HOTMIC

Horizontal and vertical oceanic distribution, transport, and impact of microplastics

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JPI OCEANS

GEOMAR

The HOTMIC consortium:

- GEOMAR Helmholtz-Centre for Ocean Research Kiel (Dr. Aaron Beck, Prof. Eric Achterberg, Dr. Mark Lenz, Dr. Matthias Haeckel) (Germany)
- Institute of Hydrochemistry (IWC), Technical University of Munich (TUM) (Dr. Natalia Ivleva) (Germany)
- University of Southern Denmark (Prof. Jamileh Javidpour) (Denmark)
- Portuguese Institute for Sea and Atmosphere (Dr. Miguel Caetano) (Portugal)
- MARE – Marine and Environmental Sciences Centre (Dr. João Canning Clode) (Portugal)
- Università di Pisa (Prof. Valter Castelvetro) (Italy)
- Ghent University (Prof. Ann Vanreusel) (Belgium)
- University of Tartu (Prof. Jonne Kotta) (Estonia)

and associated partners:

- Utrecht University (Prof. Erik van Sebille) (Netherlands)
- Marine Institute (Dr. Jeffrey Fisher) (Ireland)

Input, transport, and fate of plastics in the ocean

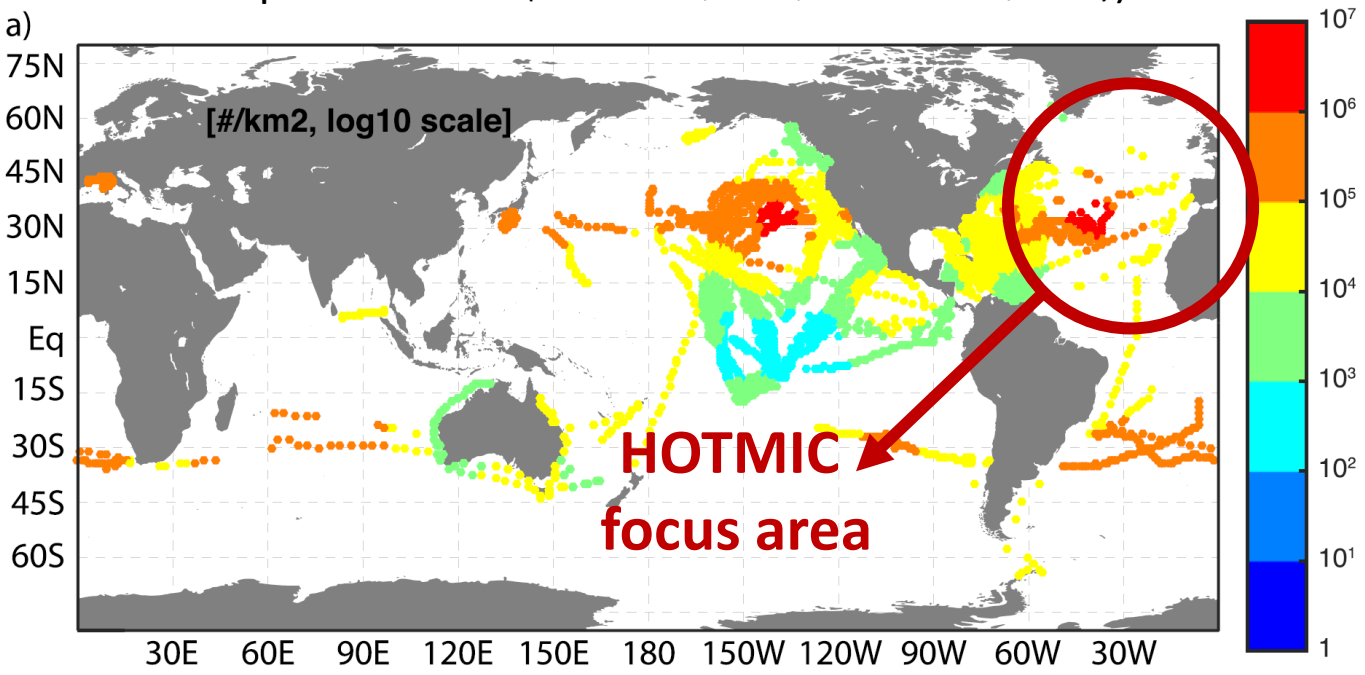
5-13 MT of plastic debris enters the ocean annually *(Jambeck et al., 2015)*

In the open ocean, this debris accumulates in central gyres *(Law et al., 2010)*

But only about ~1.7 MT has been found in the surface ocean *(Eriksen et al., 2014)*

Microplastics in surface trawls

(The North Atlantic gyre contains ~20% of the global ocean plastic debris *(Cózar et al., 2014; Eriksen et al., 2014)*)



van Sebille et al., 2015

Where is the missing plastic, and how did it get there?

