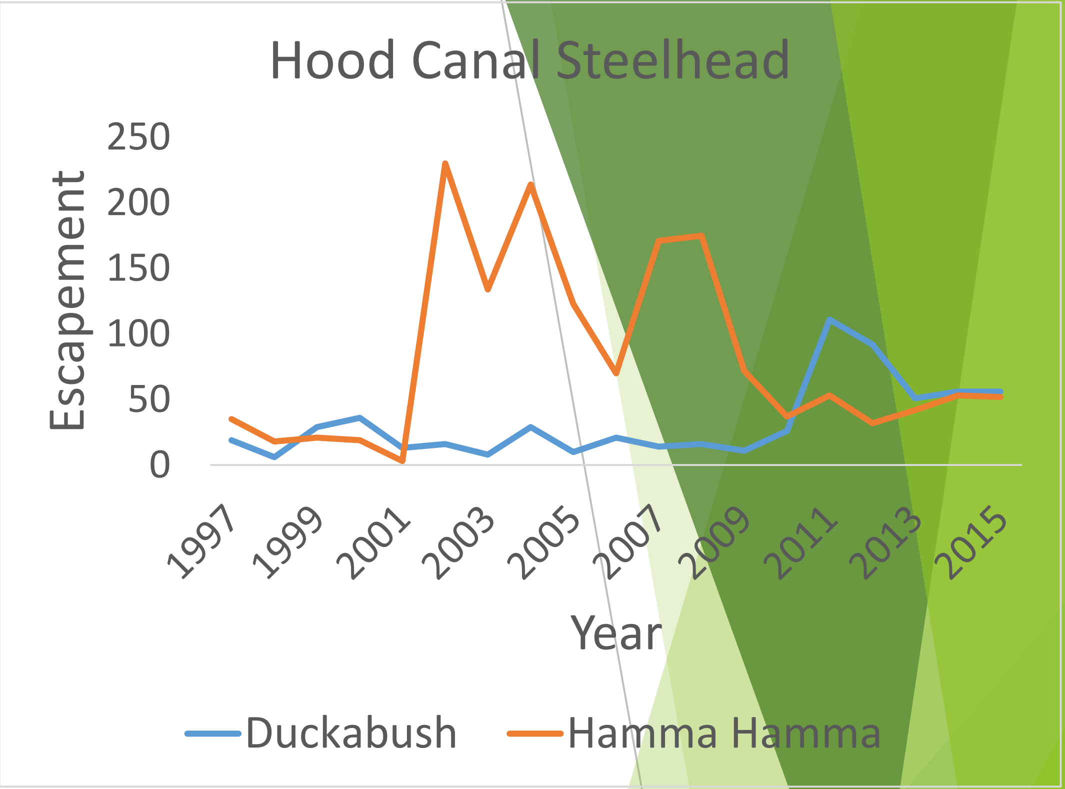
Background

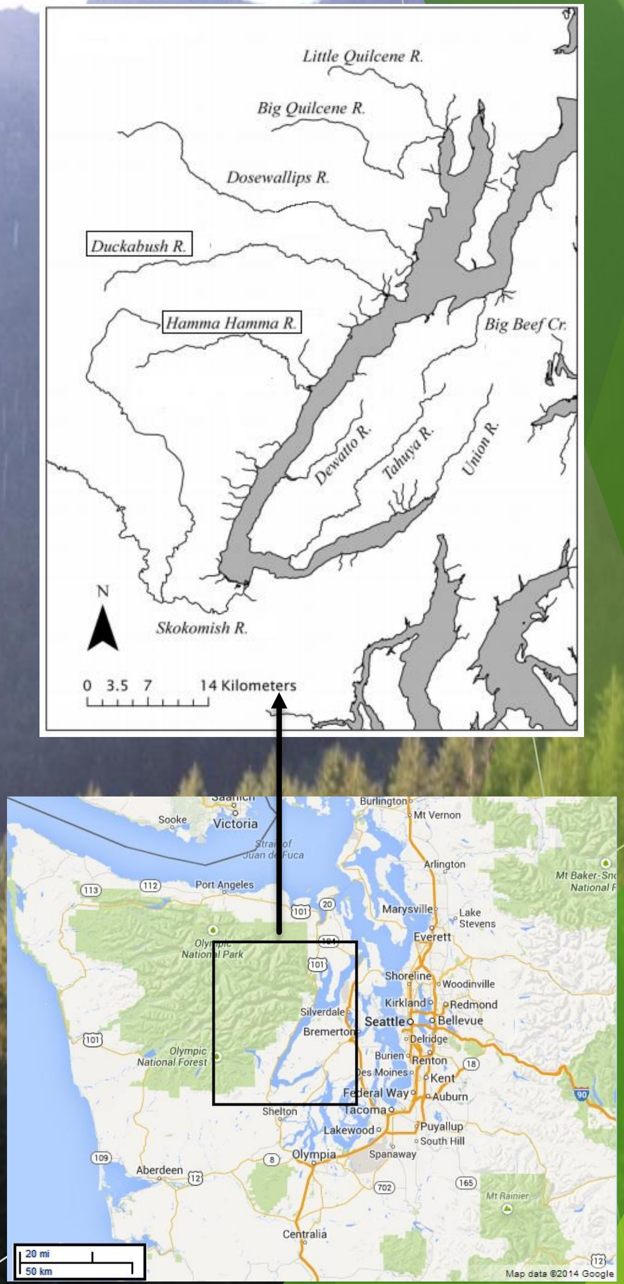
- Coast-wide steelhead populations have declined in abundance over the past century.
- The Puget Sound DPS was listed as threatened in 2007.
  - Prior to the listing Western Hood Canal population segment was at 1.7% of historic abundance.
  - Supplementation program in started in the late 1990's.
- Juvenile steelhead spend 1-3 years in freshwater and this may be a critical period for overall survival of steelhead.
  - Observed annual freshwater survival rates in Hood Canal watersheds low (~6% to 20%).
    - Decline with age in the upper reaches.
    - Improve with age in the lower reaches.



