Myctophids in the neritic and offshore areas of the subarctic NPO

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• Important due to:
  – substantial biomass
  – ubiquitous occurrence
  – intermediate body sizes
• Species composition and density
• Life history of dominant species
• Trophic relationships
• Role as an interface between neritic and offshore waters
Species composition and density
- Offshore transitional area-

- Transitional western NPO
- 4m² MOCNESS
- 5 - 8 tows per cruise
Species composition and density -offshore transition waters-

- **≤500m**
  - *L. jordani*
  - 2 g wwt m\(^{-2}\)
- **>500 m**
  - *Stenobrachius* spp.
  - *D. theta*
  - 6 g wwt m\(^{-2}\)

- **NO OBVIOUS SEASONAL PATTERN**
- More biomass in >500m depths
Transition neritic area

- Biannual bottom trawling survey for bottom fishes (area-swept method)
- 200 - 800m bottom depths
- ~ 4 g wwt m⁻²: conservative
- Subarctic: *D. theta*
  - Dominant during spring
- Subtropical: *D. watasei*
  - Dominant during autumn
- Transitional: *L. jordani*
- Responses to physical environs
- Life history
Life history of *Diaphus theta* (Moku et al., 2003)

- Spawn in the TR (May-July)
- Enter the SA by passive transport
- Feed and grow
- Benefit from
  - extended period of warmer temp. for reproduction
  - higher productivity during feeding season
  - Appear to utilize neritic area (i.e. shelf edge) as nursery ground
- Similar patterns: *L. jordani* and *S. nannochir* (Sassa et al., in press)
Myctophids in the central Bering Sea

• Feeding ground for Pacific salmon
• Myctophids: potential prey and competitor
• July/September, 2003
• 22 stns., a 12m² rectangular midwater trawl net,
• Oblique tow aimed at 500m depth
Myctophids in the central Bering Sea

- *Stenobrachius leucopsarus*: higher density in the central Bering Sea: 2.4 - 3.2g wwt m⁻²
- Maintain unique fauna by the semi-enclosed nature of the Bering Sea

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**Graph**

- **Density (g wwt m⁻²)**
- **Bering**: July - 3.2, Sep. - 2.4
- **Aleutian**: July - 1.3, Sep. - 1.1

**Legend**
- Blue: *S. leucopsarus*
- Orange: Other fishes (incl. non-myctophid spp.)
Summary for species composition and density in the neritic/offshore subarctic

- Offshore/neritic transitional waters (even the Bering Sea) share the dominant species in common
  - *Diaphus theta*
  - *Lampanyctus jordani*
  - *Stenobrachius leucopasarus*
- Few endemic species in the neritic waters (e.g. *Diaphus watasei* )
- Average density of <6 g wwt m\(^{-2}\) (i.e. <6 t km\(^{-2}\))
- **Conservative** estimate
- Need more reliable estimate in neritic areas
- Need to consider **net avoidance, sampling efficiency** and to establish an acoustic sampling method
Trophic role
-Salmon diets in the Bering Sea-

- 19-21%DW for sockeye
- Chum: Increase from 3% to 26%
- Reflects decrease in relative (per captita) abundance of zooplankton prey
- Smooth seasonal variation in prey availability

July

<table>
<thead>
<tr>
<th>prey</th>
<th>July DW%</th>
<th>September DW%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. helicina</td>
<td>18.8</td>
<td>21.2</td>
</tr>
<tr>
<td>Other Pisces</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atka mackerel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myctophids</td>
<td></td>
<td>25.4</td>
</tr>
<tr>
<td>Squids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gelatinous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyperiids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euphausiids</td>
<td></td>
<td></td>
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<tr>
<td>Copepods</td>
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<td></td>
</tr>
</tbody>
</table>

Total N = 1070

Chum - July

Chum - September
Trophic role in the neritic waters

- **Walleye pollock** (N=6666)
  - Distributed in lower shelf and upper slope (<250m)
  - *Diaphus theta* : exclusive importance (ca. 80% in DW)
  - Important for larger fish except for during spring
    - Reflects the *spawning migration* of *D. theta* and heavy pollock cannibalism during spring

![Diagram showing trophic roles and seasonal changes](image)
Theradfin hakeling *Laemonema longipes*

