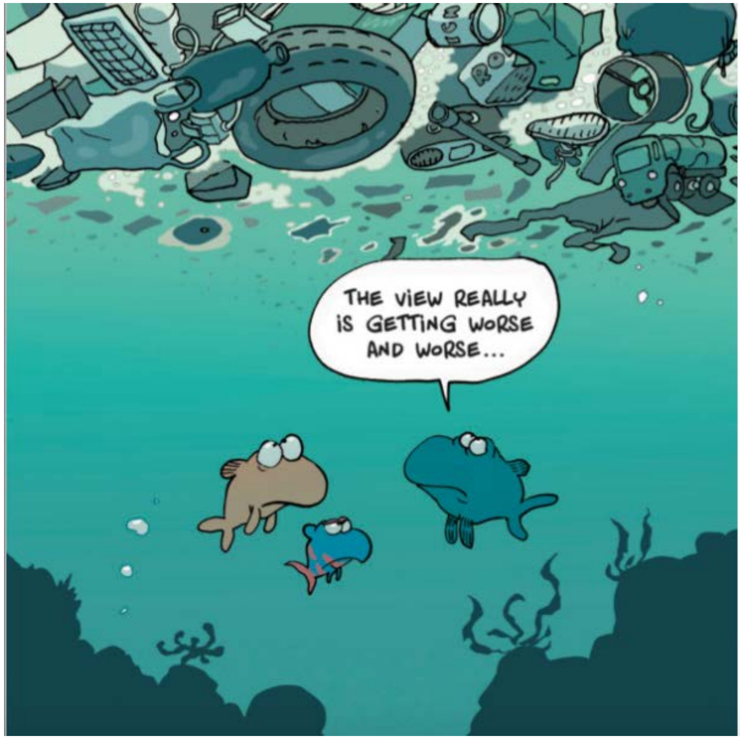
ARE MICROPLASTICS A NEW THREAT FOR THE PLANKTON FOOD WEB ?



In situ and experimental considerations

Dorothée VINCENT

UNIVERSITÉ DU LITTORAL CÔTE D'OPALE
LOG
Ifremer
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INTRODUCTION

- WHAT are microplastics ?
- WHERE do they come from ?
- WHY do MP matter ?
- WHO is impacted ?

INTRODUCTION

❑ WHAT are microplastics ?

MARINE LITTER …*'any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment*'
Galgani et al. 2010

Browne et al. (2015)

INTRODUCTION

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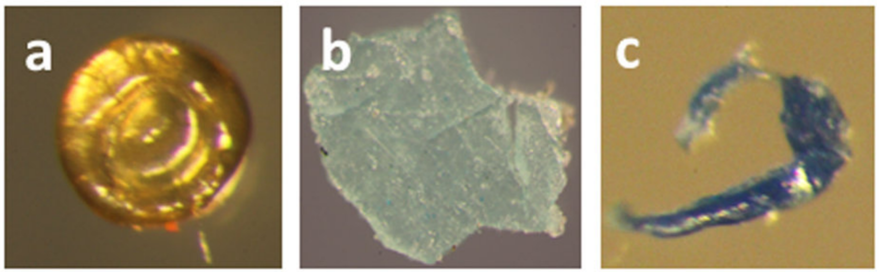
MICROPLASTICS are MARINE LITTER
< 5 mm in diameter

INTRODUCTION

❑ WHAT are microplastics ?



a) 140 µm diameter polyamide yellow-orange bead,
b) 790 µm diameter grey-green polyethylene fragment, and
c) a 160 µm long blue PVC fibre.

Cole et al. 2014

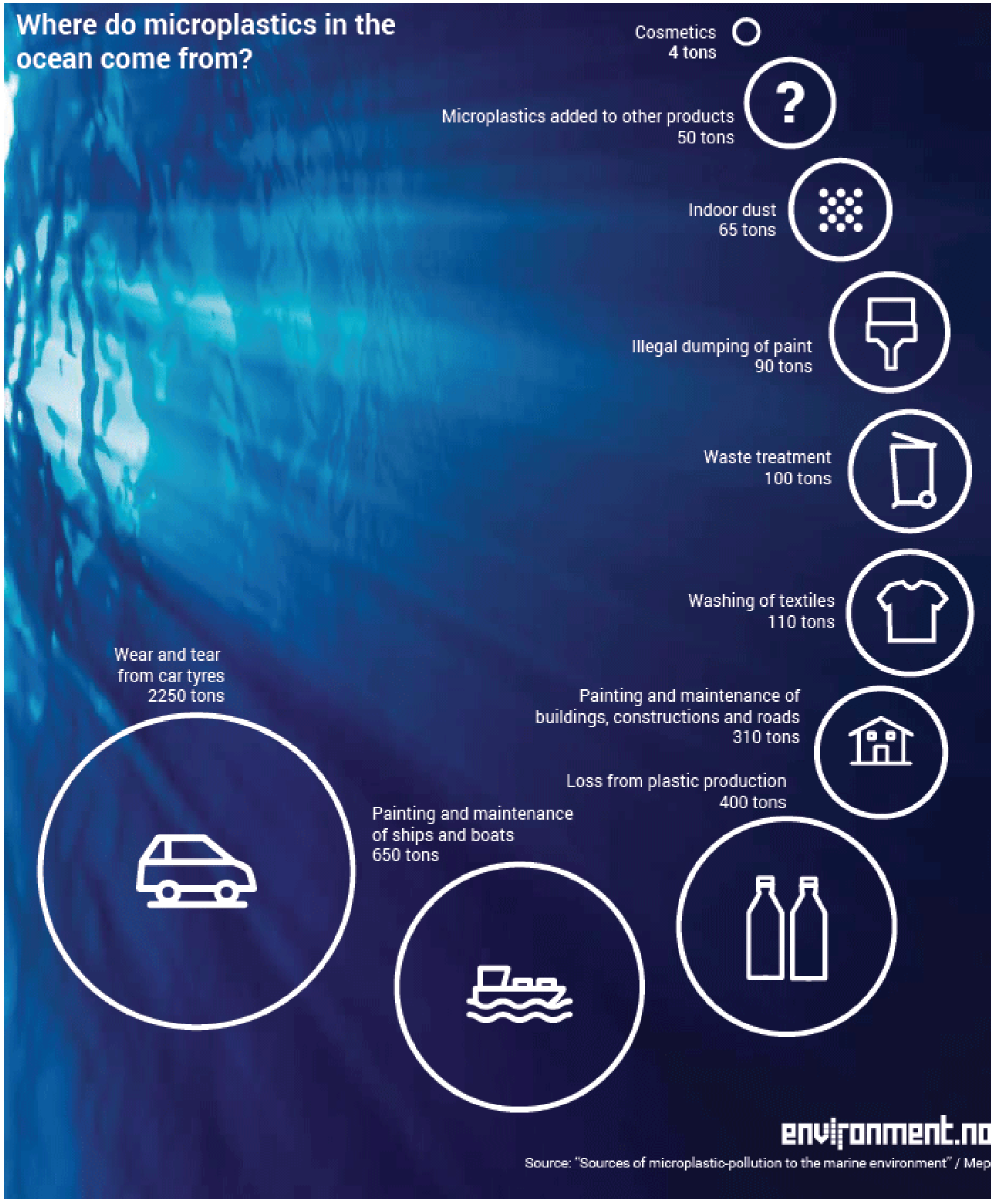
Symbol	Acronym	Full name and uses
1	PET	Polyethylene terephthalate - Fizzy drink bottles and frozen ready meal packages.
2	HDPE	High-density polyethylene - Milk and washing-up liquid bottles
3	PVC	Polyvinyl chloride - Food trays, cling film, bottles for squash, mineral water and shampoo.
4	LDPE	Low density polyethylene - Carrier bags and bin liners.
5	PP	Polypropylene - Margarine tubs, microwave-able meal trays.
6	PS	Polystyrene - Yoghurt pots, foam meat or fish trays, hamburger boxes and egg cartons, vending cups, plastic cutlery, protective packaging for electronic goods and toys.
7	Other	Any other plastics that do not fall into any of the above categories. For example melamine, often used in plastic plates and cups.

INTRODUCTION

❑ WHERE do they come from ?

- **Industrial activities**
- **Personal Care / Cleaning house**
- **Recreational activities**
- **Macroplastics fragmentation**
  - UV radiations
  - Waves
  - Physical/biological abrasion

Andrady (2011)

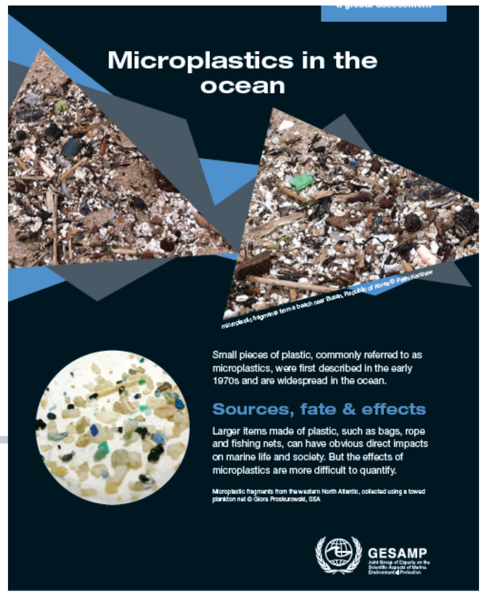


INTRODUCTION

❑ WHEN did MP start to matter ?