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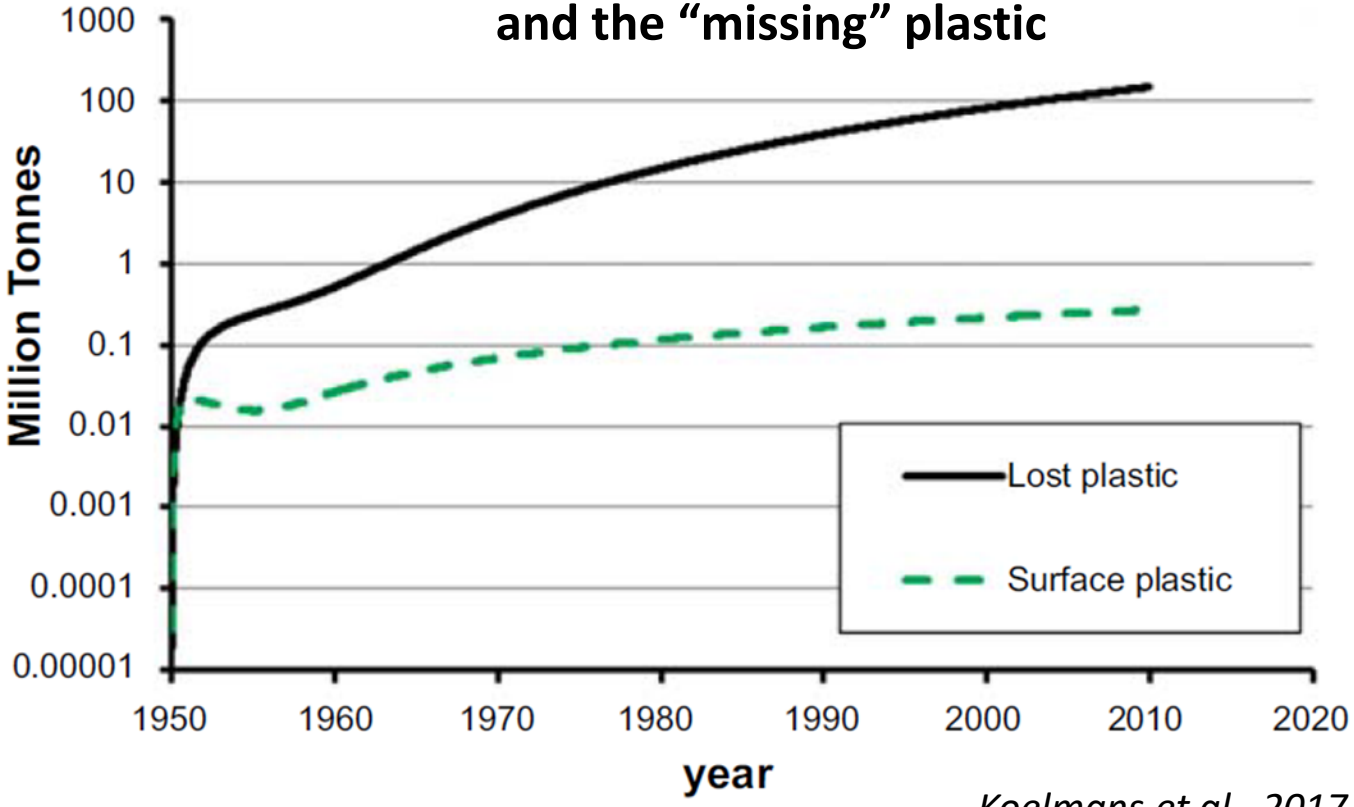
Likely causes:

1) Transfer into the ocean interior, especially by biota-plastic interactions:
- Ingestion, packaging in fecal pellets
- Capture by gelatinous zooplankton
- Biofouling, aggregation, sinking

2) Fragmented into pieces too small to be captured by current monitoring schemes

Modeled oceanic plastic debris and the "missing" plastic



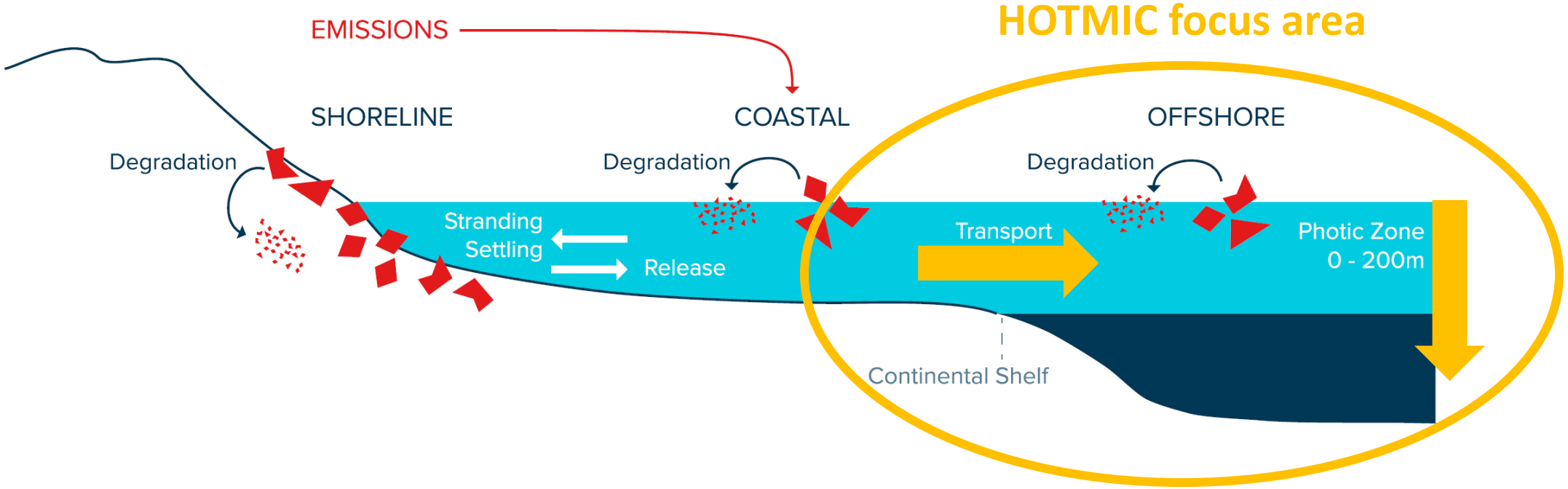
Koelmans et al., 2017

Questions to be addressed within HOTMIC:

What processes transport plastic from the coast to accumulation areas in the subtropical gyres?

