ECOSYSTEM MONITORING PROGRAM

Juvenile Chinook Diet & Macroinvertebrate Prey Availability

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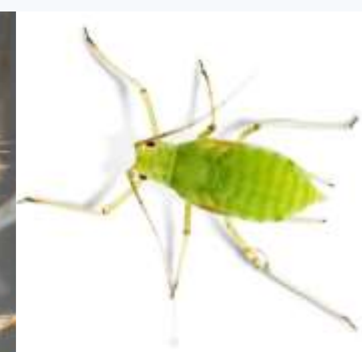
Mary Ramirez
Jeff Cordell

University of Washington




What are juvenile Chinook eating?
Does prey consumption change as fish grow larger?
Does prey consumption change over the out-migration season?
Are fish feeding differently among sites?
What can feeding patterns tell us about the quality of a habitat?

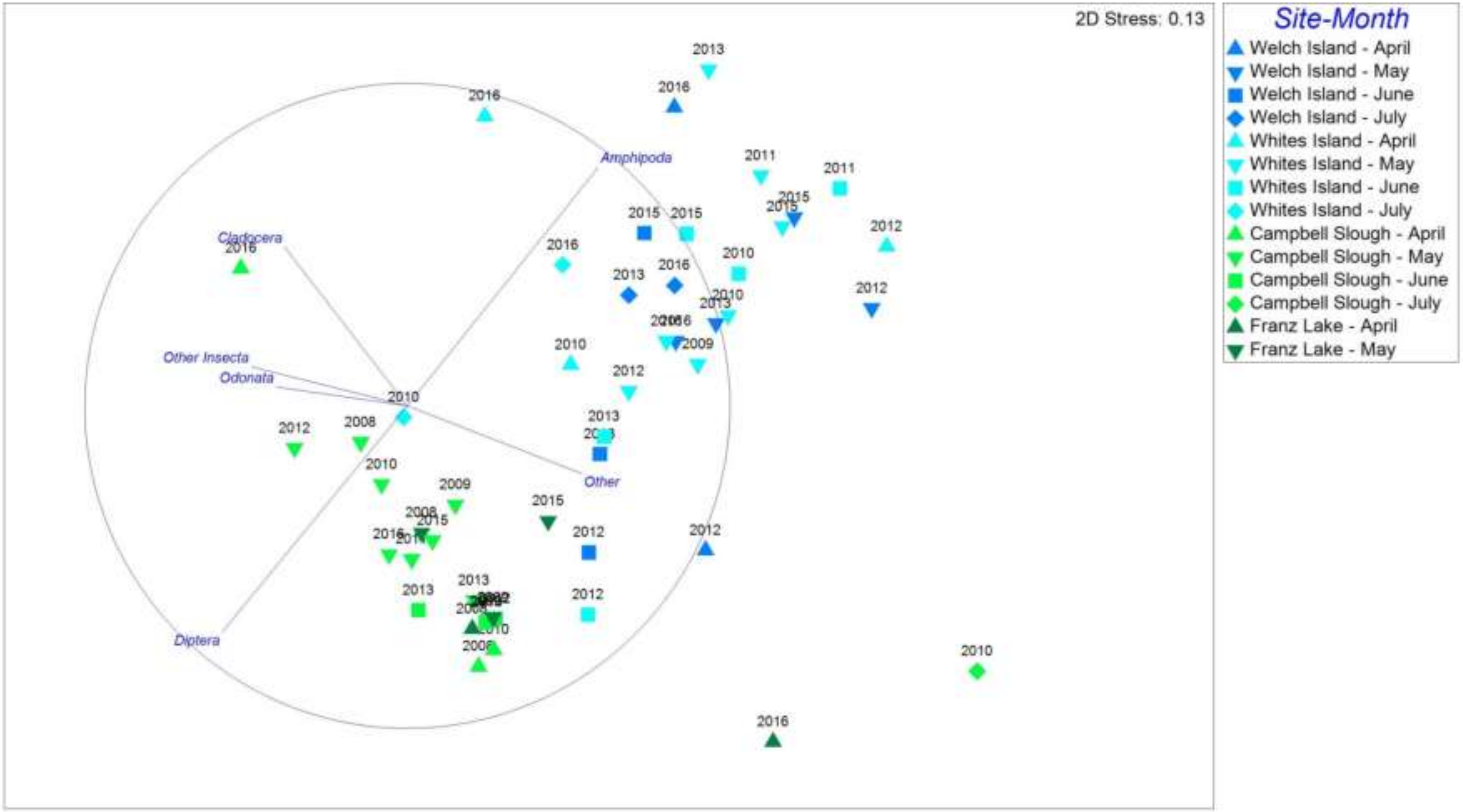
DIET

Index of Relative Importance (IRI)

Combines 3 variables into a composite index: accounts for prey weight and numbers, as well as the likelihood of taxa appearing in the diet of individuals (frequency of occurrence)

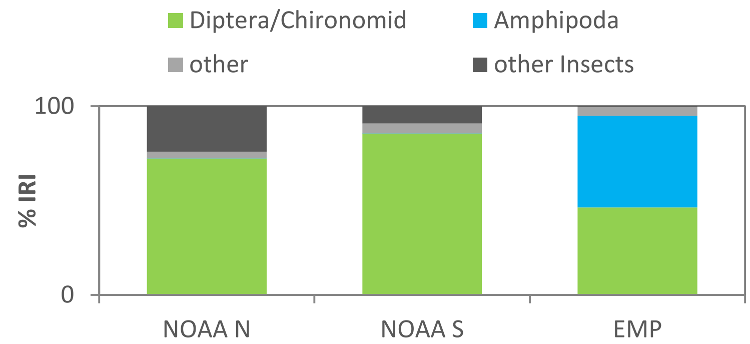
Amphipoda
Diptera
Copepoda
Cladocera
Hemiptera
Other taxa
Other Insecta
fish (# years)
% IRI (Compiled over 2008-2013, 2015-2016)
Welch Island
27 (2)
28 (4)
36 (4)
26 (4)
20 (3)
23 (3)
13 (1)
14 (2)
Whites Island
37 (3)
48 (5)
30 (6)
16 (4)
25 (5)
39 (5)
19 (3)
15 (2)
11 (2)
Campbell Slough
14 (3)
8 (2)
3 (2)
18 (4)
68 (8)
65 (8)
24 (3)
27 (4)
5 (2)
8 (1)
Franz Lake
12 (1)
3 (1)
12 (1)
3 (1)
12 (3)
4 (2)
100
75
50
25
0
30-59
60-79
80-99
April
May
June
July

Are fish feeding differently among sites?