Source: WDFW SCoRE 2017.

Background: Project Locations

- Duckabush River and Hamma Hamma Rivers, drain the eastern slope of the Olympic Mountains.
  - Rain/ Snow dominated
- Land use is minimal in both watersheds, primarily: logging and recreational.
- Both watersheds have barrier waterfalls.
  - Rkm 4.4 Hamma Hamma
  - Rkm 12.6 Duckabush
- Rainbow trout populations above the barriers and mixed rainbow trout and steelhead populations below.
  - Appear to have abundant rainbow trout populations.



Extent of Main Map
Duckabush River
Above Barrier
Upper Reach
Lower Reach
Hamma Hamma River
Above Barrier
Below Barrier
N
Upper Bound
Anadromous Barrier
Partial Barrier
PIT Tag Array and Smolt Trap
Miles
0 0.5 1 2 3 4
0 0.5 1 1.5 2 Kilometers 4 6

Growth Potential of *O. mykiss* in freshwater

- **Objective:** Determine the growth performance for each age class of *O. mykiss* in the Duckabush and Hamma Hamma Rivers.
  - Are abiotic (temperature) or biotic (prey base) factors limiting growth?
- Take a bioenergetics approach to determine if and where annual growth is limited.
- Provides daily estimates of:
  - Energy needs
  - % maximum consumption rate (indicator of food availability)
  - Total biomass of invertebrates consumed

Bioenergetics Modeling Framework

2. Temporal Diet Composition
(Field sampling)

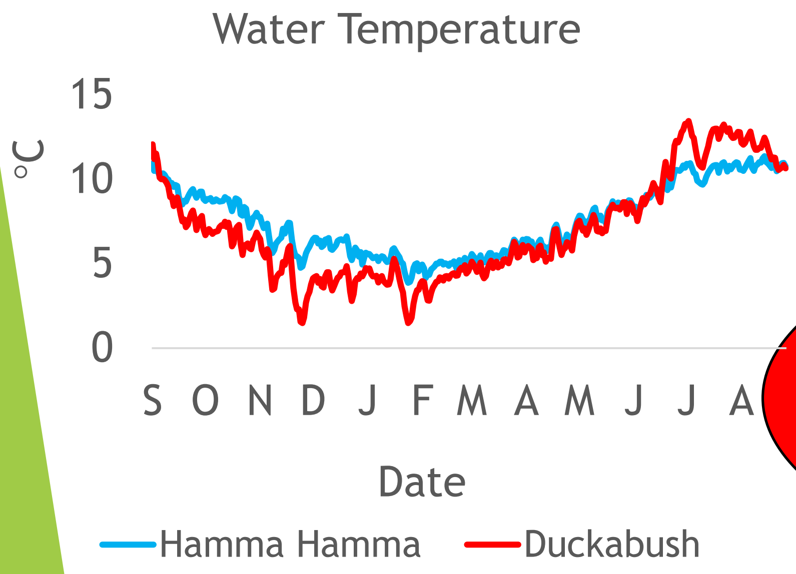
3. Consumer Growth
(Field sampling)

