UNIVERSITY OF EXETER

Micro and nano plastics

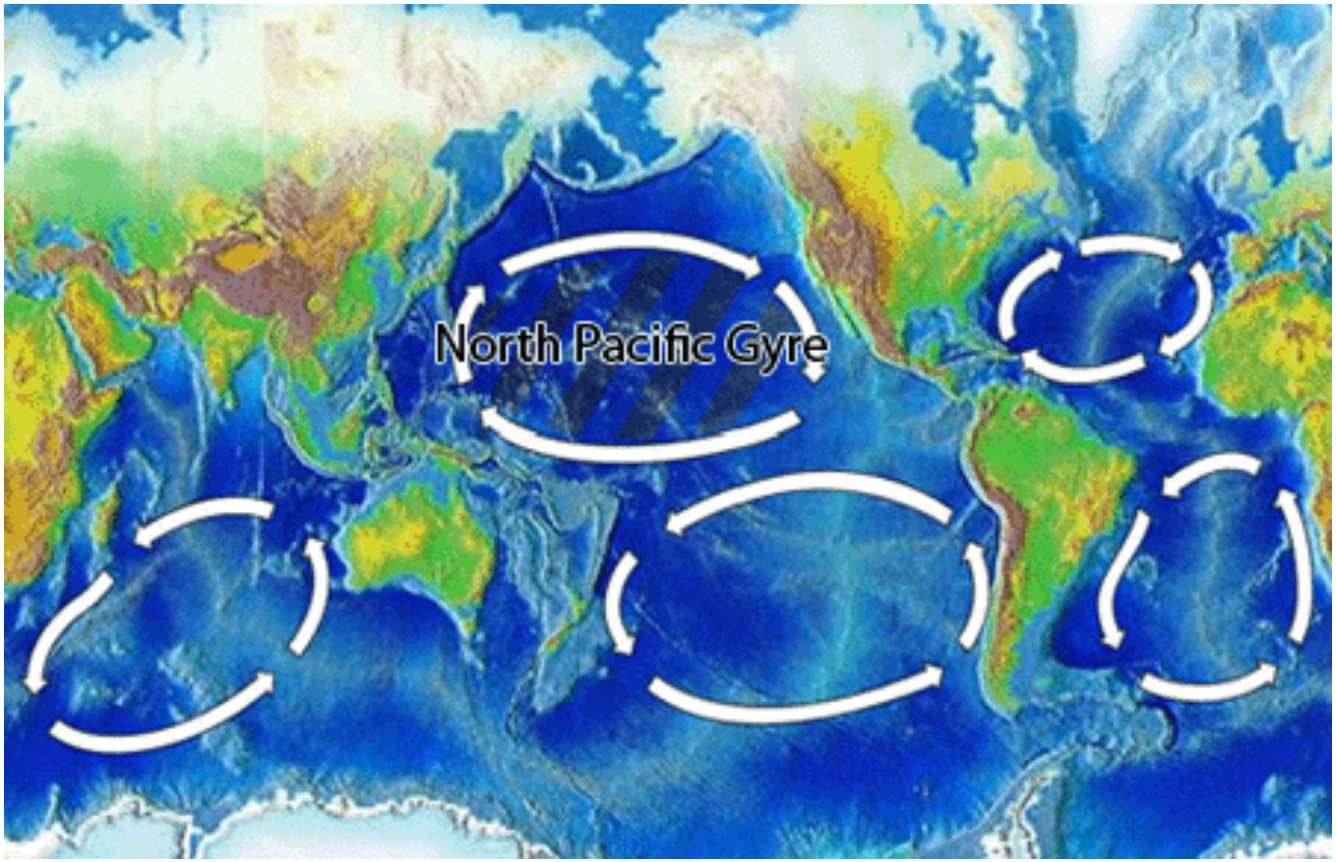
Tamara Galloway
t.s.galloway@exeter.ac.uk


100 µm

LIFE magazine Waste saves time!

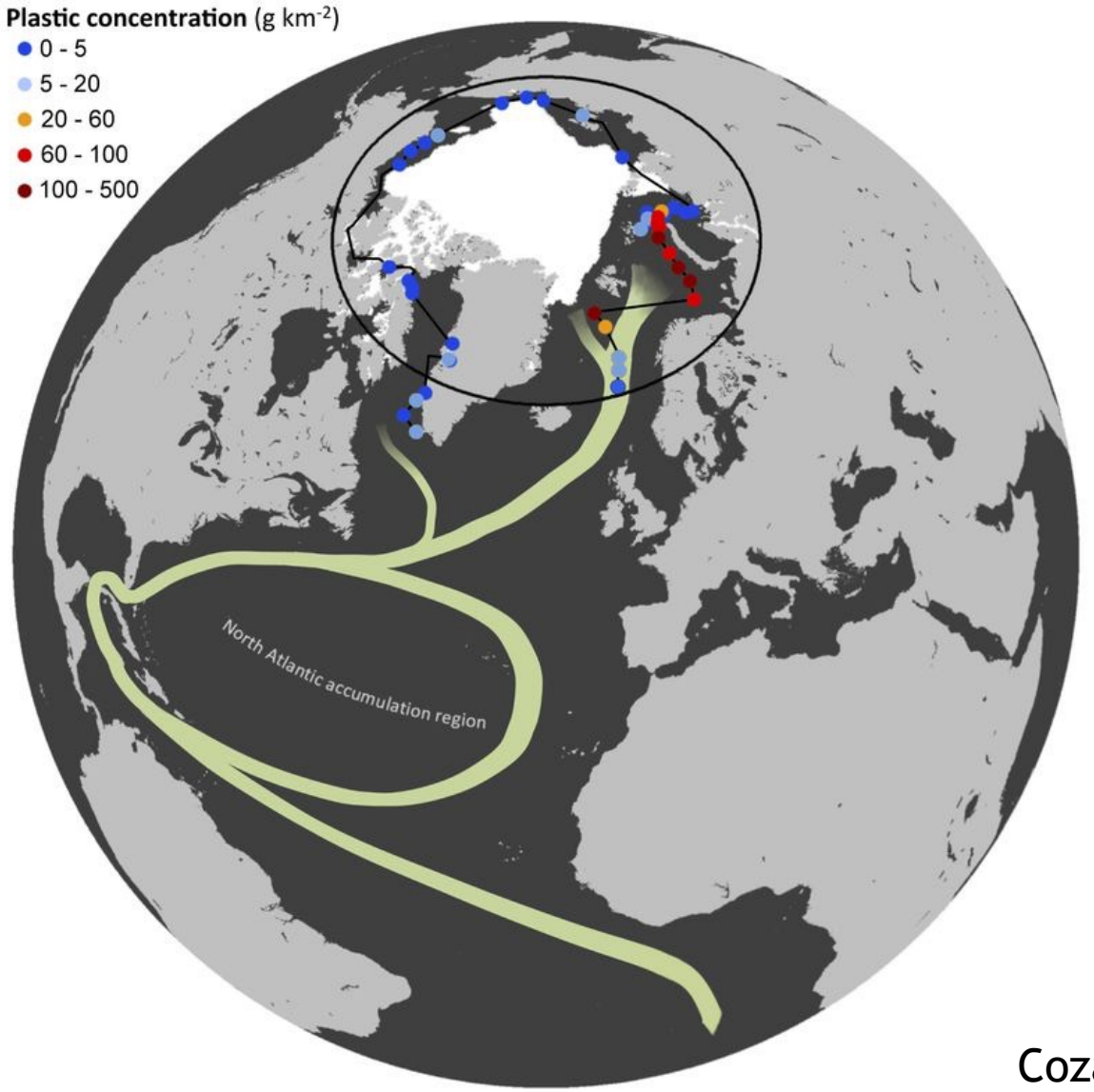
Article from 1955 extolling the labour saving benefits of disposable items: the idea of a throwaway society was born

‘Great pacific garbage patch’



In the Pacific, floating debris accumulates across 700km^2, drawn from USA (~6 years) and Japan (<1 year)

… even in the remote Arctic

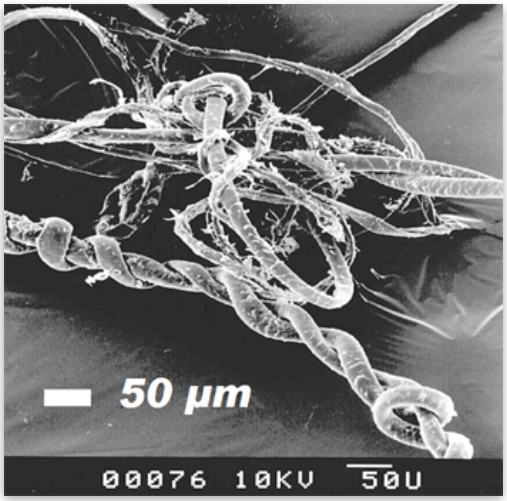


Cozar et al 2017

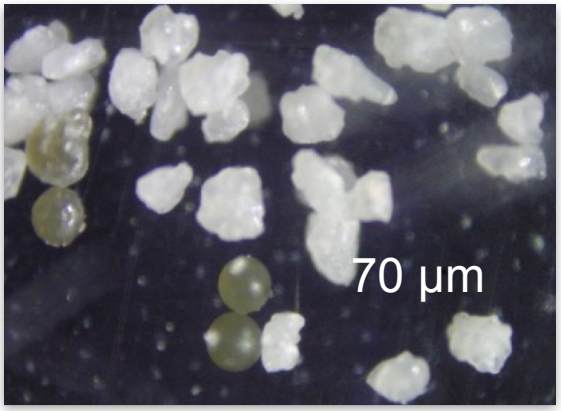
Photo: Connor Mc Donald

Microplastics

- Microscopic plastic fragments, fibres and beads <5 mm in diameter



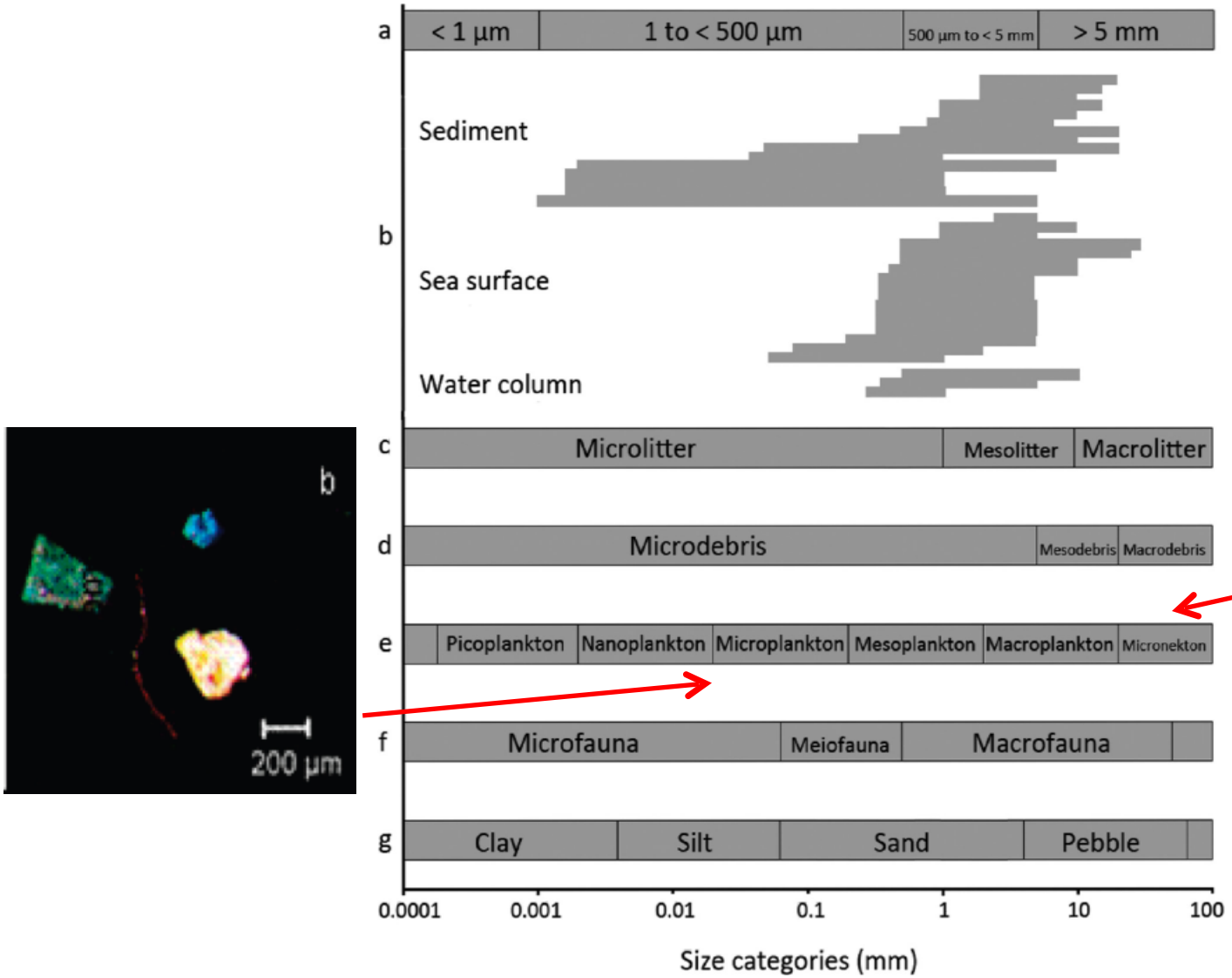
Clothing, rope, smoked cigarette butts

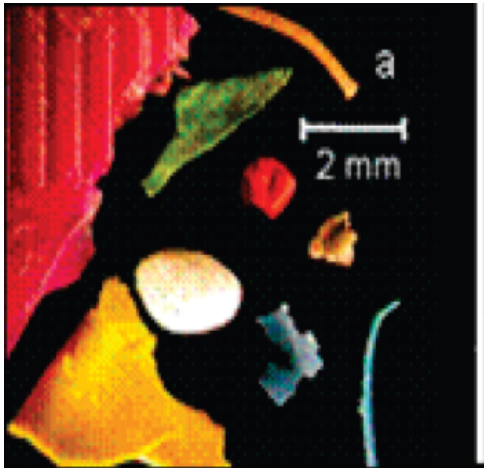


Cosmetic microbeads

Cole et al., Mar Poll Bull, 2011

Dimensions of ‘microplastics’