- Two-dimensional NMDS plot based on Bray-Curtis similarities between transformed %IRI of major prey groups in diets sampled between 2008 and 2016.
- Significant difference in prey consumption between upriver and downriver sites (ANOSIM $R=0.416$, $p<0.001$) of the more downriver sites (Welch Island and Whites Island, blue symbols) and the more upriver sites (Campbell Slough and Franz Lake, green symbols).
- The % contribution of Dipterans is greater on average from Campbell Slough and Franz Lake, while Amphipods are strongly associated with Welch Island and Whites Island.

<u>What</u> fish are eating is closely associated with <u>where</u> they are feeding.

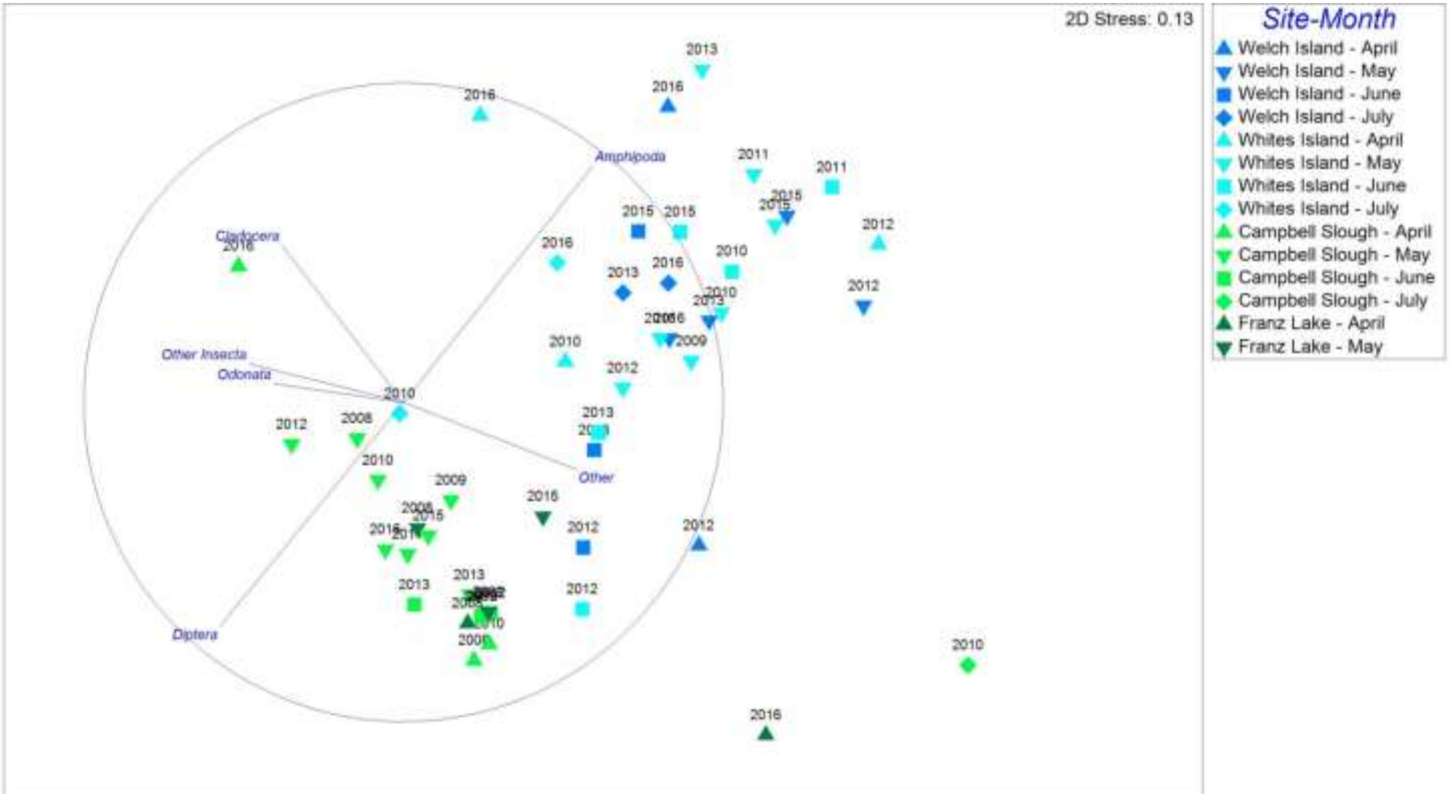


	NOAA N	NOAA S	EMP
n	63	62	160
FL mm	40-90	40-87	32-88
Mean FL	50.86	50.77	61.74

- Many small subyearling Chinook migrants rear in shallow wetland channels (secondary interior channels of emergent marsh islands).
- In general, dipteran insects, and specifically emerging chironomids, dominate the diet of juvenile Chinook, regardless of the shallow-water habitat type they occupy (emergent marsh, scrub-shrub, and forested wetlands).
- Amphipods rarely occurred in benthic samples from shallow interior channels, but dense colonies were observed in the larger adjacent tidal channels.

Bottom et al. 2011. Estuarine Habitat and Juvenile Salmon: Current and Historical Linkages in the Lower Columbia River and Estuary

Are fish feeding differently among sites?

