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Plastics and Plankton: What do we know?

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NATURAL ENVIRONMENT RESEARCH COUNCIL

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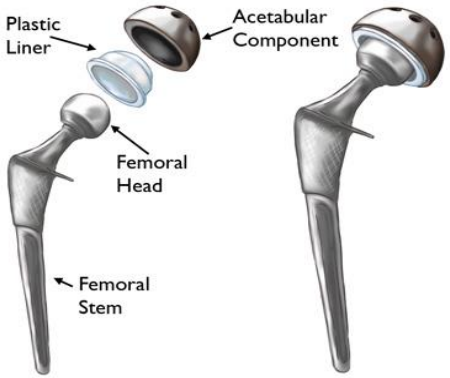
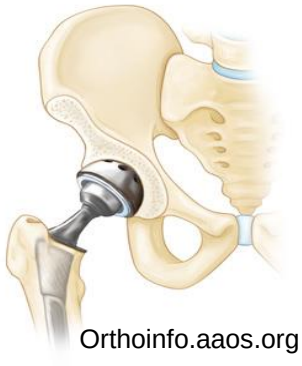
Plastics – **The Good**, The Bad and The Ugly

- Rapid growth in plastic production over the past 60 years
- > 300 million tons manufactured per year

- Medical and Health
- Building and construction
- Electrical and electronic
- Transportation
- Sport and Leisure
- Agriculture





Orthoinfo.aaos.org

Plastics – The Bad

Plastics – The Good, **The Bad** and The Ugly

Plastics – The Good, The Bad and **The Ugly**


J.M. van Coutren/Marine Photobank


Martin Porta/Marine Photobank


John Chinuntdet, 2007/Marine Photobank


NOAA


Claire Fackler, NOAA National Marine Sanctuaries/Marine Photobank

Large plastic litter is a common site on beaches, but the smaller, microscopic size fraction is of equal concern to scientists.

NOAA/NMFS

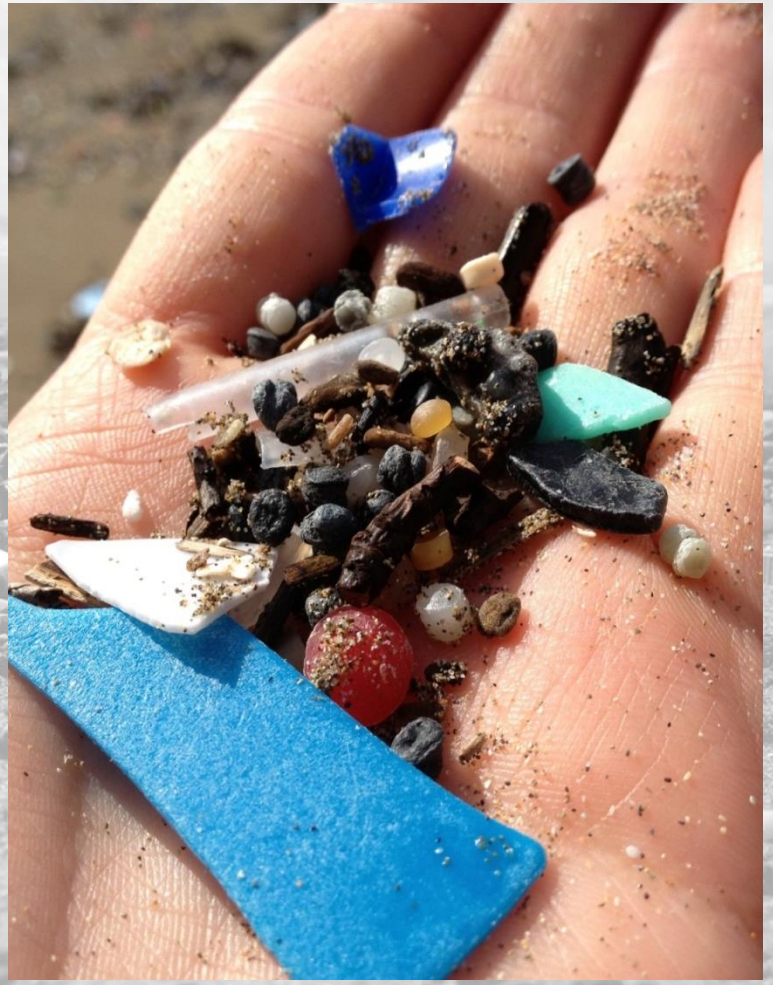
David Cayless/Marine Photobank

Microplastics

- Microplastics describe small fibres, beads, granules and fragments of plastics (<5 mm in diameter)

Microplastic fragments

- Fragmentation of large plastics into microscopic particles
- Caused by UV degradation and abrasion

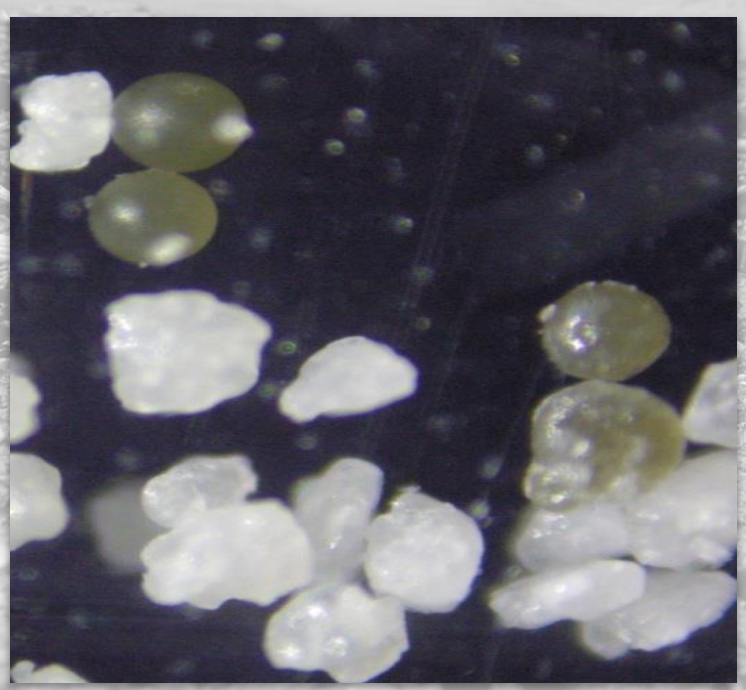


Nurdles

- Also known as “mermaid’s tears”
- Used to make everyday plastics

Microbeads

"40,000 particles in 25 mL of shower gel"



Microplastic fibres

"a single garment can produce **>1900 fibres** per wash"

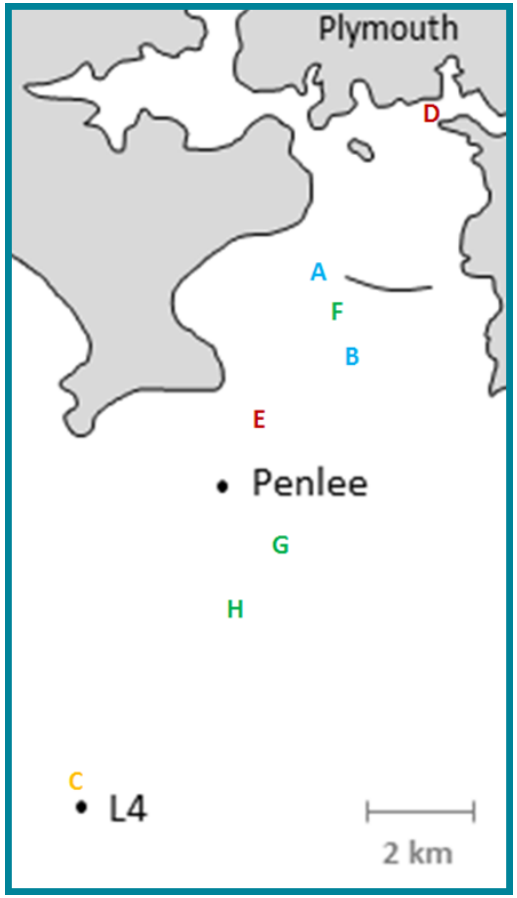
“estimated that at least 5.25 trillion plastic particles are currently floating at sea”

Eriksen *et al.* (2014) PlosONE

Are Marine microplastics underestimated?