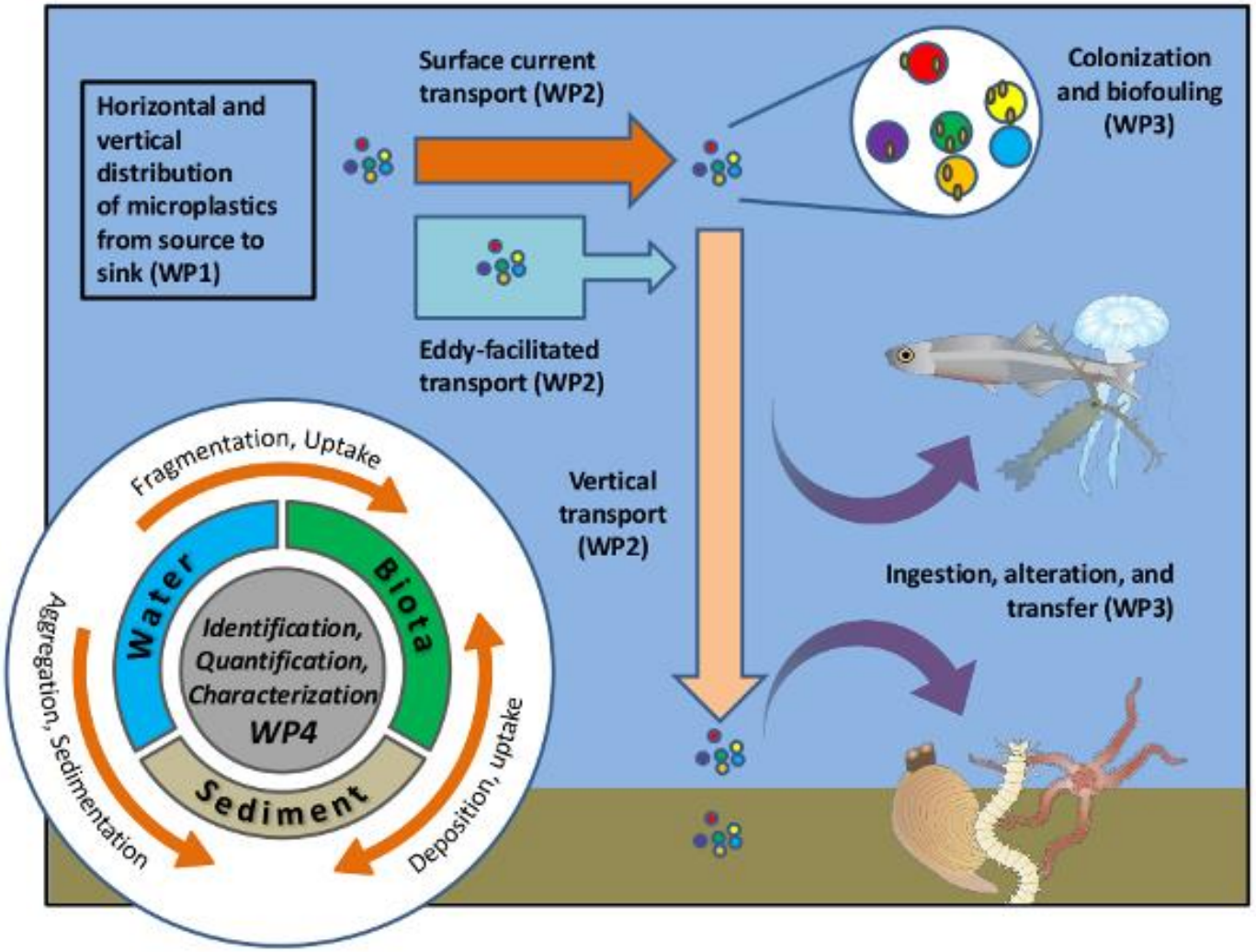
What mechanisms control fragmentation and vertical export of plastics in the open ocean?

What is the ultimate fate of marine plastic debris, and what is its effect on open and deep ocean ecosystems?