4. Consumer Energy Density
(~5800 J/g)

1. Thermal Experience
(Temperature Loggers)

Bioenergetics Model

5. Prey Energy Density
(Literature Values)

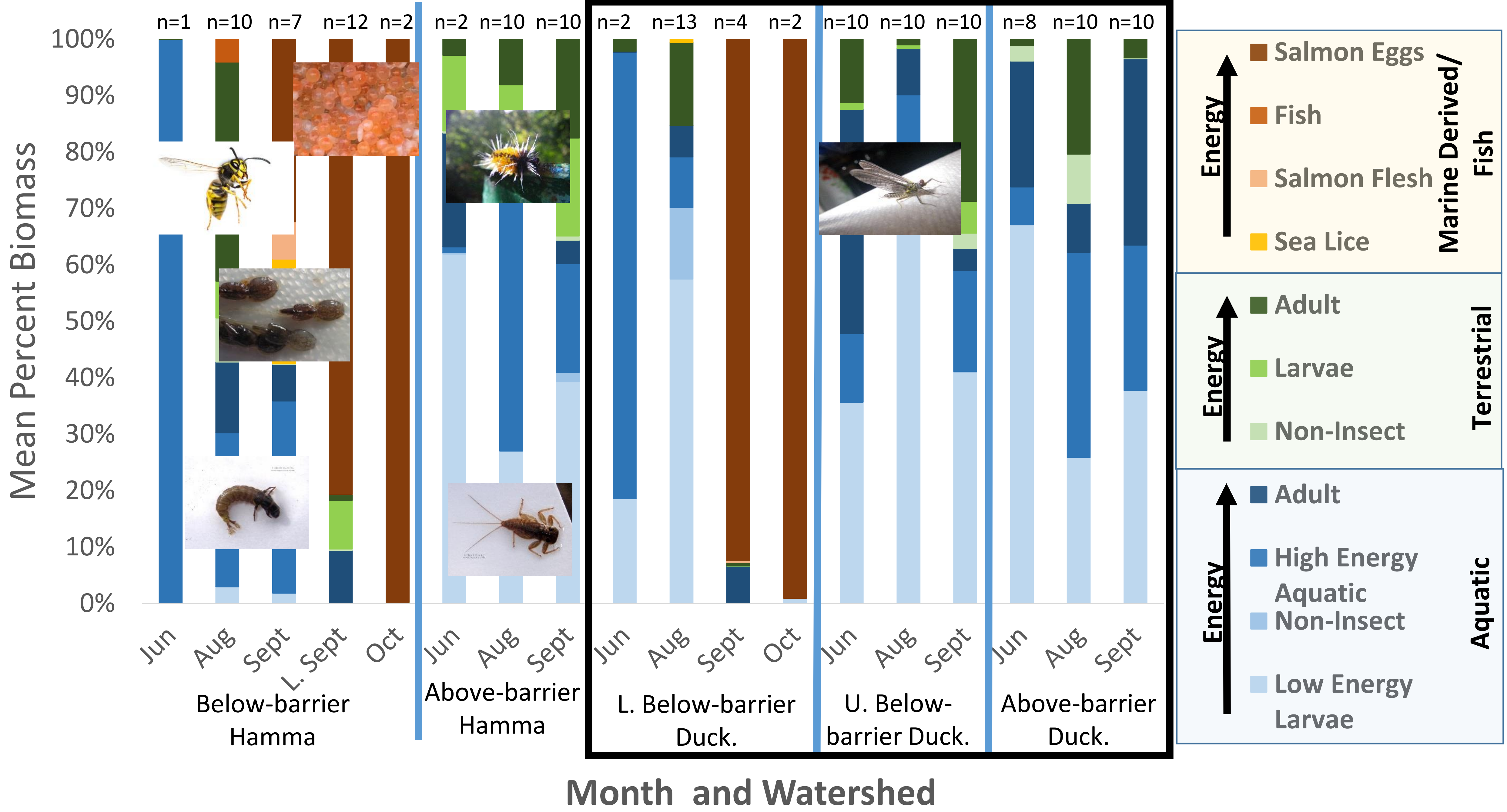


Consumption/Feeding Rate (g) Estimate

2. Diet Composition and Prey Supply - Methods

- Fish diets were collected from a subsample of fish via gastric lavage during the summer/ fall of 2015.
  - June, August, September (all reaches) and October (lower rivers only)
- All diet items are identified to the order level and group by energy content.