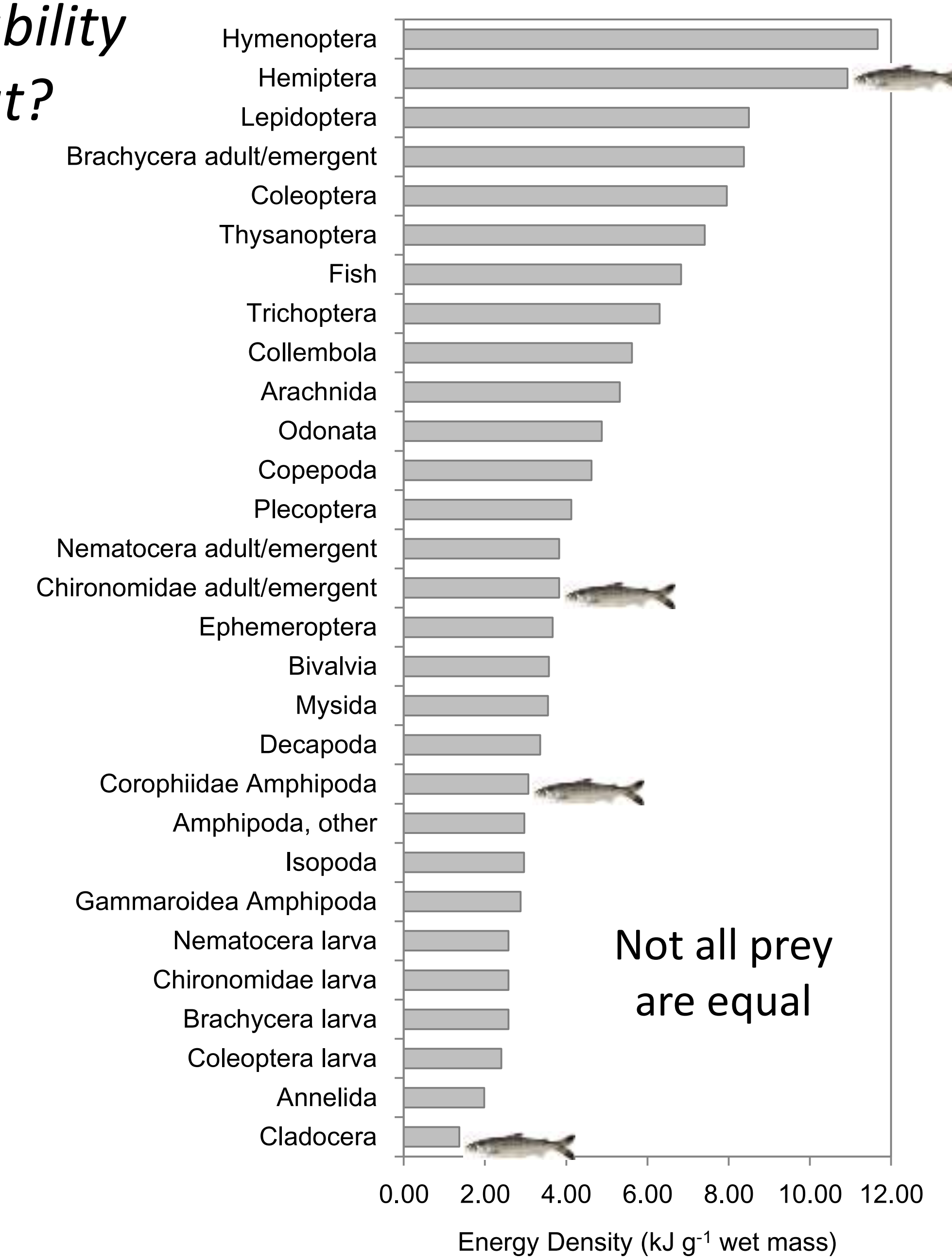


Yes. A shift from diets dominated by dipterans and other insects at Campbell Slough and Franz Lake to primarily amphipods and dipterans at Welch and Whites Island has been consistently shown over study years.

However, it is likely that there is much more behind this than simply position in the estuarine gradient…

- Sediment grain size
- Organic content
- Water depth
- Channel morhpology

What can prey selection and availability tell us about the quality of a habitat?



Energy densities were acquired from the literature and compiled in David et al. (2016)

What can prey selection and availability tell us about the quality of a habitat?

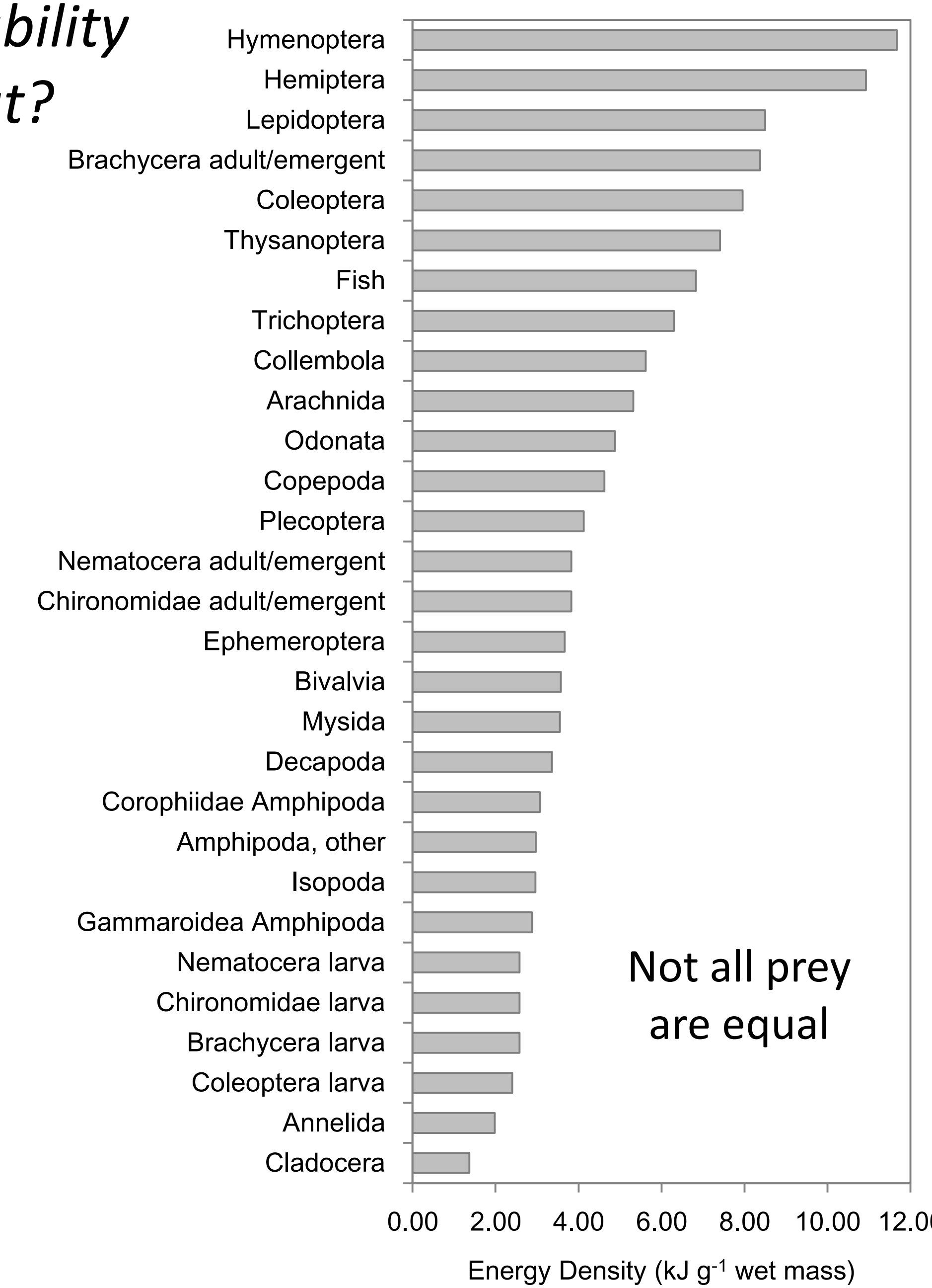
Energy Ration

Energy ration (ER), was calculated as a measure of energy consumption for each juvenile Chinook salmon and is driven by prey availability and quality.

$$ER = \frac{\sum w_i \cdot k_i}{W}$$

w = prey mass consumed of prey taxa *i*
k = energy density (kJ g^{-1} wet mass) of prey taxa *i*
W = total fish mass (g)

Thus, Energy Ration equals kilojoules consumed per gram of fish.