- Microplastics = « Emerging pollutants »

International
Pellet Watch
Global Monitoring of POPs using Beached Plastic Resin Pellets.



marine debris program OFFICE OF RESPONSE AND RESTORATION

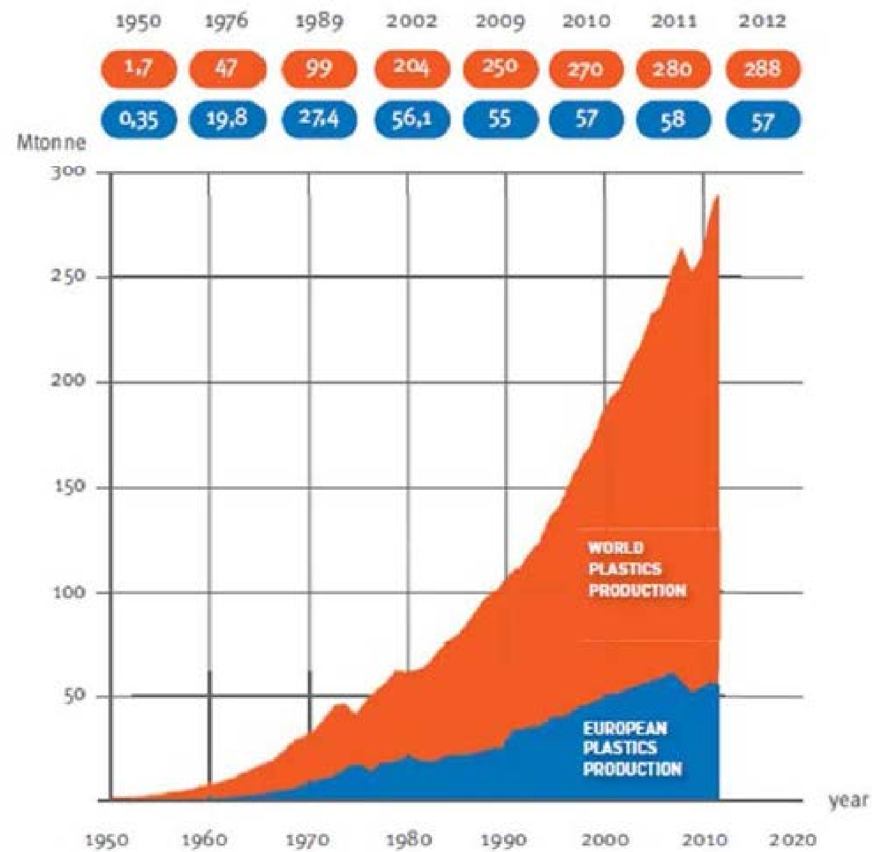
ABOUT US | DISCOVER THE ISSUE | CURRENT EFFORTS | EDUCATIONAL MATERIALS | IN YOUR REGION | MULTIMEDIA

INTRODUCTION

❑ WHEN did MP start to matter ?

- Microplastics = « Emergent pollutants »

- **Back to the 1970s** (Carpenter & Smith 1972)
- **« Ocean garbage patches »** (Moore et al. 2001)
- **« Microplastics »** (Thompson et al. 2004)



1960 : 0.5 million tons yr^{-1}
2013 : 300 millions tons yr^{-1}

Avio et al. 2016

INTRODUCTION

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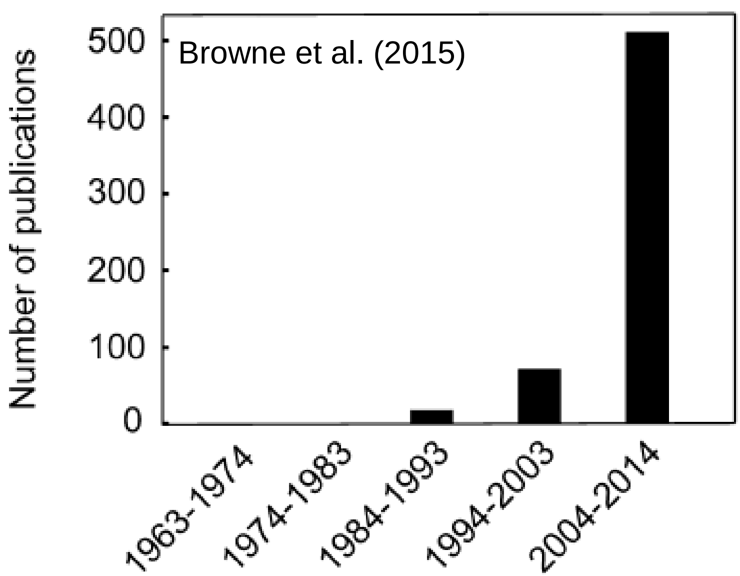

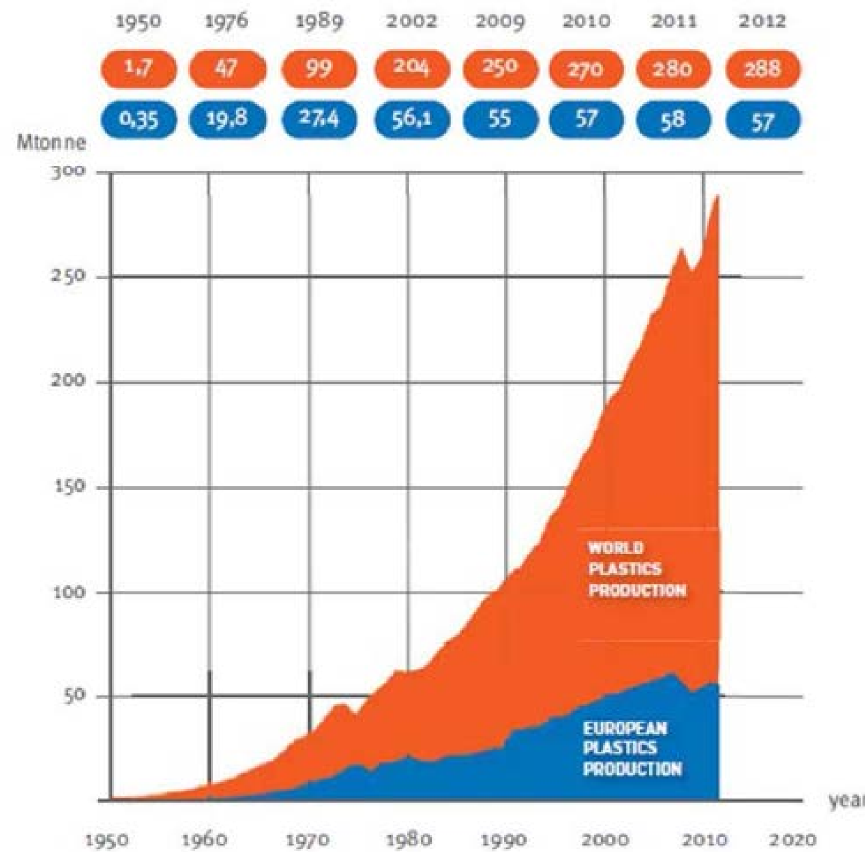

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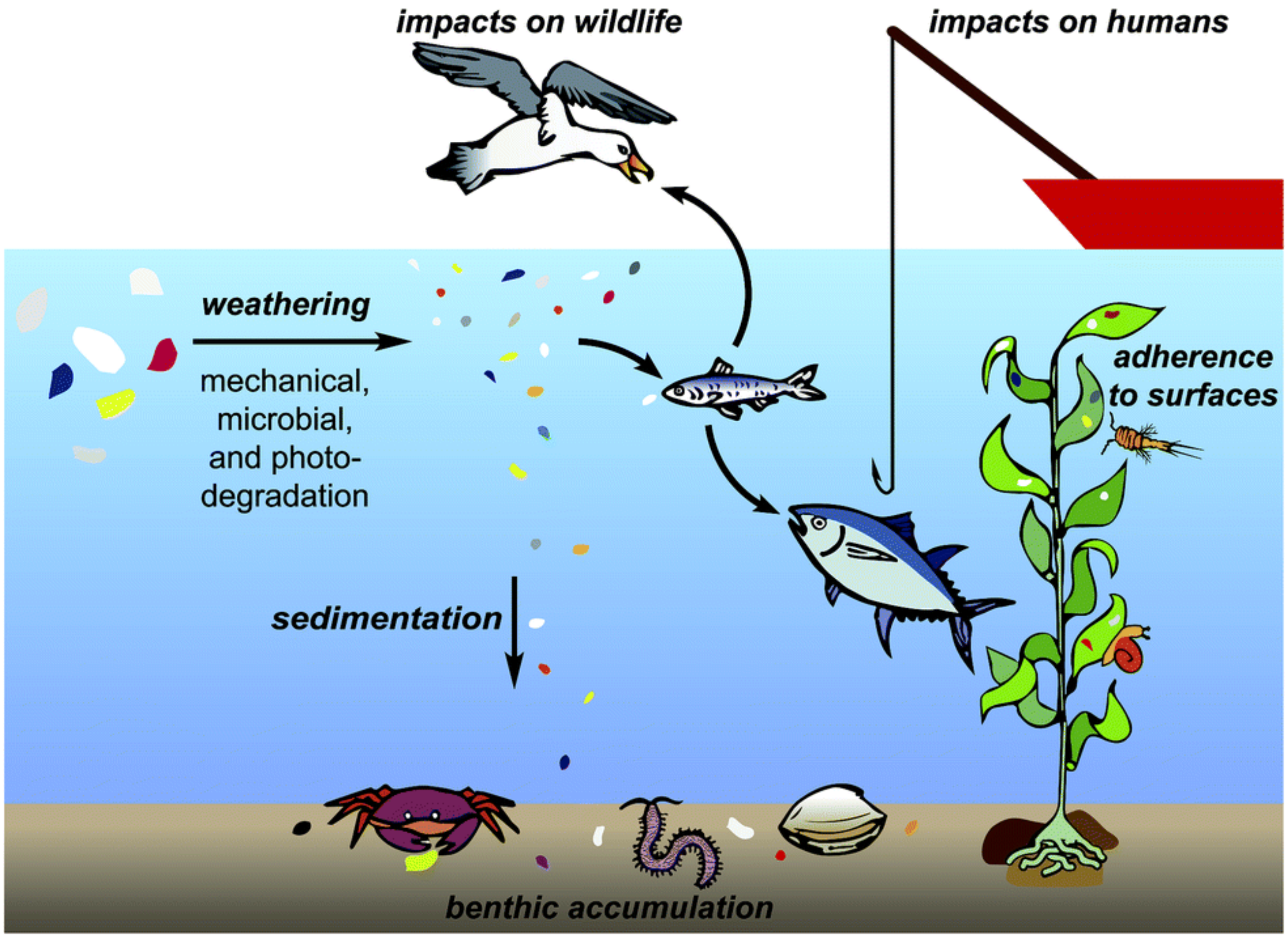
INTRODUCTION

❑ WHY do MP matter ?