Modified from Lebreton et al., 2019

HOTMIC project structure



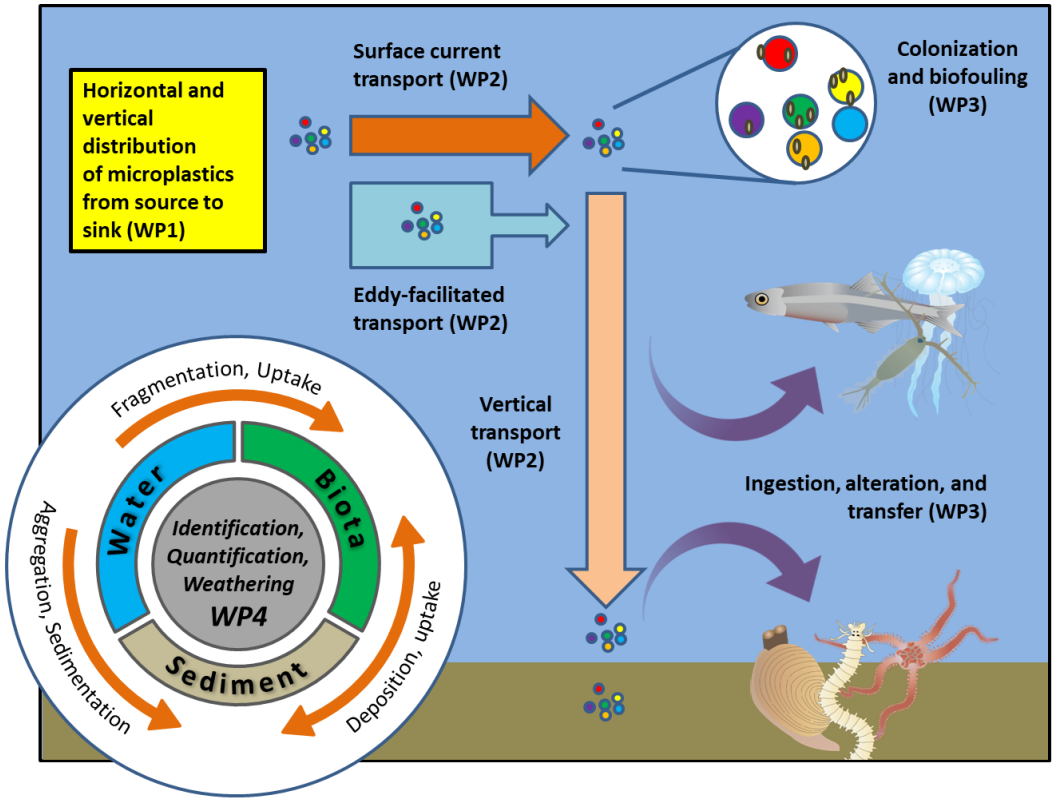
Workpackage Overview

WP1: Distribution from coast to deep sea (Lead: IPMA)

1) Quantify abundance, composition, and size of MP particles,
and dissolved plastics additives

- in surface waters, from land to the North Atlantic gyre
- from surface to deep waters to sediments, under the "garbage patch"

2) Development and testing of novel *Flow2Vortex* sampling device for MP



Workpackage Overview

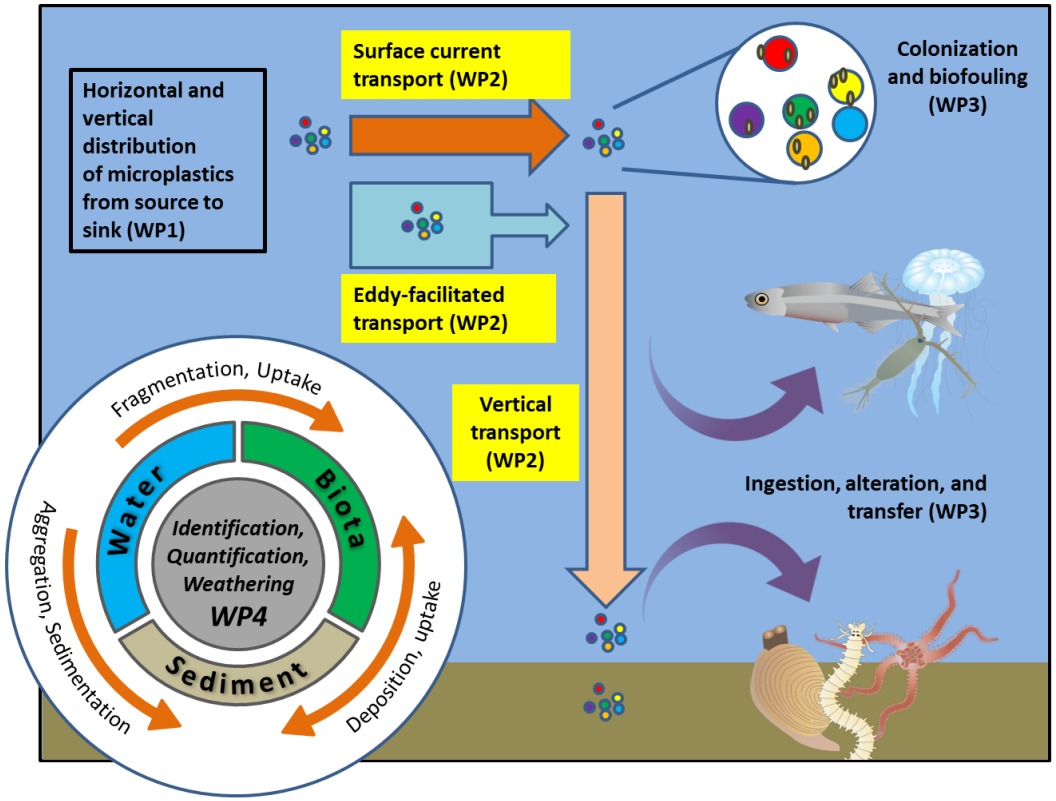
WP2: Mechanisms of transport and alteration (Lead: GEOMAR)

1) Quantify lateral MP transport fluxes
from land to open ocean
- role of surface currents vs. eddy-facilitated transport

2) Quantify the vertical flux of MP particles
under the North Atlantic garbage patch