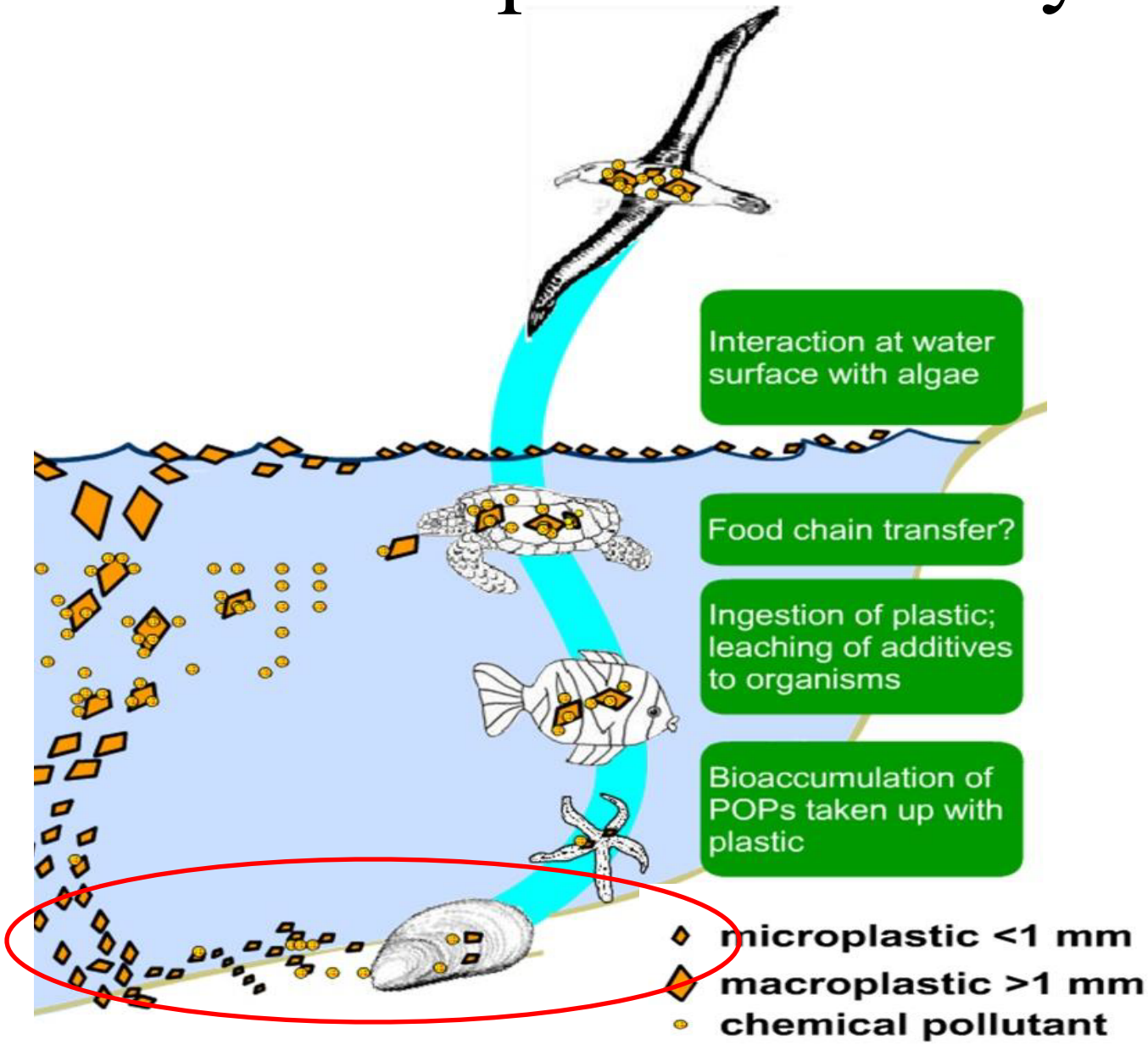




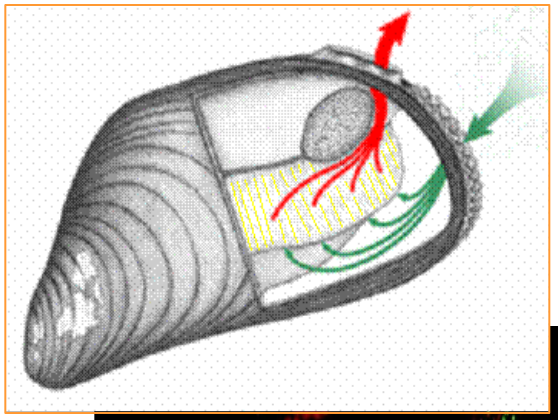
Hidalgo et al., 2012

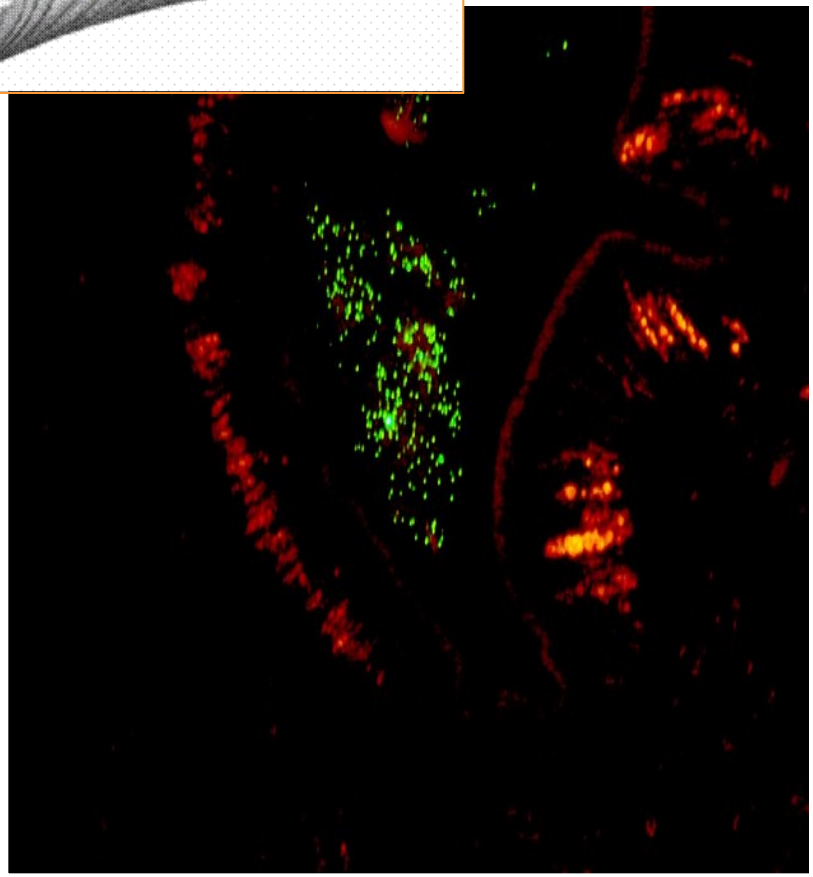
Is microplastic ingested?

Which species to study?

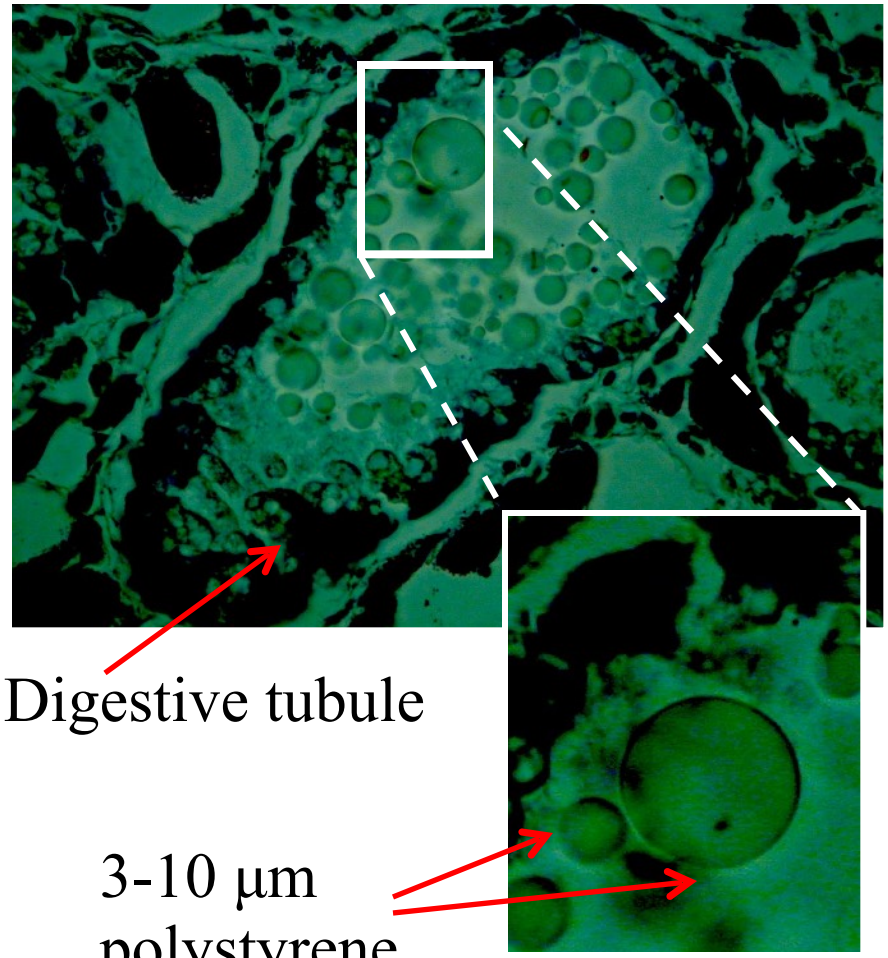


Particles are ingested and pass to the digestive tubules





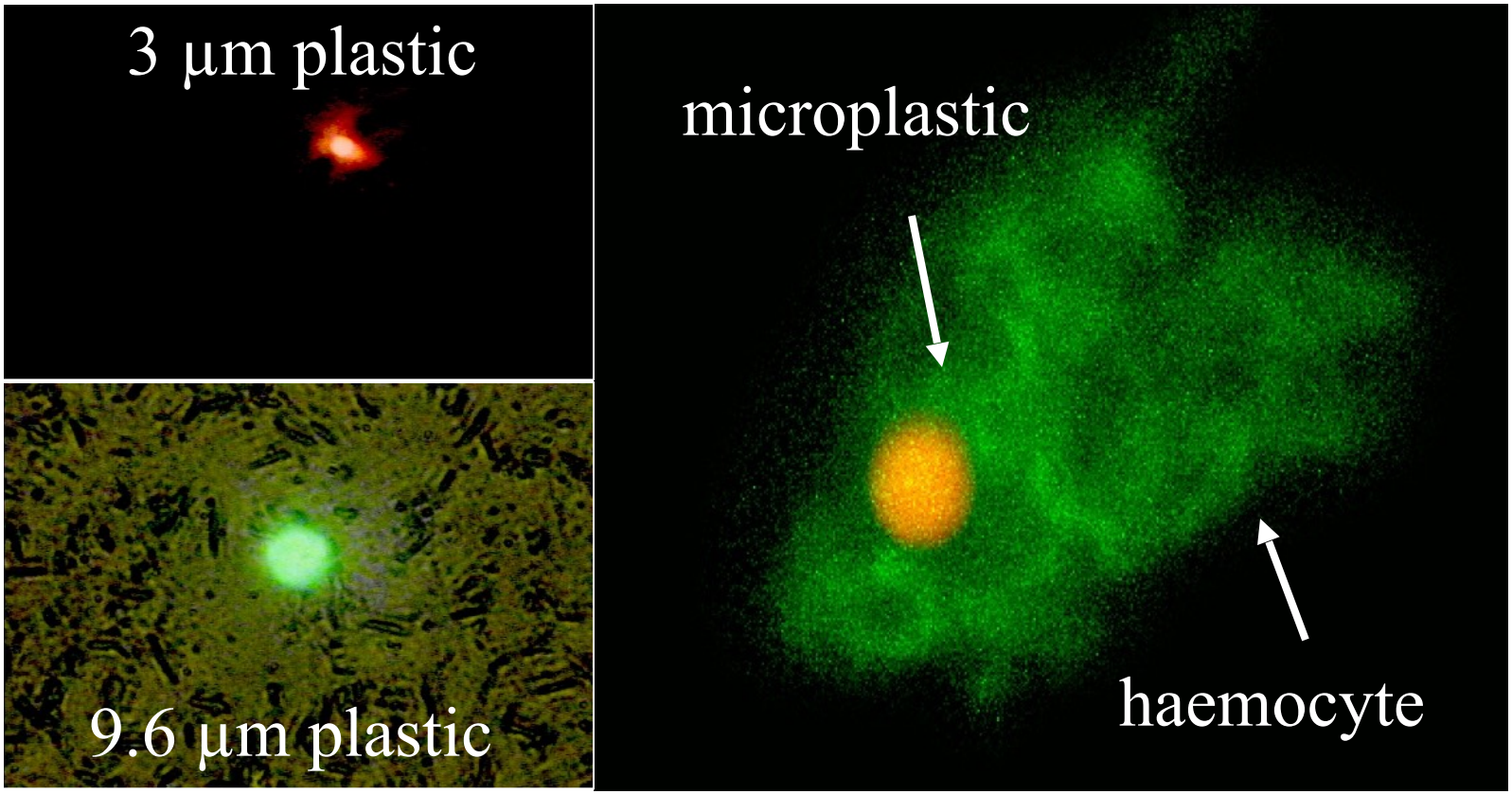
3 µm fluorescent polystyrene in gut cavity of *M. edulis*



Browne *et al*., ES&T 2007

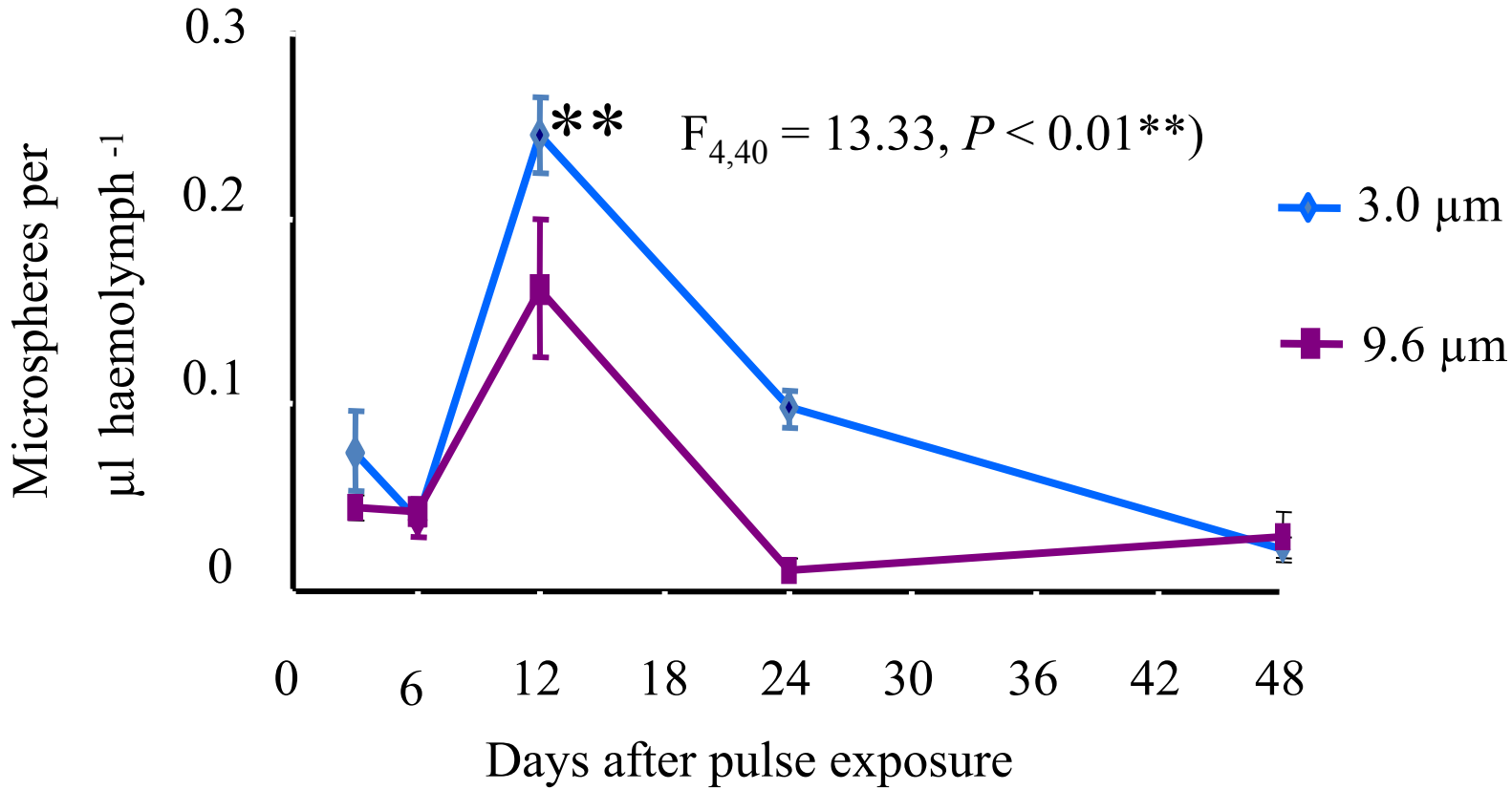
And accumulate in haemolymph

Both sizes found in haemolymph and haemocytes



Browne et al., ES&T 2007

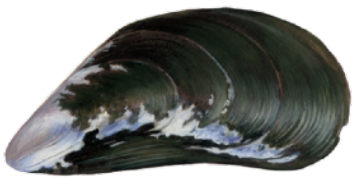
Particles are retained for up to 48 days

