Walleye pollock condition in the Bering Sea

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The issue: Fish condition (e.g. energy density, amount of lipid, amount of protein) can vary based on time of year, location, “climate change” etc.

The question: How to develop a condition index that is easily applicable to the field (e.g. aboard ship)? Currently, almost all field condition indices for fish are based on body length because balances can’t easily be used on a ship to measure fish mass.

The problem: Length cannot distinguish lean or fat fish. That is, fish of the same length can be heavy, light, thin or fat.
The Solution: Build a condition metric based on fish size (volume).

We have successfully developed methods in other animals (seals and sea lions) that allow us to estimate mass by using a body volume index.

In this PCCRC project, we are developing a comprehensive volume/condition index in pollock that will allow research teams to estimate condition based on simple field measurements of 2-3 body dimensions.
Volume

Archimedes” devices for measuring true volume of pollock have been built and used.
Results

Regressions:

Mass vs actual (Archimedes) volume

Actual volume vs calculated volume
Calculated volume vs actual (Archimedes volume)

\[ y = 1.0339x - 7.9471 \]
\[ R^2 = 0.9767 \]
Calculated volume and Actual volume vs Mass

\[ y = 1.0222x - 2.4514 \]
\[ R^2 = 0.9989 \]

\[ y = 1.0581x - 10.643 \]
\[ R^2 = 0.978 \]
Conclusions from Part 1:

1. Pollock volume is readily calculated from three simple measurements (total length, width and height)

2. Volume and mass are tightly correlated

3. Therefore, mass can be calculated from length, width, height.

4. While mass can be regressed from only length, volume may be a better calculator at certain points in the pollock growth curve
BASIS Pollock Mass vs Length

More than 600 gm mass change with less than 5 cm length change in this region
Next:

Does volume relate to fish condition?

This is similar to the Body Mass Index (BMI) concept used in human medicine

**Necessary Data:**

1. Volume (morphs)
2. Energy
   1. Water %
   2. Lipid %
   3. Calories
Step 1: How do % water and % lipid relate in pollock?

\[
y = -0.7987x + 66.121 \\
R^2 = 0.7914
\]
Step 2: How do % lipid and calories relate in pollock?

\[
y = 88.402x + 788.51 \\
R^2 = 0.9189
\]
Total calories / fish vs volume

\[ y = 1241.3x - 11376 \]
\[ R^2 = 0.9265 \]
Calories/gm dry vs Volume for fish < 400 ml

\[ y = 2.3114x + 4834.3 \]

\[ R^2 = 0.5497 \]
Calories/gm dry vs Volume for fish > 400 ml

What happens in this area?

Are there fundamental differences between large and small pollock?
Next steps:

1. Increase “N” values for all measurements
2. Increase range of animal size to test relationships
3. Compare BASIS fish with other locations (e.g. Chiswells)
Final products

**Immediate use:**
Teams on board ship measure pollock length and 2-3 other simple caliper values. Using our tables, they will be able to read “condition” value for fish.

**Intermediate use:** Provide measured body composition for BASIS samples.

**Longer term use:**
Move field away from “length only” condition indices for fish, test in other species, technique available to other fisheries.
Part 1: Morphometrics

**Completed**: Obtain pollock samples from BASIS collection (n= 2354)

**Completed**: Create mass vs length relationship for entire collection (Figure 1)

**Completed**: Create size histogram (below) to select subsamples for study.
Part 3: Chemistry

Energy (calories)  Water  Lipid  Protein

Examples of these types of calorie and water data from pollock utilized in one of our Steller sea lion feeding trials

Energy density of prey in ASLC Steller sea lion diets during 2001-2004. Values are expressed as the mean kcal g$^{-1}$ (n=10).

<table>
<thead>
<tr>
<th>Species</th>
<th>Sample Date</th>
<th>Supplier</th>
<th>kcal/g Dry Mass</th>
<th>% Water</th>
<th>kcal/g Wet Mass</th>
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</thead>
<tbody>
<tr>
<td>Walleye Pollock</td>
<td>9/2001</td>
<td>At Sea Processors/&quot;Northern Jaeger&quot;</td>
<td>5.50</td>
<td>0.81</td>
<td>1.04</td>
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<td>Walleye Pollock</td>
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<td>5.40</td>
<td>0.79</td>
<td>1.12</td>
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<td>At Sea Processors/&quot;Pride of the Sea&quot;</td>
<td>5.18</td>
<td>0.79</td>
<td>1.07</td>
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<td>5.30</td>
<td>0.79</td>
<td>1.14</td>
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<td>5.33</td>
<td>0.78</td>
<td>1.16</td>
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<td>5.10</td>
<td>0.75</td>
<td>1.27</td>
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<td>1.41</td>
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<td>At Sea Processors/&quot;American Triumph&quot;</td>
<td>5.23</td>
<td>0.77</td>
<td>1.20</td>
</tr>
</tbody>
</table>
Part 5: Tables

In the laboratory, we will have measured the true body composition of the fish.

We will also obtain 3-4 simple caliper measurements (e.g. length, height, width) that we will correlate to body condition. Because these simple measurements are related to volume and because volume is related to mass, we can derive how condition is related to the SIZE of the fish, not just its length.

We then produce tables that can be taken to sea. The field teams will collect the 3-4 simple body measurements and read condition values from our tables. They don’t have to measure volume, mass etc. We will have derived regressions for those from this laboratory study.
A representative sample of predominantly juvenile walleye pollock caught by midwater trawl. *Photo by Johanna J. Vollenweider.*
Pollock are the general shape of two cones connected together at the point of greatest girth. The index volume of these cones is determined by the equation:

\[ \text{Volume index} = \text{Total Length} \times \text{girth}^2 \]

For pollock, we measure in the laboratory

1. Total length
2. Height at max girth
3. Width at max girth
4. Maximum girth
5. Actual “Archimedes” volume