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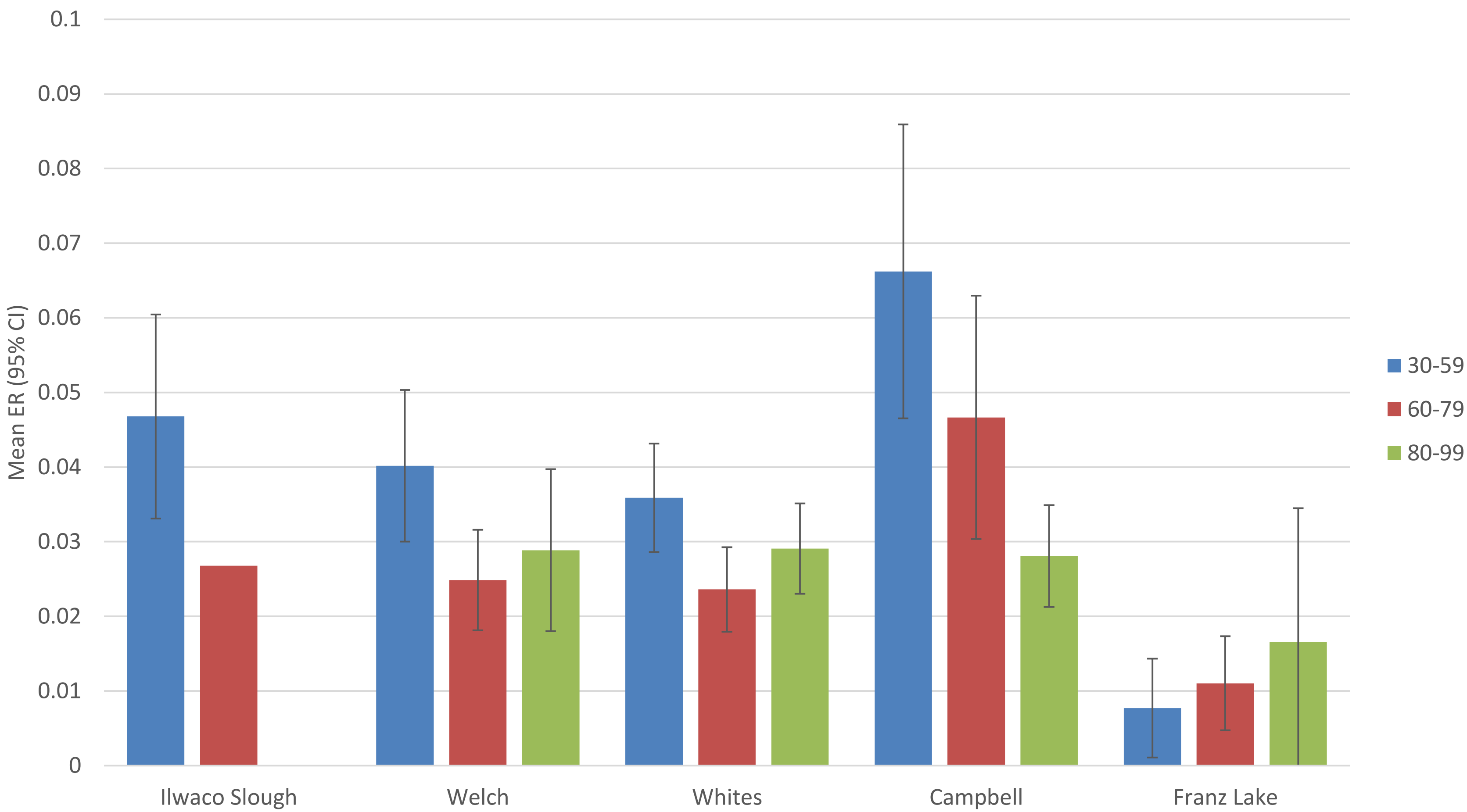
Energy Ration

*by **site, size class***

compiled over 2008-2013, 2015-2016; April, May, June

reflects both fullness and energy consumed



Maintenance Metabolism

Fiechter et al. (2015) included maintenance metabolism as part of a bioenergetics model to identify the effects of environmental conditions on juvenile Chinook growth and condition in central California.

Maintenance metabolism (J_M) represents the cost of metabolic upkeep and varies with temperature and body mass, such that:

$$J_M = j_m \cdot e^{dT} \cdot W$$

j_m = mass specific maintenance cost at 0° C = 0.003 (Fiechter et al. 2015)
d = temperature coefficient for biomass assimilation = 0.068 (Stuart and Ibarra, 1991)
T = temperature at time of capture
W = fish body mass.