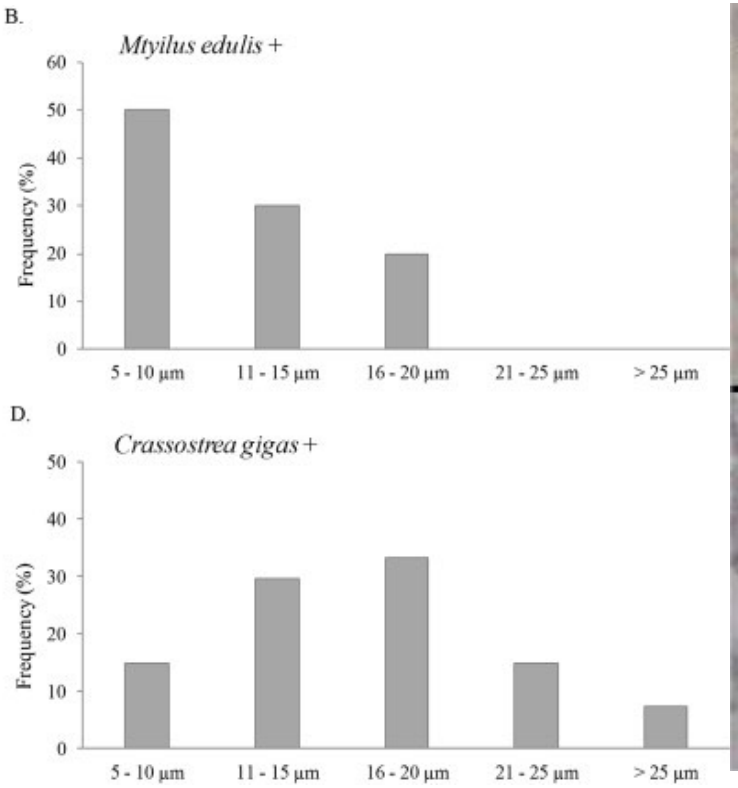


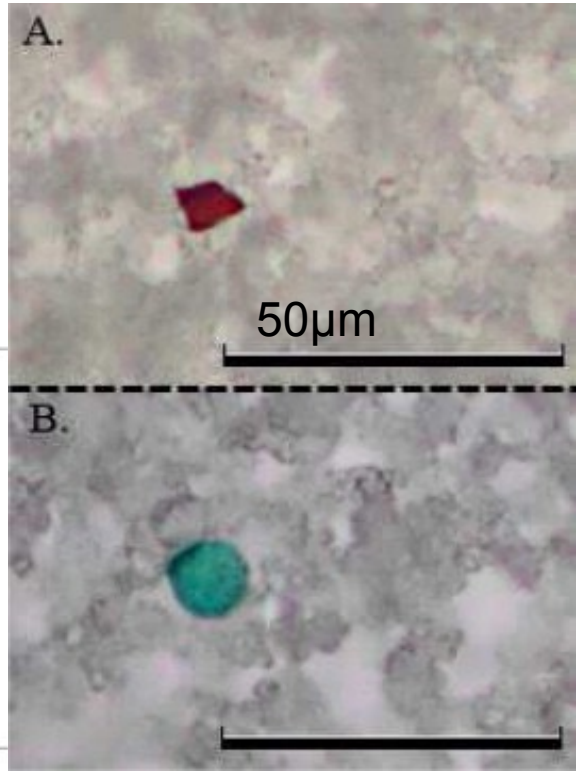
3.0 > 9.6 µm ($F_{1,40} = 9.87$, $P < 0.01$ **)

Browne et al., ES&T 2007

Microplastics in bivalves cultured for human consumption



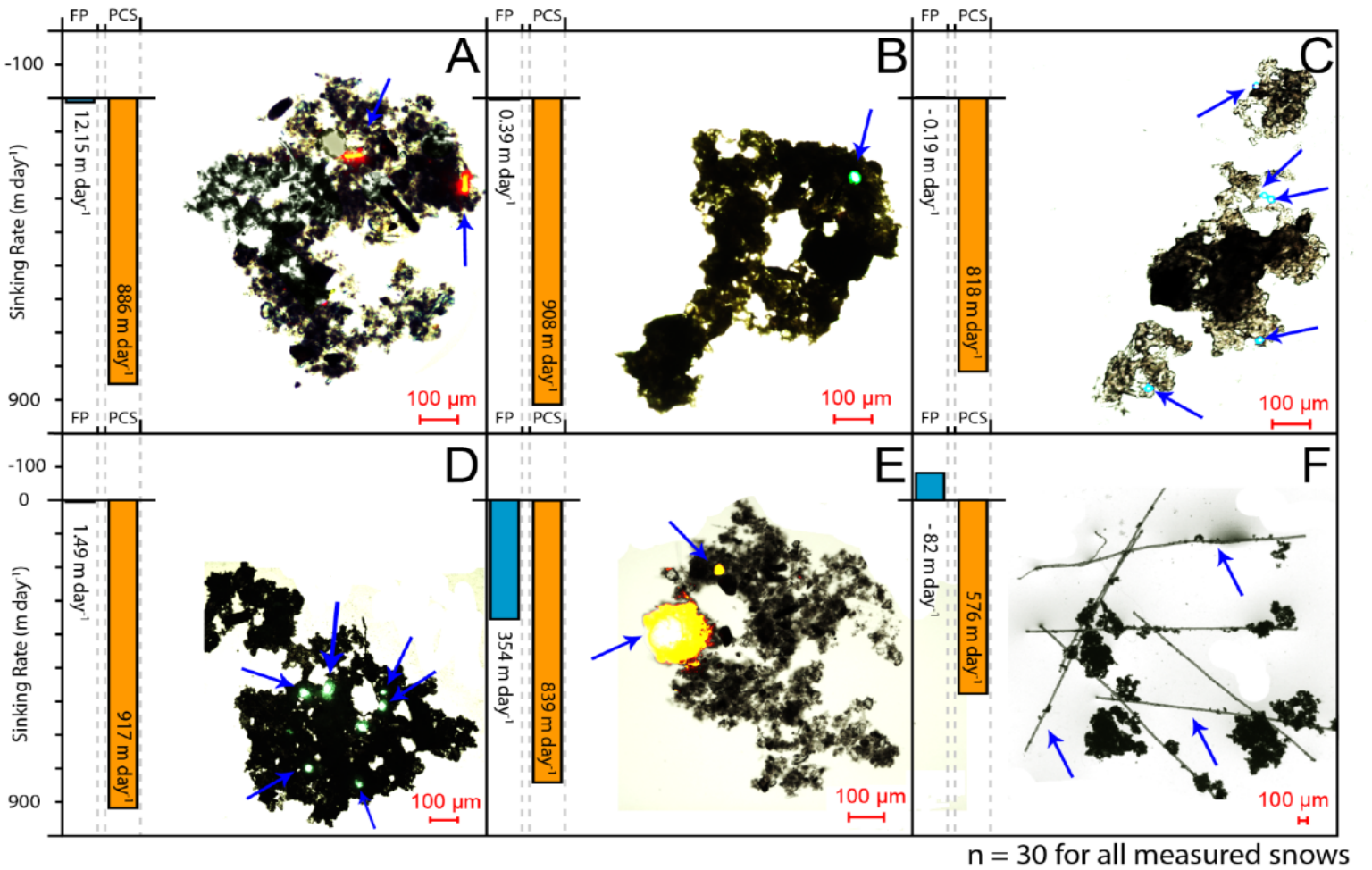




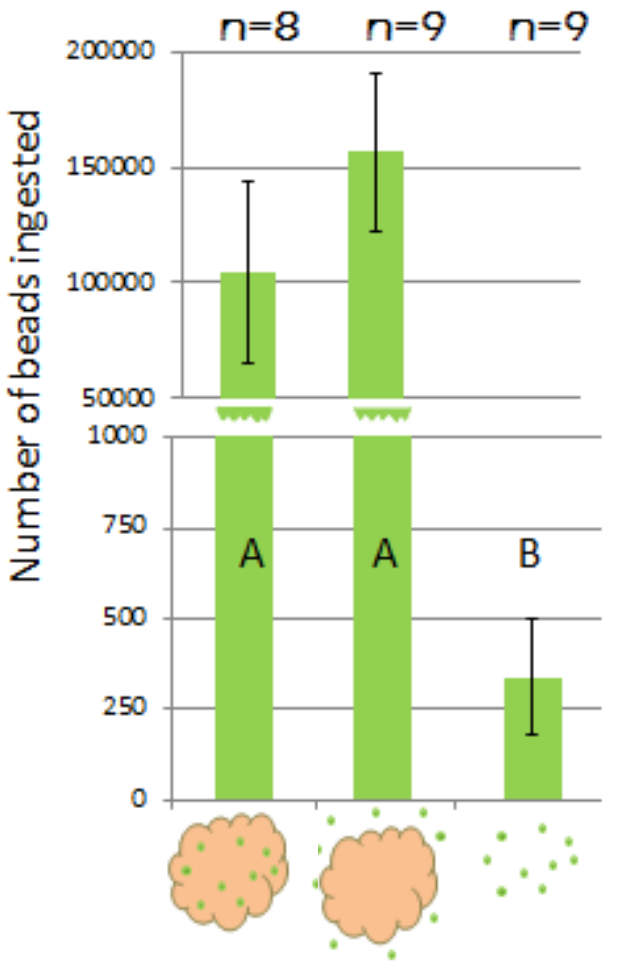
mean 0.36 ± 0.07 particles g^{-1} mussel, = average person consumes 11,000 particles per year from seafood

Van Cauwenberghe and Janssen, 2014 Env Poll 193:65-70

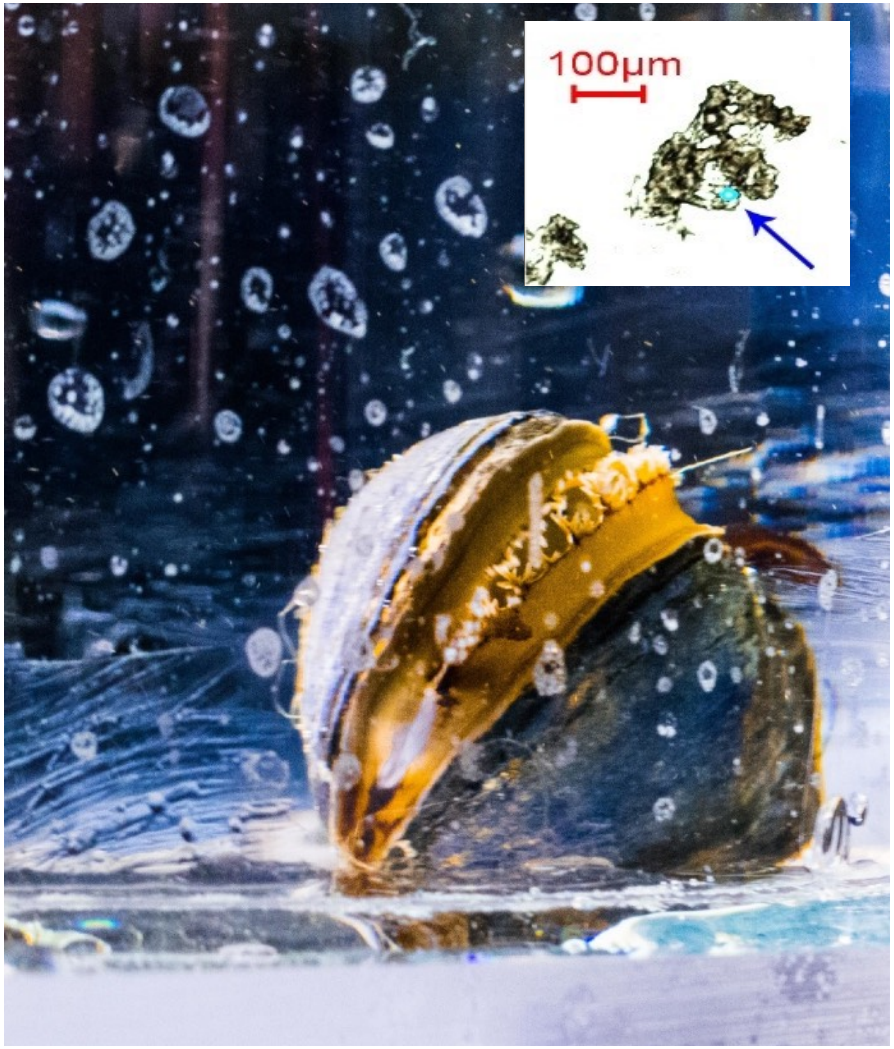
Marine snow


FP
PCS
A
B
C
D
E
F
-100
0
900
Sinking Rate (m day⁻¹)
12.15 m day⁻¹
886 m day⁻¹
0.39 m day⁻¹
908 m day⁻¹
- 0.19 m day⁻¹
818 m day⁻¹
1.49 m day⁻¹
917 m day⁻¹
354 m day⁻¹
839 m day⁻¹
- 82 m day⁻¹
576 m day⁻¹
100 µm
n = 30 for all measured snows