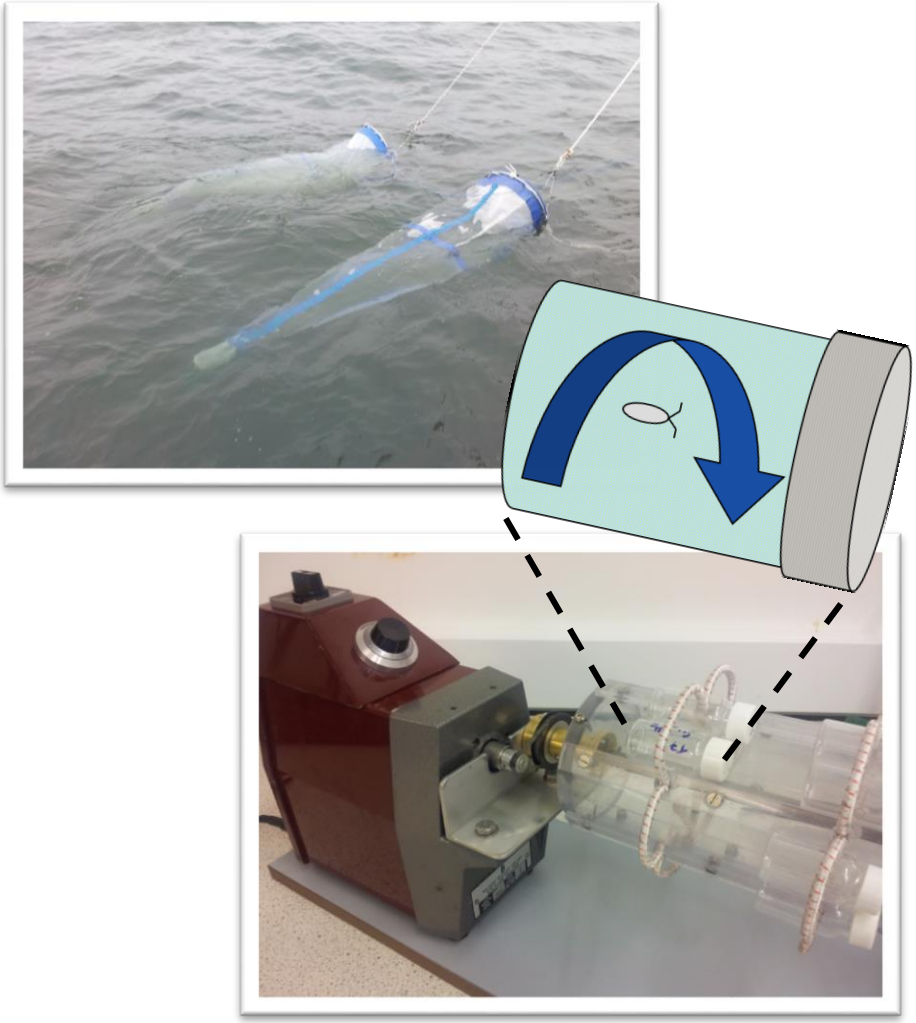
Microplastic per m^{-3} collected by 100, 335 and 500 µm nets; Plymouth (UK).

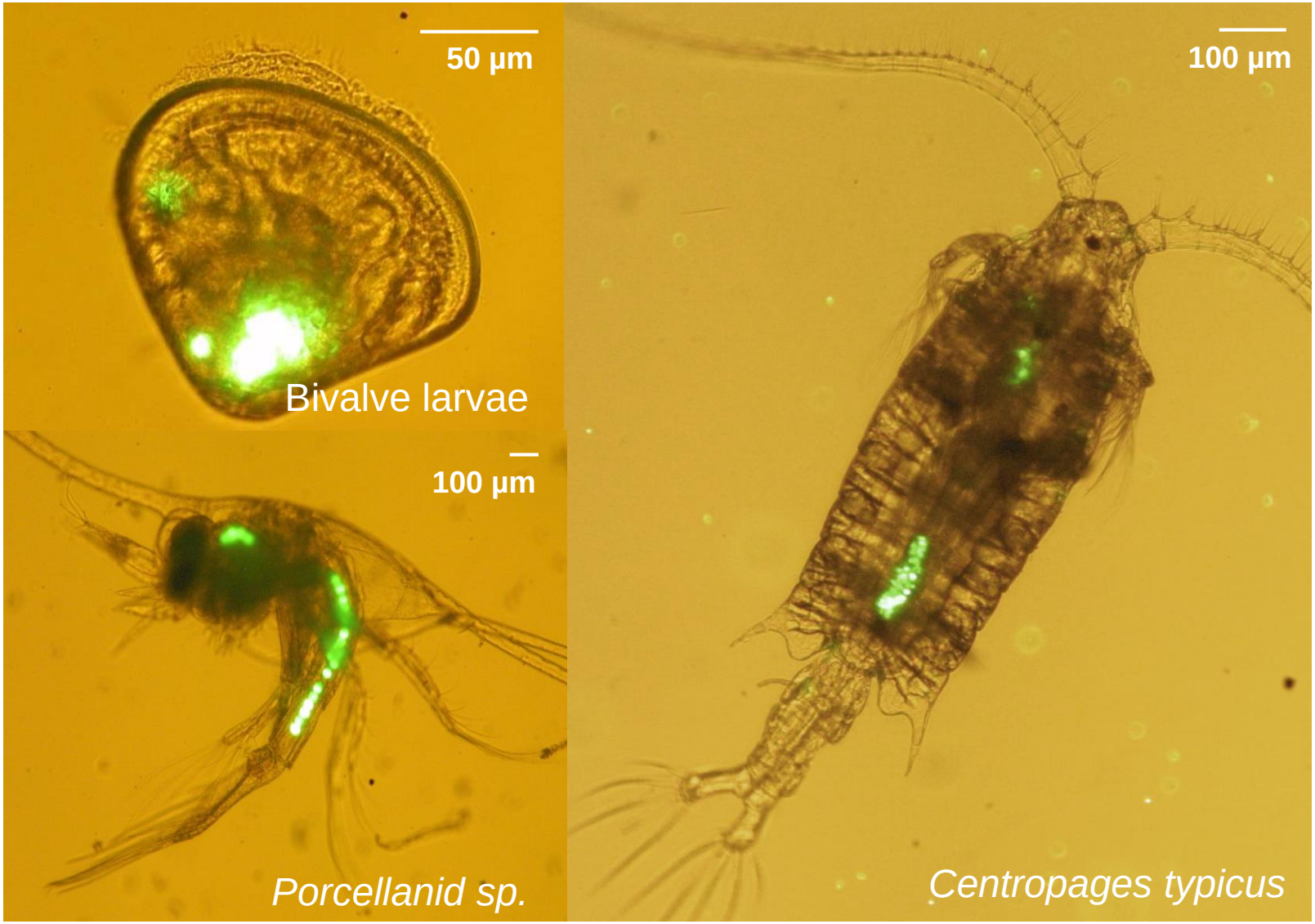
- Higher concentration of microplastics found in 100 µm nets
- Least in the 500 µm nets,
- Indicates sampling with larger mesh sizes fails to give accurate estimates of microplastic abundance