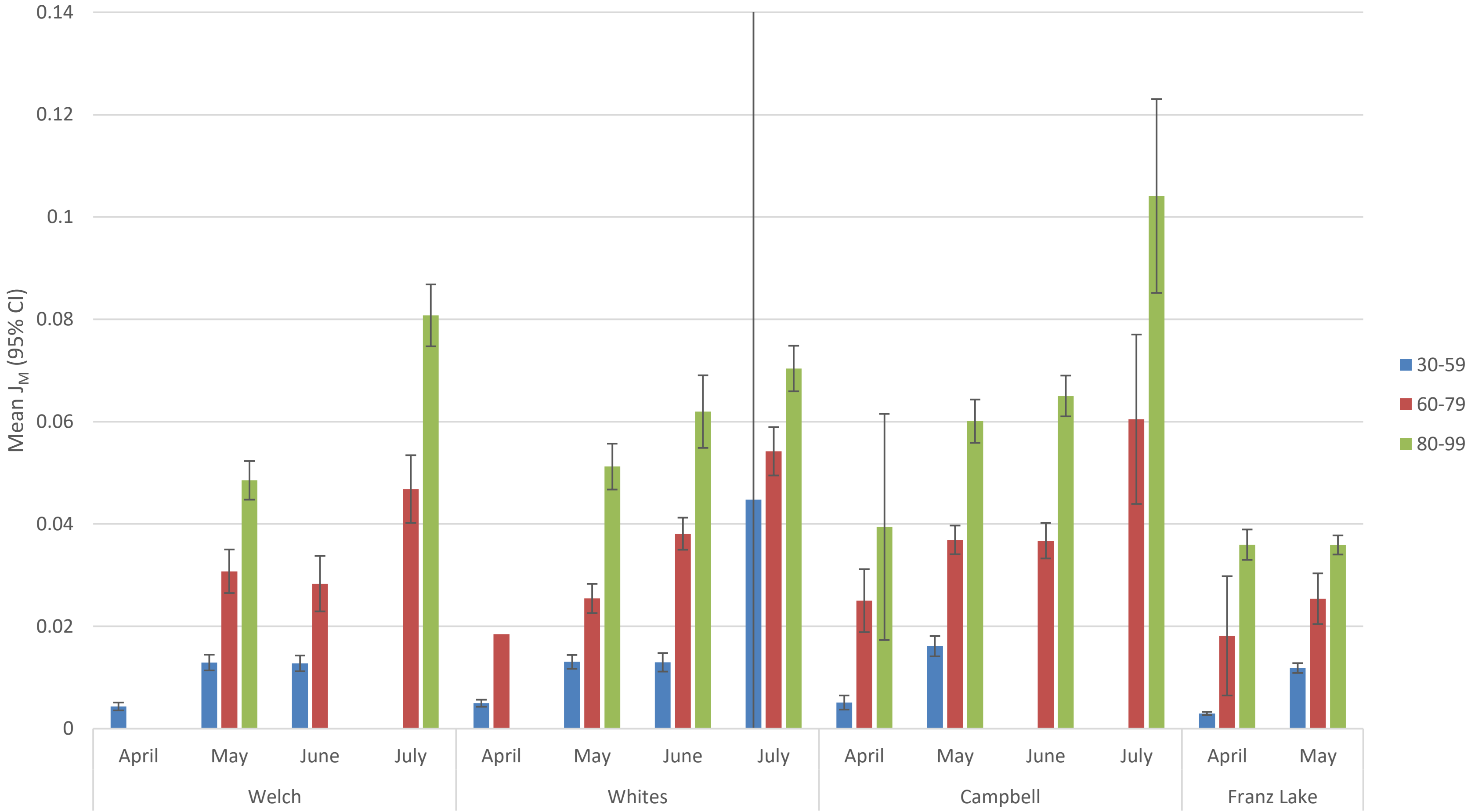
Maintenance metabolism increases with higher temperatures and with fish size such that larger fish in warmer temperatures would have higher metabolic needs

Fiechter, J., D.D. Huff, B.T. Martin, D.W. Jackson, C.A. Edwards, K.A. Rose, E.N. Curchitser, K.S. Hedstrom, S.T. Lindley, and B.K. Wells. 2015.Environmental conditions impacting juvenile Chinook salmon growth off central California: An ecosystem model analysis. Geophysical Research Letters.