Marine snows enhance ingestion



ANOVA: F (3, 32) = 12.38, p = <.0001

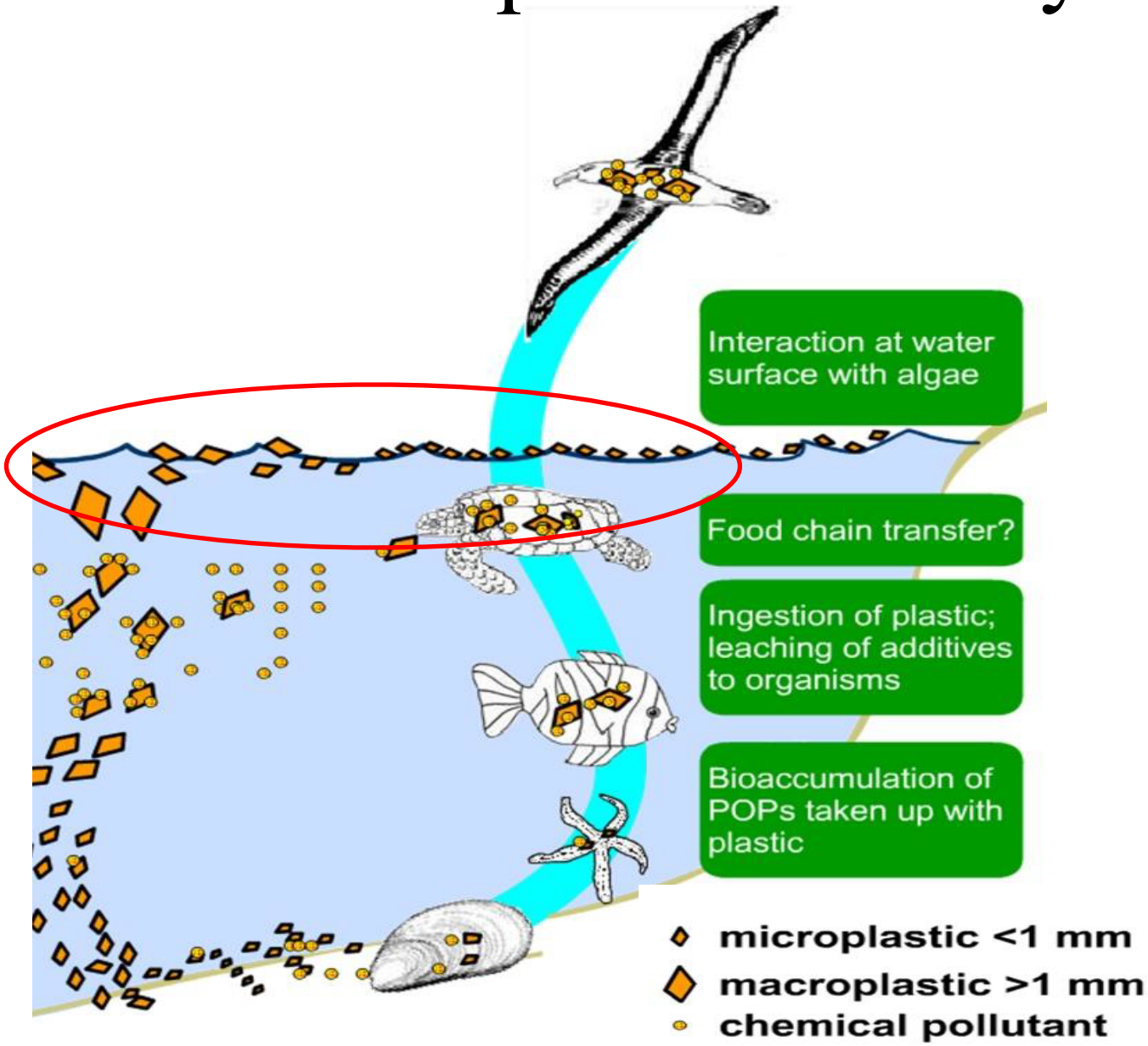


Porter et al in review

Biological effects?


~1 million seabird, >100,000
marine mammals killed/maimed
each year (UN 2012)

Which species to study?

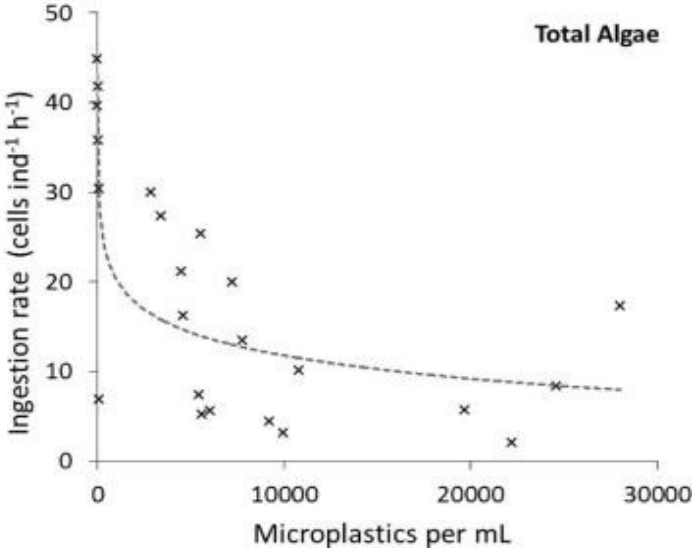


Cole et al., ES&T 2013

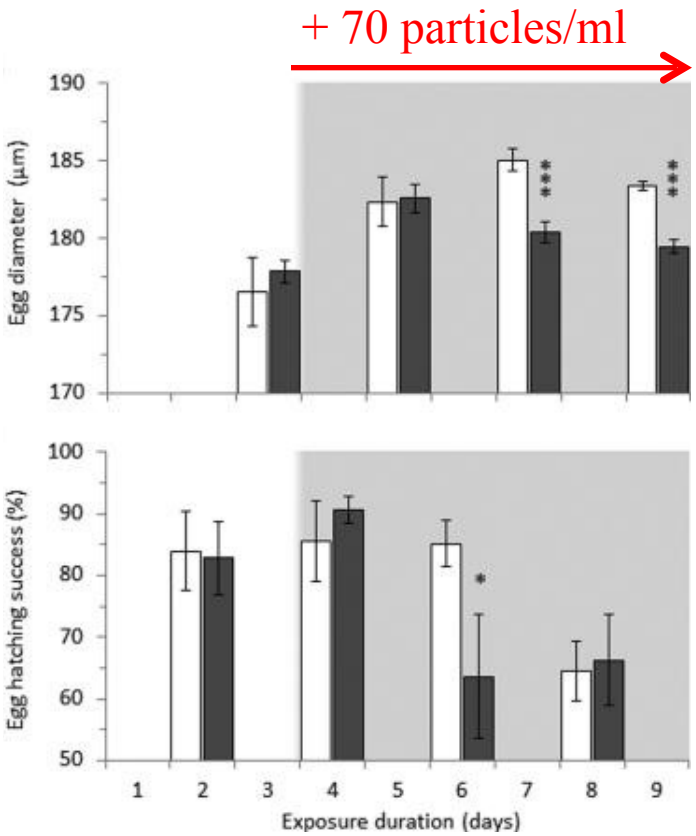
Centropages typicus

30 µm microbeads extracted from Clearasil facewash

Biological effects

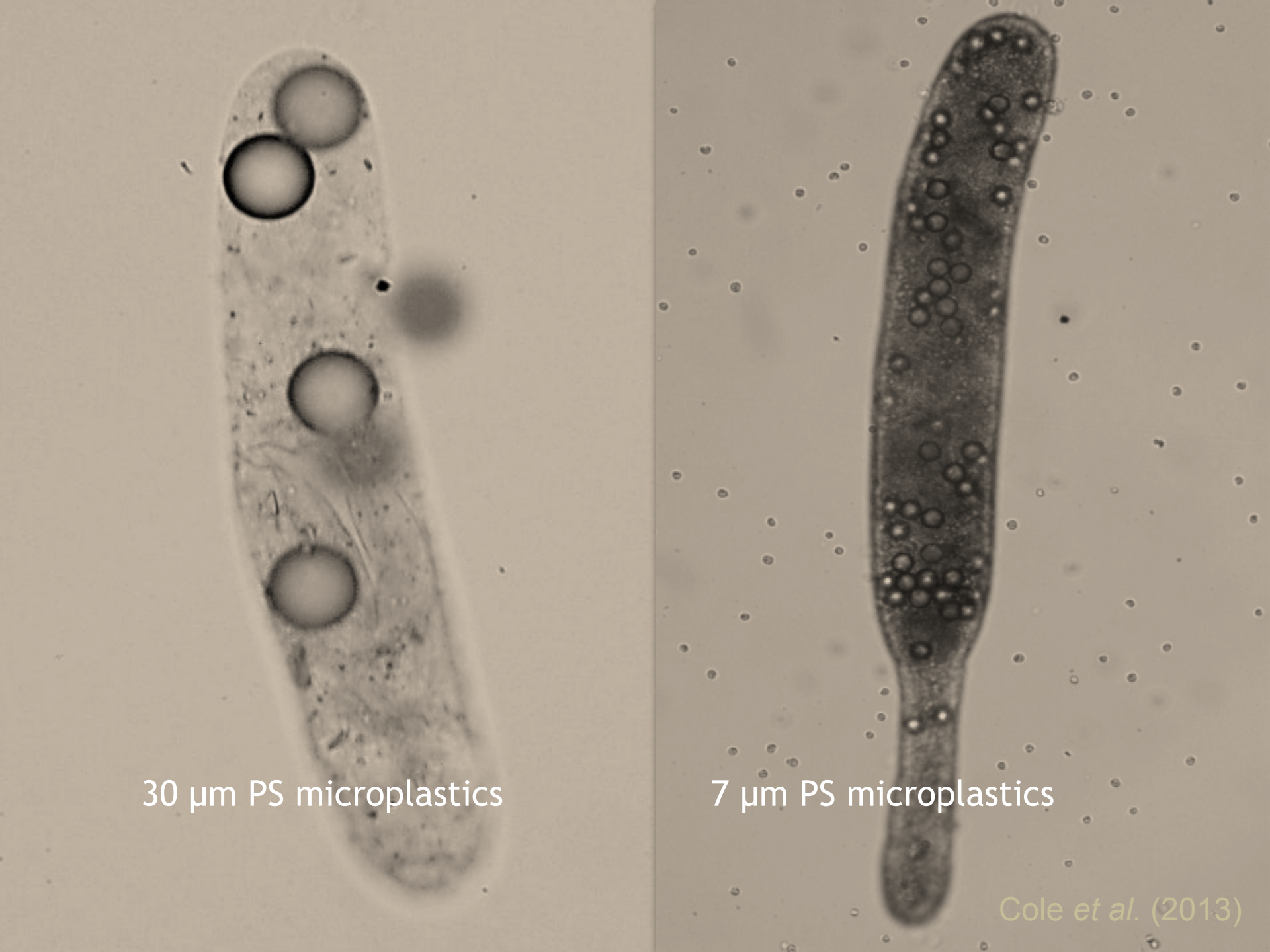


reduced algal feeding over 24h

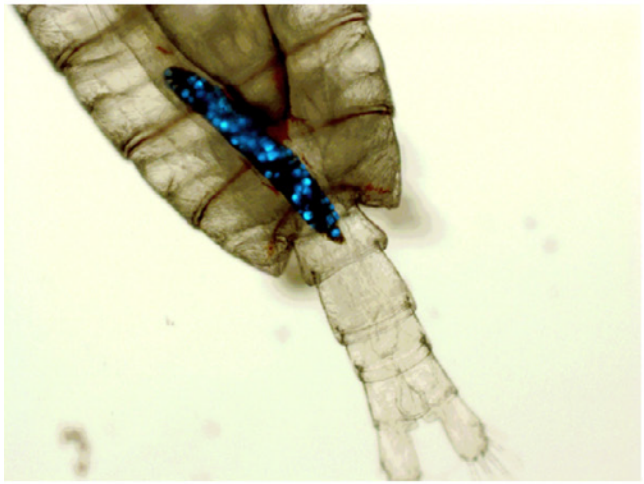


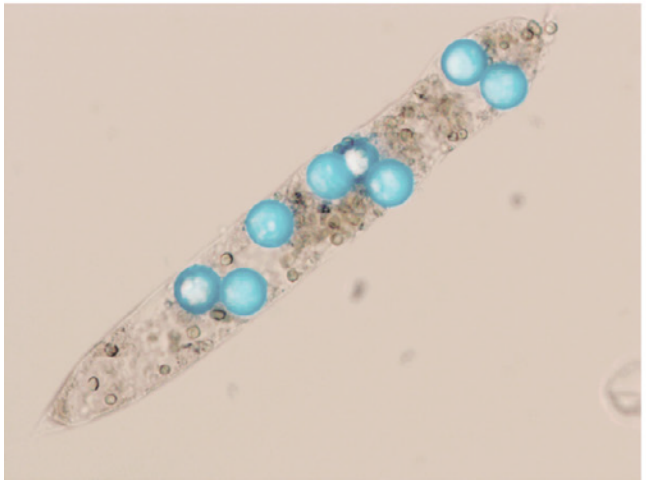
reduced fecundity after 10 days

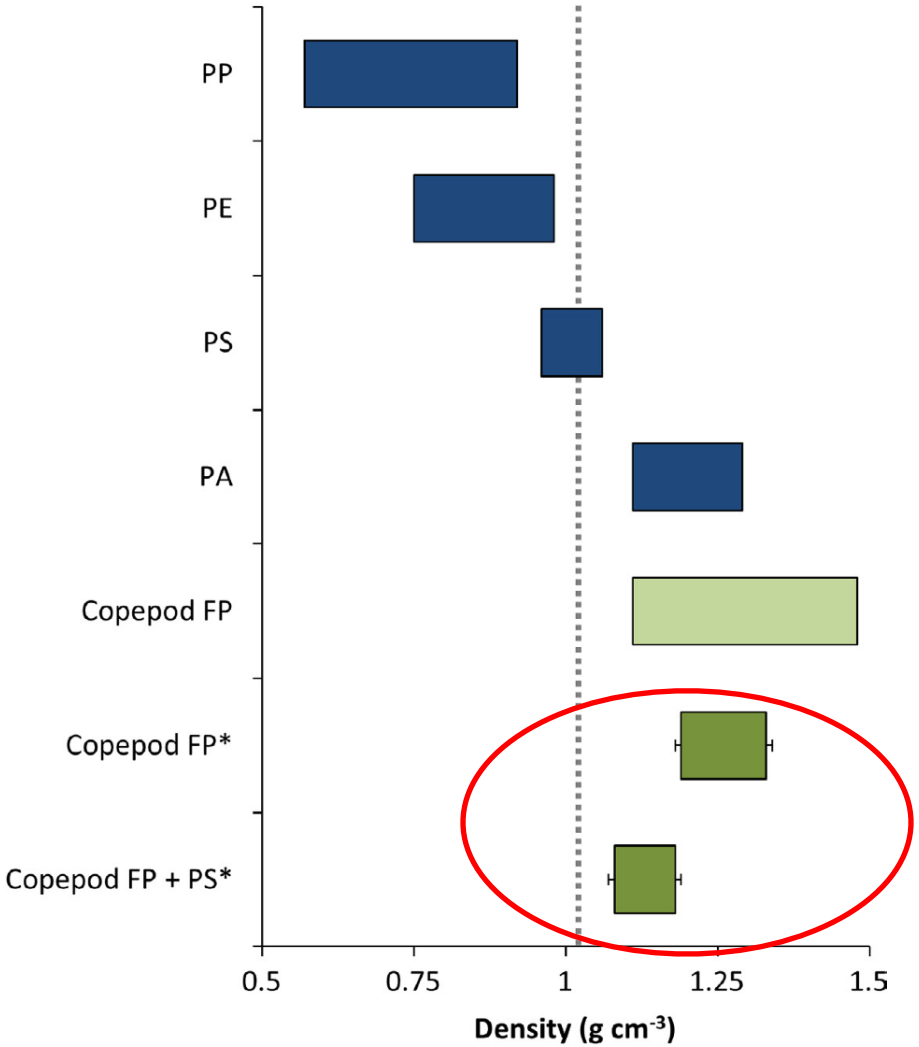
Cole et al., 2015 ES&T


30 µm PS microplastics
7 µm PS microplastics
Cole *et al.* (2013)

Do plastics alter faecal pellets?