Lin (2016)

INTRODUCTION

❑ WHY do MP matter ?

- **MP are everywhere**
  - from Surface to Bottom
  - from pole to pole — Ivar Do Sul & Costa (2014)
  - marine biota

INTRODUCTION

❑ WHY do MP matter ?

- **MP are everywhere**

- **MP are within the size range available prey**

- Effective ingestion by Invertebrates and Vertebrates

Polychaetes, Crustaceans, Bivalves (Cole et al. 2015; Van Moos et al. 2012; Setälä al. 2016)
Fish and Birds (Battaglia et al. 2016; Mazurais et al. 2015; Wilcox et al. 2015)

- Trophic transfer is also demonstrated

Within the plankton food web (copepods -> mysids, Setälä et al. 2014)

Within the benthic food web (mussel -> crab , Farell & Nelson, 2013)

INTRODUCTION

❑ WHY do MP matter ?

- **MP are everywhere**

- **MP are within the size range available prey**

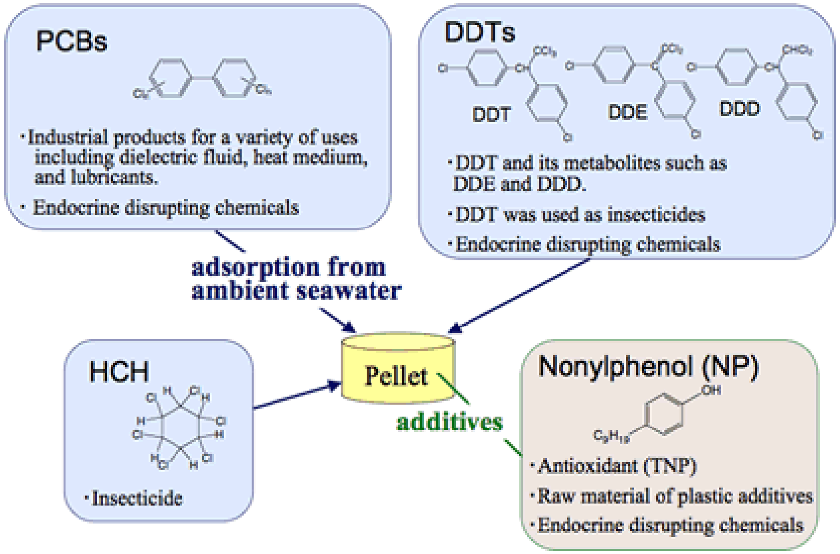
- **MP have deleterious impacts**
  - **Physical damages/injuries** (internal abrasion, blockages, Wright et al. 2013)
    (Alterations of tissue; Paul-Pont et al. in press)
  - **Physiology** (feeding rates, secondary production, reproduction)
    - copepods (Cole et al. 2014-2016)
    - bivalves (Sussarellu et al. 2016)

INTRODUCTION

❑ WHY do MP matter ?

- **MP are everywhere**
- **MP are within the size range available prey**
- **Can have deleterious impacts**
- **Facilitate chemical transfers**

Lu et al. (2016)
Oliveira et al. (2013)
Wardrobe et al. (2016)



INTRODUCTION

❑ WHY do MP matter ?

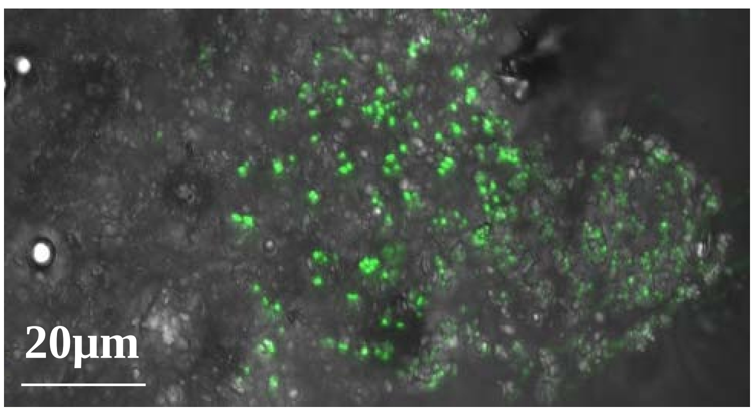
- **MP are everywhere**
- **MP are within the size range available prey**
- **Can have deleterious impacts**
- **Facilitate chemical transfers**
- **Potential vectors to transport fouling / exotic rafting species/ Pathogens**

Carson et al. (2013)
Zettler et al. (2013)
Reisser et al. (2014)

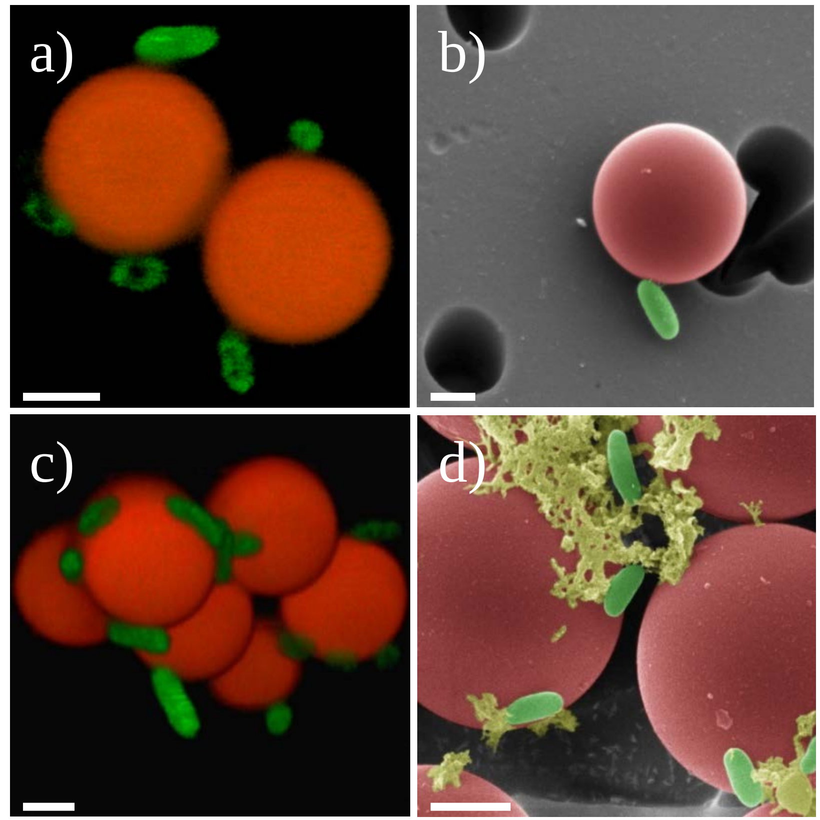
INTRODUCTION

❑ WHY do MP matter ?

Colonisation of microplastics (PS, PMMA, PVC) *vs.* natural particles (chitin, silica) by the fluorescent *Vibrio crassostreae* J2-9 GFP strain



Colonisation of MP by *V. crassostrea* is favored and strenghtened by aggregation



Foulon et al. (submitted)

ADVERSE EFFECTS ON PLANKTON COMPONENTS

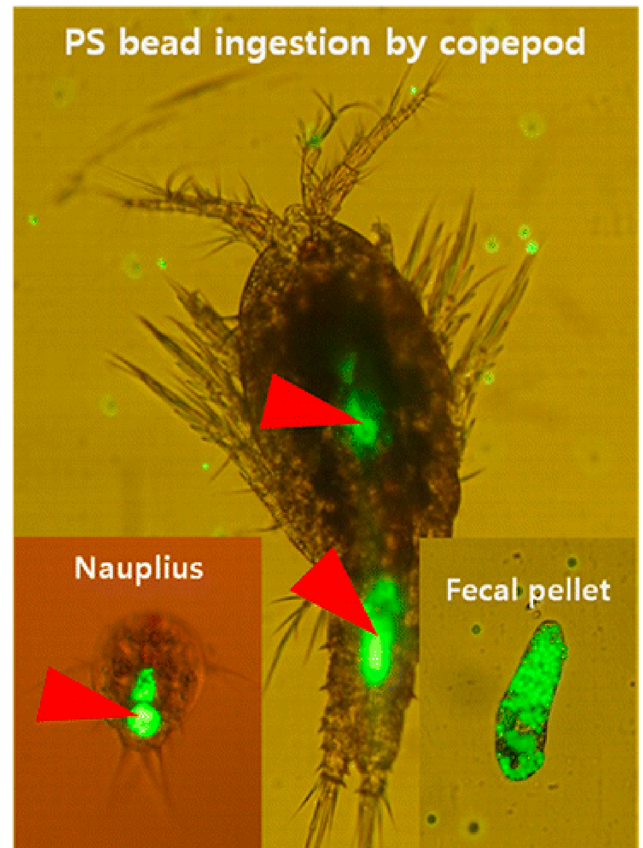
- ❑ **DELETERIOUS EFFECTS ON INGESTION AND SURVIVAL**
- ❑ **DELETERIOUS EFFECTS CAN BE LOWERED BY SEAWATER VISCOSITY**
- ❑ **CONCLUSION**