3) Understand physical processes controlling vertical transport

4) Characterize MP chemical composition and weathering state along time and space gradients



Workpackage Overview

WP3: Biota-plastic interactions and impacts (Lead: SDU)

1) Measure abundance and composition of MPs in biota from different trophic levels from the sea surface to the infauna of sediments

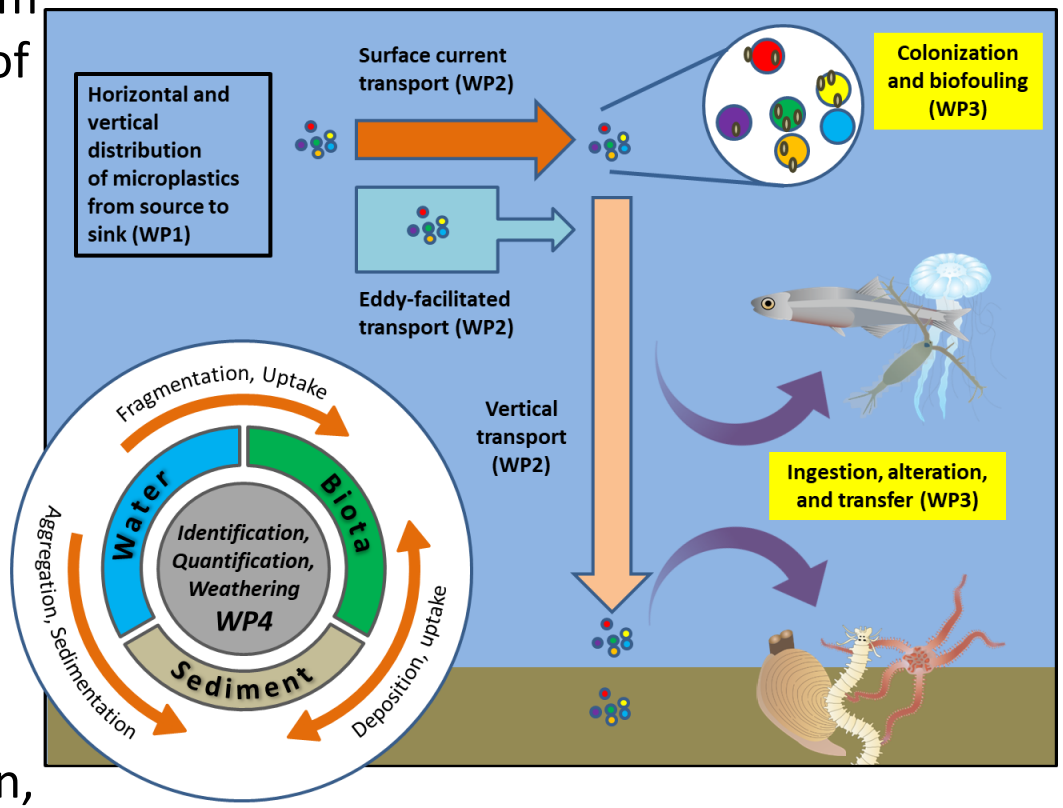
2) Evaluate MP association with and effects on adhesive biological entities, especially fish eggs and larvae

3) Quantify abundance and composition of biofilms and biofoulers on plastics from sea surface to sediments

4) Understand the factors that determine MP rejection or ingestion by marine invertebrates

5) Understand the role of marine biota on MP formation

6) Assess the role of biota, especially gelatinous zooplankton, and biogenic aggregates on vertical MP particle transport



Workpackage Overview

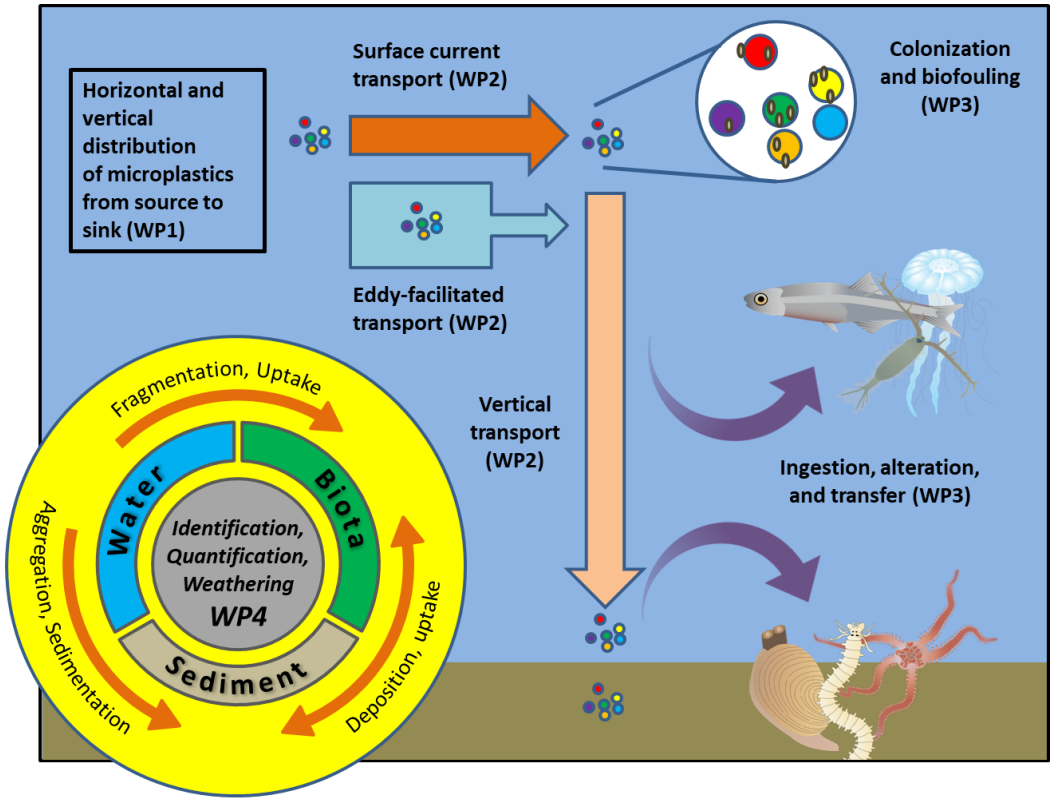
WP4: Analytical challenges and solutions (Lead: IWC-TUM)