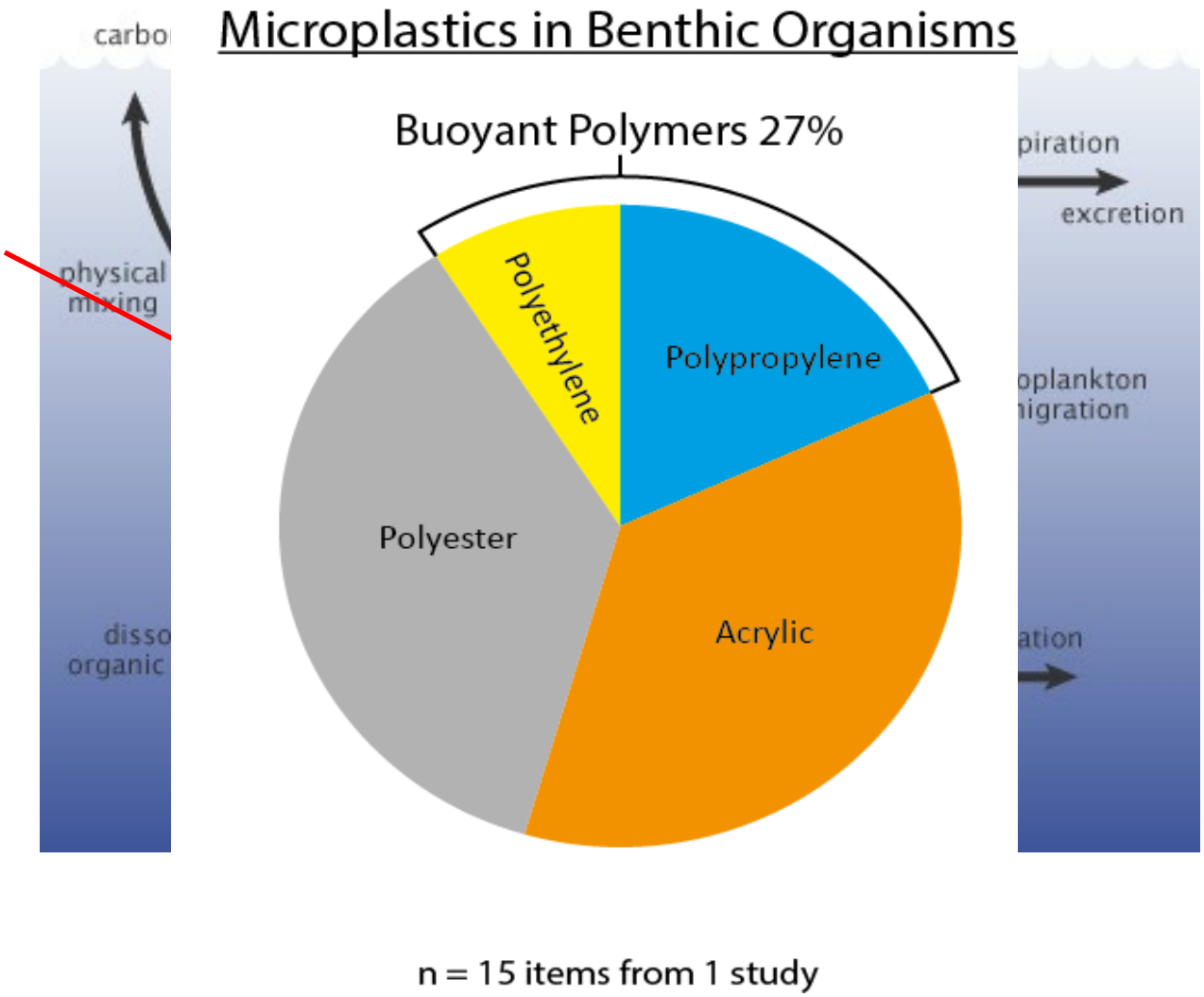




Cole et al 2016 ES&T

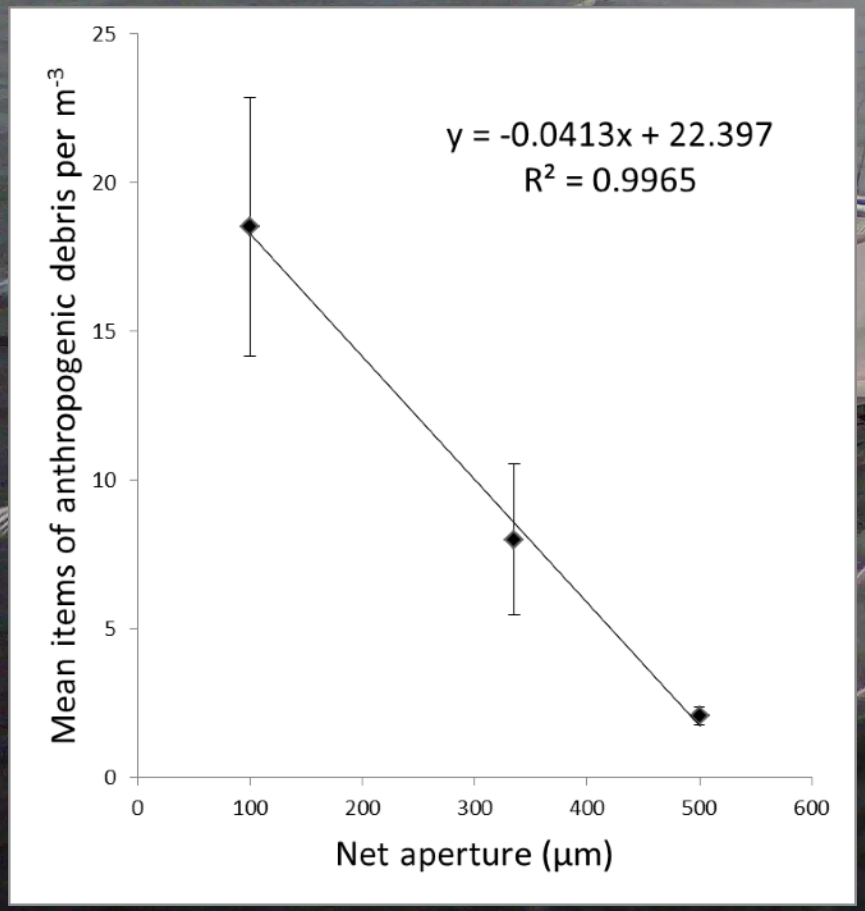
Ecological consequences

- Altered carbon cycling in the ocean?
- Microplastic sink?
- Transport of contaminants?

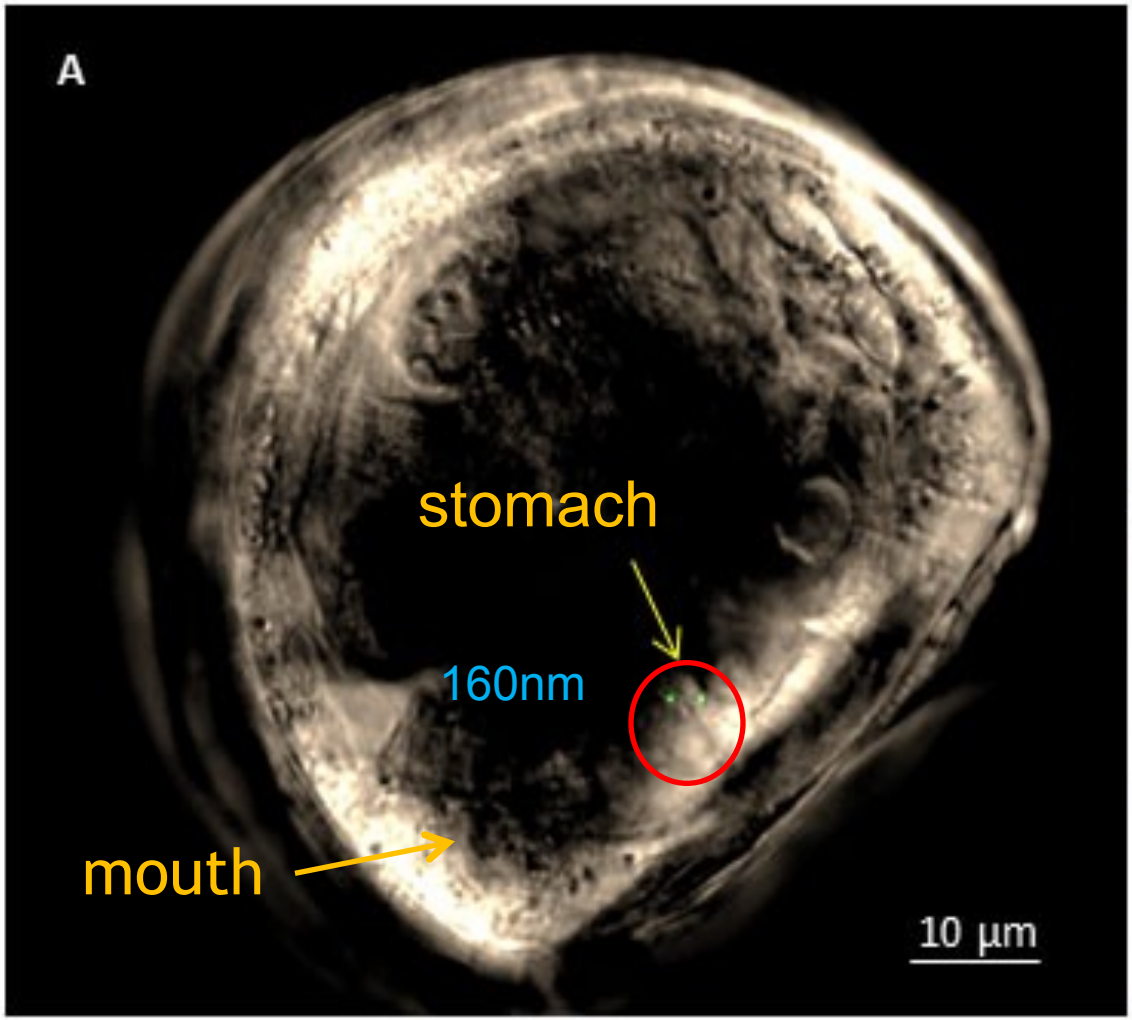


Micro versus nano

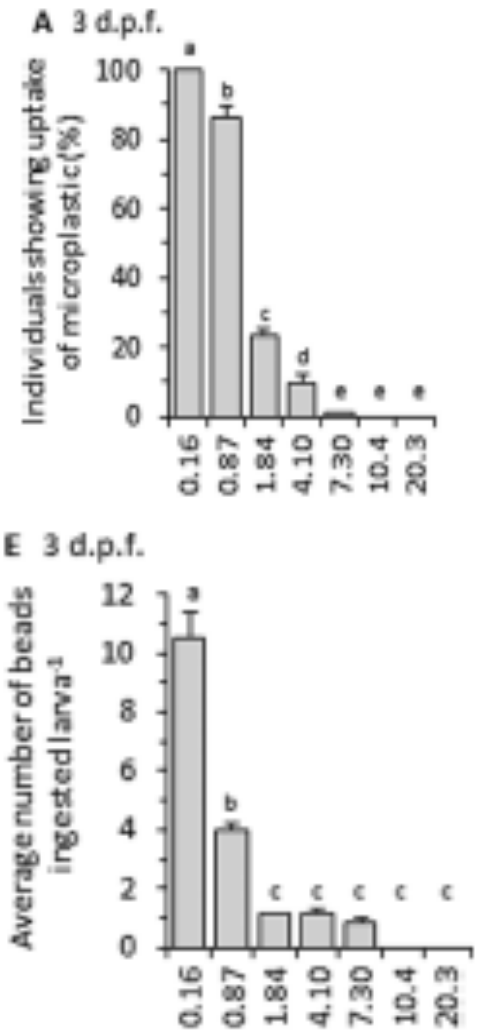
Smaller net, more particles



Oysters: Size selectivity

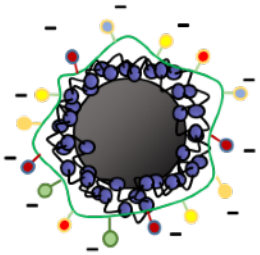


3 day old oyster larvae



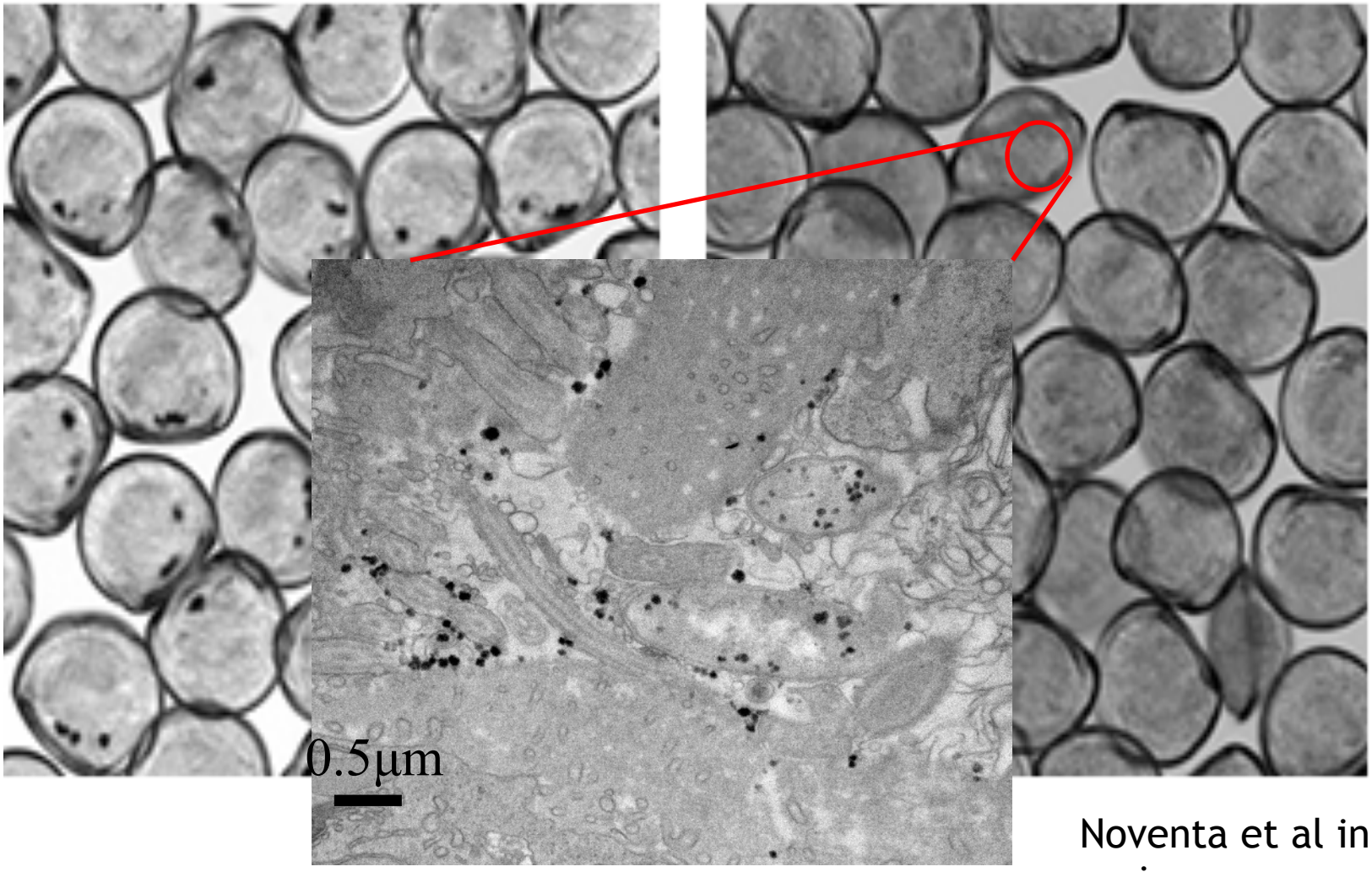
Cole et al 2016 ES&T doi: 10.1021/acs.est.5b04099