Adverse effects on Plankton components

❑ DELETERIOUS EFFECTS ON INGESTION AND SURVIVAL

- Feeding mode : ‘non selective’ suspension feeder
- Size spectra of MPs ~ prey

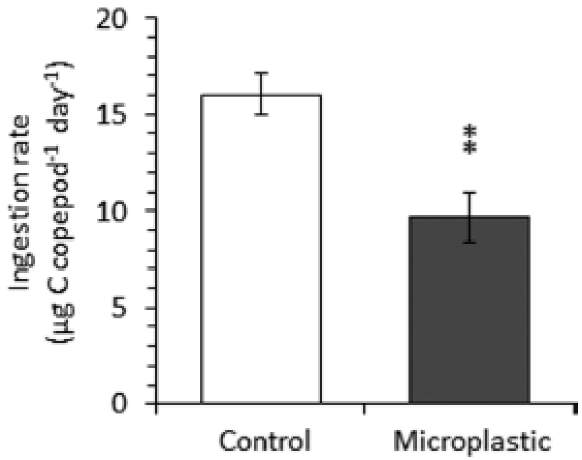
Cole et al. (2013)

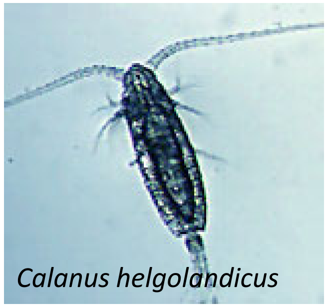


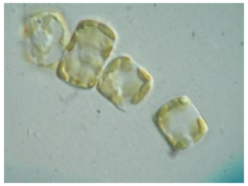
Lee et al. (2013)

Adverse effects on Plankton components

❑ DELETERIOUS EFFECTS ON INGESTION AND SURVIVAL







Thalassiosira weissflogii

●

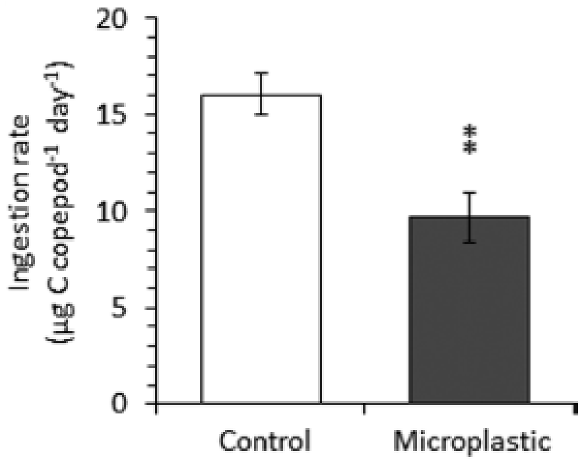
PS beads (20µm)
75 mL^{-1}

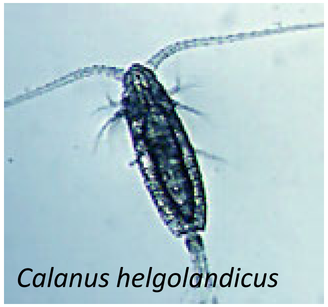
➔ **Decrease in ingestion**

Cole et al. (2014, 2015, 2016)

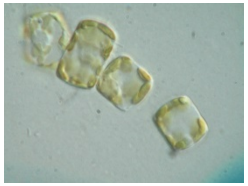
Adverse effects on Plankton components

❑ DELETERIOUS EFFECTS ON INGESTION AND SURVIVAL





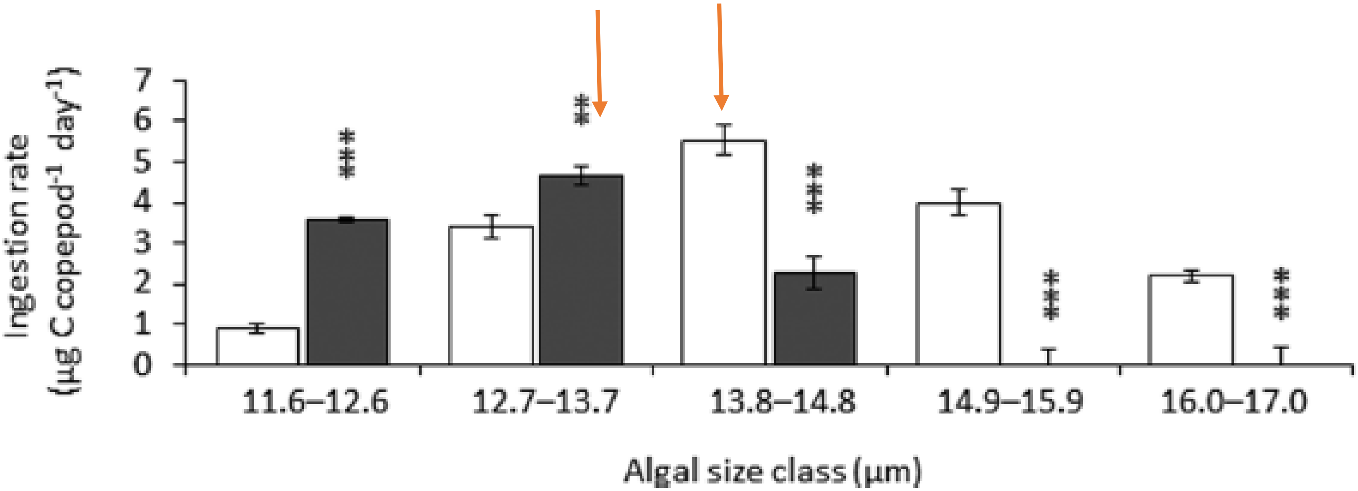
Calanus helgolandicus



Thalassiosira weissflogii

● PS beads (20µm)
75 mL^{-1}

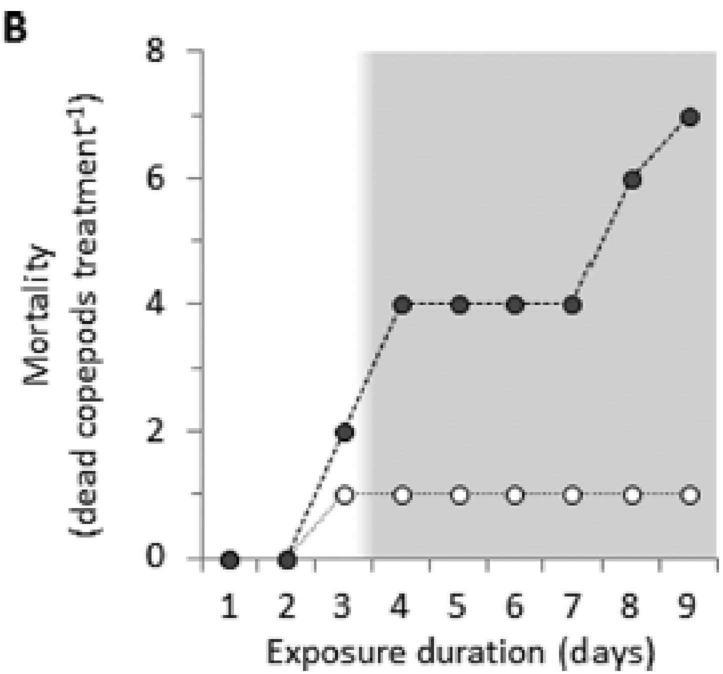
Decrease in ingestion (40% C biomass)
Shift in prey size

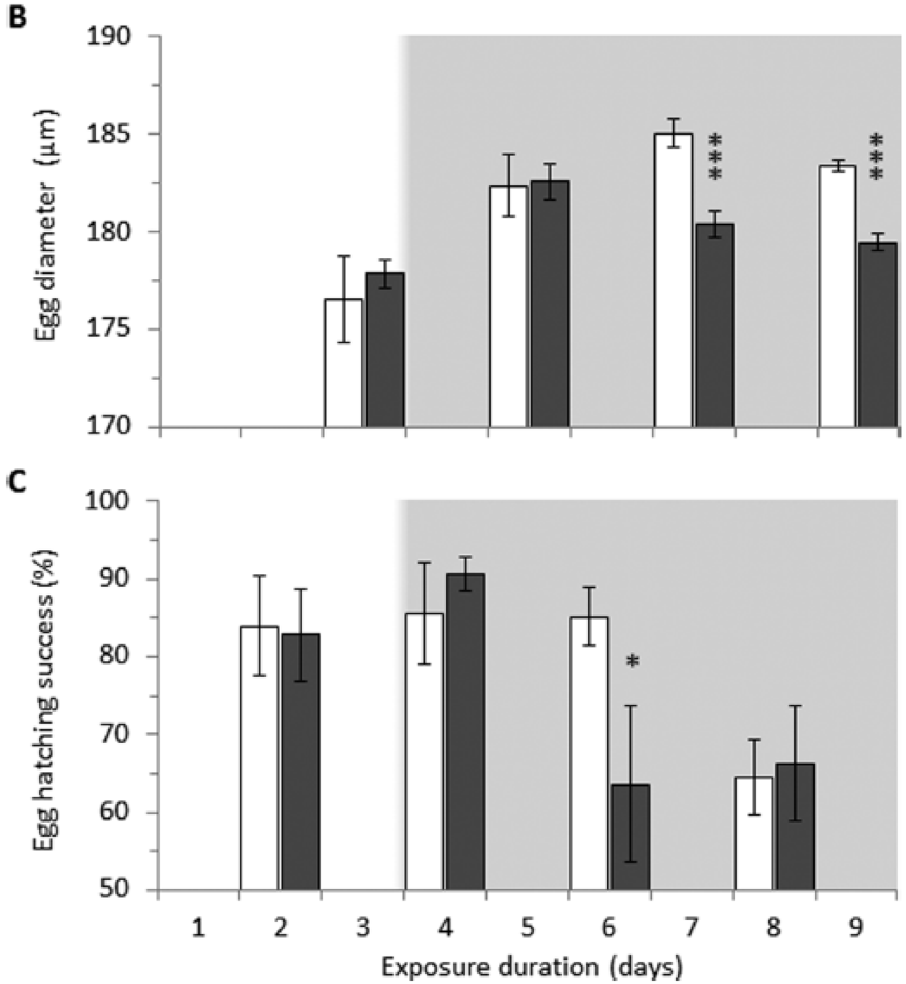


Cole et al. (2015)

