Linking growth and diet in Strait of Georgia juvenile coho salmon

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There is regional variation of IGF1 (growth) within Strait of Georgia juvenile coho in 2014

Mean IGF-1 = 66.8 ng/mL
StDev = ± 20.57
n = 538
Primary Components of Individual Growth

1. Temperature
2. Food Consumption
Primary Components of Individual Growth

We can assume that growth is some function of temperature, food quantity, and food quality such that:

\[ \text{Food} \times \text{Temp} \times \text{Quantity} \times \text{Quality} = \text{Growth} \]
Is there a link between Food Quality (Primary Diet Category) and Growth (IGF-1)?

Food Quality $= \text{Growth}$

Food: Temp $\times$ Quantity $\times$

Influencing Factors

Response Variable

Primary Diet Category

Influencing factor

IGF-1

Response variable
Measuring individual recent growth with insulin-like growth factor-1

What is IGF-1?
- Hormone released from the liver following food consumption
- IGF-1 travels to the tissue and stimulates body growth
Primary Diet Category: Diet component comprising at least 60% of overall stomach contents

1. Crab megalops/Crab zoea
2. Hyperiid
3. Euphasiid
4. Herring
5. Larval/Juvenile Fish (ex, Sandlance, larval flatfish, fish remains)
6. Shrimp
7. Mixed (No leading primary component, ie 50% crab 50% hyperiid)
8. Other (Low n, ie insect, gammarid, mysiiid)
9. Empty

*Raw diet contents analyzed and provided by Chrys Neville and Carol Cooper (DFO)*
It might look familiar, but this is not “diet” as you are probably used to seeing it reported

<table>
<thead>
<tr>
<th>Nutritional/feeding ecology:</th>
<th>VS</th>
<th>Nutritional physiology:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community based</td>
<td></td>
<td>Individual based</td>
</tr>
</tbody>
</table>

**WHAT**, **WHERE**, and **HOW MUCH** of “it” are juvenile salmon eating?

*If you are interested in the nutritional ecology of juvenile salmon in the Strait of Georgia, stay tuned for Chrys Neville’s talk during the meeting... She is more qualified to address this.*

Is there a physiological **RESPONSE** associated with **WHAT** and **WHERE** juvenile salmon are eating “it”?
It might look familiar, but this is not “diet” as you are probably used to seeing it reported.

**Nutritional physiology:**

<table>
<thead>
<tr>
<th>WHAT</th>
<th>Primary Diet Category</th>
<th>WHERE</th>
<th>RESPONSE</th>
</tr>
</thead>
</table>
| Individual based   | IGF-1                 | Strait of Georgia | Is there a physiological RESPONSE associated with WHAT and WHERE juvenile salmon are eating “it”?

It might look familiar, but this is not “diet” as you are probably used to seeing it reported.
Plasma samples (NWFSC) and % diet composition (DFO) collected during June/July Strait of Georgia survey on W.E. Ricker 2012-2015
Due to differences in sample size between years, four consistent regions across all years were selected for full analysis.
Is there inter- or intra- annual variation in IGF-1?

In order to determine if IGF-1 (growth) is influenced by Primary Diet Category (food quality), we first must observe differences in IGF-1 within the sampling regions in at least one of the sampling years.
Growth varies between regions and years in juvenile coho

Regions (N to S): Disc(D); NSOG(N); SOG(S); SSOG(SS)
Comparisons of both years with and without annual variance

Regions (N to S): Disc(D); NSOG(N); SOG(S); SSOG(SS)
Primary Diet Category → IGF-1

Influencing factor

Response variable
Primary Diet Category also varies between regions and years

% of individuals in Primary Diet Category

Regions (N to S): Disc(D); NSOG(N); SOG(S); SSOG(SS)
“Empty”, “Other”, and “Mixed” categories are difficult to interpret.
“Shrimp” and “Euphasiid” categories were not abundant

Regions (N to S): Disc(D); NSOG(N); SOG(S); SSOG(SS)
"Crab", "Hyp", "Herring", and "Fish" categories were common across years and regions.
**Remember the goal is to test:**

Is there a physiological **RESPONSE** associated with **WHAT** and **WHERE** juvenile salmon are eating “it”? Not to accurately qualify percent of diet composition.

<table>
<thead>
<tr>
<th>Total number of juvenile coho (2012-2015)</th>
<th>IGF-1 and Diet for all regions in the Strait of Georgia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>865</strong></td>
<td></td>
</tr>
<tr>
<td><strong>610</strong></td>
<td>IGF-1 and Diet in four regions represented in all years</td>
</tr>
<tr>
<td><strong>436</strong></td>
<td>Primary Diet Category classified as Crab, Hyp, Herring, and Fish</td>
</tr>
</tbody>
</table>
Similar pattern of Primary Diet Category found in 2012 and 2014
Average IGF-1 varies with Primary Diet Category

Mean IGF-1 (ng/mL) vs. Primary Diet Category

2012

Disc  | NSOG  | SOG   | SSOG  |
80    | 90    | 70    | 80    |
90    | 100   | 80    | 90    |
100   | 110   | 90    | 100   |

2014

Disc  | NSOG  | SOG   | SSOG  |
60    | 70    | 50    | 60    |
70    | 80    | 60    | 70    |
80    | 90    | 70    | 80    |

n > 2 only
IGF-1 is higher in Herring Diet Category fish

Mean IGF-1 (ng/mL)

2012

Disc | NSOG | SOG | SSOG

2014

Disc | NSOG | SOG | SSOG

n > 2 only
IGF-1 is lower in Hyperiid Diet Category fish

Mean IGF-1 (ng/mL)