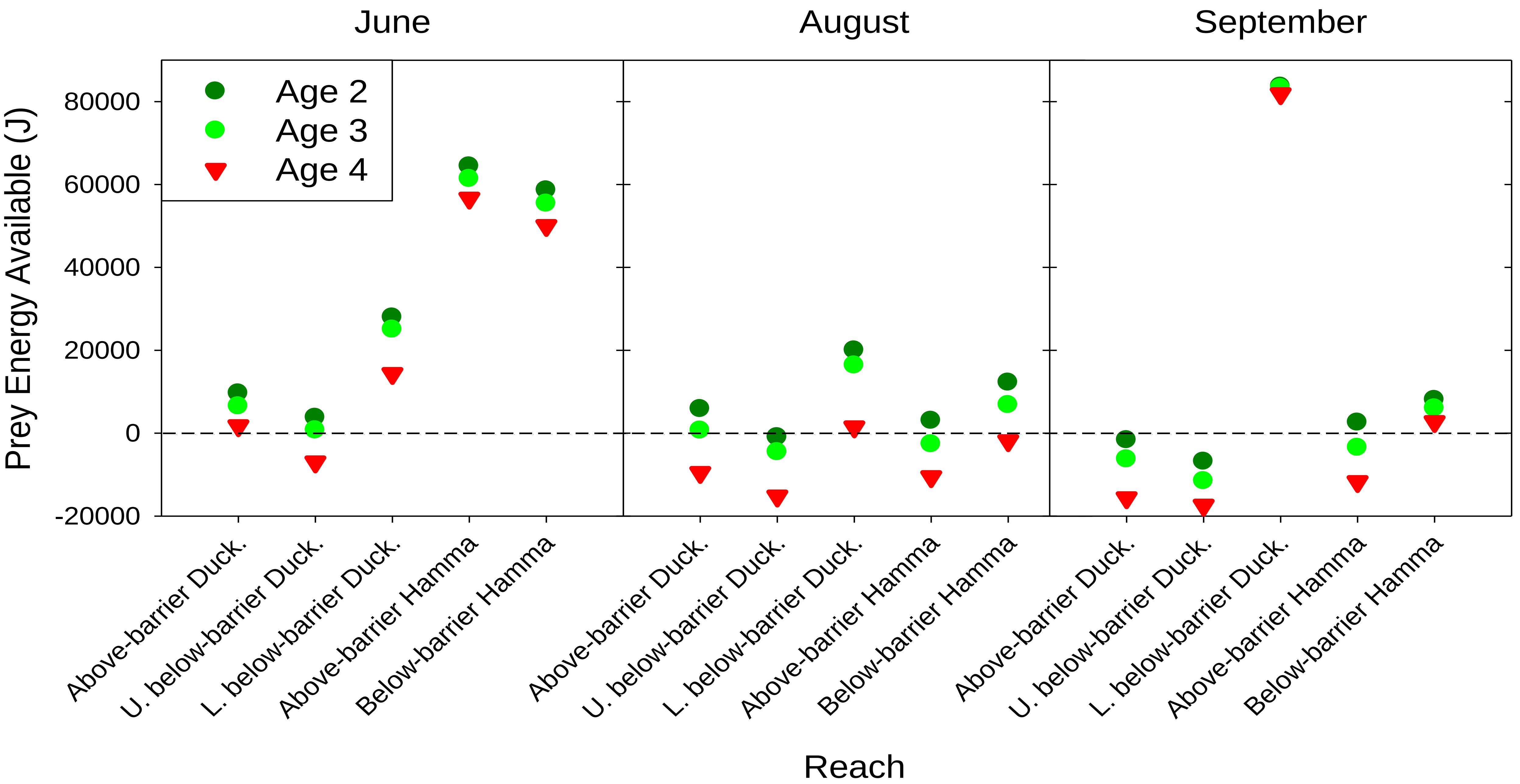
2. Diet Composition



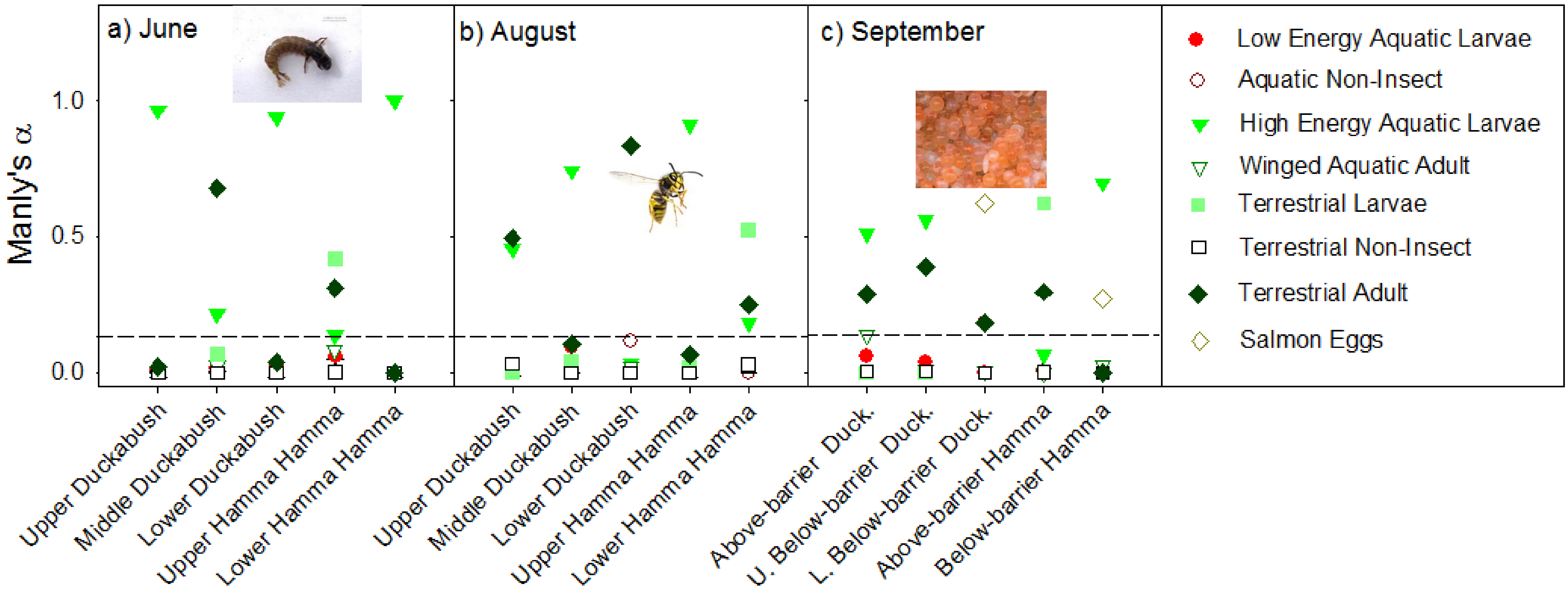
Prey Supply Methods

- The prey supply was analyzed by sampling drift invertebrates.
  - Collected during June, August and September of 2015, in areas that correspond with fish collection sites.
    - Riffle habitat (<0.5 m deep, > 0.3 m/s velocity).
- Daily prey supply was calculated by multiplying drift (g)/hour by the hours of daylight between civil twilight.
  - Converted to prey energy available (J) and compared with the dietary needs to attain the observed growth.
- A selectivity analysis using Manly's α compared prey items in diet with drift sample collections.