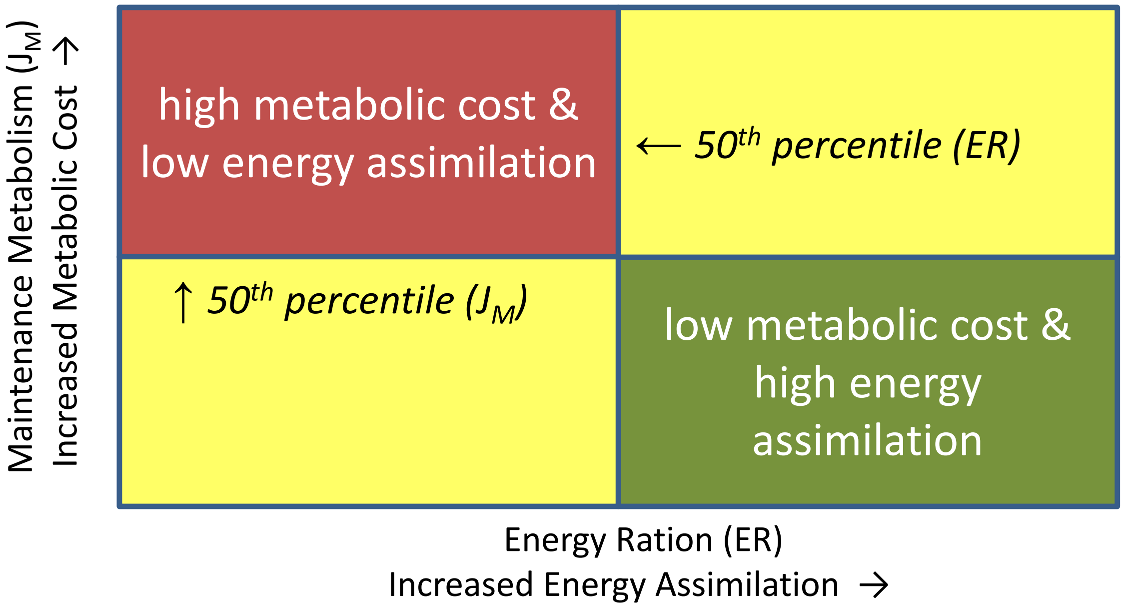
Maintenance Metabolism

by site, month, size class,

compiled over 2008-2013, 2015-2016



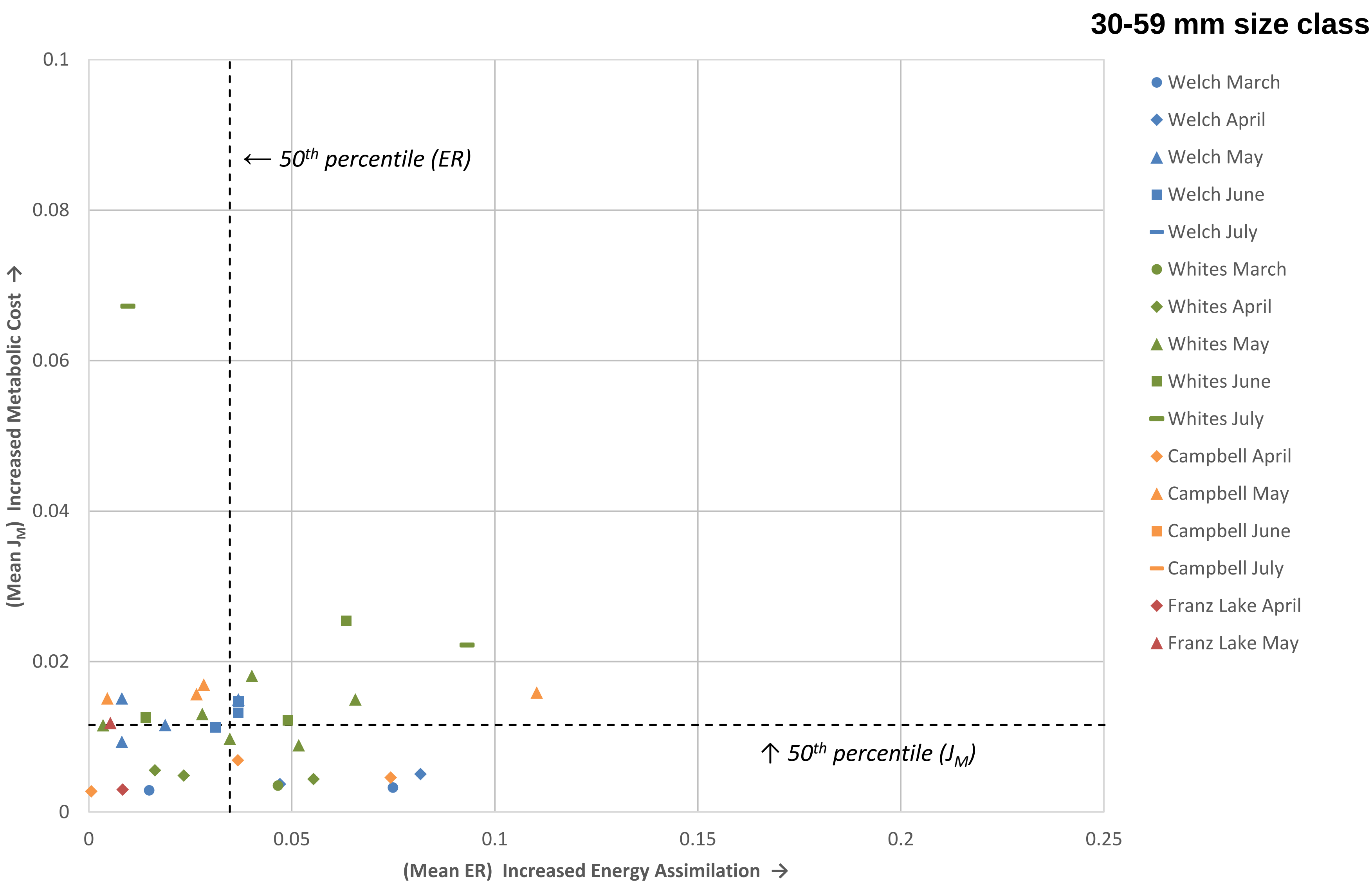
For juvenile Chinook salmon, low metabolic cost and high energy assimilation represent relatively positive growing conditions (lower right quadrant), while high metabolic cost and low energy assimilation represent relatively poor growing conditions (upper left quadrant).



- Evaluate where/when salmon experience relatively good or poor growing conditions.
- Compare habitat quality across different time scales.
  - How do the conditions at a site change over the juvenile Chinook out-migration season?
  - How do the conditions at a site change over years or decades that experience large scale differences in climate?
- Compare habitat quality among different sites.
  - For example, salmon sampled from a new restoration site could be plotted along the long term averages from the trend sites to provide an evaluation of the new habitat relative to other areas in the estuary. As well as tracking the progress of a restored site over years or decades.

Maintenance Metabolism & Energy Ration

- *Each point represents the average of fish collected at a site, month, year, within length size class*



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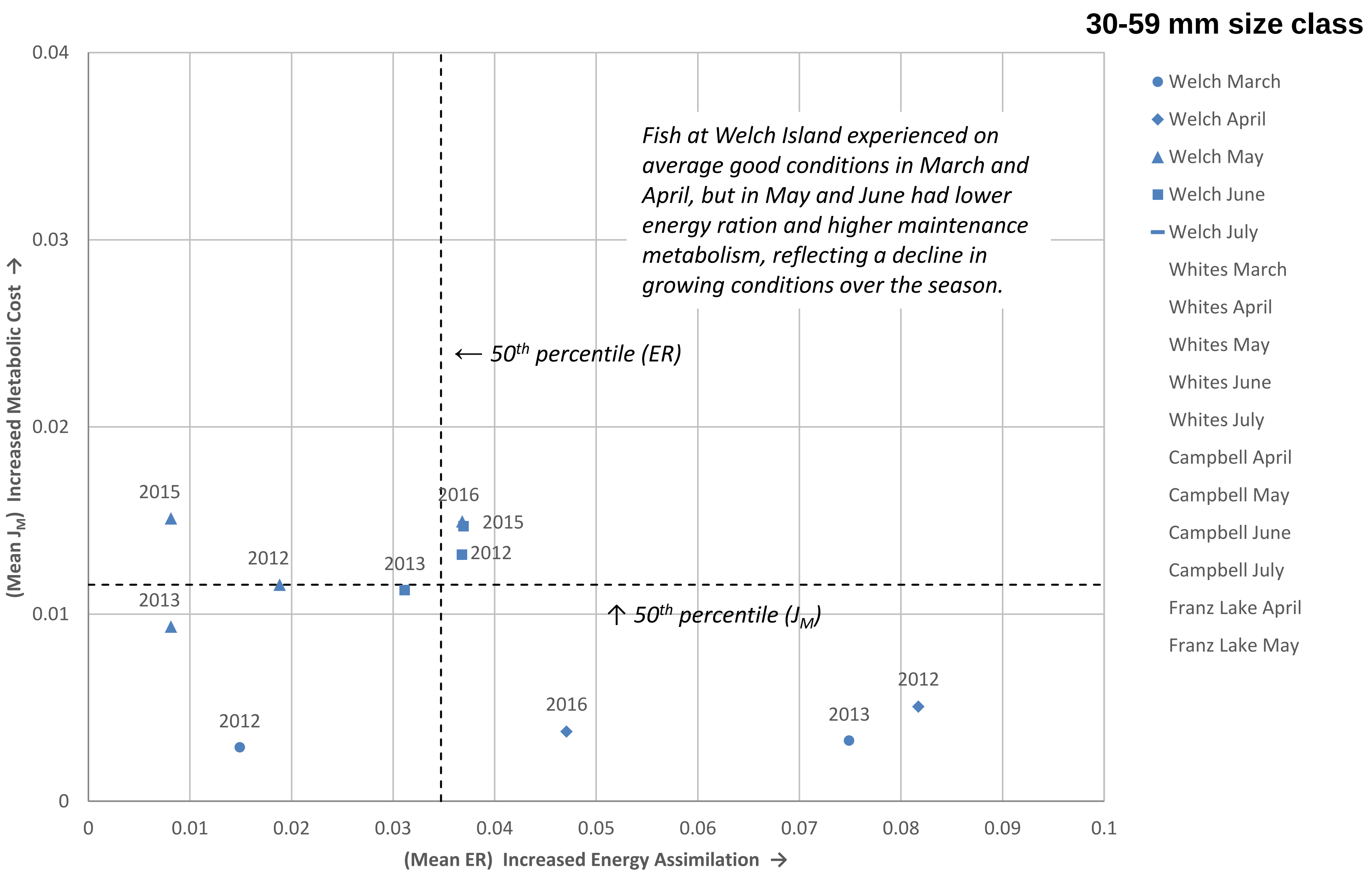