Translocation into tissues



+ 5mg/ml humic acid

+5 mg/ml BSA

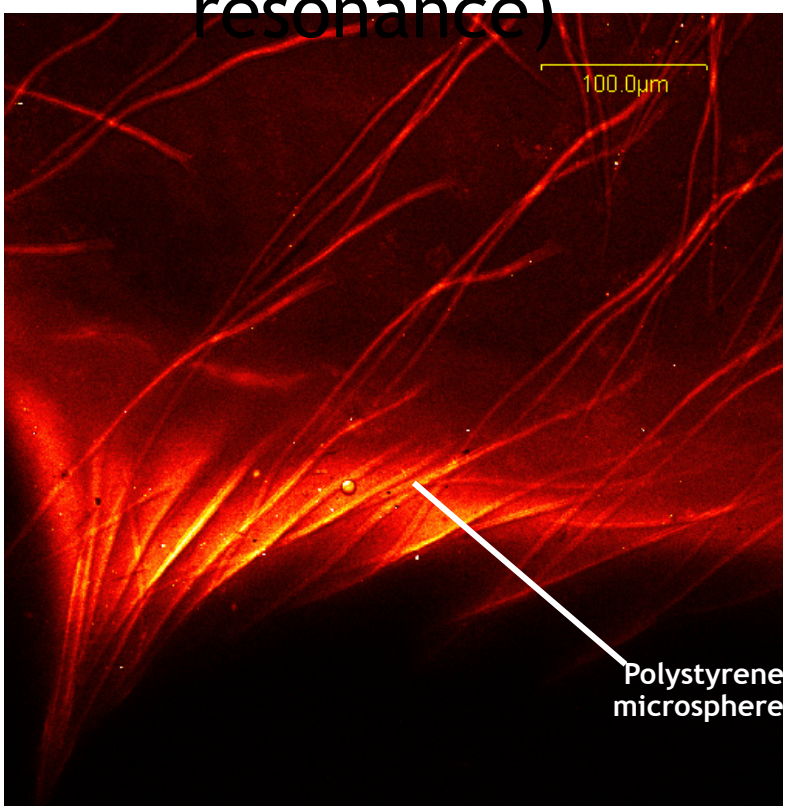


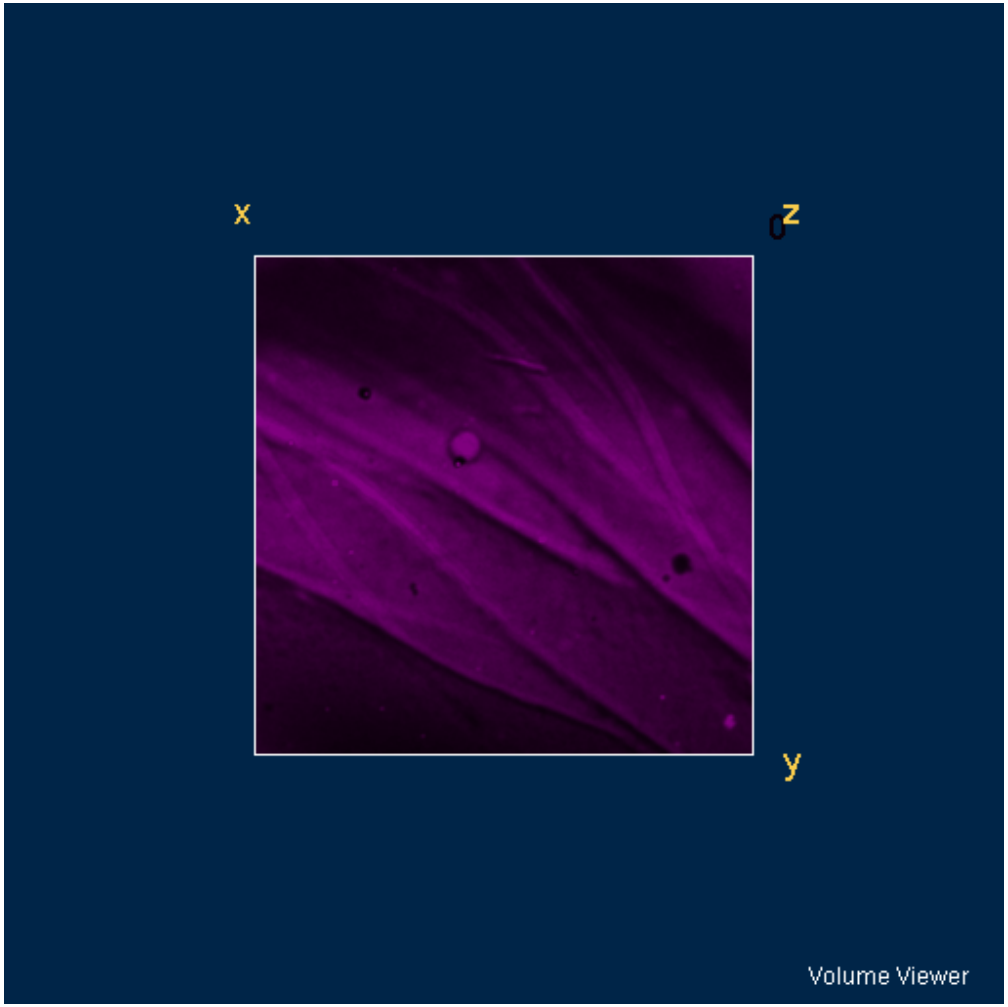
Noventa et al in

Identifying nanoplastics *in situ*

Coherent anti-Stokes Raman spectroscopy

Raman scattering image at 2845 cm^{-1} (C-H bond resonance)



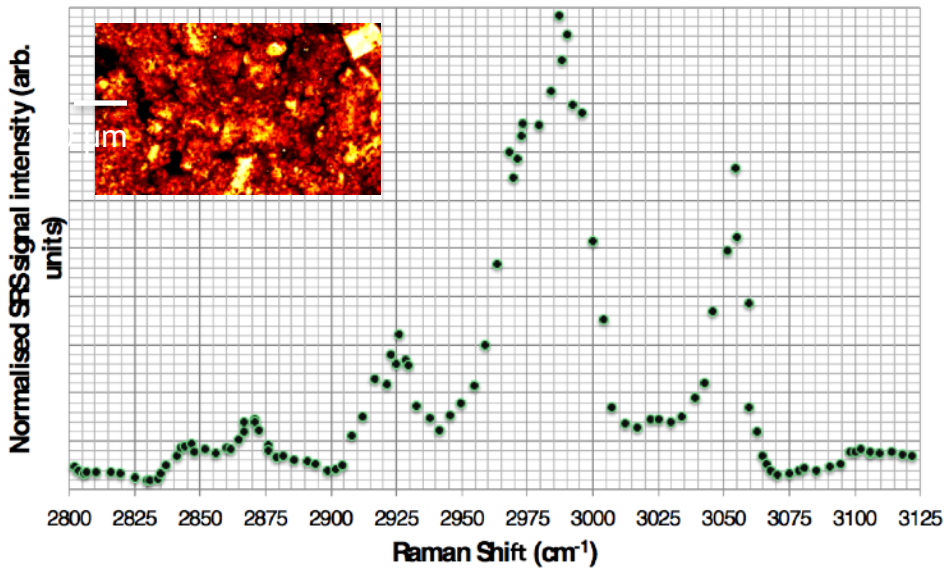


Watts et al., 2014 ES&T

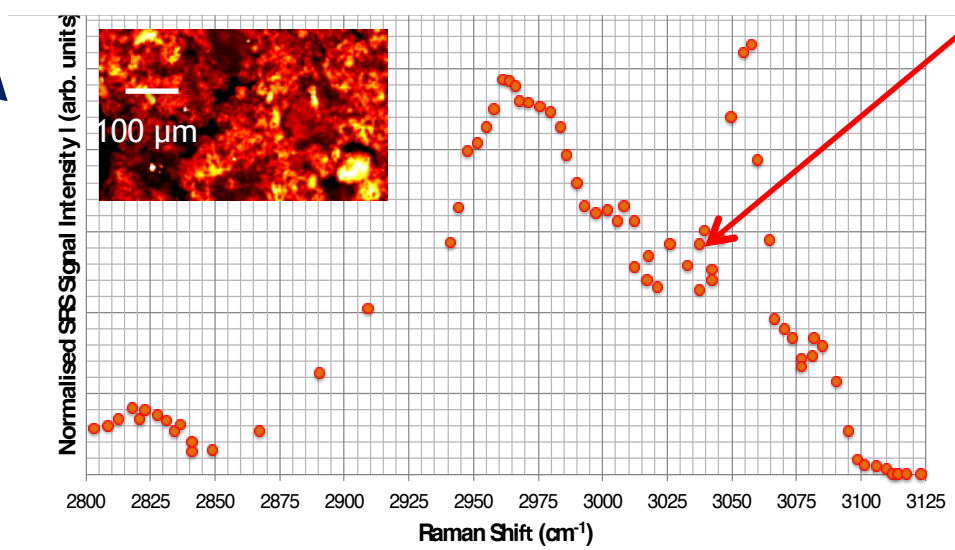
Hyperspectral Synchronised Raman

fish food spiked with 0.01% 70nm nanoplastic (Acrylic ester)

CH_2 Raman resonance at 2845 cm^{-1}.