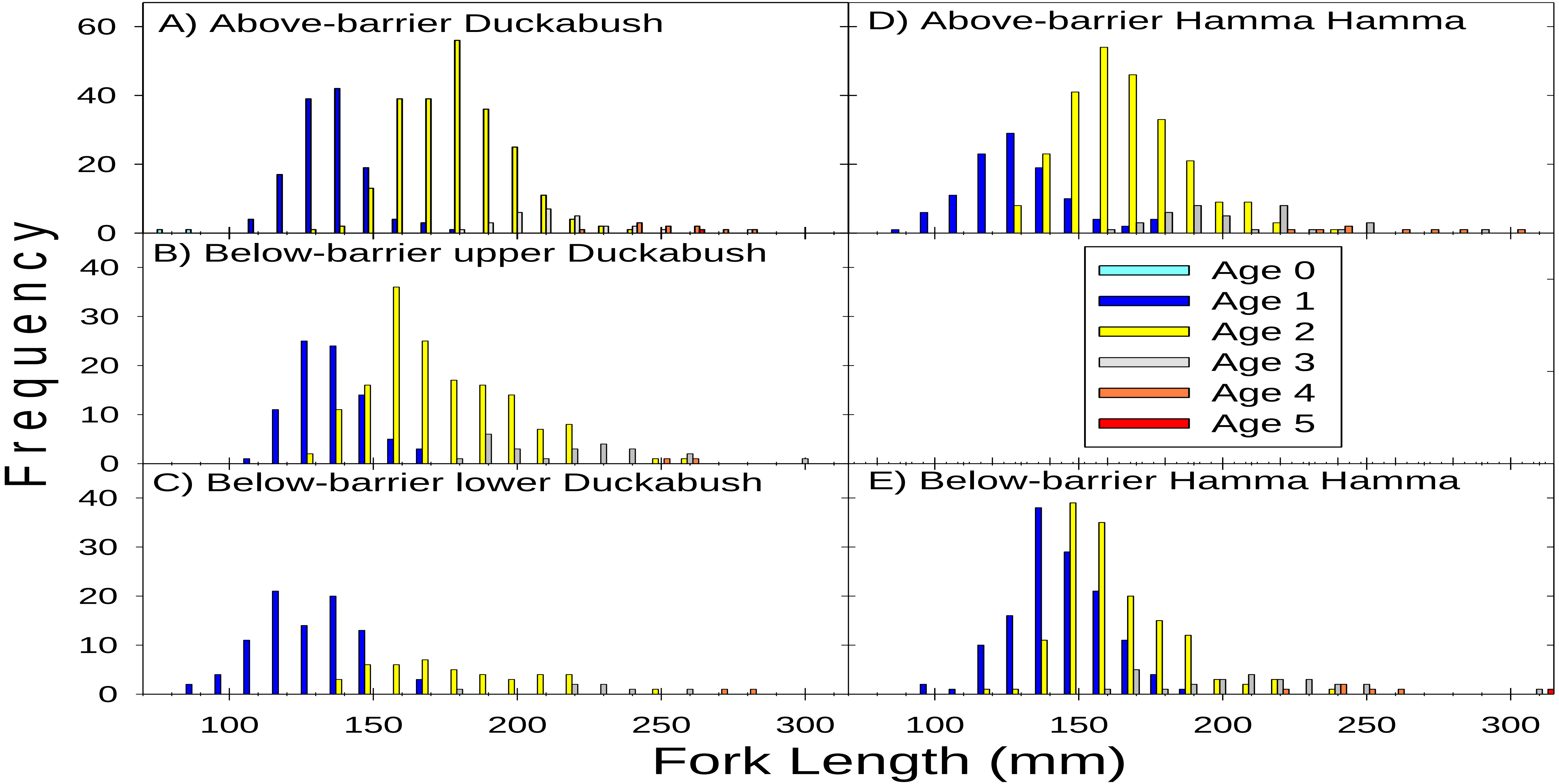
Prey Supply


June
August
September
Age 2
Age 3
Age 4
Prey Energy Available (J)
80000
60000
40000
20000
0
-20000
Above-barrier Duck.
U. below-barrier Duck.
L. below-barrier Duck.
Above-barrier Hamma
Below-barrier Hamma
Reach