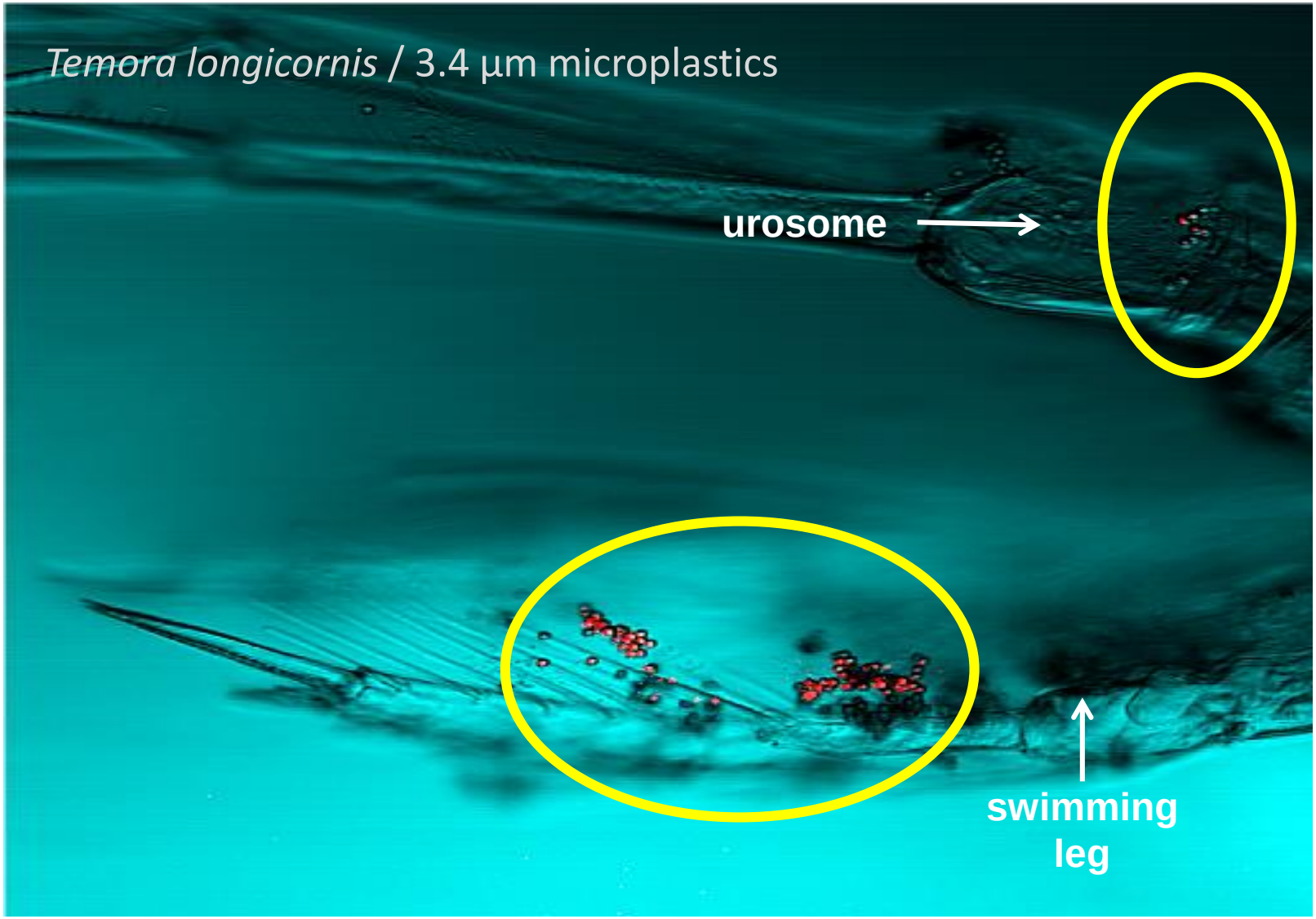
Can zooplankton ingest microplastics?

- Zooplankton
  - 15 taxa (English Channel)
- Exposure
  - Fluorescent/standard polystyrene beads
  - 2 – 30 µm diameter
- Bio-imaging
  - Fluorescent microscopy
  - Coherent anti-Stokes Raman scattering (CARS) microscopy
  - Live observations





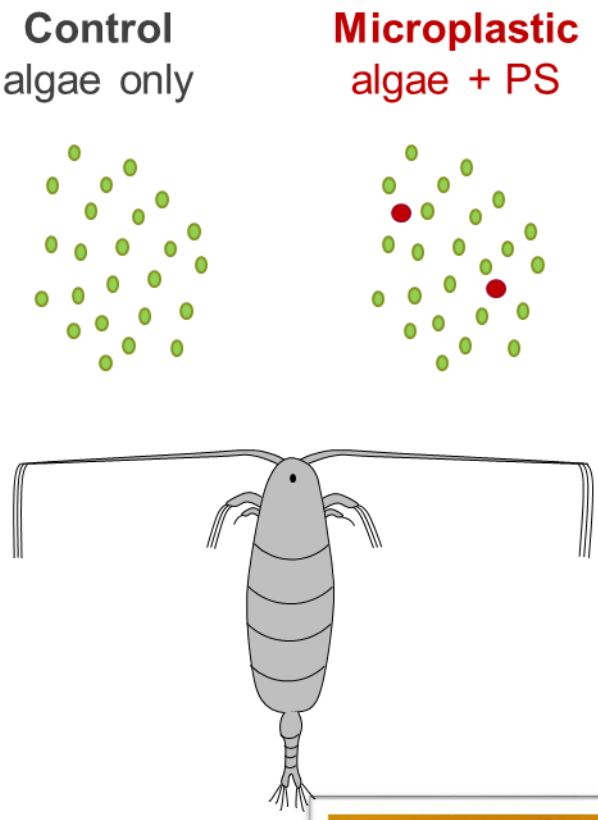
Cole *et al.* (2013)



Cole *et al.* (2013)