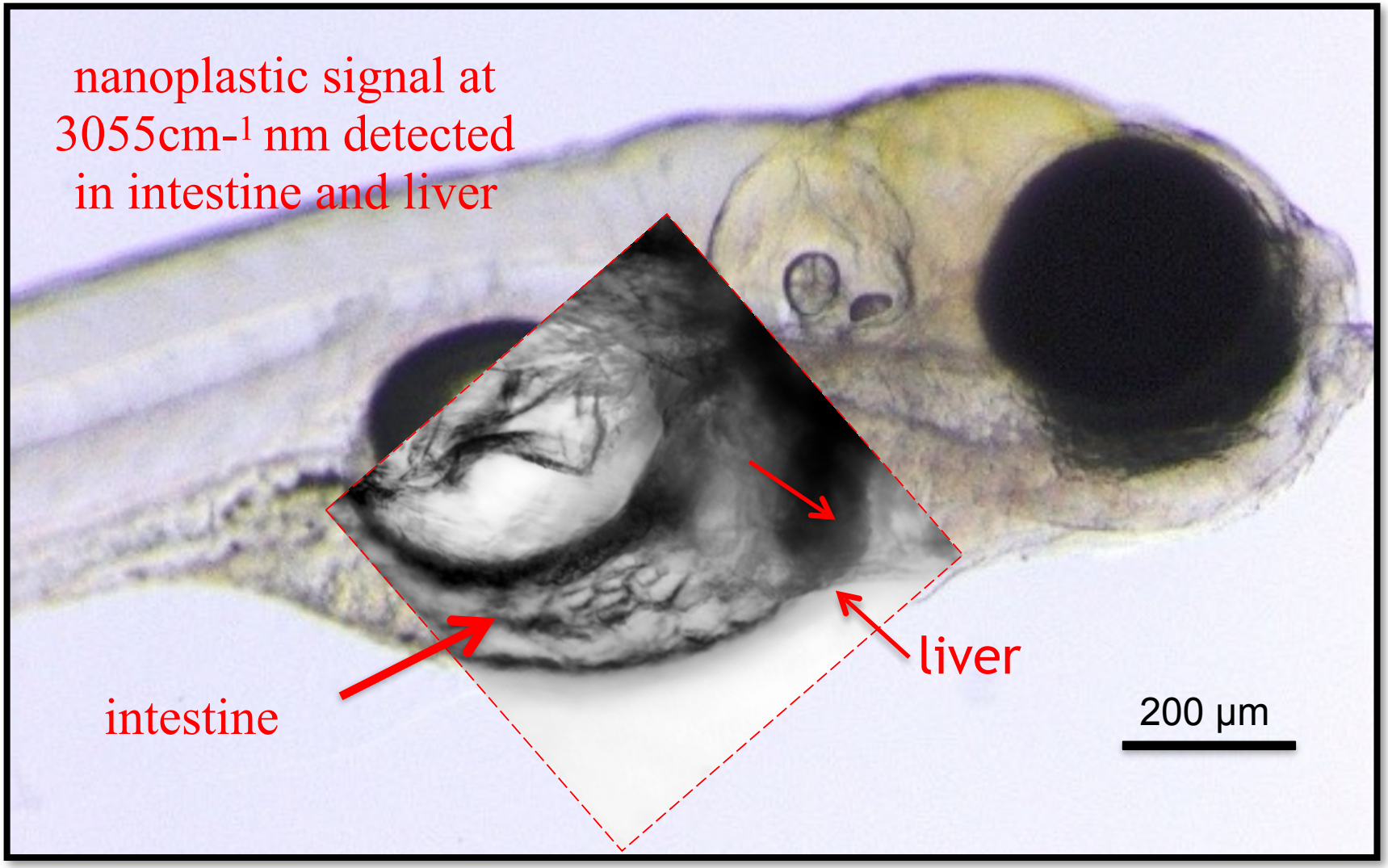


benzene ring marker peak at 305 cm^{-1} = Acrylic este

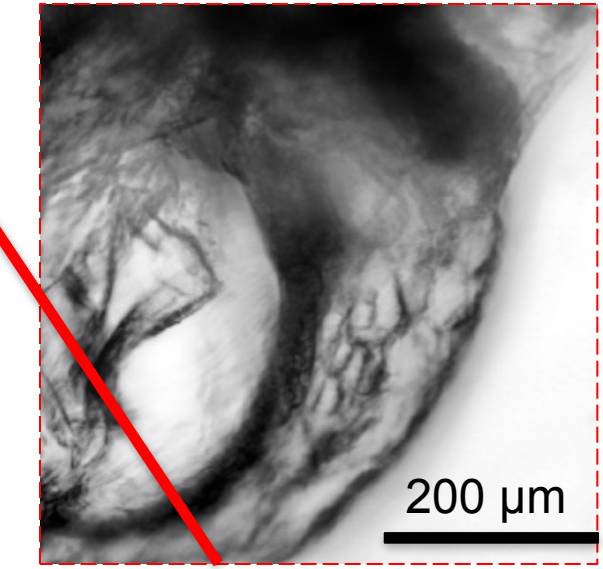


Ingestion by zebrafish

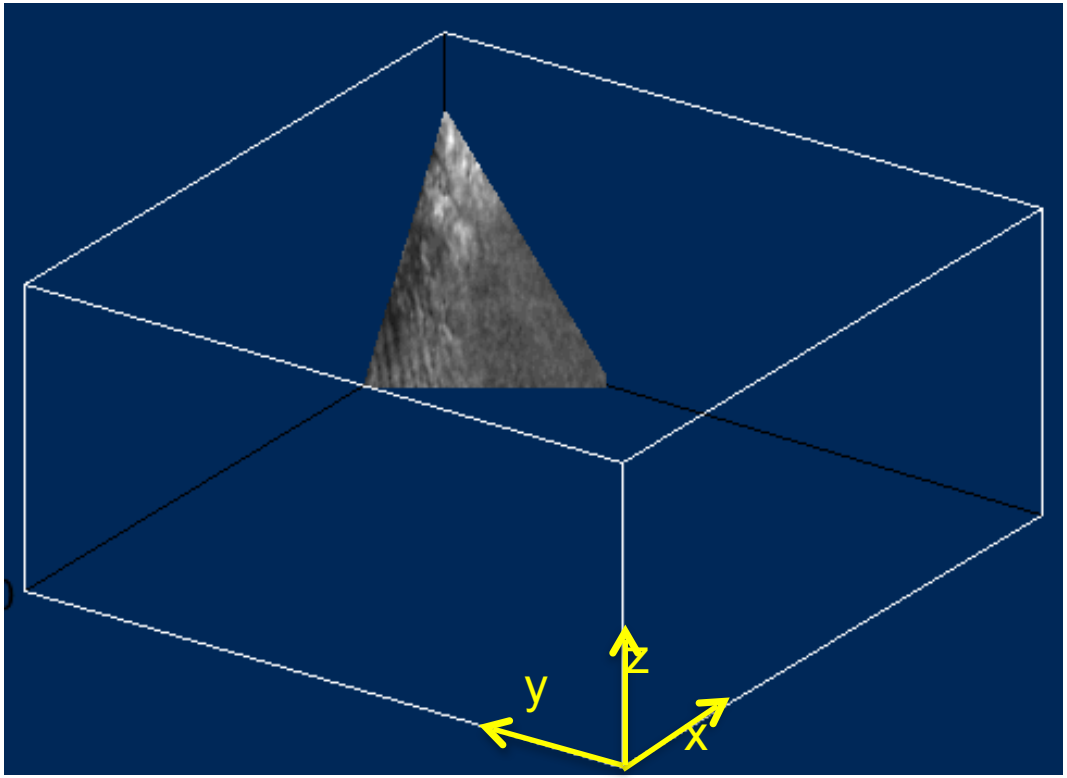
fish fed with food spiked with 0.01% acrylic ester nanoplastic

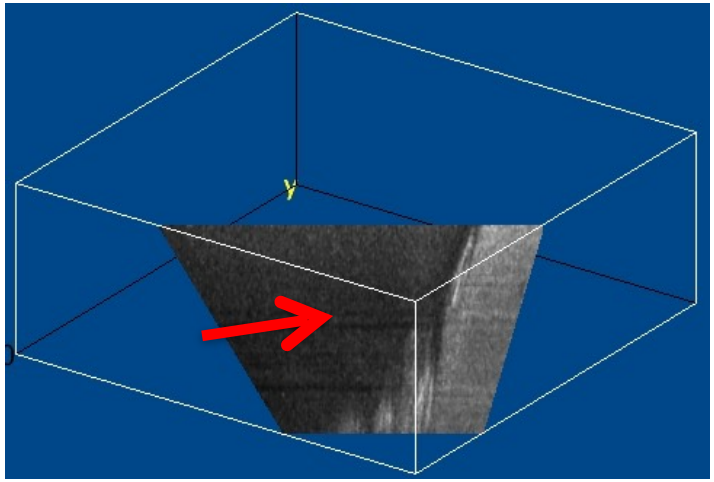


3-D fly-through of the fish

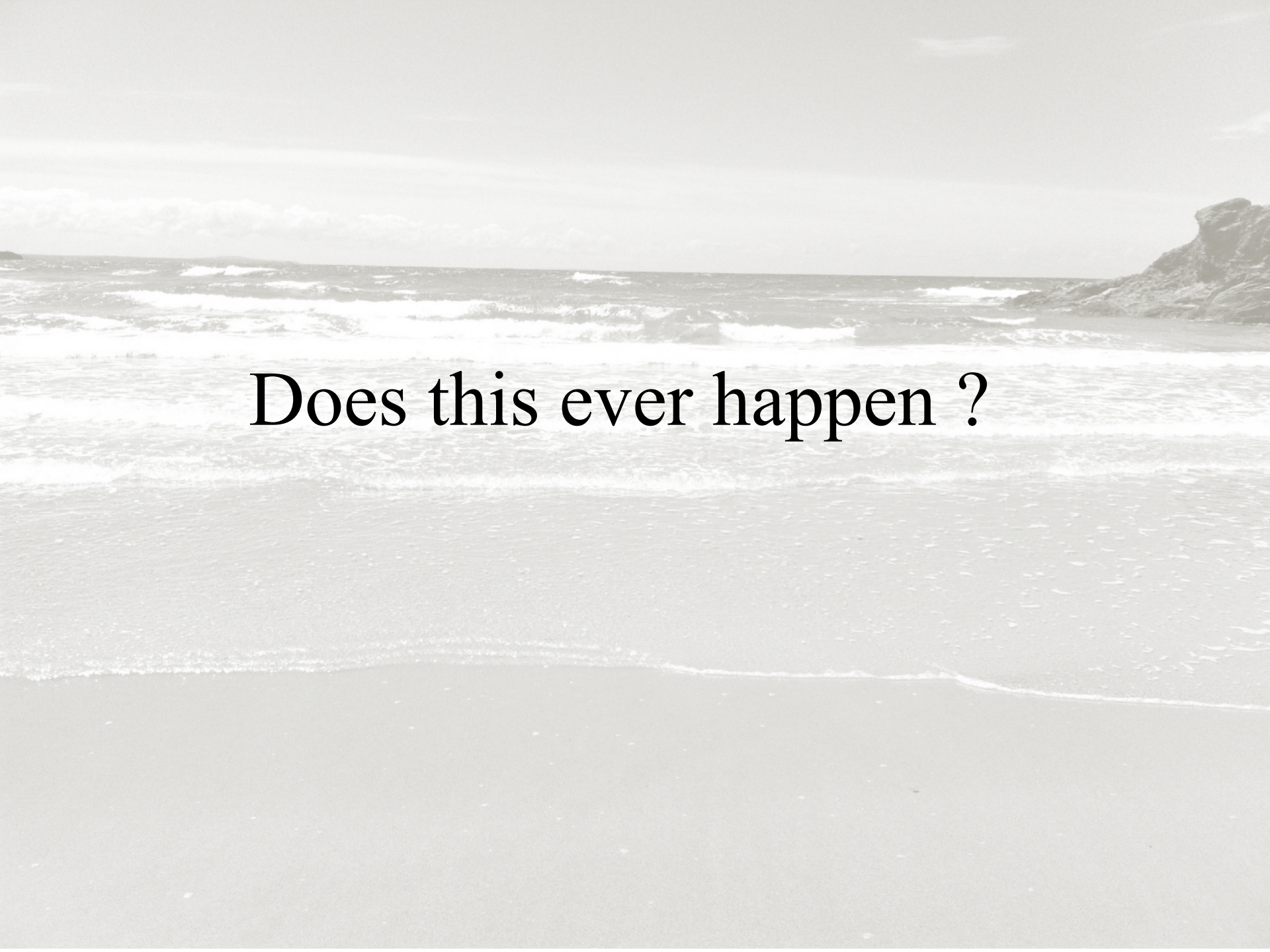


Acronal signal in liver: Epi-detected CARS with 2845 cm^{-1} CH_2 resonance.



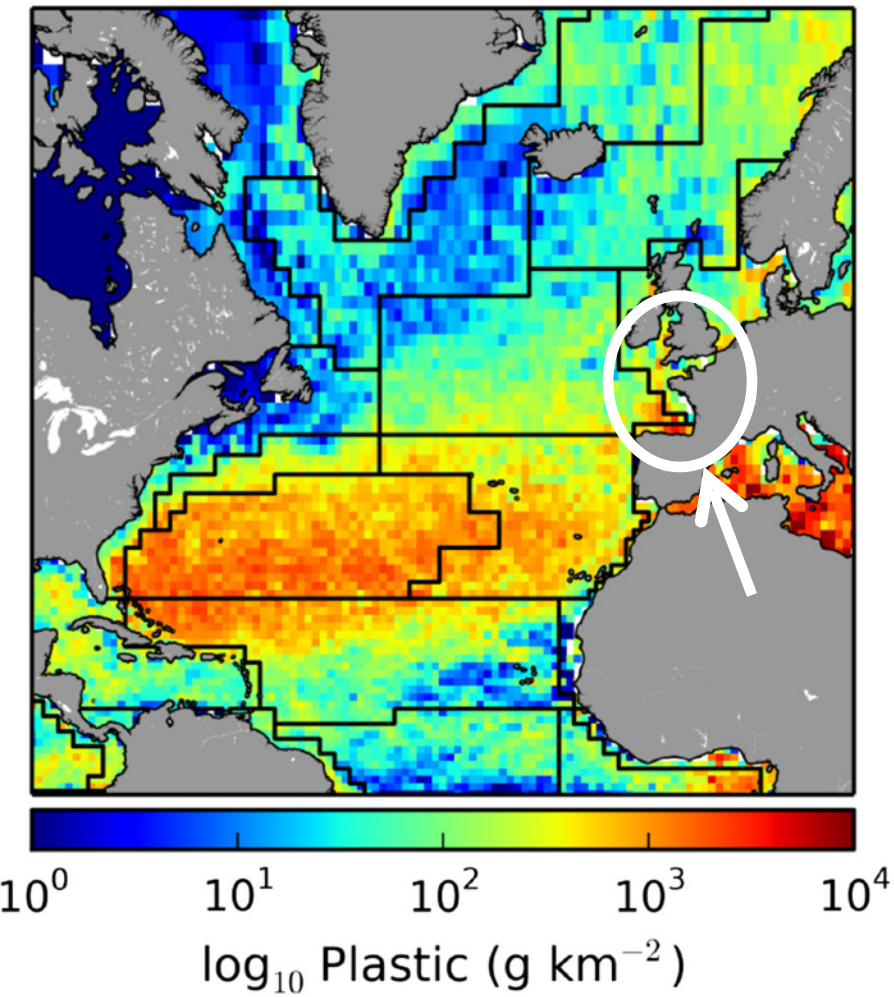


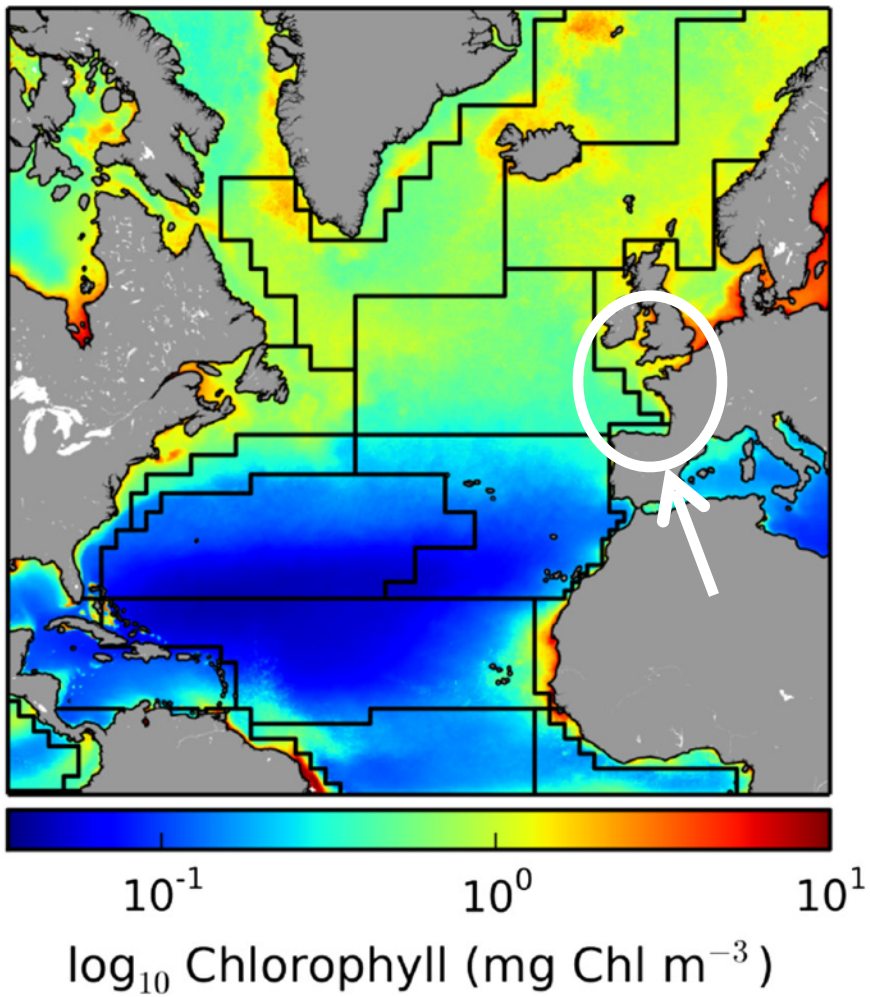
Galloway et al 2017 Env Sci nano



Does this ever happen ?