ADVERSE EFFECTS ON PLANKTON COMPONENTS

❑ DELETERIOUS EFFECTS ON INGESTION AND SURVIVAL



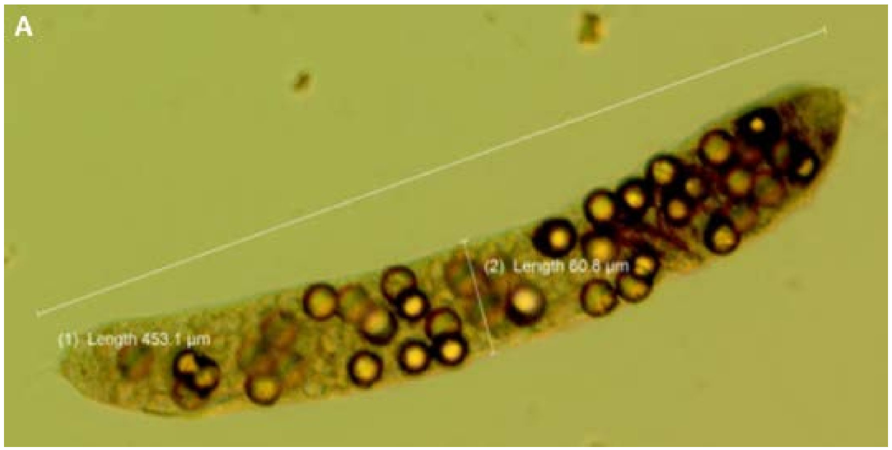


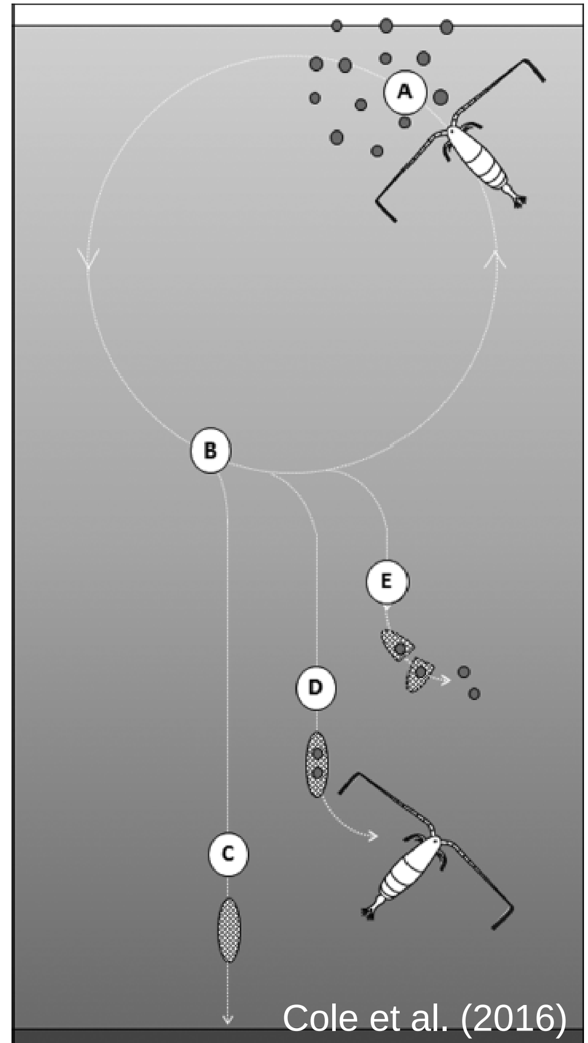
Survival, Egg size, hatching success

Cole et al. (2015)

ADVERSE EFFECTS ON PLANKTON COMPONENTS

❑ DELETERIOUS EFFECTS ON INGESTION AND SURVIVAL





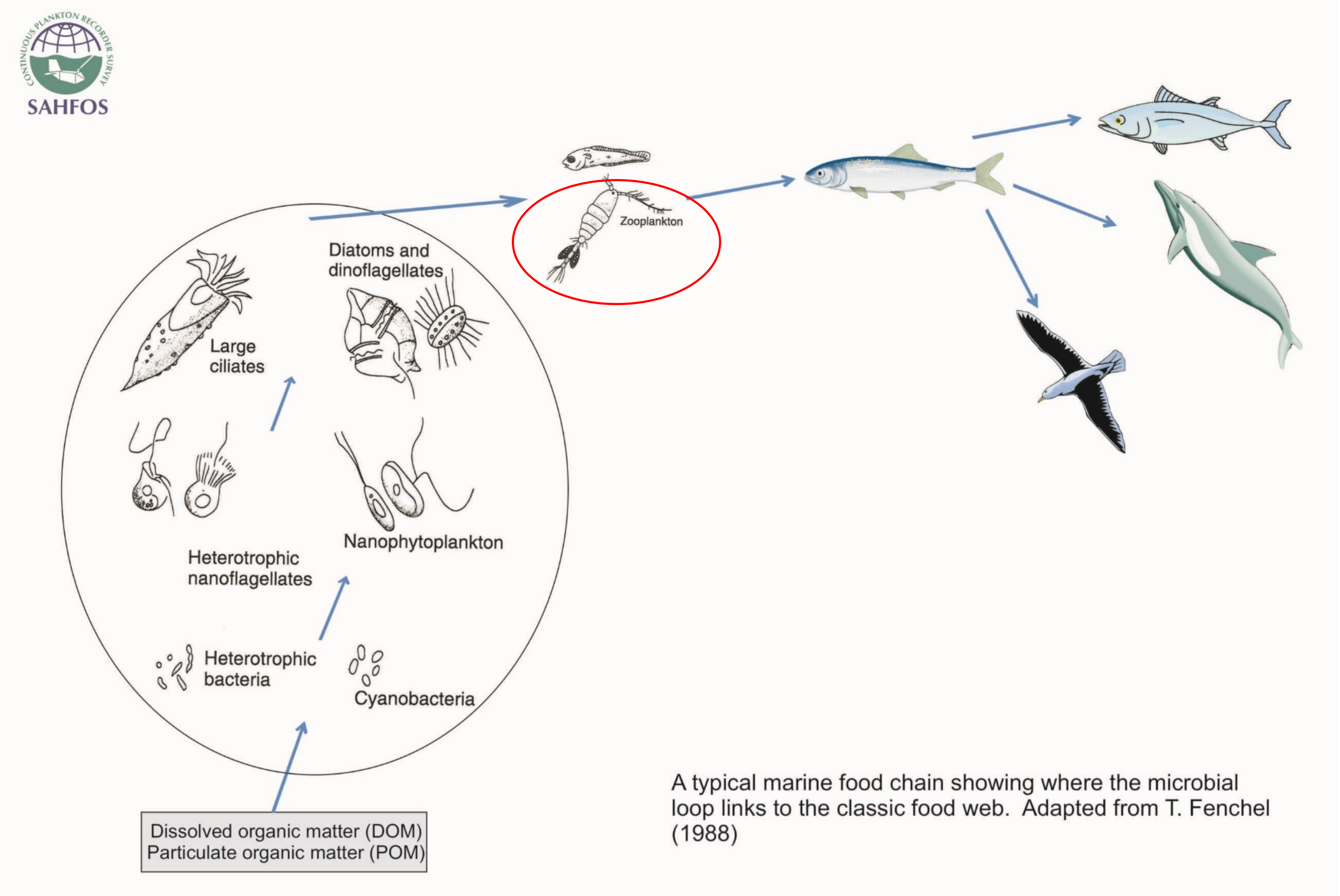
Cole et al. (2016)

Egestion of MP

- High Buoyancy of fecal pellets
- Low resistance to degradation

Impact on vertical transport (BCP)

FROM ZOOPLANKTON TO FISH LARVAE



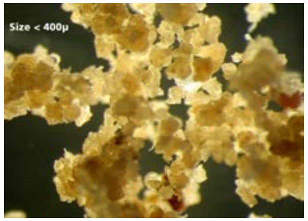
A typical marine food chain showing where the microbial loop links to the classic food web. Adapted from T. Fenchel (1988)

ADVERSE EFFECTS ON PLANKTON COMPONENTS

❑ DELETERIOUS EFFECTS ON INGESTION AND SURVIVAL

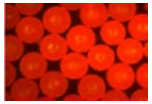
● PE beads (10-45 µm)
10^4-10^5 MP g^{-1} food