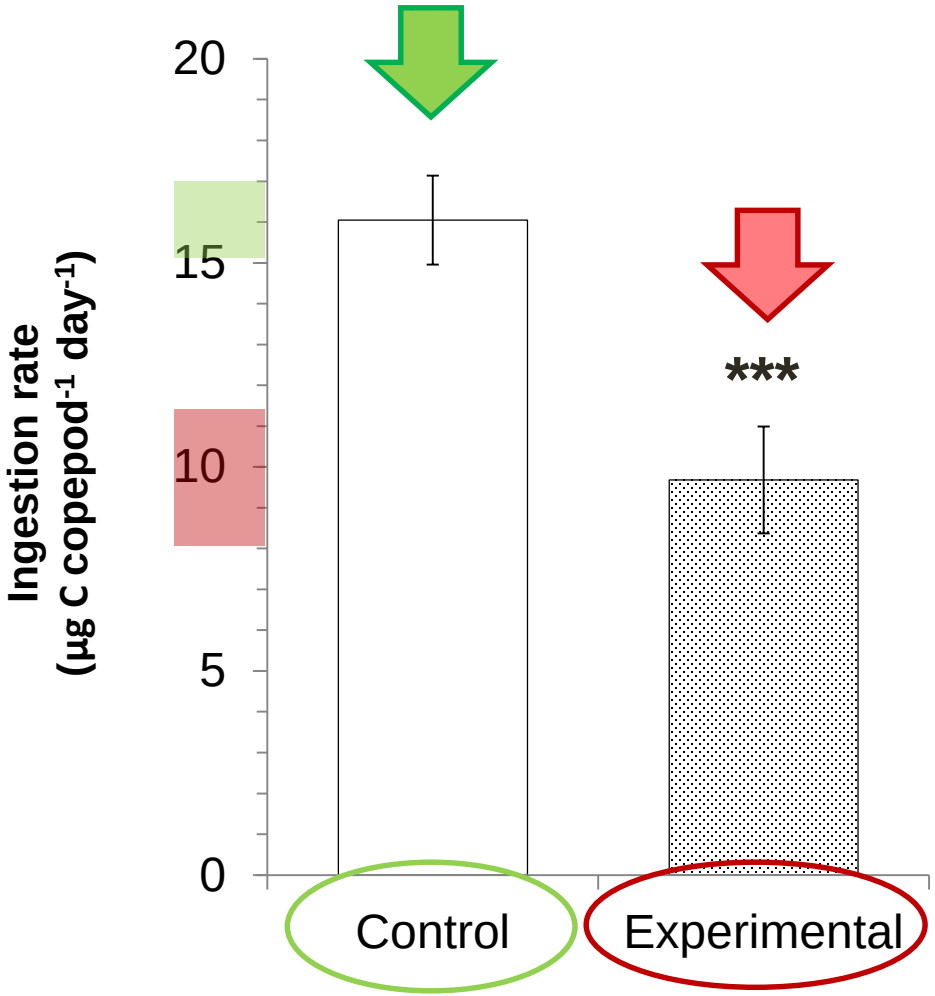
Consequences of microplastic ingestion in copepods

- Copepod
  - *Calanus helgolandicus (*adult females)
- Fed
  - Fed: cultured T. weissflogii prey [~ 800 cells mL-1]
- Exposure
  - 20 µm diameter polystyrene microplastics
  - [~65 microplastics mL^{-1}]
  - with cultured prey (*Thalassiosira weisflogii*)
- Endpoints:
  - ingestion rate, oxygen consumption rate (metabolism), egg production rate, egg size, hatching success and mortality



Microplastics interfere with copepod feeding

24h exposure to 20µm PS (65 microplastics mL^{-1})

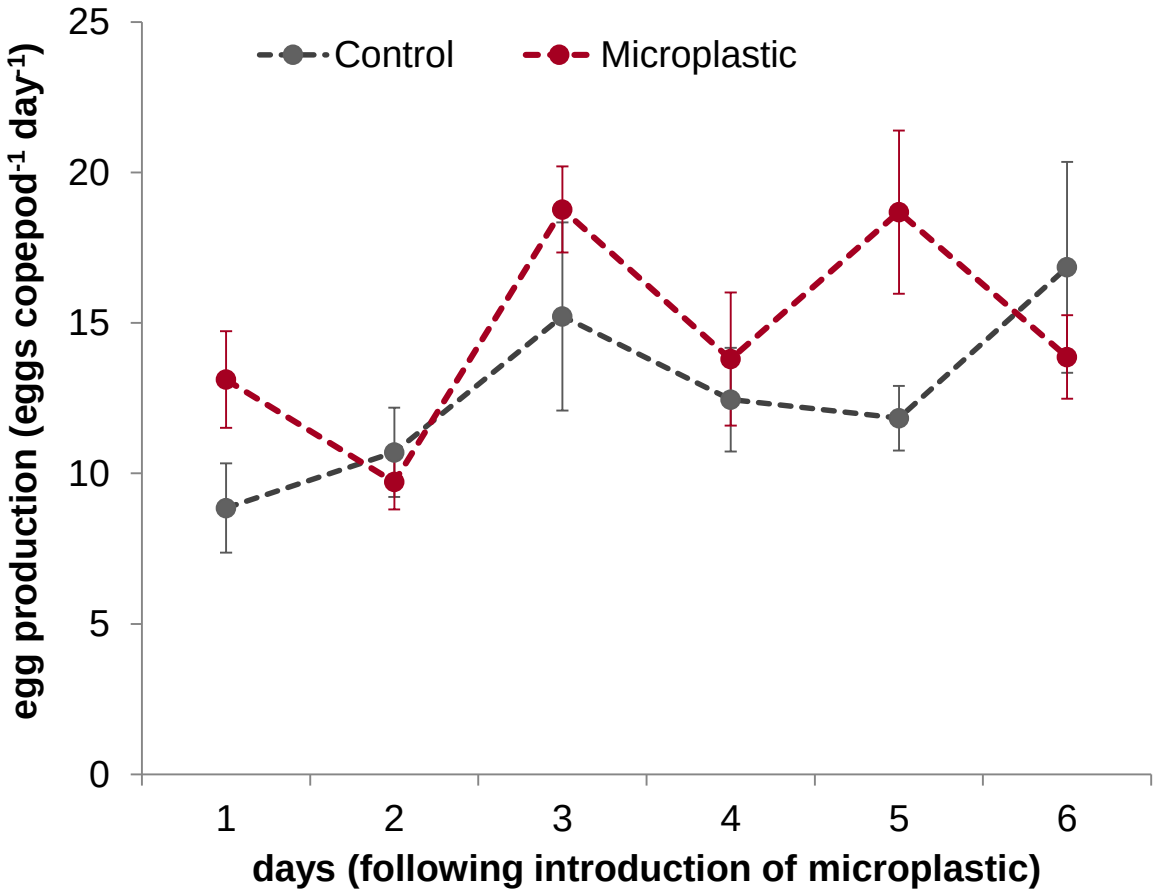


Results

Significant (40%) reduction in carbon (biomass/energy) ingested

Impact to egg production rate

Exposure to 20µm PS (65 microplastics mL^{-1})



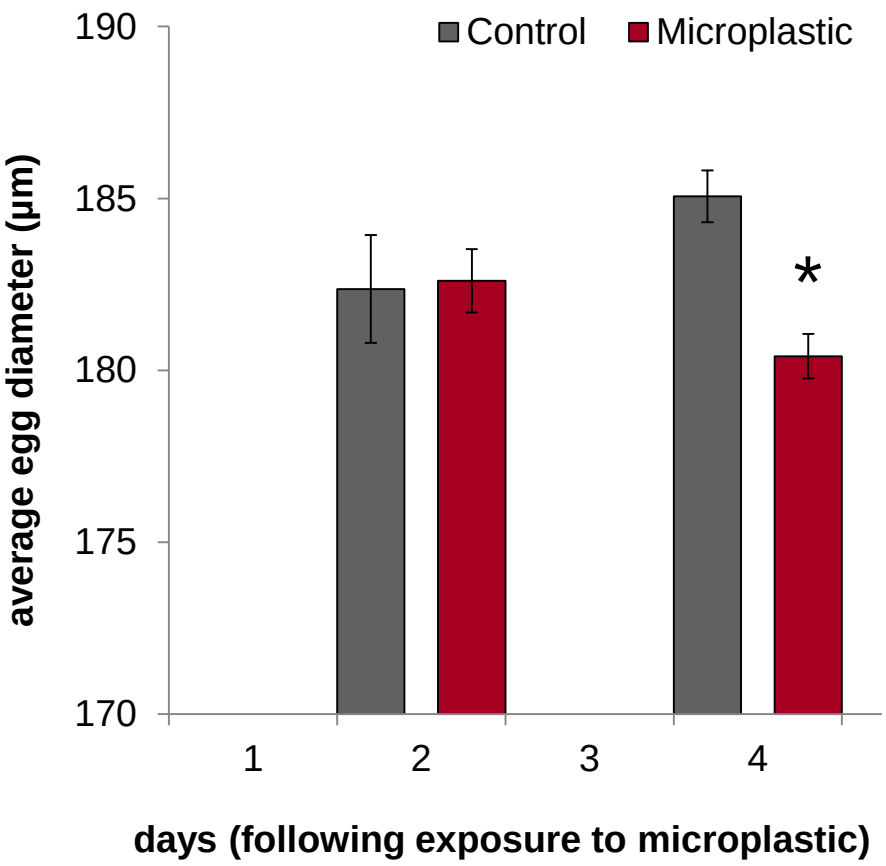
Results

No significant impact on egg production rate

Cole *et al.* (2015) ES&T

Impact to egg size

Exposure to 20µm PS (65 microplastics mL^{-1})