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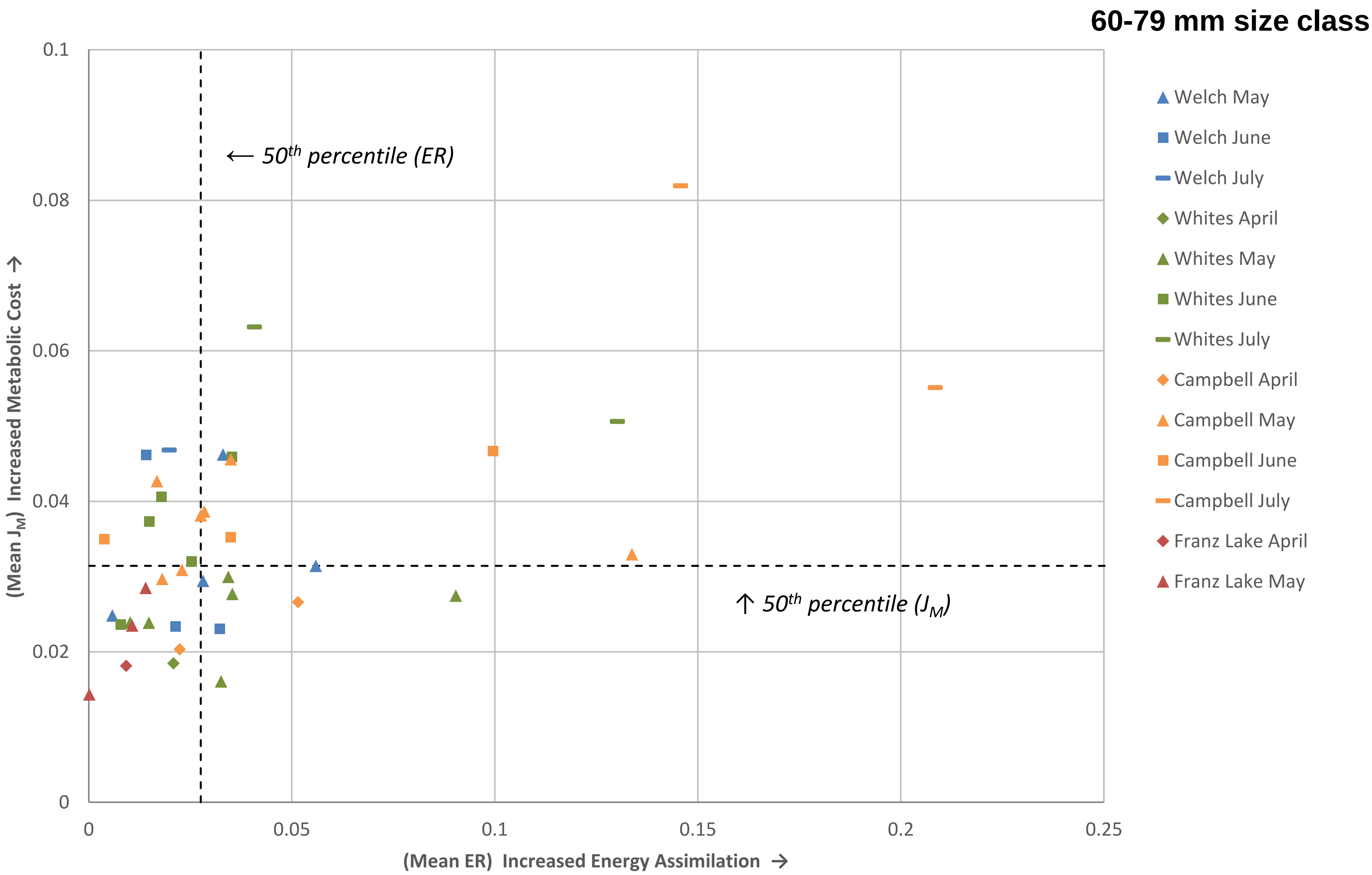
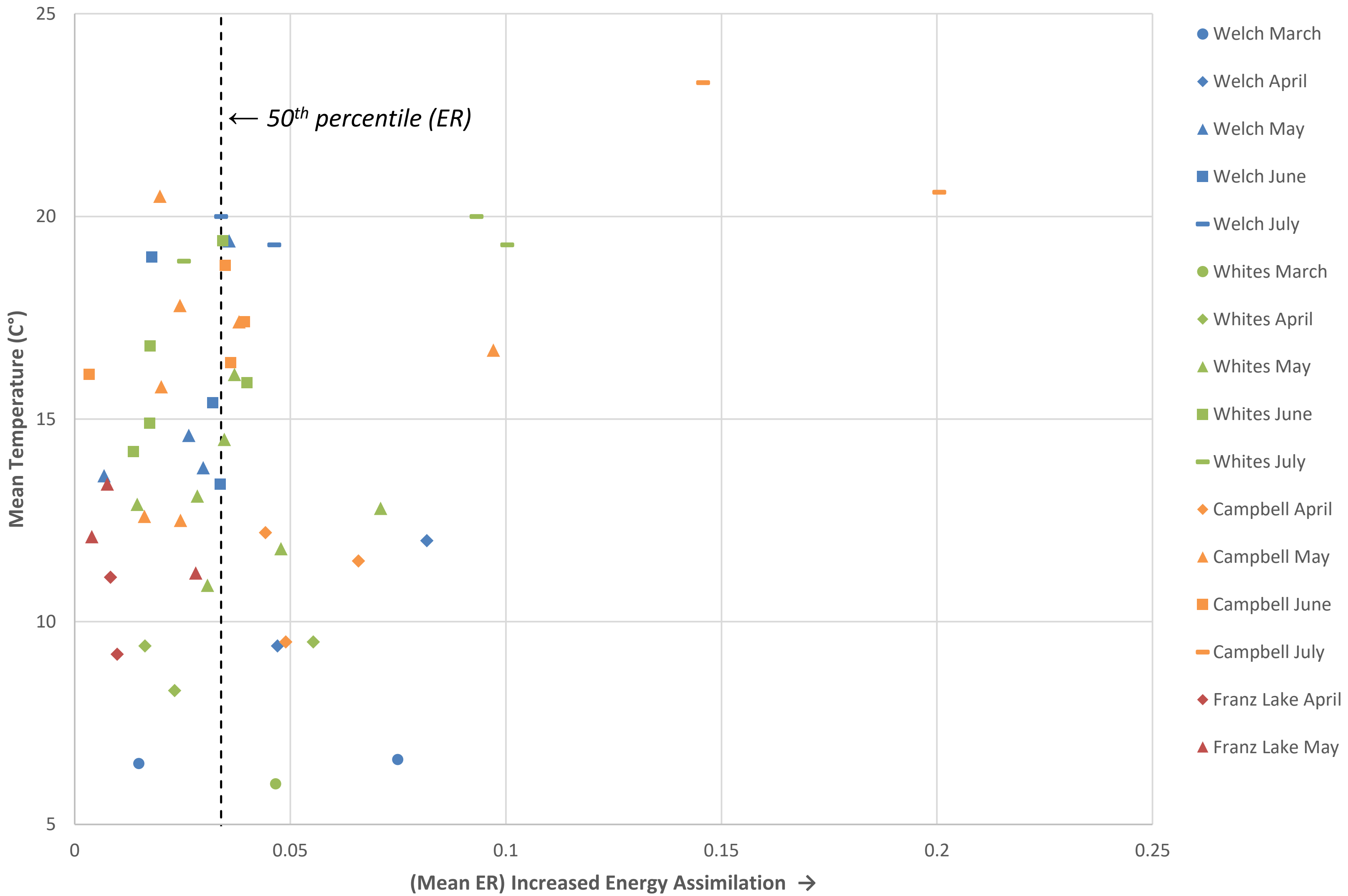


