Combining Stomach Content and Fatty Acid Analyses to Assess Forage Fish Diets

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**Embayments:**

- forage fish feeding habitats
- complex features leading to variable ecosystems
- fine-scale studies needed to increase key-process resolution

**Forage Fish:**

- spp. composition & biomass
- lipid & energy contents
- diets

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Months</td>
<td>May, Aug</td>
<td>May, Aug</td>
<td>Nov</td>
<td>Apr</td>
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</tbody>
</table>
forage fish diets

Pacific herring (*Clupea pallasii*), walleye pollock (*Theragra chalcogramma*), capelin (*Mallotus villosus*), and eulachon (*Thaleichthys pacificus*)

stomach content analysis

- established and extensively used
  - logistically easy
  - data interpretation straightforward
- mid-water trawls during surveys
  - 11 m cod end with 0.1 m mesh and 0.025 m mesh liner
  - total length 5 to 50 cm
- results overview
  - 38 identified taxonomy groups in 907 samples
  - euphausiids and copepods as dominant prey
  - low diversity
forage fish stomach content analysis

problem I: underestimate of copepods
- high evacuation rates of forage fish stomach contents
- copepods digested faster than euphausiids
- daytime sampling

problem II: underestimate of diet diversity, resulting in low power of detecting diet differences
- compromises in taxa and sizes
  - less information than needed to detect differences
- strongly pulsed prey supply
  - uniform prey
solution: fatty acid (FA) analysis

for problem I: natural biomarkers of calanoid copepods
unique FA, assimilated by predators with little modification

for problem II: diversified prey FA
zooplankton’s highly variable and dynamic FA profiles
integrated view of diets from the last (up to) several weeks

FA: building blocks of lipids

\[
\begin{align*}
\text{C}22:6\text{n3} \\
4,7,10,13,16,19\text{-docosahexaenoic acid (‘DHA’)}
\end{align*}
\]

FA analysis
lipid extraction: whole-body homogenates
identification of FA methyl esters: GC-MS
257 fish, 80 zooplankton
37 FA quantified, compositional data

http://www.lipidlibrary.co.uk/
Multi-Dimensional Scaling (MDS) based on Bray Curtis similarity
zooplankton fatty acids

- euphausiids
- copepods
- chaetognaths
- pteropods

C20:1n11
C22:1n11

mean±2*SD
Pacific herring
stomach contents
Uganik Bay

copepods: important prey during winter feeding
walleye pollock stomach contents, Uganik Bay, May 2004

### Size Class Distribution

<table>
<thead>
<tr>
<th>Size Class</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Length (cm)</td>
<td>13.6-15.5</td>
<td>23.6-28.9</td>
<td>32.5-43.5</td>
</tr>
</tbody>
</table>

- **Small**
  - Pelagic Copepods: 50%
  - Amphipods: 10%
  - Pteropods: 10%
  - Larvaceans: 20%
  - Euphausiids: 10%

- **Medium**
  - Pelagic Copepods: 40%
  - Amphipods: 20%
  - Pteropods: 10%
  - Larvaceans: 10%
  - Euphausiids: 20%

- **Large**
  - Pelagic Copepods: 60%
  - Amphipods: 10%
  - Pteropods: 10%
  - Larvaceans: 10%
  - Euphausiids: 10%
walleye pollock fatty acids, Uganik Bay, May 2004

MDS based on Bray Curtis similarity
Pacific herring fec}

MDS based on Bray Curtis similarity
Pacific herring fatty acids, Uganik Bay, April 2007
capelin, May 2005

No significant spatial difference detected in stomach contents
Capelin fatty acids, May 2005

MDS based on Bray Curtis similarity
capelin, May 2005

Calanoid copepods vs. alternatives

C14:0
C16:0
C16:1n7
C18:1n7
C18:1n9C
C18:4n3
C20:1n11
C20:5n3
C22:1n11
C22:6n3

0 20 40 60

Tonki
Perenosa
Uganik large
Uganik small

mean±2*SD
diatoms
calanoid copepods
dinoflagellates

Diagrams showing the distribution of fatty acids across different species and groups.
Summary

- fatty acid analysis complementary to stomach content analysis
- ontogenetic and seasonal variations
- copepods as important prey in winter
  - high degree of spatial overlap between forage fish and copepods
  - forage fish low turnover rates making fatty acid analysis a useful tool for winter sampling
- spatial variations
  - within bays and among bays
  - differences in prey availability and food web origins
Acknowledgement

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Captain and crew of F/V Alaskan

Iluhi Schimmetka-Tesch and Mike Trussell

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Staff and colleagues in Fisheries Industrial Technology Center, School of Fisheries and Ocean Science, UAF

UAF library staff

Friends

My mom