Mesozooplankton demands match carbon flux in the twilight zone

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Carbon Export
Particle flux

Mesozooplankton biomass profile
(Steinberg et al. 2008)
Particle flux

Wilson et al. 2008
Particle flux

Mesozooplankton biomass profile (Steinberg et al. 2008)

Wilson et al. 2008
Carbon demand

• Carbon is essential
  Maintenance of all body functions including:
  respiration, growth, reproduction, locomotion, use of senses, etc.

• Acquired by feeding
Case study: Pacific

Bacterial & zooplankton carbon demands exceeded POC flux attenuation by far!

ALOHA: Station in subtropical Pacific
Steinberg et al. 2008
Aim of this study

Does POC flux attenuation satisfy mesozooplankton carbon demands in the North Atlantic?
ARIES
Autosampling & Recording Instrumented Environmental Sampling System

- towed behind the ship
- 110 samples
- 55 discrete depth intervals
PELAGRA
Neutrally buoyant sediment trap
Mesozooplankton carbon demands

1. Samples were size-fractioned
2. Identified
3. Enumerated
4. Analysed for dry weight
5. Carbon demand calculated for different groups

<table>
<thead>
<tr>
<th>Size class</th>
<th>Copepods</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;2000</td>
<td>Genus level</td>
<td>Large copepods</td>
</tr>
<tr>
<td>1000-2000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500-1000</td>
<td>Oithona. Oncaea, Calanoid</td>
<td>Small copepods</td>
</tr>
<tr>
<td>350-500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>200-350</td>
<td></td>
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</tr>
</tbody>
</table>

- Amphipods
- Chaetognaths
- Euphausids
- Ostracods
- Polychaetes
- Pteropods
Carbon demand calculations

Oxygen consumption
\( \ln O_2 = a_1 + a_2 \ln DW + a_3 \text{temp} \) (Ikeda 1985)

Respiration rate
\( O_2 \text{cons} \times RQ \times (12/24.4) \)

Carbon demand
\( \text{Respiration} / (AE \times R) \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value used</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ</td>
<td>Respiratory Quotient</td>
<td>0.72 – 0.97 (Gnaiger 1983)</td>
</tr>
<tr>
<td>AE</td>
<td>Absorption Efficiency</td>
<td>0.47 – 0.85 (Mayor et al. 2010)</td>
</tr>
<tr>
<td>R</td>
<td>Respired C fraction</td>
<td>0.40 – 0.85 (Parson et al. 1984)</td>
</tr>
<tr>
<td>Ikeda conversion</td>
<td>( R^2 = 93.9 )</td>
<td>(Ikeda 1985)</td>
</tr>
</tbody>
</table>
1. PELAGRA deployment: 48 h

2. Particles were caught in PELAGRA sample cups containing 4% formalin

3. Aliquots were filtered onto pre-combusted GF/F filters, dried, and POC measured using an elemental analyser
1 Aug 09    – St. 1
3-6 Aug 09 – PELAGRA
7/8 Aug 09 – St. 2
Flux attenuation

Attenuation between

50-600 m:
67 mg C m$^{-2}$ d$^{-1}$

50-200 m:
55 mg C m$^{-2}$ d$^{-1}$

200-600 m:
12 mg C m$^{-2}$ d$^{-1}$
Community composition

Station 1

0-200 m

200-600 m

600-1000 m

Station 2

0-200 m

200-600 m

600-1000 m

mg DW m⁻³

mg DW m⁻³

Amphipod
Chaetognaths
Copepod.large
Copepod.small
Euphausid
Ostracod
Polychaete
Pteropod
Mesozooplankton biomass

St. 1

St. 2

Depth (m)

Depth (m)

Dry Weight (mg m\(^{-3}\))

Dry Weight (mg m\(^{-3}\))

night
day

night
day

- Amphipod
- Chaetognaths
- Copepod.large
- Copepod.small
- Euphausid
- Ostracod
- Polychaete
- Pteropod

30 10 0 10 30
30 10 0 10 30

1000 800 400 200 0
1000 800 400 200 0
Can C demands be satisfied?

Yes!

Mesozooplankton carbon demands between 50–600 m can be satisfied by the bulk POC flux.
• We estimated
  – Mesozooplankton C demand at 2 stations during day and night
  – POC flux attenuation using 5 PELAGRAs

• We found
  – Mesozooplankton can live of bulk POC flux attenuation between 50 – 600 m!
How reliable are our estimates?

(1) PELAGRA

– All traps followed the same water mass
– Top trap estimates match 234Th and Marine Snow Catcher data

→ Fairly confident
How reliable are our estimates?

(2) Carbon Demands

1. Patchiness

2. Bacteria, microzooplankton, macrozooplankton, nekton???

3. Animals partly damaged or squeezed
   → Loss of biomass

4. Conversion of biomass into CD: many uncertainties
Flux attenuation

Steinberg et al. 2008

POC (mg C m\(^{-2}\) d\(^{-1}\))

Depth (m)
Does depth matter?

50-200 m

200-600 m

mg C m$^{-2}$ d$^{-1}$

\(\Delta\text{POC}\) St.1  St.2

\(\Delta\text{POC}\) St.1  St.2
Steinberg et al. 2008

Metabolic C demand or loss of sinking POC flux (mg C m$^{-2}$ d$^{-1}$)

ALOHA dep. 1  ALOHA dep. 2

This study

mg C m$^{-2}$ d$^{-1}$

$\Delta$POC St.1  St.2

$\Delta$POC  Day  Night
- High biomass of resident mesozooplankton at depths
- Cannot satisfy metabolic requirements by feeding between 200-600 m alone.
- But: System is balanced between 50-600 m!
Thanks! 😊

Sari Giering