Sea bass (*Dicentrarchus labrax*)
from 7 to 45 dph

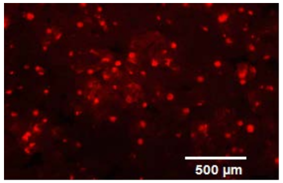


Inert diet

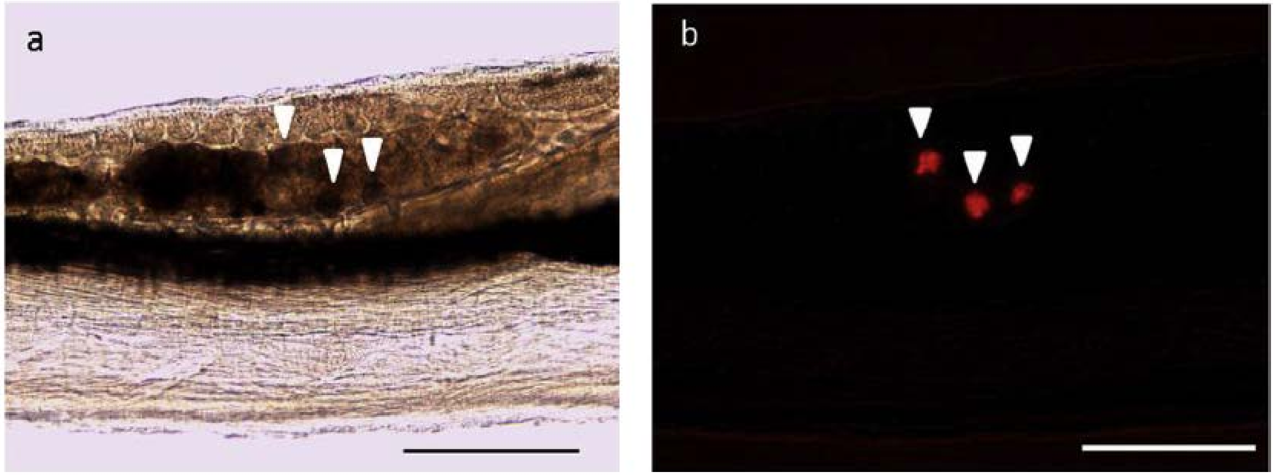
+



PE fluorescent beads



Inert diet with incorporated PE at 10^5 beads/g diet



European sea bass larvae from experimental group 10X at 20 dph containing three fluorescent Polyethylene microbeads (arrows) in its digestive tract. a: bright field; b: dark field. Scale bars represent 250 mm.

Impact on ingestion, growth and gene expression

Mazurais et al. (2015)

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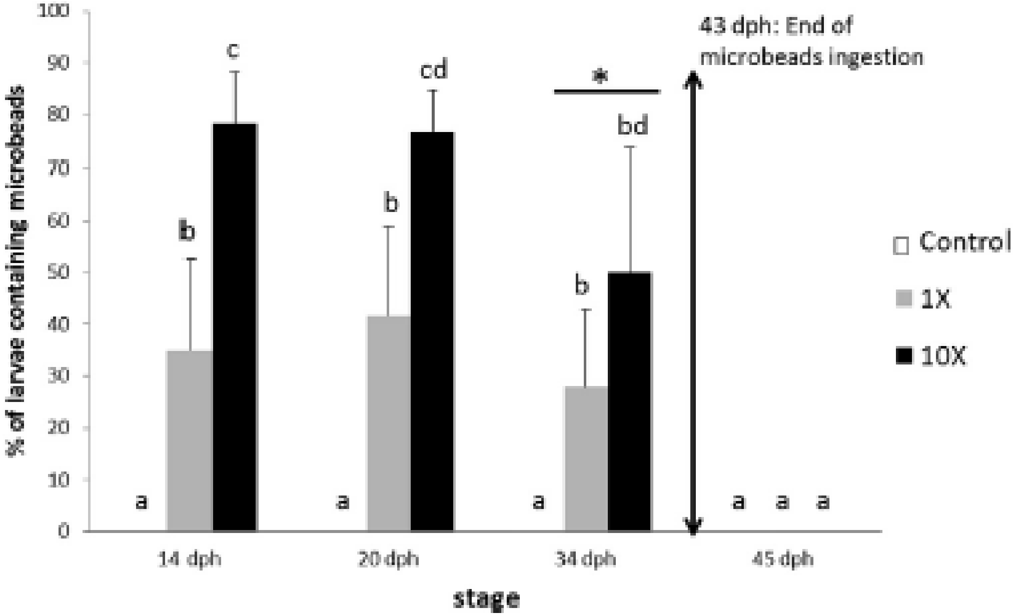

More beads → More ingestion
More Beads → More mortality (54% for 10^5 MP g^{-1} compared to controls)

~ Gut obstruction

Mazurais et al. (2015)

Adverse effects on Plankton components

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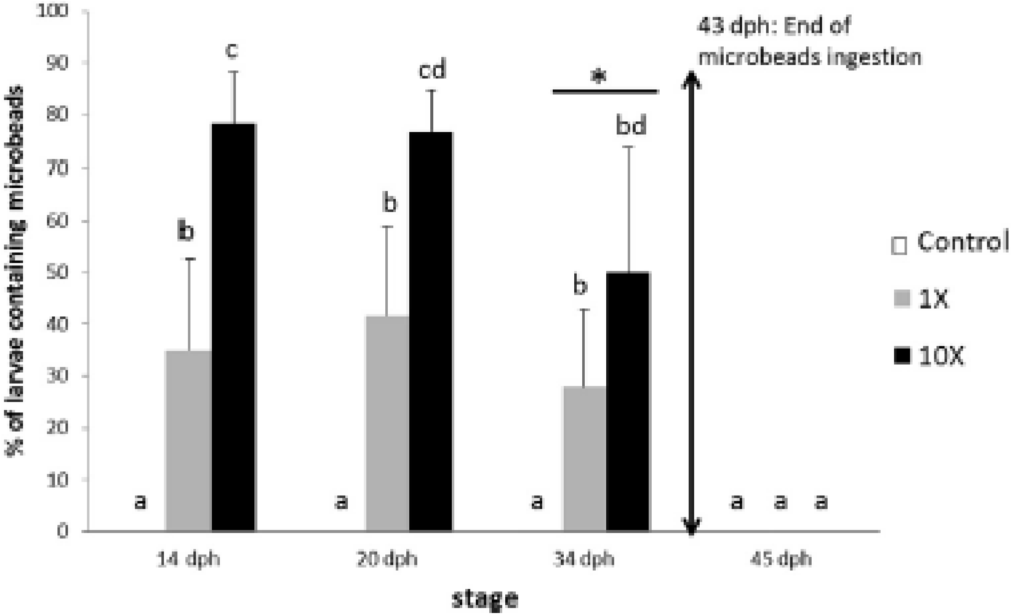

More beads → More ingestion

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~ Gut obstruction

More beads → changes in gene expression

BUT

Marginal changes at the transcriptional level

Same growth (no energetic deficiencies) → high egestion efficiency

Mazurais et al. (2015)

ADVERSE EFFECTS ON PLANKTON COMPONENTS

- ☒ DELETERIOUS EFFECTS ON INGESTION AND SURVIVAL
- ❑ DELETERIOUS EFFECTS CAN BE LOWERED BY SEAWATER VISCOSITY
- ❑ DISCUSSION & CONCLUSION

Adverse Effects on plankton components

❑ DELETERIOUS EFFECTS CAN BE LOWERED BY SEAWATER VISCOSITY

- **Viscosity** is **fluid's resistance to flow**.

  Internal friction of a moving fluid.

"The ability of a fluid to stick ot itself"

ADVERSE EFFECTS ON PLANKTON COMPONENTS

❑ DELETERIOUS EFFECTS CAN BE LOWERED BY SEAWATER VISCOSITY

- **Viscosity** is **fluid's resistance to flow**.
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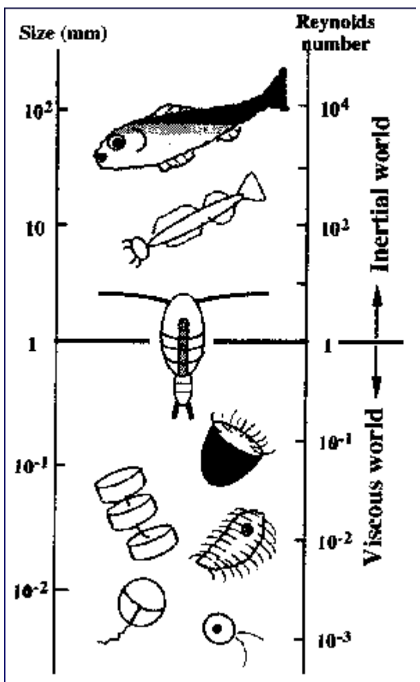
- Impacts physiological processes at small Reynolds numbers (Podolsky 1994 ; Bolton & Havenhand 1998, 2005)



Naganuma (1996)

Adverse Effects on plankton components

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- Depends on
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  Biopolymers, Macromolecules and Proteins (Qin et al. 2015) – **phytoplankton**

ADVERSE EFFECTS ON PLANKTON COMPONENTS

❑ DELETERIOUS EFFECTS CAN BE LOWERED BY SEAWATER VISCOSITY

Foam formation induced by *P. globosa* bloom (eastern English Channel)

ADVERSE EFFECTS ON PLANKTON COMPONENTS

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Can viscosity lower MP contamination by zooplankton ?