- *Is temperature a better parameter to use in conjunction with Energy Ration?*

Temperature & Energy Ration

- *Each point represents the average of fish collected at a site, month, year*



Temperature & Energy Ration

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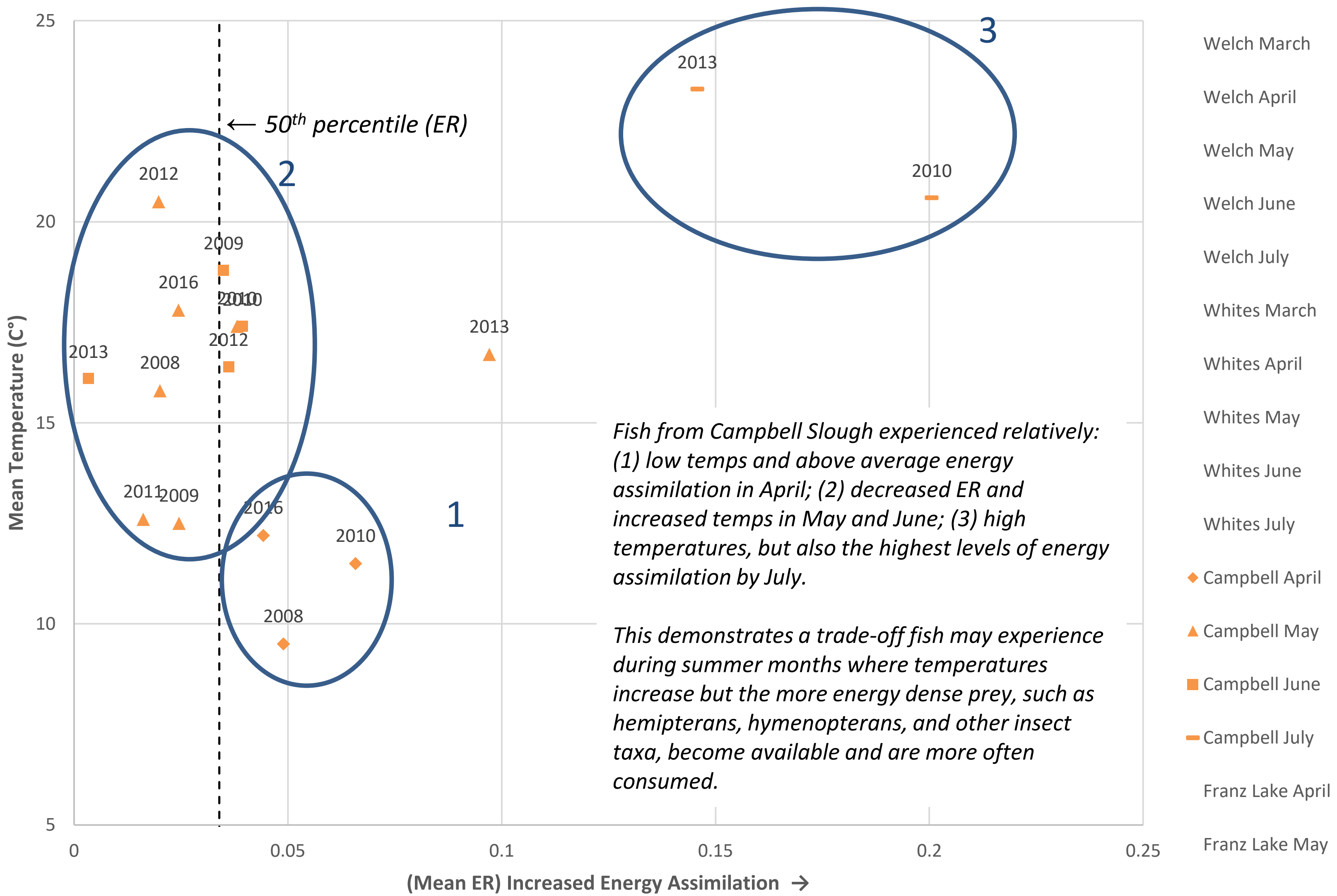

Fish from Campbell Slough experienced relatively: (1) low temps and above average energy assimilation in April; (2) decreased ER and increased temps in May and June; (3) high temperatures, but also the highest levels of energy assimilation by July.

This demonstrates a trade-off fish may experience during summer months where temperatures increase but the more energy dense prey, such as hemipterans, hymenopterans, and other insect taxa, become available and are more often consumed.

Next Steps

- Process 2017 samples (benthic, neuston, diet)
- Compare availability of diptera and amphipods among sites
- Compare IRI and Energy Ration among sites, to past years
- Explore further the quadrant charts of habitat quality and the use of Maintenance Metabolism as a model term