1) Development and application of improved methods for quantification of different MP down to nanometer range

2) Development of Raman-based automated identification, quantification and characterisation of MP particles <10 µm and microfibers

3) Improvement of 2D & 3D in situ Raman analysis of MP, incl. particles <10 µm in biota

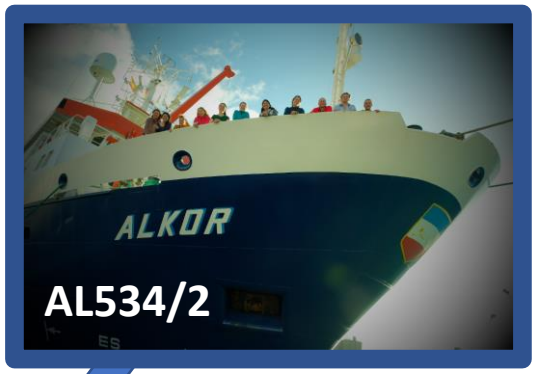
4) Intercomparison of methods for determination of MP in the entire size range (1 µm - 5 mm) in different environmental matrices

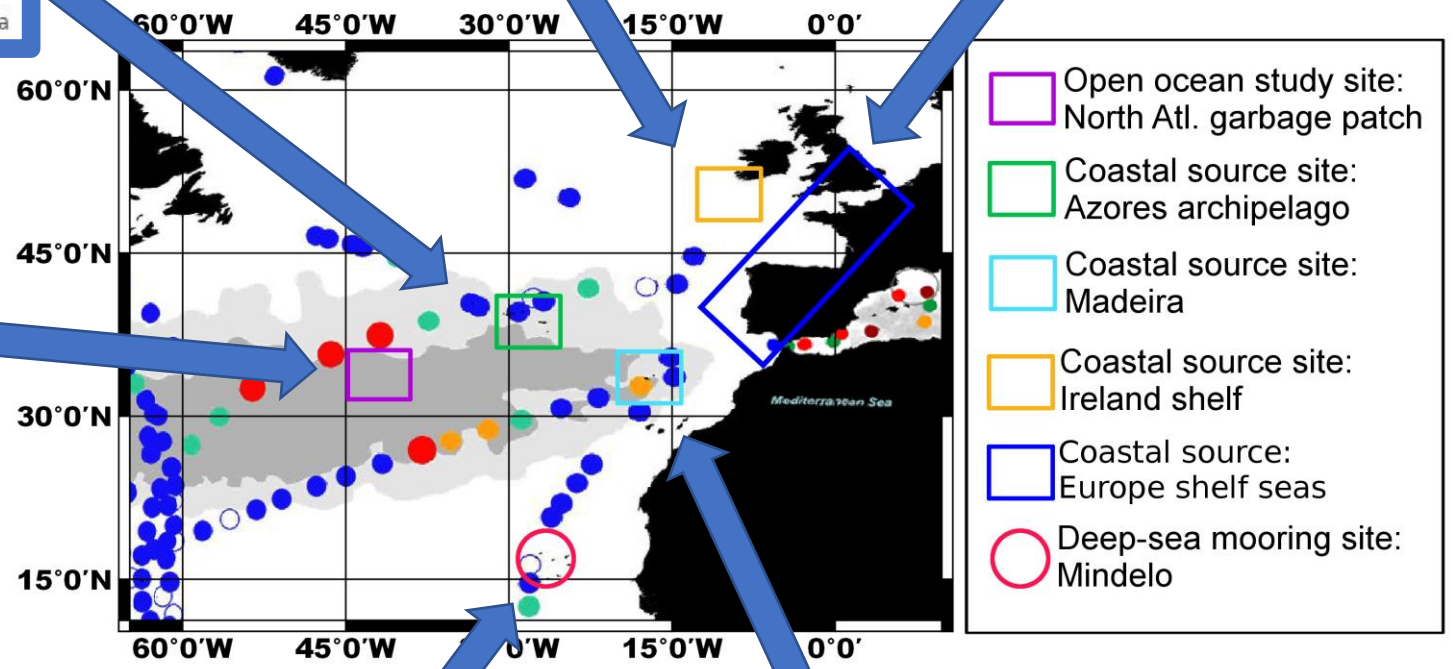


HOTMIC study region

IPMA
Instituto Português do Mar e da Atmosfera

Foras na Mara
Marine Institute





OSCM
Ocean Science Centre Mindelo

MARE

Modified from Cozar et al., 2014

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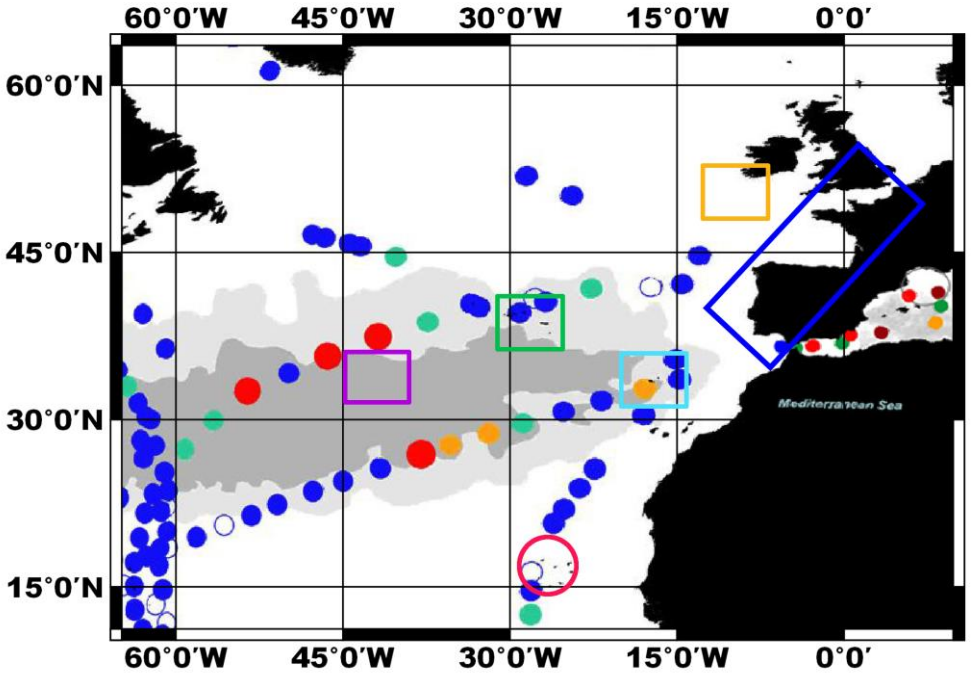
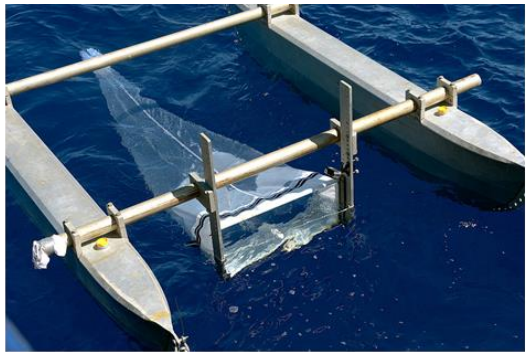
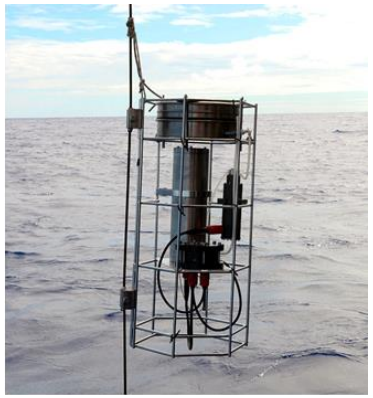
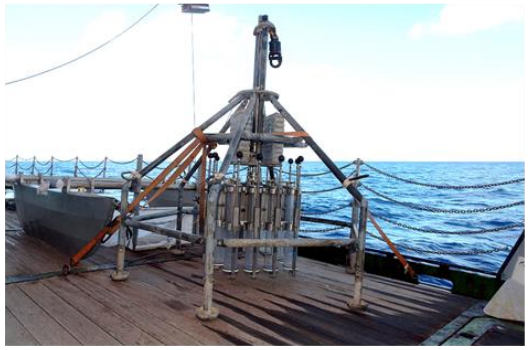
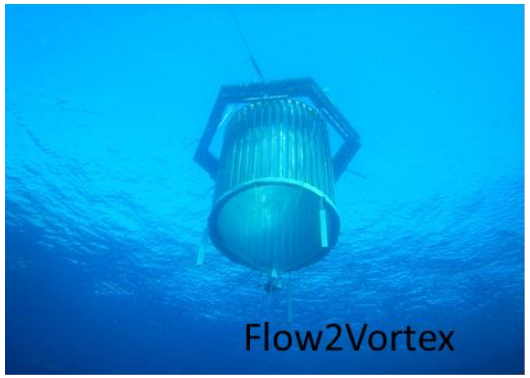
Sampling and Experimentation