Seuront & Vincent (2008)

ADVERSE EFFECTS ON PLANKTON COMPONENTS

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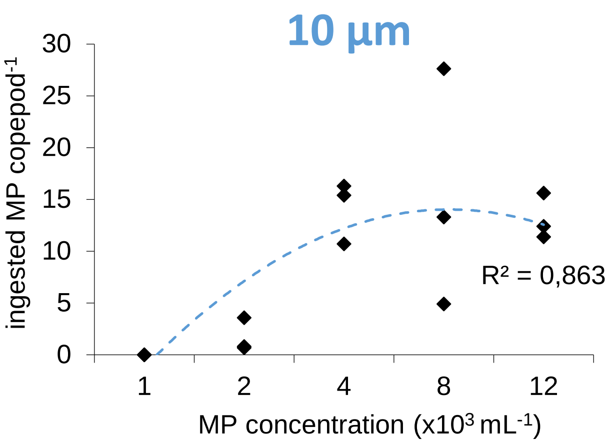
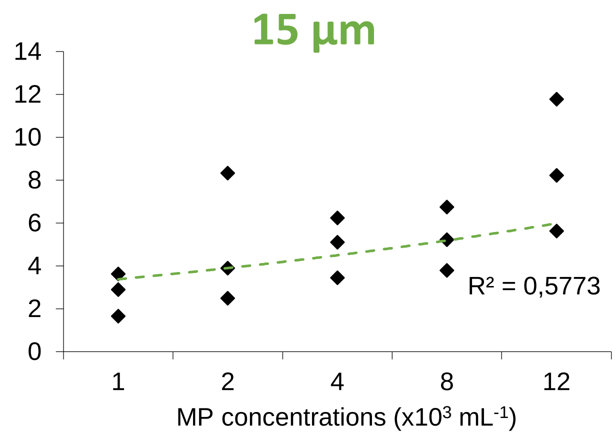
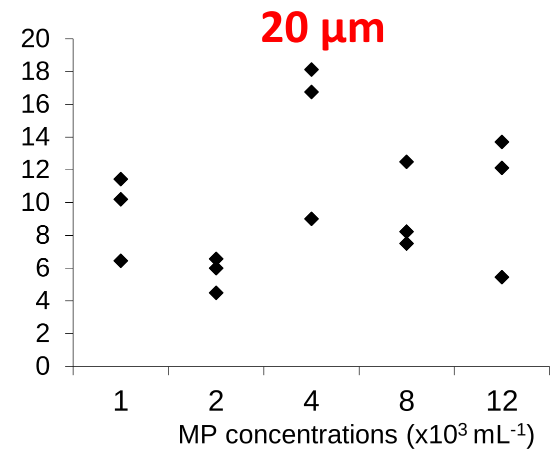
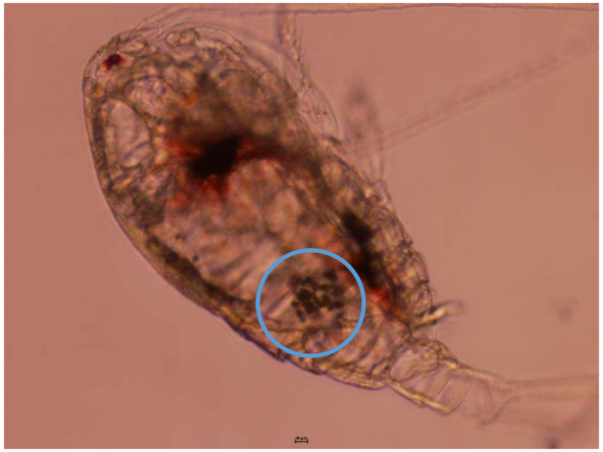




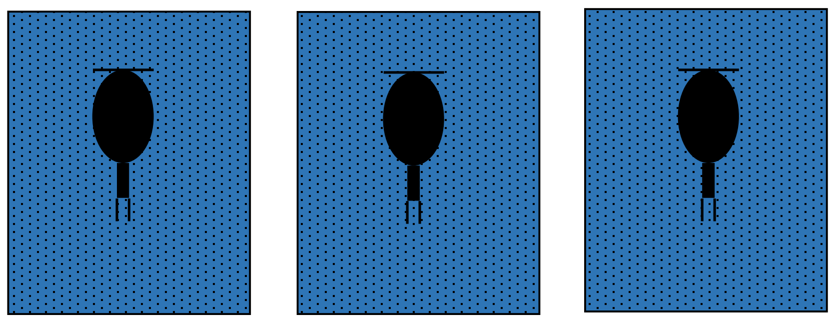




ADVERSE EFFECTS ON PLANKTON COMPONENTS

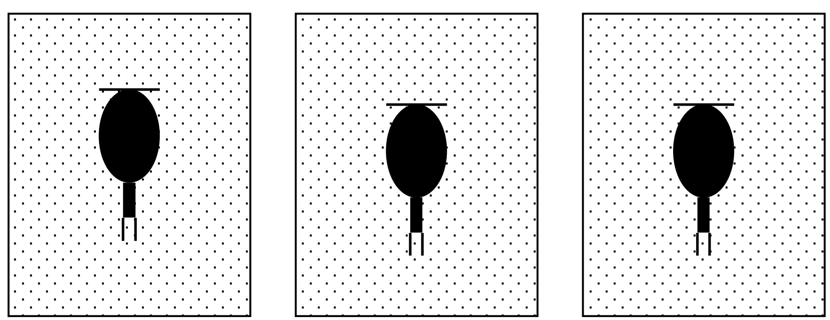
❑ DELETERIOUS EFFECTS CAN BE LOWERED BY SEAWATER VISCOSITY

Tests (Copepods + MP + Ficoll)



20% Increase in viscosity

Controls (Copepods + MP)



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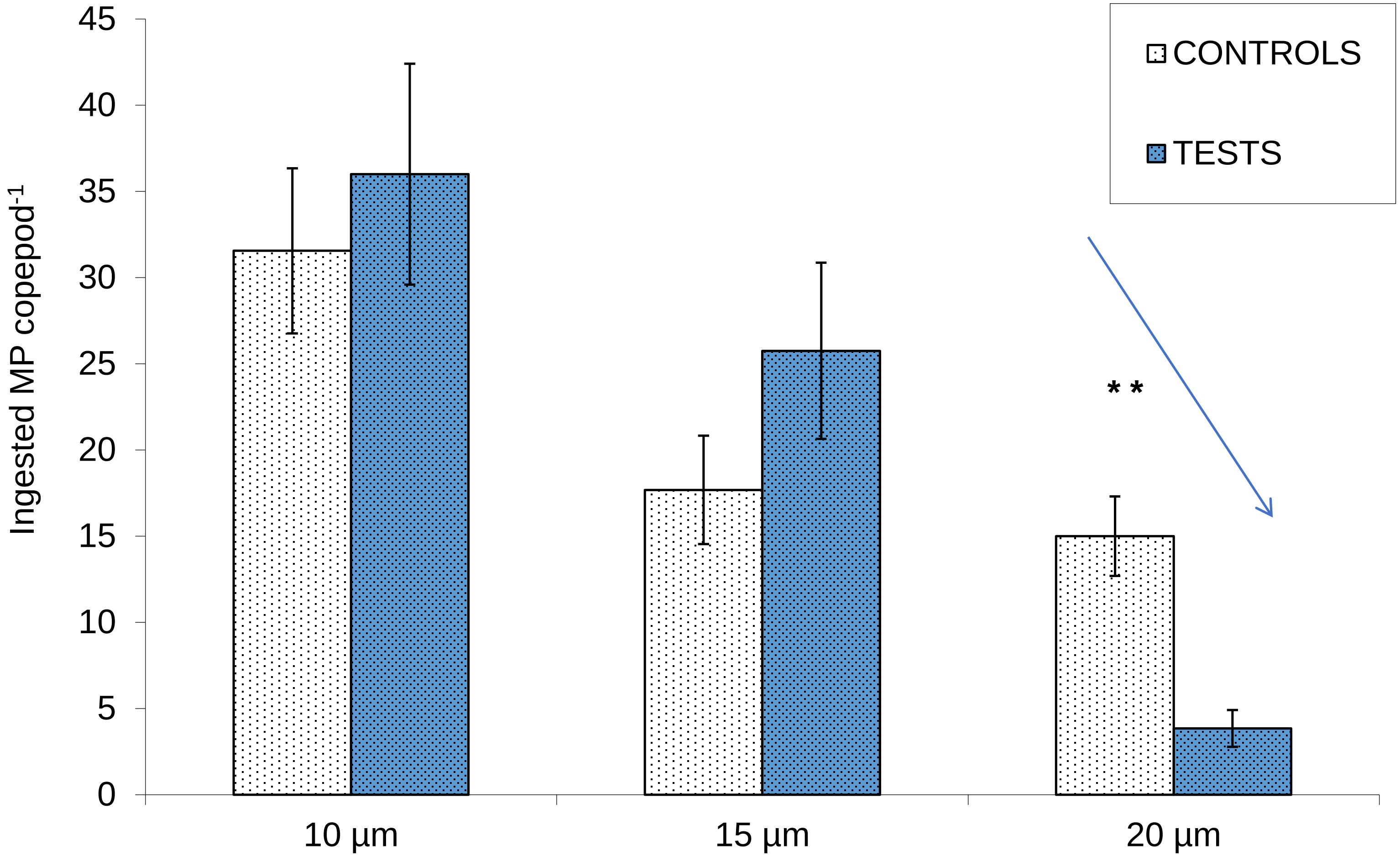