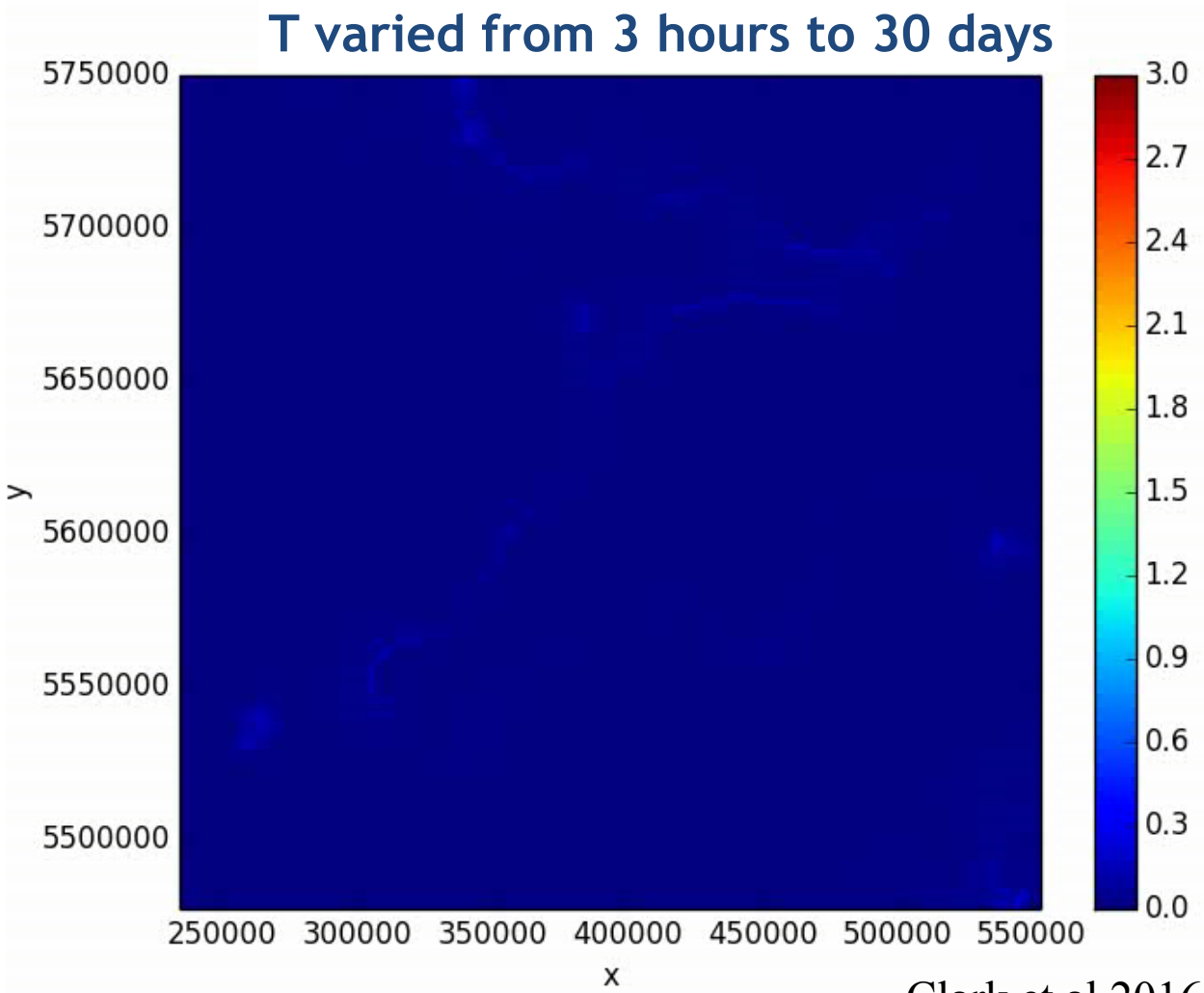
Plastic debris versus chlorophyll





Clarke et al Frontiers in Ecol Environ 2016

Identifying hotspots using particle tracking models

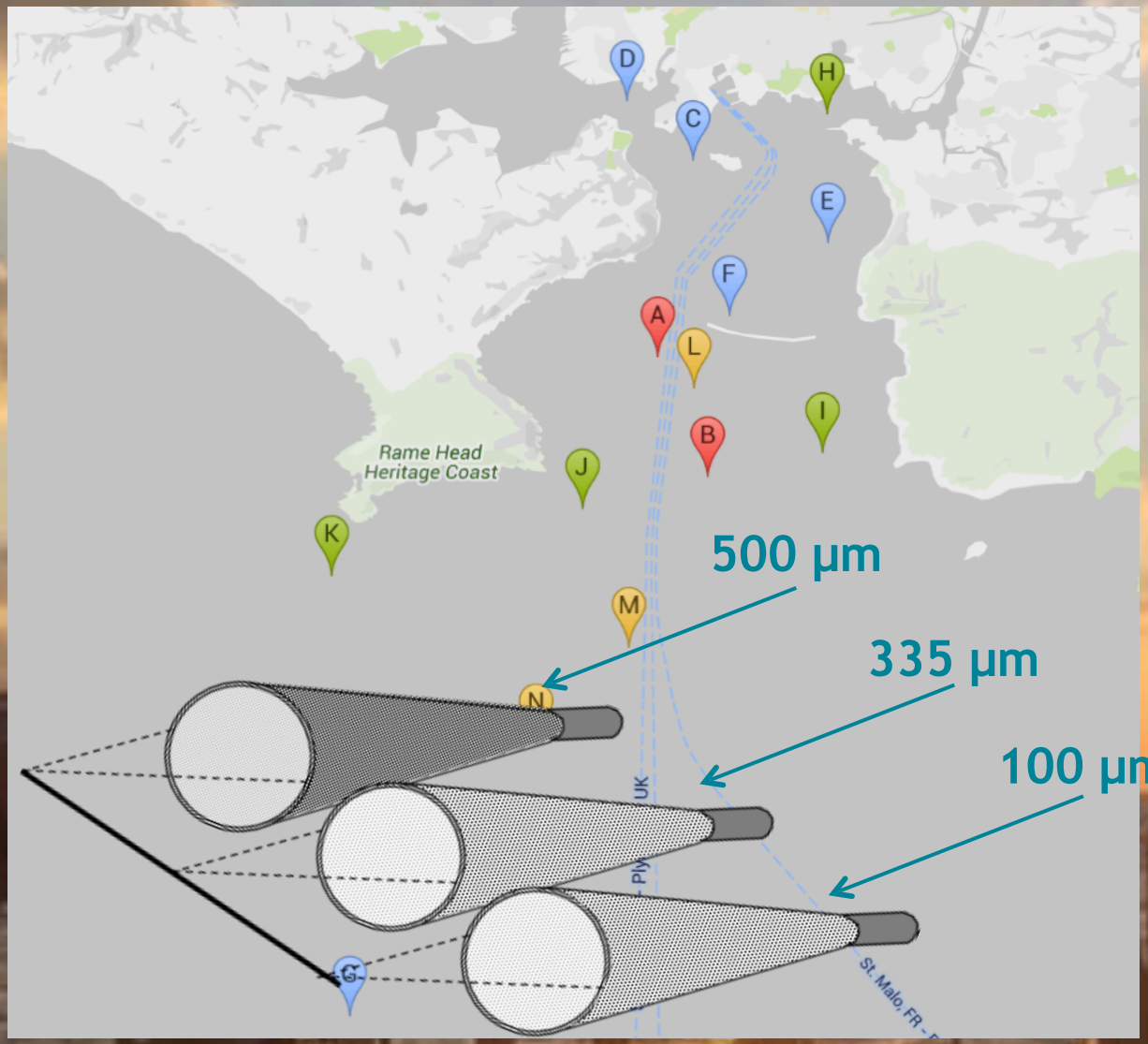


Finite Volume coastal ocean model (FVCOM)

Highlights separatrices that delineate dynamically distinct regions.

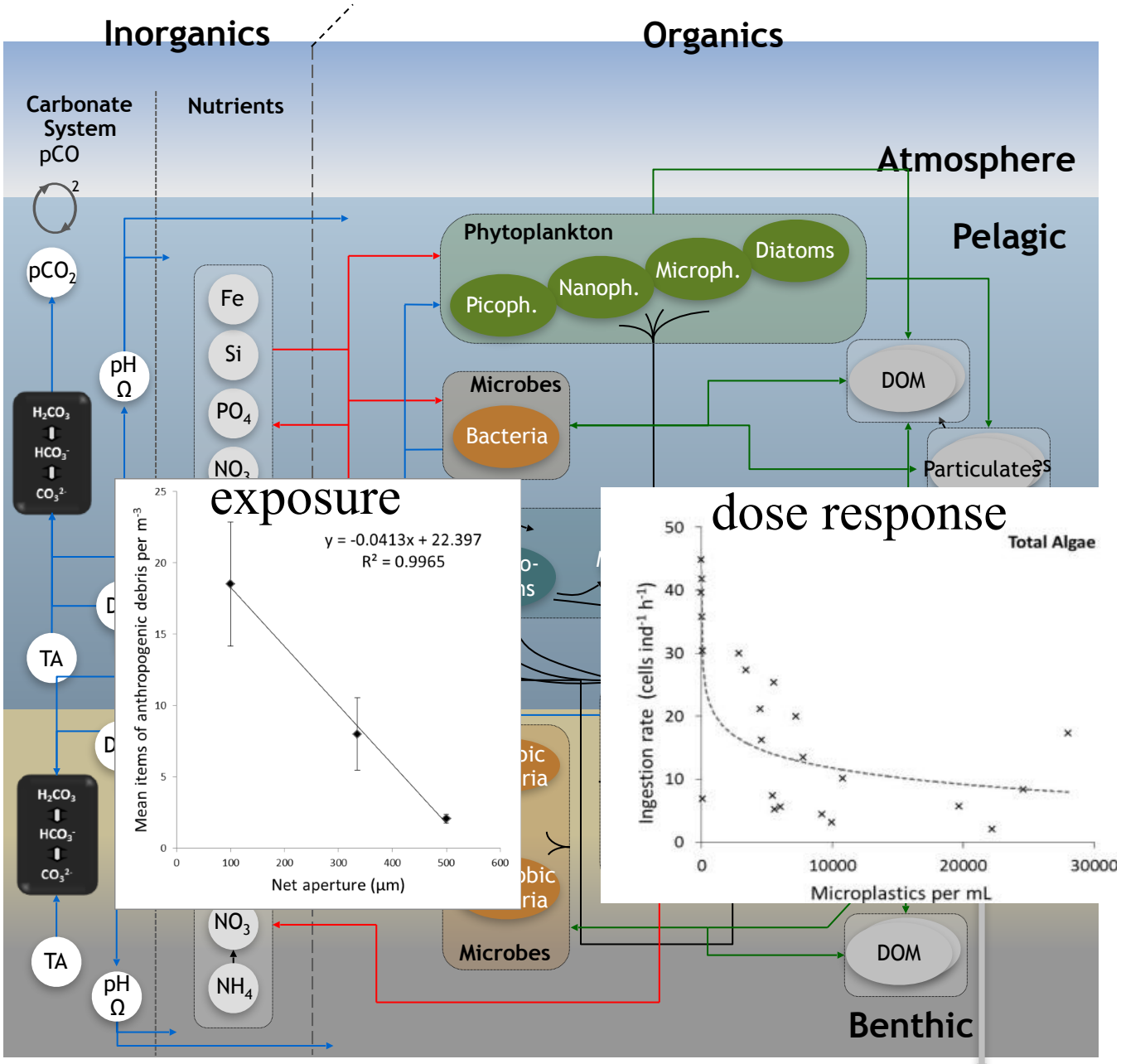
Clark et al 2016 Frontiers Ecol Environ

Field sampling



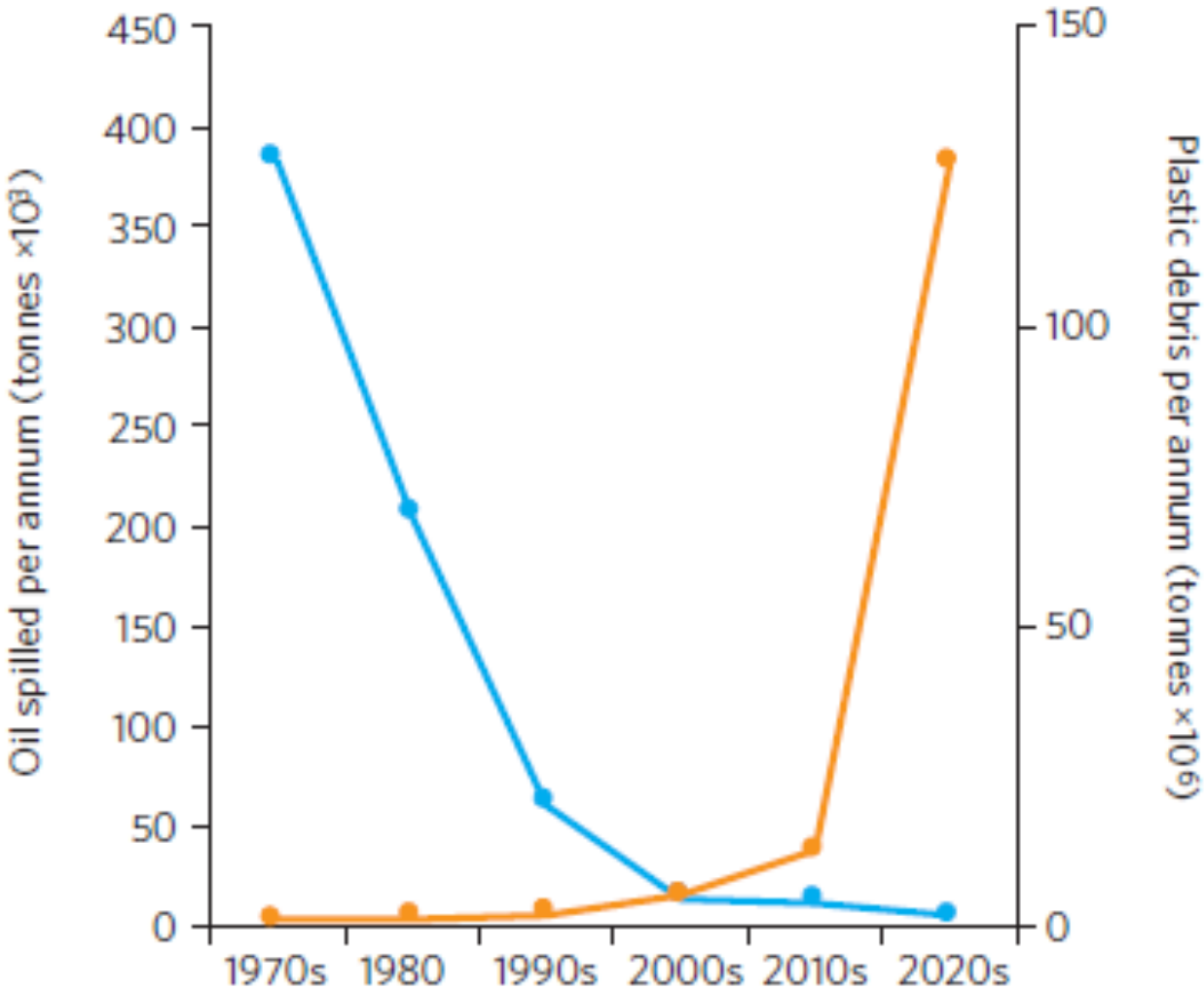
Nets towed for 10 minutes/500m,

ERSEM: European Regional Shelf Seas Ecosystem Model



	features
4	primary producers • diatoms • picophytoplankton • nanophytoplankton • microphytoplankton
3	zooplankton groups • heterotrophic nanoflagellates • microzooplankton • mesozooplankton
3	benthic fauna groups • meiofauna • suspension feeders • deposit feeders
5	chemical elements C, N, P, Si, Fe

We can improve things…!



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#oneless

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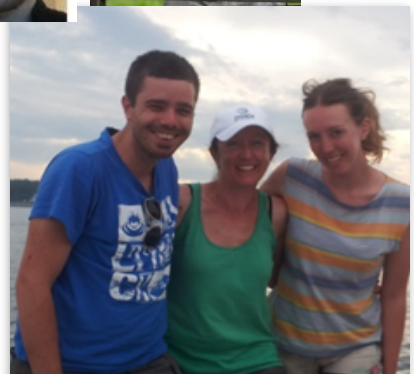
PLASTIC OCEANS

MORE OCEAN LESS PLASTIC™ 5 GYRES INSTITUTE

Galloway et al 2017 Nature Eco Evo

Acknowledgements



- Exeter: Andrew Watts, Matthew Cole, Stephanie Wright, Ceri Lewis, Rhys Goodhead, Julian Moger, Craig Dedman, Brendan Godley, Adam Porter, Seta Noventa
- Plymouth: Richard Thompson, Mark Browne, Pennie Lindeque, Elaine Fileman
- Rozalia project, USA: Rachel Miller
- Amsterdam: Heather Leslie
- Norway: Andy Booth

UNIVERSITY OF EXETER

SEVENTH FRAMEWORK PROGRAMME

NATURAL ENVIRONMENT RESEARCH COUNCIL

defra Department for Environment Food and Rural Affairs

The Leverhulme Trust

http://www.rozaliaproject.org/