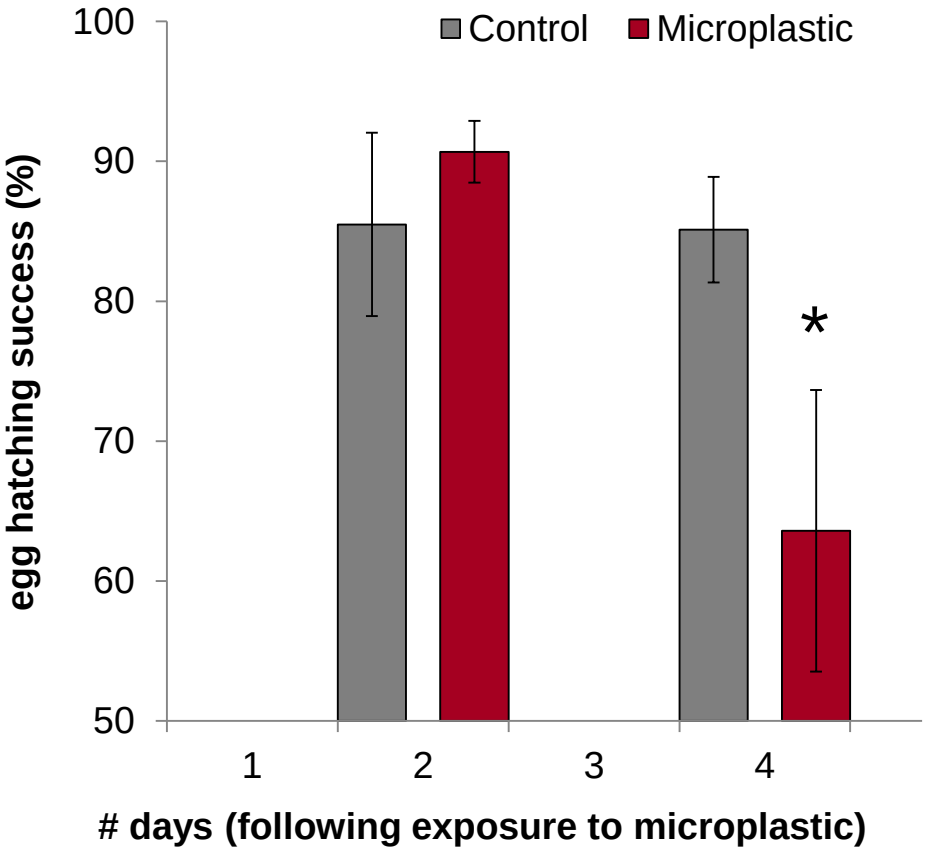
Results

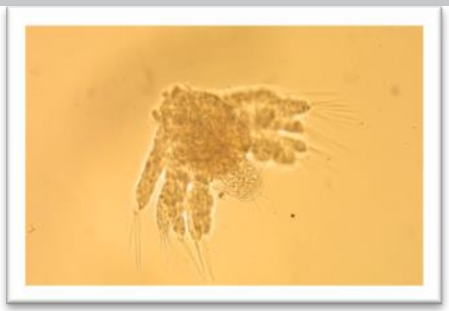
Microplastic exposed copepods produced significantly smaller eggs (days 4+)… less energy put into reproduction

Cole *et al.* (2015) ES&T

Impact to egg hatching success

Exposure to 20µm PS (65 microplastics mL^{-1})





Results

Microplastic exposed copepods produced eggs with significantly reduced hatching success (day 4+)

Cole *et al.* (2015) ES&T

Health impacts

Exposure to 20µm PS (65 microplastics mL^{-1})

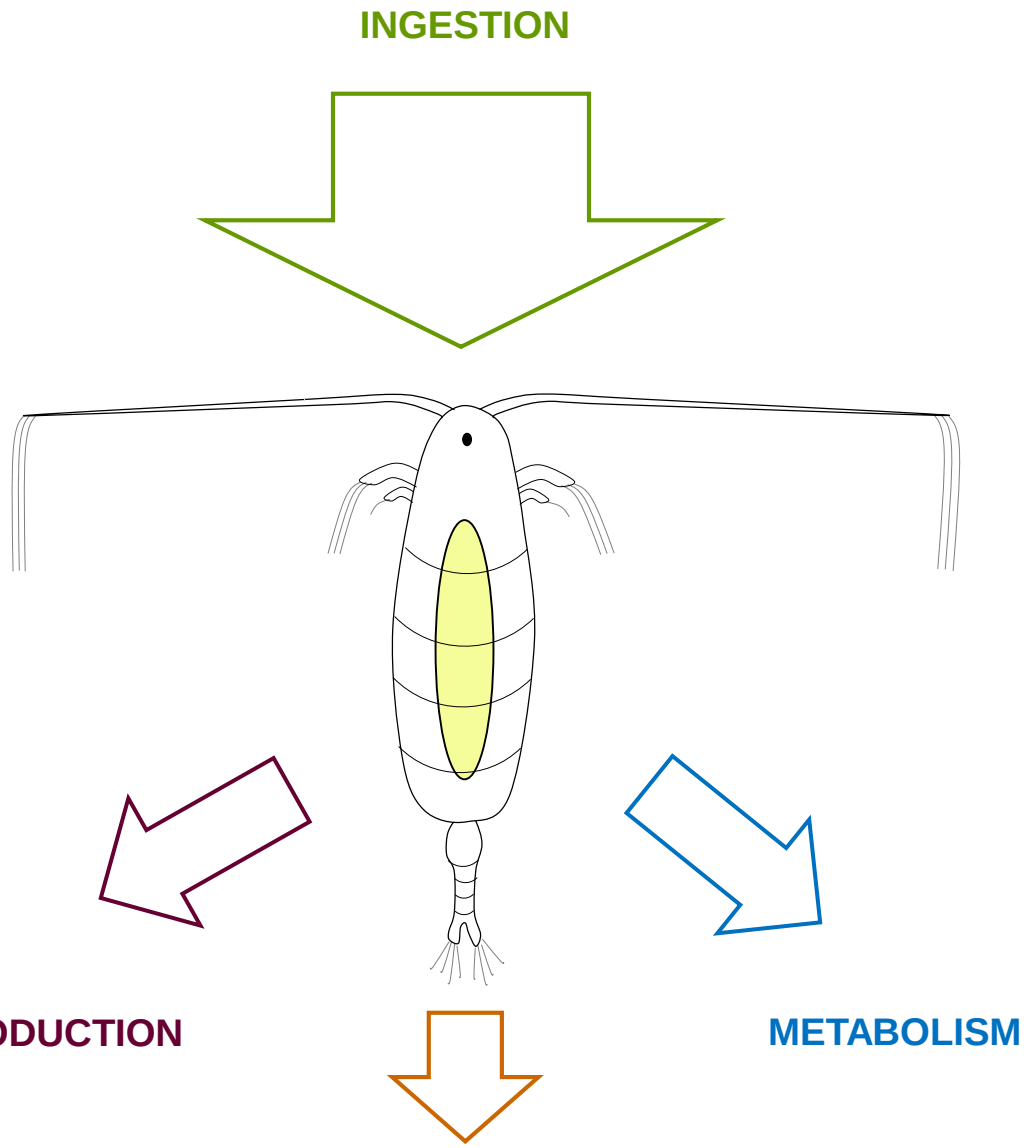
- **Oxygen consumption rate (metabolic rate)**
  No significant difference between treatments.