Prey Selectivity



3. Growth: 2014 Length Frequencies



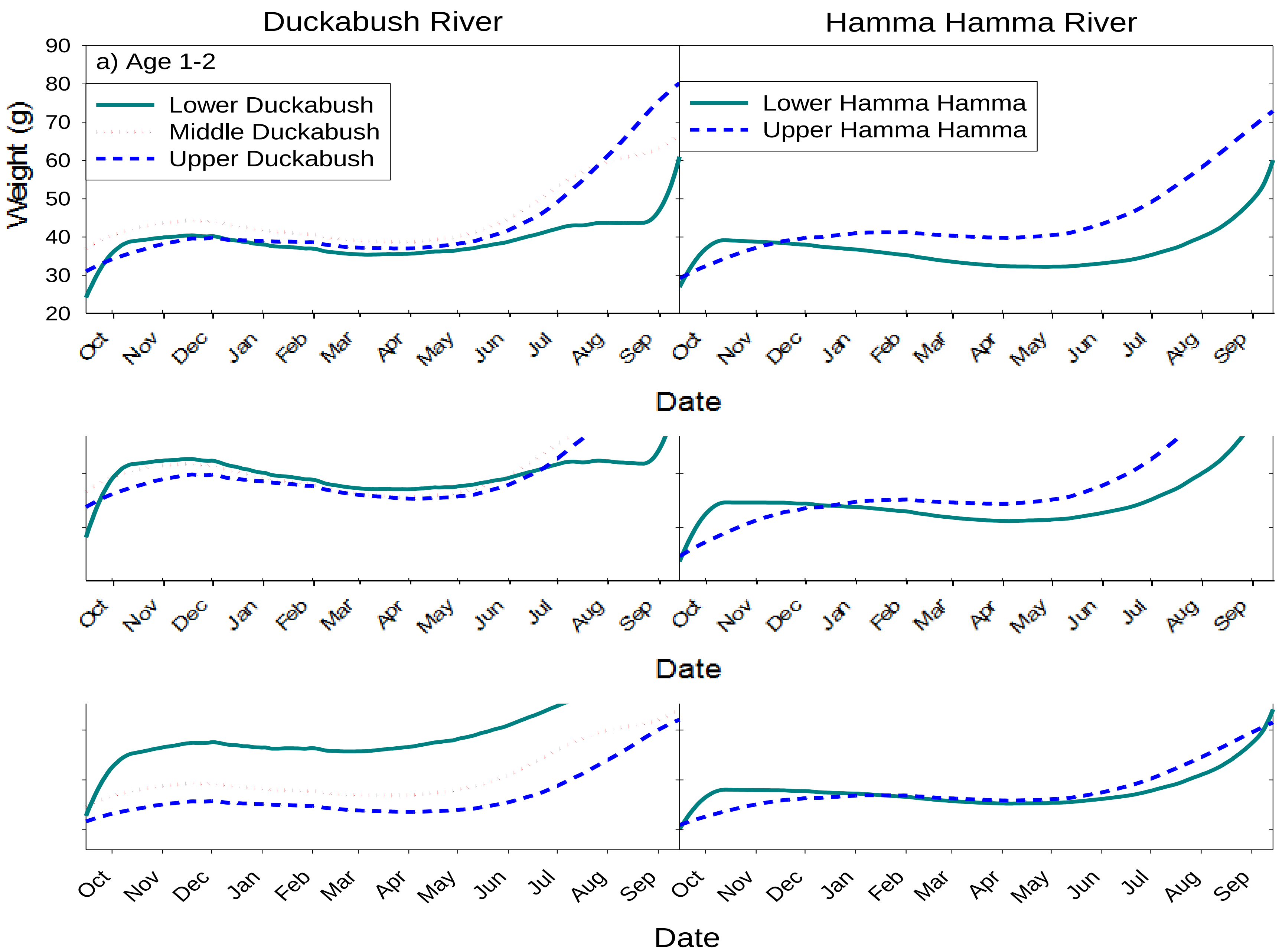
Bioenergetic Model Results

Consumption rate: Annual % Cmax

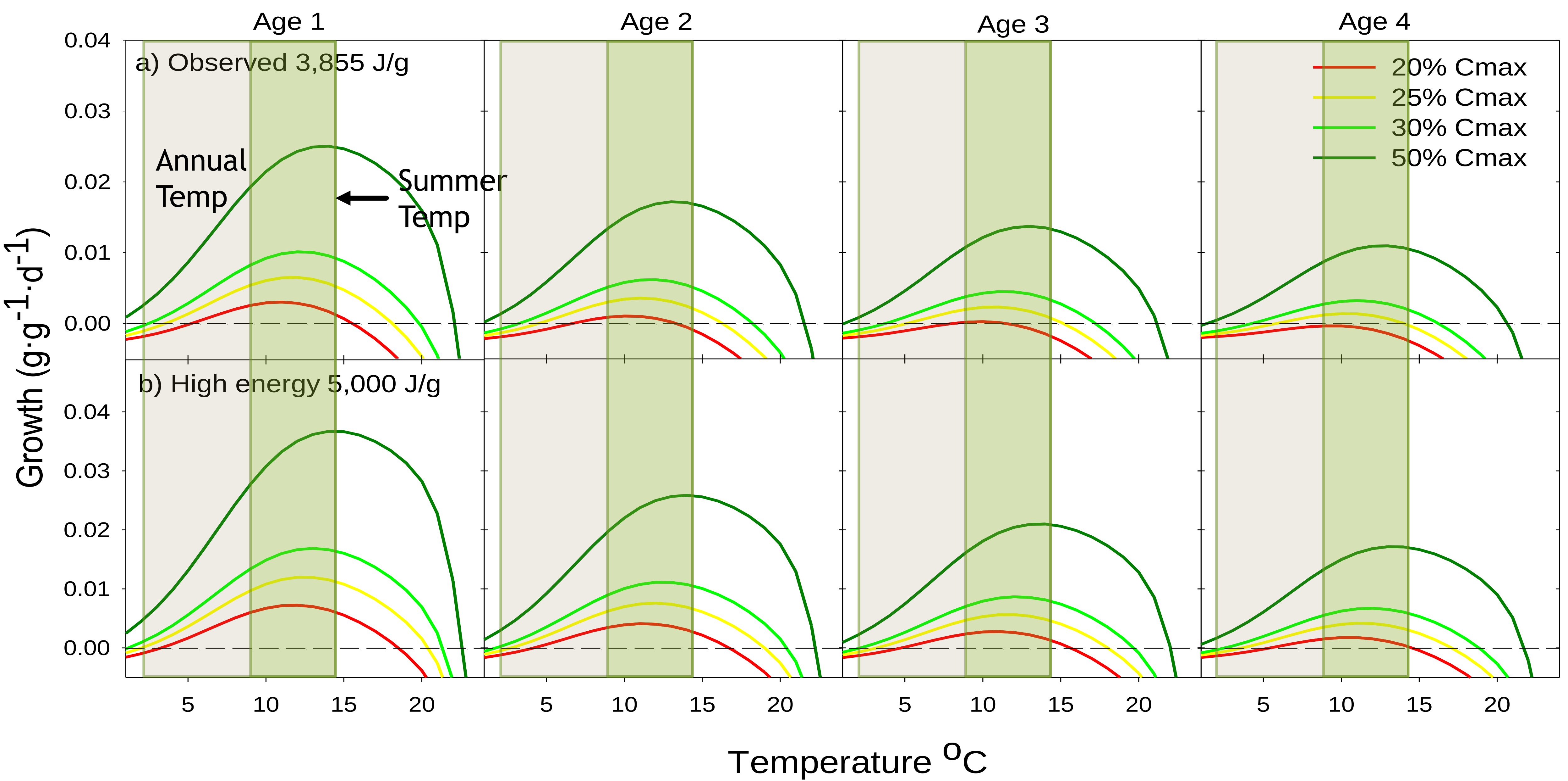
Reach	Age 1 to 2	Age 2 to 3	Age 3-4
Above-barrier Duckabush	28.2	29.1	32.3
Upper below-barrier Duckabush	25.4	26.7	31.7
Lower below-barrier Duckabush	20.1	21.7	28.1
Above-barrier Hamma Hamma	26.6	29.4	31.2
Lower below-barrier Hamma Hamma	19.6	22.5	25.0