ADVERSE EFFECTS ON PLANKTON COMPONENTS

❑ DELETERIOUS EFFECTS CAN BE LOWERED BY SEAWATER VISCOSITY

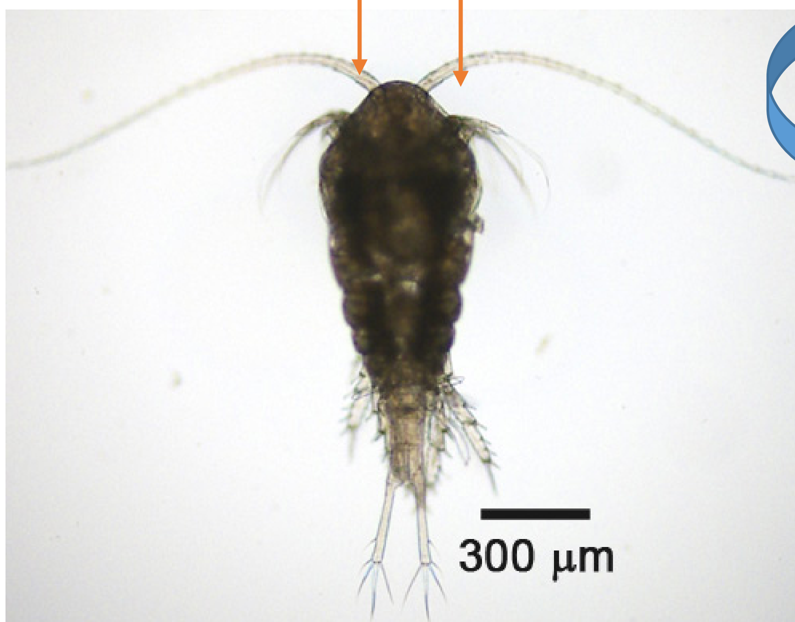
Feeding current > Viscosity

10

15

20

Viscosity > Feeding current



Viscosity does lower MP ingestion

Viscosity level
MP size

ADVERSE EFFECTS ON PLANKTON COMPONENTS

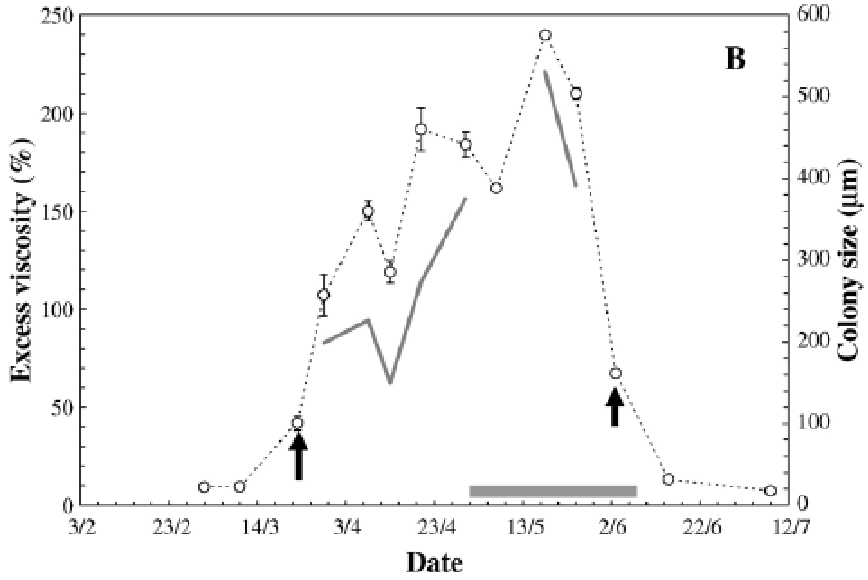
❑ DELETERIOUS EFFECTS CAN BE LOWERED BY SEAWATER VISCOSITY

Viscosity does lower MP ingestion

Viscosity level
MP size

Seuront et al. (2006)
Viscosity can increase up to 250%

Good news for zooplankton
BUT.....



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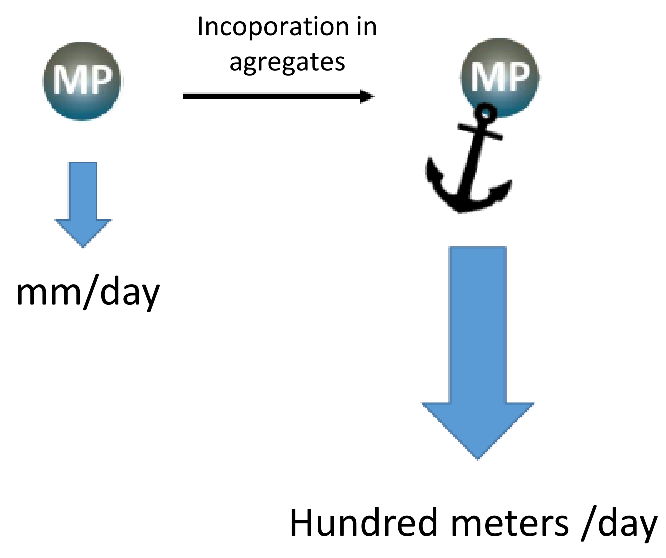

BAD news for the Benthos

Long et al. (2015, submitted)

ADVERSE EFFECTS ON PLANKTON COMPONENTS

Research on MP are increasing ~ MP pollution

- increase in awareness
- increase in technical devices and sampling efforts

Challenging issues

- Concentrations
- Types of MP (spherical beads, composition)
- Nanoplastics

Review

Is there any consistency between the microplastics found in the field and those used in laboratory experiments?☆

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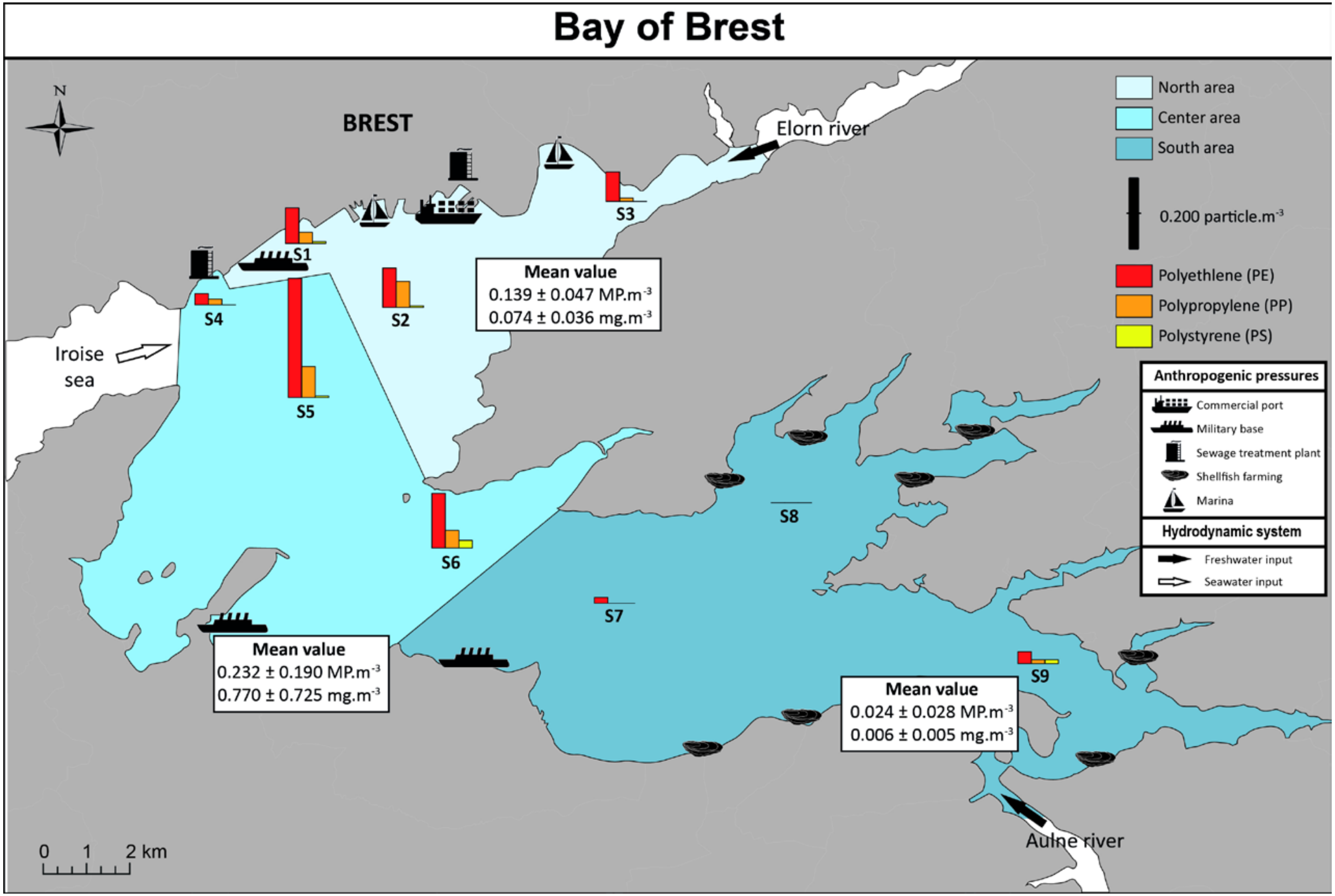
ADVERSE EFFECTS ON PLANKTON COMPONENTS



Frère et al. (in prep)

Adverse effects on Plankton components

Perspectives

Why in some cases MP are chosen or avoided ?

to better understand selectivity mechanisms against microplastics

Trophic transfer in the plankton webs ?

to assess whether copepods are efficient MP vectors and their impact on higher trophic levels (e.g. gut obstruction ?)

What about your bugs ?

THANK YOU