- **Mortality**
  Microplastic exposed copepods showed higher rates of mortality.

Cole *et al.* (2015) ES&T

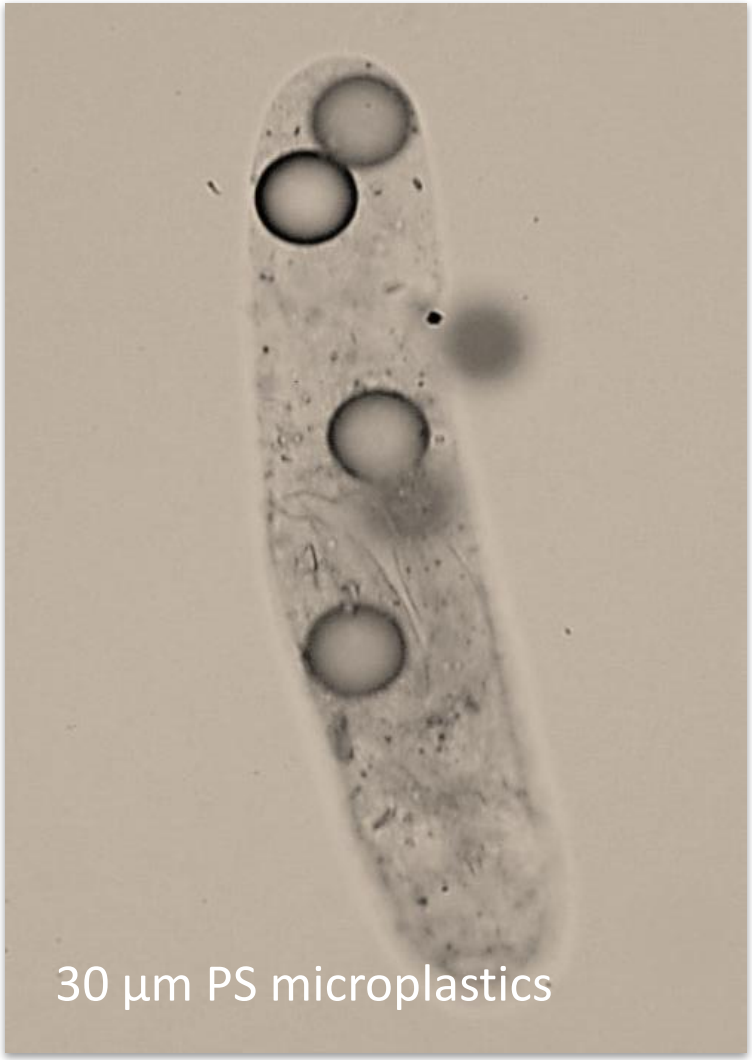
Summary

- Zooplankton have capacity to ingest microplastics
- Microplastics reduce energetic uptake of copepods
- Repercussions for reproductive outputs and survival



Cole *et al.* (2015) ES&T

Microplastics within copepod faecal pellets



Can microplastics alter faecal pellets (FP)?

Copepod faecal pellets:

- Source of food for marine organism
- Contribute to marine vertical carbon flux.

Hypothesise

- Faecal pellets are a vector for transport of microplastics
- Low-density microplastics alter properties and sinking rates of FP
- Faecal pellets facilitate transfer microplastics to other marine animals

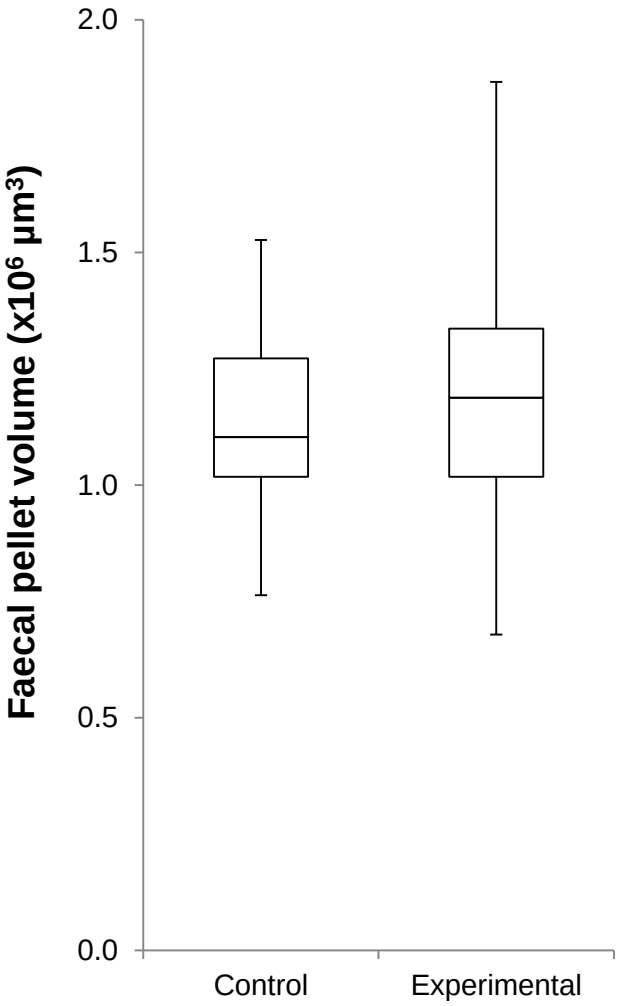
Exposure:

- *Calanus helgolandicus*
- Fed natural seawater
- Absence/presence of 20 µm polystyrene microplastics