(Skagit River Range 20-28%) (Thompson and Beauchamp 2016)

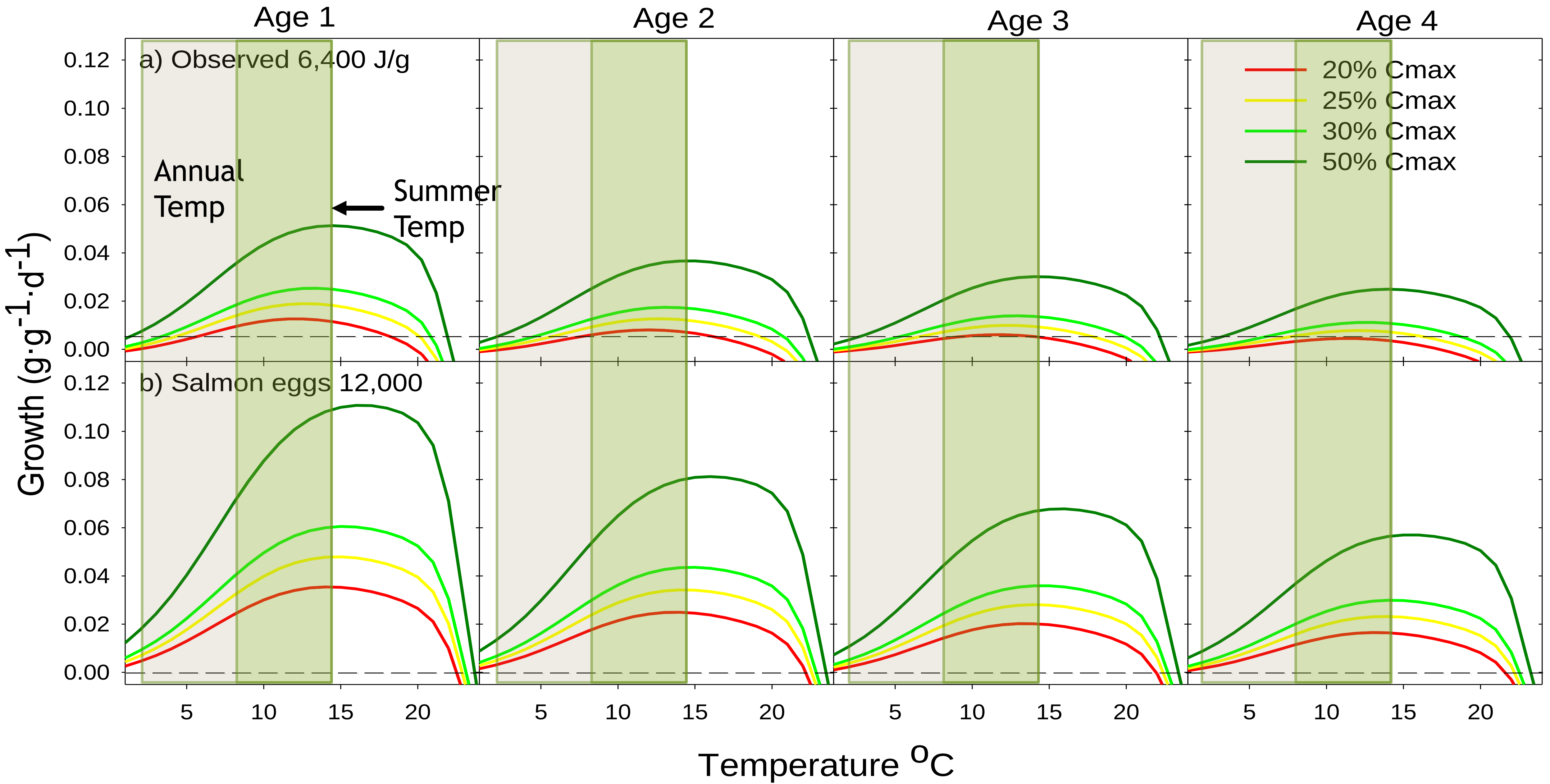
Model Results – Annual Growth



Upper River Growth Sensitivity



Lower River Growth Selectivity



Conclusions

- Overall consumption rates are low indicating growth limitations are occurring.
  - Cold temperatures may limit late-fall to spring growth, but summer temperatures are near optimal.
  - There is very little scope for growth for age-2 and older fish in the upper watersheds.
  - Lower watersheds are less limited than the upper watersheds.
  - Prey quality and quantity appears to have a significant effect on growth, particularly for older fish.
- Growth limitations are likely influencing the low freshwater survival rates observed in the watersheds.
- Delayed smoltification due to poor growth opportunities and high freshwater mortality may be a significant factor limiting these populations.

Questions?