Microplastic ingestion: the role of taste

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Sources of microplastics

- Microplastics: < 5 mm in size
Microplastics in marine environments: occurrence, distribution and effects

- Plastics form the largest part of marine debris
- Distribution data sporadic and inconsistent
- Macrofauna + macroplastic: starvation, suffocation, entanglement
- Emerging knowledge on microplastics effects on organisms

<table>
<thead>
<tr>
<th>Organism</th>
<th>Species</th>
<th>Polymer</th>
<th>Size (μM)</th>
<th>Concentrations</th>
<th>Duration</th>
<th>Ingestion (Y/N/NA)</th>
<th>Effect (L/SL/N/NA)</th>
<th>Organ</th>
<th>Organism Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea urchin (larva)</td>
<td><em>T. grattia</em></td>
<td>PE (fluorescent)</td>
<td>10-40</td>
<td>1,10,100 and 300 particles/mL</td>
<td>5 days</td>
<td>Y</td>
<td>N</td>
<td>Gut</td>
<td>WO</td>
</tr>
<tr>
<td>Polychaetes</td>
<td><em>A. marina</em></td>
<td>PVC (unplasticized)</td>
<td>Dust</td>
<td>0 - 5% sediment weight</td>
<td>4 weeks</td>
<td>Y</td>
<td>S-L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polychaetes</td>
<td><em>A. marina</em></td>
<td>PS (fluorescent) (± PCB in sediment)</td>
<td>400-1,300</td>
<td>0 - 7.4% sediment weight</td>
<td>28 days</td>
<td>Y</td>
<td>S-L</td>
<td>WO</td>
<td></td>
</tr>
<tr>
<td>Blue mussel</td>
<td><em>M. edulis</em></td>
<td>PS (fluorescent)</td>
<td>3 and 9.6</td>
<td>15,000 individual spheres</td>
<td>3 h and 2 h exposure</td>
<td>Y</td>
<td>S-L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barnacles</td>
<td><em>S. balanoides</em></td>
<td>Natural occurring microplastics</td>
<td>NA</td>
<td></td>
<td>NA</td>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lugworms</td>
<td><em>A. marina</em></td>
<td>Polystyrene (fluorescent)</td>
<td>NA</td>
<td></td>
<td>NA</td>
<td>Y</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shore crab</td>
<td><em>C. maenas</em></td>
<td>Polystyrene (fluorescent)</td>
<td>8 - 10</td>
<td>4.0 x 10^1 microspheres/L</td>
<td>24 hours</td>
<td>Y</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue mussel</td>
<td><em>M. edulis</em></td>
<td>High-density polyethylene (HD-PE)</td>
<td>0-80 μm</td>
<td>2.5 g HDPE-thf</td>
<td>96 hours</td>
<td>Y</td>
<td>S-L</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Microplastics in arctic marine environments: ecosystem health implications

- Estimated flux to the Arctic: 62,000 – 105,000 tonnes year\(^{-1}\) (Zarfl & Matthies 2010)
- Role of zooplankton
  - ingestion/bioaccumulation
  - contaminant transfer (e.g. POPs to lipids)
  - food chain effects (biomagnification)
  - Vertical transport
  - C-flux perturbations
Microplastics in arctic waters

- 0 – 11.5 particles m\(^{-3}\) (Lusher et al. 2015)

- 38 – 234 particles m\(^{-3}\) in ice cores (Obbard et al. 2014)

- human activities increase: shipping, tourism, offshore industries

→ more microplastics (?)
Microplastics and zooplankton

- Overlap in size between microplastics and typical food items (μm range)
- Plastic ingestion is experimentally confirmed (Cole et al. 2013, Setälä et al. 2014)
- Impacts on survival, feeding and fecundity (Cole et al. 2015, Lee et al. 2013)
Microplastics and zooplankton: the role of taste
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Photos: Nerheim et al. in prep, Carson et al. 2013, Reisser et al. 2014

"epiplastic diatoms"
Microplastics and zooplankton: the role of taste

- Plankton sampling in Håkøybotn, Tromsø (Norway)
Microplastics and zooplankton: the role of taste

- Fluorescent polystyrene (PS) beads, 15 and 30 μm diameter
- Fouled particles: soaking 3 weeks in native seawater
- Incubation in filtered (1 μm) seawater in 0.5 L glass bottles
- Rotating plankton wheel
- Observations with a fluorescence stereoscope
Microplastics and zooplankton: zooplankton taxa and plastic size

- 4 species:
  - Small copepods: *Acartia longiremis*, *Pseudocalanus* spp.
  - Large copepod: *Calanus finmarchicus*
  - Decapod larvae
- 15/30 µm PS beads, control without microplastics
- 10 individuals per bottle
- 24h exposure
- 0.333 mg L\(^{-1}\) = 23/148 beads mL\(^{-1}\)
Microplastics and zooplankton: zooplankton taxa and plastic size

![Graph showing the fraction of individuals ingesting plastic for different zooplankton taxa and plastic sizes](image)

- **Acartia**
  - 15 µm: n=9, 30 µm: n=10
  - Fraction ingesting plastic: 0.8

- **Pseudocalanus**
  - 15 µm: n=18, 30 µm: n=17
  - Fraction ingesting plastic: 0.6

- **Calanus**
  - 15 µm: n=9
  - Fraction ingesting plastic: 0.8

- **Decapoda**
  - 15 µm: n=9, 30 µm: n=5
  - Fraction ingesting plastic: 0.6

Bead diameter:
- □ 15 µm
- ■ 30 µm
Microplastics and biofouling: effect on ingestion

- *Acartia longiremis* ♀
  - 200 particles mL\(^{-1}\)
  - 5 replicates @ 10 individuals
  - 24 hours

- *Calanus finmarchicus* CV
  - 100 particles mL\(^{-1}\)
  - 10 replicates @ 10 individuals
  - 4 hours

Endpoints: % ingesting ind., # ingested, survival
Microplastics and biofouling: effect on ingestion

Positive effect of biofouling

t-test:
Acartia $p = 0.026$
Calanus $p = 0.007$
Microplastics and biofouling: effect on ingestion

Positive effect of biofouling

t-test:

*Acartia*  \( p = 0.032 \)

*Calanus*  n.s.

Error bars: 95% CI
Microplastics and biofouling: conclusions

- PS-bead ingestion is **species-specific** and bead **size dependent**
- **Body size** and filter **mesh size** of feeding apparatus are important
- Encounter and **filtration rates** determine plastic uptake

\[\text{Calanus} > \text{Acartia}\]

- Fouled beads were more frequently ingested than clean beads
- **Selectivity** difference between species: \textit{Calanus} less selective than \textit{Acartia}

\[\text{Chemical perception: biofilms disguise plastic as nutritious food}\]

- Survival was not affected (not shown, short-term experiment)
- High proportion of beads was **egested** after 4+ hours
Microplastics and biofouling: open questions

• What determines individual intra-specific differences (high variability)?
  o Why are some individuals more selective than others?
• How will varying plastic properties affect ingestion dynamics
  o Shape (beads vs. fragments vs. fibers)
• How can ingestion in situ at realistic concentrations be determined?
• Are there chronic and/or sublethal health effects on zooplankton?
• At what rates are microplastics transferred to the next trophic level
  o Planktivorous zooplankton (e.g. chaetognaths)
  o Fish larvae
  o seabirds
Microplastics and biofouling: acknowledgements

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