Faecal pellet analysis

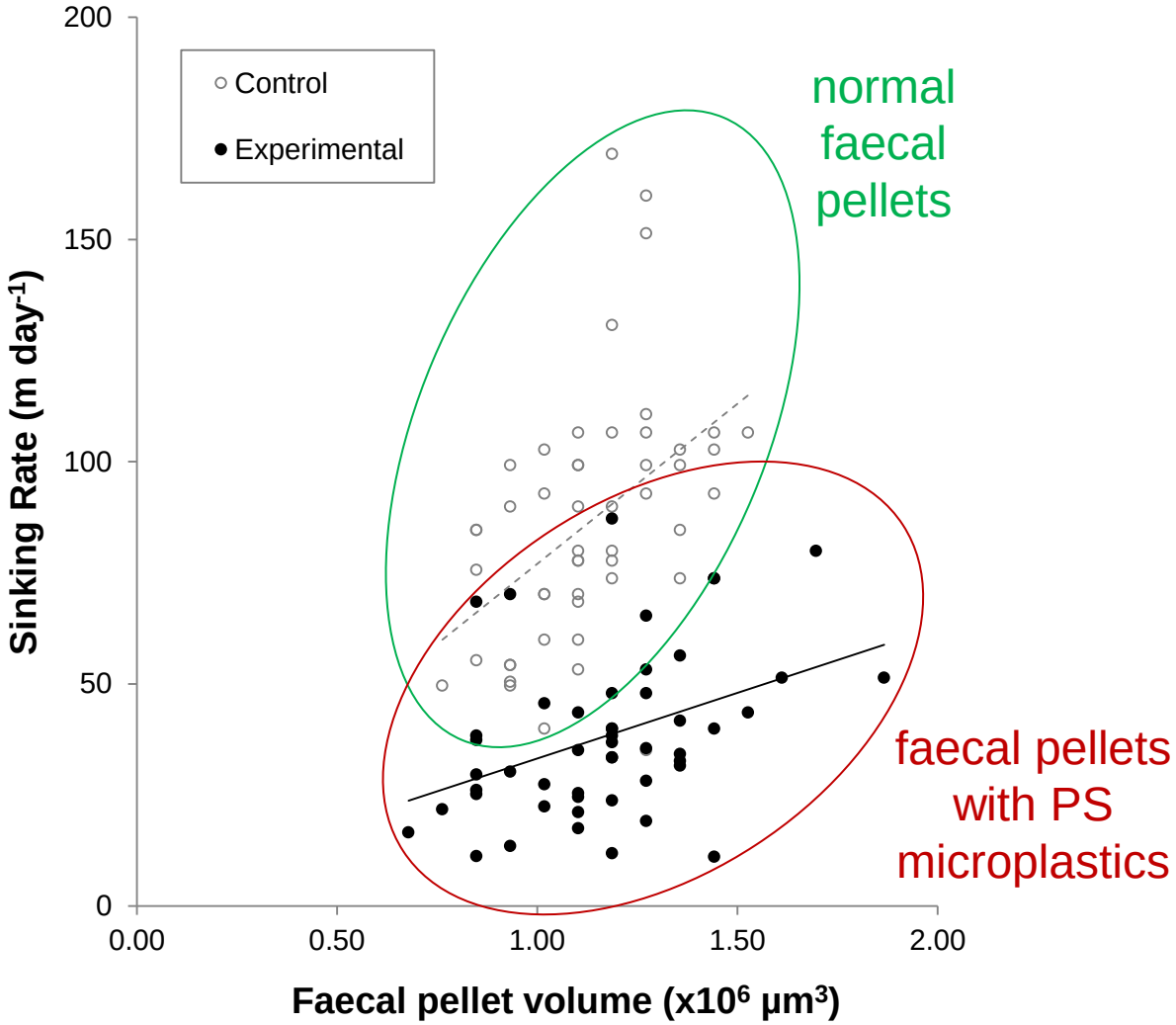
- Volume
- Partial/whole
- Sinking rates

Can microplastics alter faecal pellets?



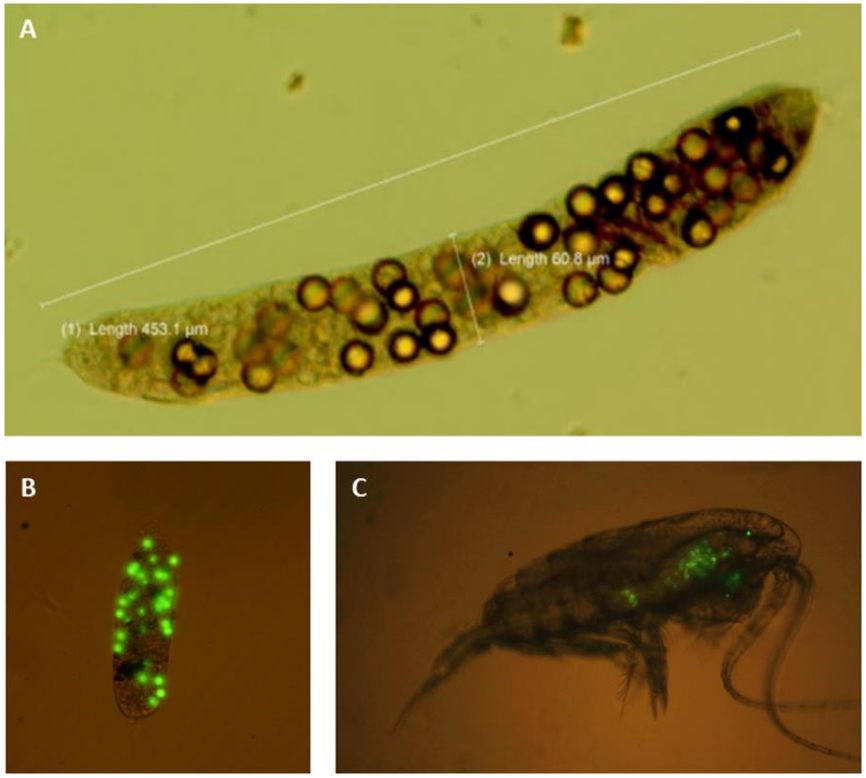
Cole *et al.* (2016) ES&T

Can microplastics alter faecal pellets?



Cole *et al.* (2016) ES&T

Coprophagy



Microplastics, encapsulated within the FP of *Centropages Typicus*, can be transferred to *Calanus* via coprophagy

Cole *et al.* (2016) ES&T

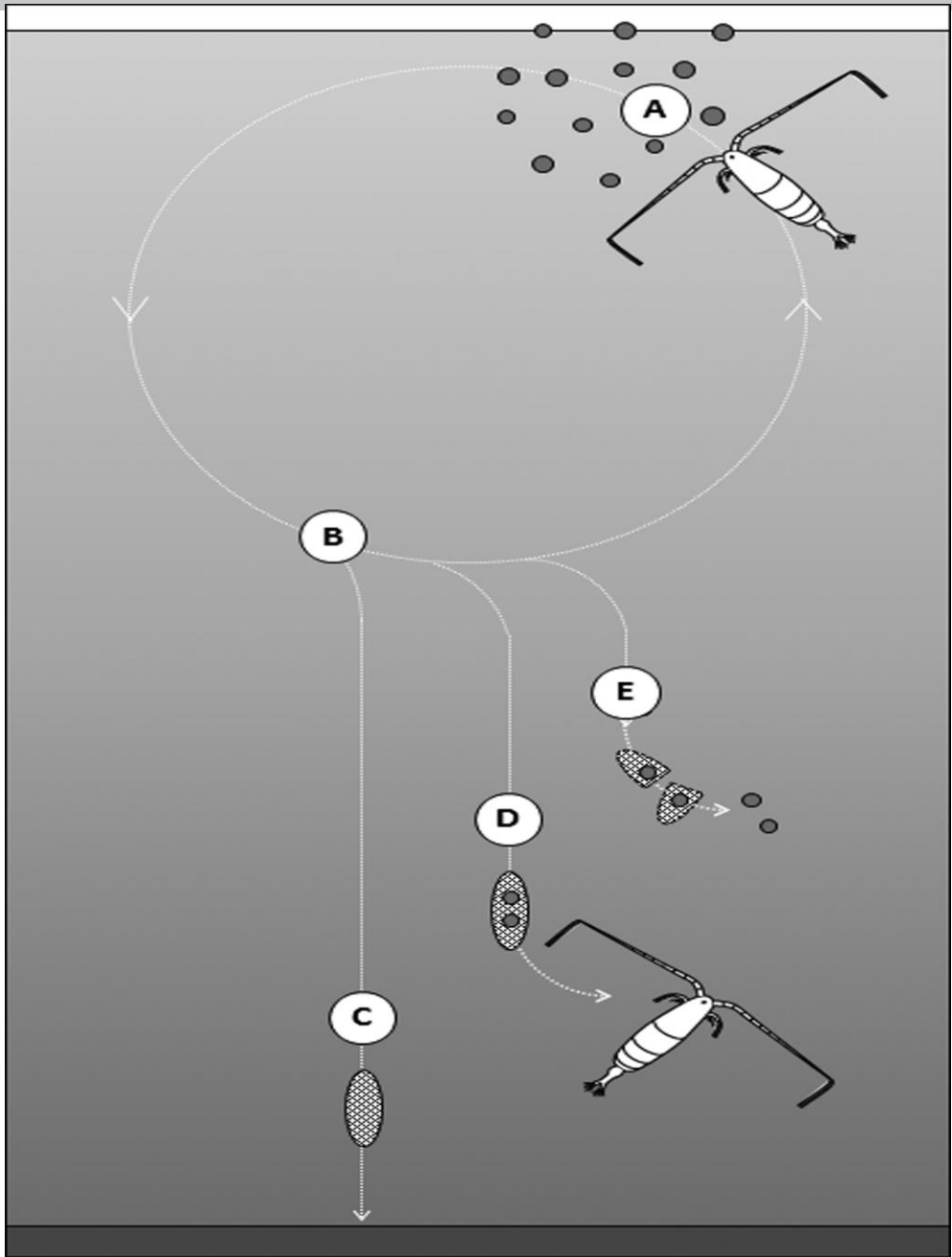
Summary:

Faecal pellets with microplastics

- Less structural integrity
- More likely to break up

Sink more slowly

- Increases opportunity for FP to be eaten
- Trophic transfer of microplastic
- Reduces organic matter reaching benthos
- Increases particulate matter in water column



Cole *et al.* (2016) ES&T

Field-based observations

Biomonitoring studies have confirmed consumption of plastics by wild marine animals:

- Seabirds (Wilcox et al., 2015)
- Mesopelagic fish (Lusher, 2015)
- Estuarine crustaceans (Murray and Cowrie, 2011)
- Intertidal shellfish (Van Cauwenberghe and Janssen, 2014)

Ingestion of Microplastics by Zooplankton

(Desforges, Galbraith and Ross, 2015)
Northeast Pacific Ocean

Copepod	***Neocalanus cristatus***	**1 µP per 17 individuals (556 ±149 µm)**
Euphausiid	***Euphausia pacifica***	**1 µP per 34 individuals (816 ±108 µm)**

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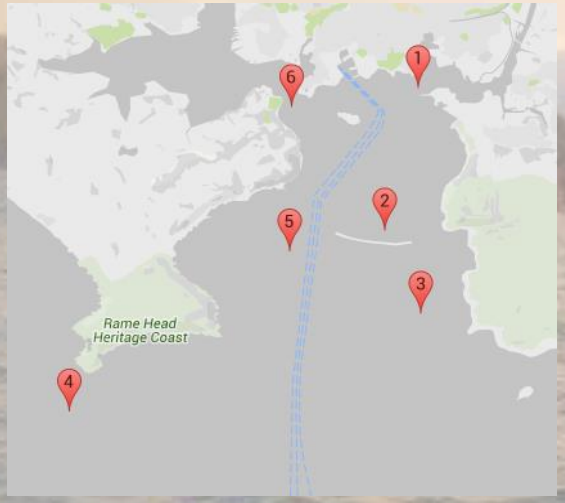
Ingestion in the natural environment

- Six sites selected with hydrodynamic models and sampled across a one year time series



- Determine whether zooplankton in these waters are ingesting microplastics

63 µm – for microplastics

200 µm – for zooplankton distribution

200 µm – for microplastic ingestion

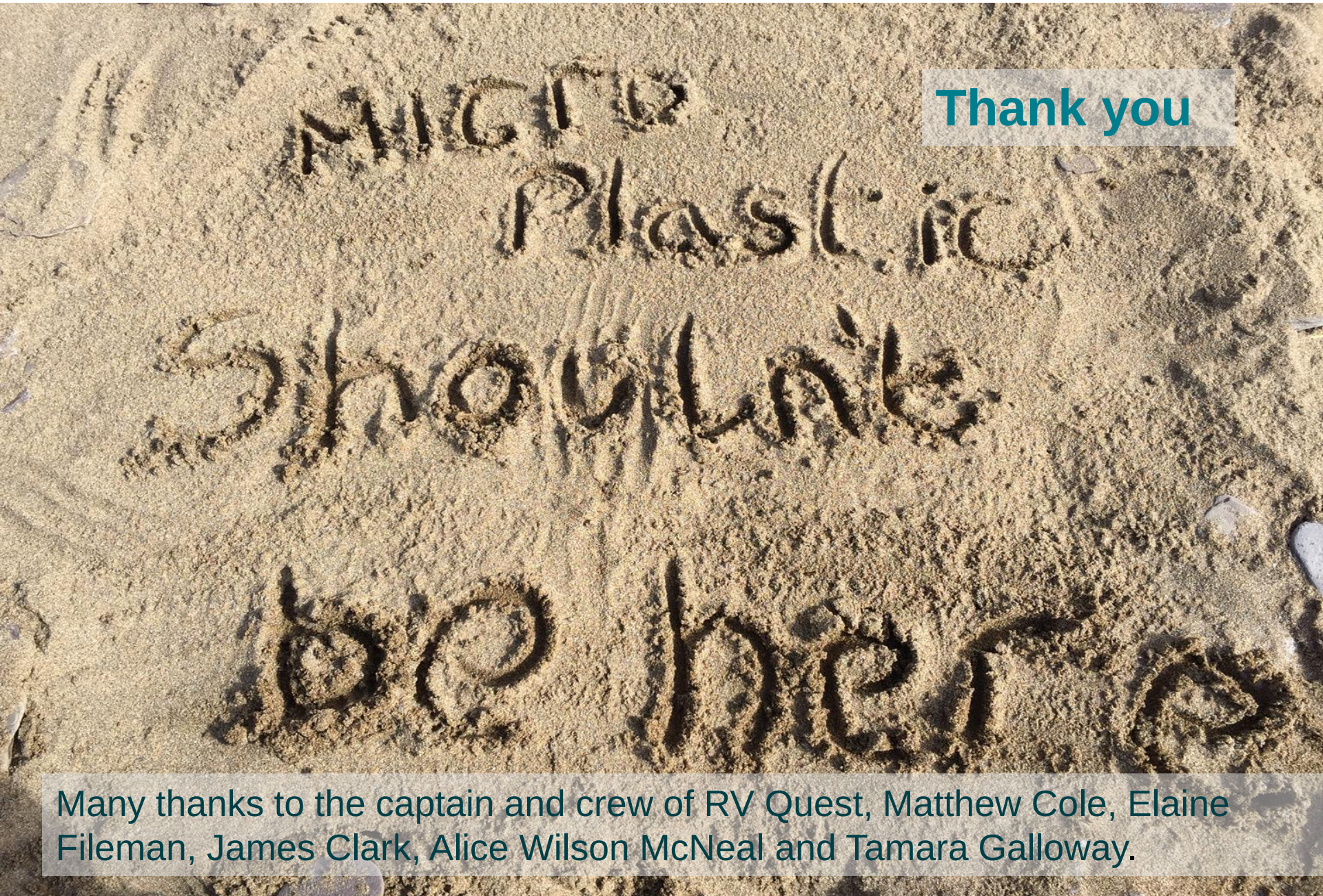
Summary

- Vast quantities of µP in marine environment
- Increasing environmental and economic concern
- Long-term fate of µP poorly understood, marine life may play important role.
- Lab Expts:
  - µP ingested by copepods (alter feeding behaviour, -ve affect reproduction)
  - µP egested in faecal pellets (decrease sinking rate, transport vectors, trophic transfer via coprophagy)
- Ecological context:
  - Zooplankton and µP overlap in marine environment
  - Zooplankton ingest µP in the wild

- More lab expts and field observations needed to clarify the impact of µP on zooplankton and marine ecosystems; including the potential to contaminate the food chain

What can we do?

- Use plastic wisely
- Reduce, reuse, recycle
- Avoid cosmetic products with microbeads
- Help inform and educate the public
- Support a circular economy



Thank you

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