2012

- Disc
- NSOG
- SOG
- SSOG

2014

- Disc
- NSOG
- SOG
- SSOG

n > 2 only
Similar distributions of Primary Diet Category found in 2013 and 2015

Regions (N to S): Disc(D); NSOG(N); SOG(S); SSOG(SS)
Average IGF-1 varies with Primary Diet Category

- Crab
- Hyp
- Herring
- Fish

**Mean IGF-1 (ng/mL)**

<table>
<thead>
<tr>
<th></th>
<th>Disc</th>
<th>NSOG</th>
<th>SOG</th>
<th>SSOG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2013</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2015</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n > 2 only
IGF-1 is lower in Hyperiidi Diet Category fish

Mean IGF-1 (ng/mL)

2013

Disc | NSOG | SOG | SSOG

2015

Disc | NSOG | SOG | SSOG

n > 2 only
IGF-1 concentration does vary (within region) with Primary Diet Category

When present (2012 and 2014): **HIGHER** IGF-1 in **Herring** Diet Category individuals.


Do regional differences in Primary Diet Category correlate to overall regional IGF-1 concentration?
Does regional Primary Diet Category proportion correlate with regional growth?

Regions (N to S): Disc(D); NSOG(N); SOG(S); SSOG(SS)
Positive relationship between Percent Regional Primary Diet Category and IGF-1 in Herring and Fish

Herring

Fish

\[ R^2 = 0.41 \]
\[ p = 0.04 \]

\[ R^2 = 0.22 \]
\[ p = 0.10 \]
Negative relationship between Percent Regional Primary Diet Category and IGF-1 in Hyperiid

Nega.ve rela.onship between Percent Regional Primary Diet Category and IGF-1 in Hyperiid

Cmeg/CZ

Hyperiid

R² = 0.47
p = 0.02
Observed three different relationships between Primary Diet Category and IGF-1

Primary Diet Category → IGF-1

Influencing factor

Response variable

↑ Herring/Fish  
↑ Hyperiid  
↑ Crab  

↑ growth  
↓ growth  
↑↓ growth
Observed three different relationships between Primary Diet Category and IGF-1

Food Temp x Quantity x Quality = Growth

- Herring/Fish (GOOD)
- Hyperiid (BAD)
- Crab (OK or Food Quantity more important/weighted?)
There are likely differences in level of importance for these influencing factors:

\[
\text{Food} \times \text{Temp} \times \text{Quantity} \times \text{Quality} = \text{Growth}
\]

We were able to observe significant positive (Herring) and negative (Hyperiid) relationships between increases in the Primary Diet Category prevalence and IGF-1 without the inclusion of Temperature or Food Quantity.

\[
\text{Food} \times \text{Food} \times \text{Temp} \times \text{Quantity} \times \text{Quality} = \text{Growth}
\]

However for some Primary Diet Categories (ie Crab and Fish), inclusion of other factors may or may not change the relationship to growth.
How can field based physiological “experiments” inform ecologically?

Coupling nutritional physiology with feeding and prey ecology.

Why were hyperiids more prevalent as a Primary Diet Component in 2013 and 2015?

Why were herring a more prevalent as a Primary Diet Component in 2012 and 2014?
What’s next?

• How to handle Mixed Category
• Incorporate quality “measures”
  – Caloric and Protein content per Primary Diet Category
• Even/Odd Pattern
  – Primary Diet Category (Herring, Hyp, and Crab) and growth pattern
  – Adult pink?
• Stable isotopes
  – Does Primary Diet Category reflect longer term diet?
Acknowledgements

Department of Fisheries and Oceans: Carol Cooper, Dave Preikshot, Tyler Zubkowski, analysts at Institute of Ocean Sciences, PBS survey volunteers, and the captains and crews of the W.E. Ricker

NW Fisheries Science Center: Bridget Ferriss, Shelly Nance, and Larissa Rohrbach

UW- SAFS: Graham Young and Dave Beauchamp

Pacific Salmon Commission
IGF

Cmeg/CZ only (12-15)

Fullness
Differences in fork length across regions does little to explain differences in IGF1 concentration.
Diet Classification Mean Fork Length (mm) per Region

\[ R^2 = 0.58 \]

\[ R^2 = 0.40 \]

\[ R^2 = 0.55 \]
<table>
<thead>
<tr>
<th></th>
<th>Herring</th>
<th></th>
<th>Fish</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R²</td>
<td>p-value</td>
<td>R²</td>
<td>p-value</td>
</tr>
<tr>
<td>IGF-1 ~ (Log)Percent</td>
<td>0.41</td>
<td>0.04</td>
<td>0.22</td>
<td>0.10</td>
</tr>
<tr>
<td>IGF-1 ~ (Log)Percent + Region</td>
<td>0.82</td>
<td>0.04</td>
<td>0.72</td>
<td>0.03</td>
</tr>
<tr>
<td>Length ~ (Log)Percent</td>
<td>0.22</td>
<td>0.17</td>
<td>0.04</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>Hyp</td>
<td>Cmeg/CZ</td>
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</tr>
<tr>
<td></td>
<td>R²</td>
<td>p-value</td>
<td>R²</td>
<td>p-value</td>
</tr>
<tr>
<td>IGF~LogPercent</td>
<td>0.47</td>
<td>0.02</td>
<td>0.06</td>
<td>0.37</td>
</tr>
<tr>
<td>IGF~LogPercent + Region</td>
<td>0.87</td>
<td>0.009</td>
<td>0.54</td>
<td>0.05</td>
</tr>
<tr>
<td>Length~LogPercent</td>
<td>0.31</td>
<td>0.07</td>
<td>0.06</td>
<td>0.36</td>
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