- Predominant over the **upper/mid slope** (300-1000m bottom depths) of the western Pacific
- **N=1388**
- Important for larger fish
  - *D. theta* (ca. 60% in DW)
  - *Lampanyctus* spp. (25%)
- Obscure **seasonal** and **bathymetric** difference:
  - Reflect ubiquitousness and seasonal stability
Estimating predation impact on myctophids by theradfin hakeling

- Densely distributed over upper/mid-slope in the Doto area (7.9 g m⁻²)
- Ca. 40% in overall diet
- Density: 7.9 g m⁻² (by trawl survey)
- Daily ration: 0.3% BW (*Stenobrachius nannochir*; Moku et al. 2000)
- **Annual consumption**
  \[
  = \text{pred. density} \times \text{prop. in diet} \times \text{daily ration} \times 365 \\
  = 7.9 \text{ g m}^{-2} \times 0.4 \times 0.3\% \text{ d}^{-1} \times 365 \text{ d} \\
  = 3.46 \text{ g m}^{-2} \text{ y}^{-1} \text{ (total: } 3.46 \times 6000\text{km}^{2} = 20,800 \text{ t})
  \]
- Considering average density of myctophids, <6 g wwt m⁻², this predation pressure is too heavy. 
  So, **supplement by migration seems essential**.
Estimating Myctophid predation by pollock using an age-structured bottom-up model

- **Area modeled**
  - Off SE Hokkaido Island
  - 100-250m depths (Doto area)
  - ca. 5000km²
- **Model components**
  - Pollock (10 age classes)
  - Predators (generic & cannibal)
  - Fishery (Trawl & Gillnet)
  - Prey
    - Copepods
    - Euphausiids
    - Myctophids
    - Squids
    - Pollock
- **Processes considered**
  - Recruitment (i.e. Settlement)
  - Mortality
    - Predation
    - Cannibalism
    - Fishery
  - Growth
  - Feeding
  - Prey production

\[
\text{Pred}(\text{pol})_j = \sum_{j=1}^{10} \left( \text{MaxI}(T_i) \frac{\phi_{ij} S_j (B_j - P_j)_j}{H + \sum_{j=1}^{14} \phi_{ij} S_j (B_j - P_j)} \right)
\]
Estimating Myctophid predation by pollock using an age-structured bottom-up model

- Model well imitated observed variation of pollock diet by season and fish size
- 83% concordance in average
- Predation pressure of pollock on mesopelagic fish (mainly *D. theta*) was calculated by Monte-Carlo simulation with population variability.
- Predation (6.3 gm\(^{-2}\)y\(^{-1}\)) well outstripped average biomass (1.5 gm\(^{-2}\)) and production (2.3 gm\(^{-2}\)y\(^{-1}\)) of myctophids.
- Supplement from offshore is essential to support pollock during autumn and winter

<table>
<thead>
<tr>
<th>Property</th>
<th><em>N. cristatus</em></th>
<th>Euph.</th>
<th>Myctophids</th>
<th>Mesopel. squids</th>
<th>Pollock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production (g m(^{-2}) yr(^{-1}))</td>
<td>43.1±0.2</td>
<td>17.2±0.1</td>
<td>2.3±0.1</td>
<td>1.5±0.1</td>
<td>16.5±2.0</td>
</tr>
<tr>
<td>Avg. B (g m(^{-2}) yr(^{-1}))</td>
<td>7.7±0.2</td>
<td>10.1±0.2</td>
<td>1.5±0.1</td>
<td>0.4±0.1</td>
<td>40.9±4.9</td>
</tr>
<tr>
<td>Advective supply (g m(^{-2}) yr(^{-1}))</td>
<td>18.8±2.9</td>
<td>40.9±4.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>P/B</td>
<td>5.8</td>
<td>2.1</td>
<td>1.5</td>
<td>3.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Predation by pollock (g m(^{-2}))</td>
<td>10.0±2.7</td>
<td>22.2±5.3</td>
<td>6.3±1.6</td>
<td>3.0±0.6</td>
<td>1.4±0.5</td>
</tr>
<tr>
<td>Pred. by micronekton (g m(^{-2}) yr(^{-1}))</td>
<td>0.5±0.1</td>
<td>9.6±0.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Conclusion - trophic role -

• Important for larger nekton during less productive seasons
• Smoothing seasonal variation in productivity
• Strong predation pressure when compared with myctophid density
  – Density estimate is conservative
  – Supplement from the offshore
    • Active migration
    • Intensification by biophysical coupling
• **Accumulating/transporting offshore production to the neritic area**