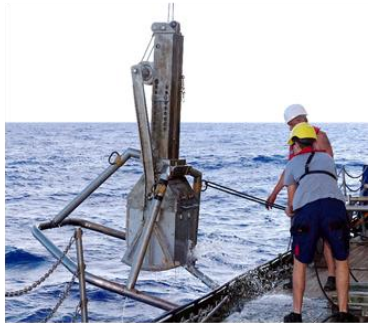












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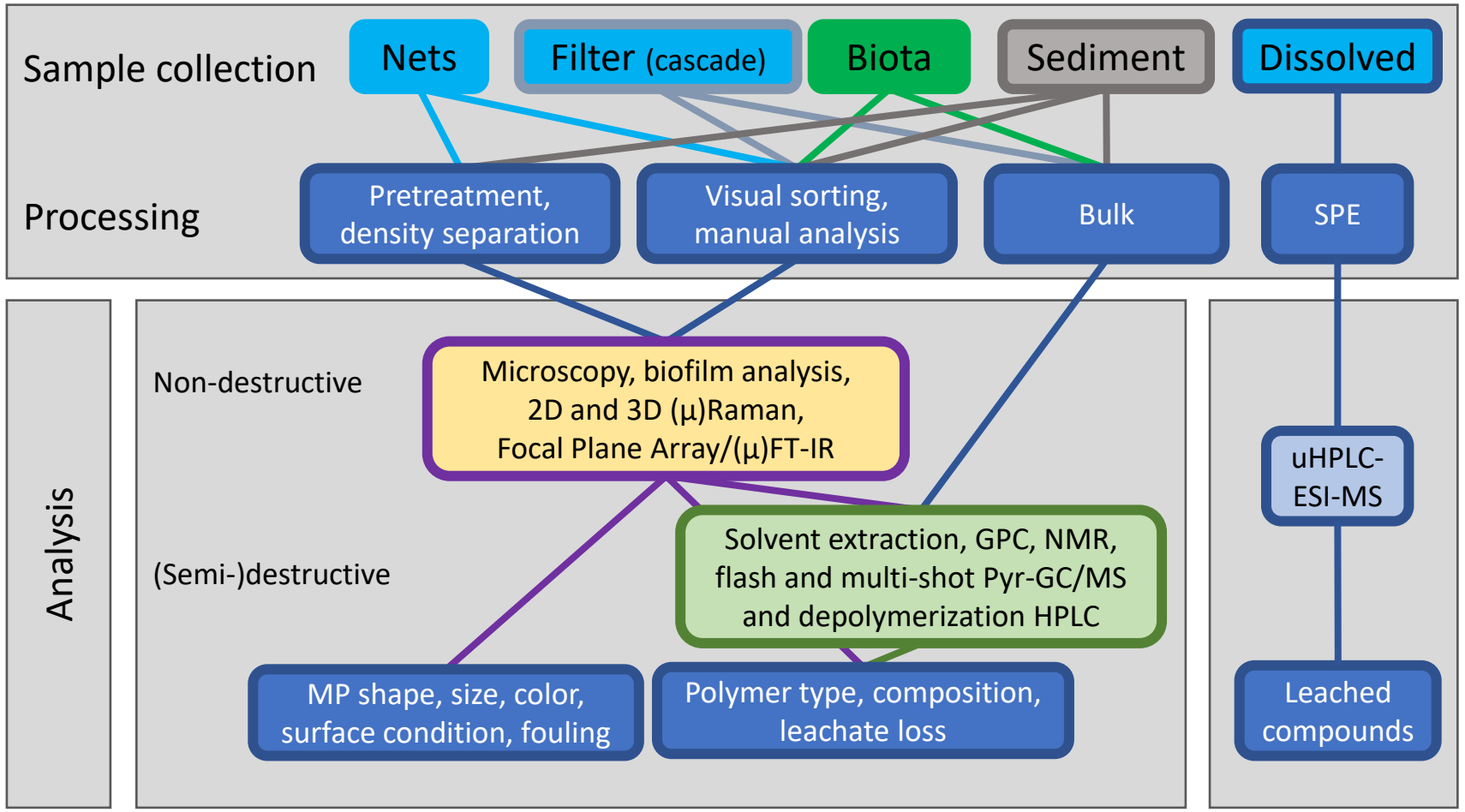
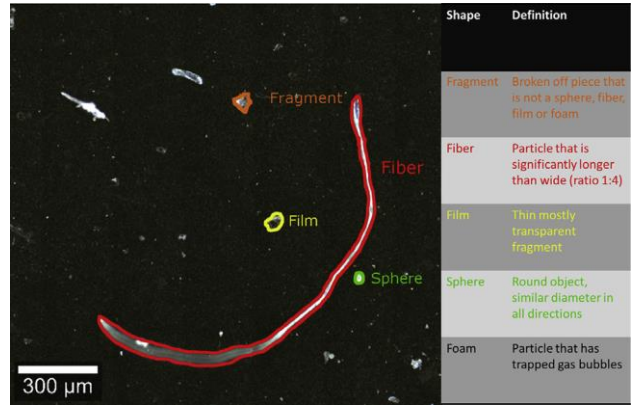
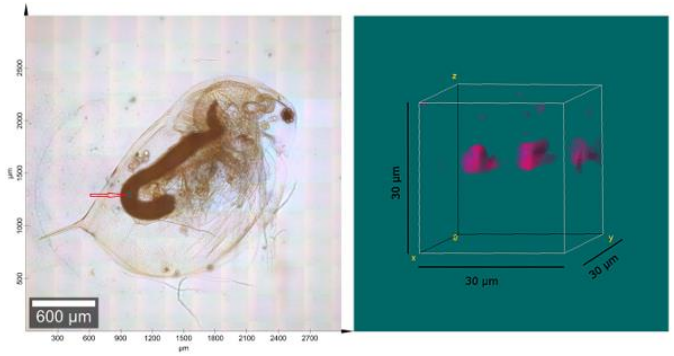
Analytical challenges and solutions (incl. quality control)





von der Esch, in Anger et al., TrAC, 2018



Imhof and Anger, IWC-TUM

Overall goals and outcomes

WP5: Coordination, integration, dissemination

1. **Map the distribution** of MP along the under-sampled pathway from coastal ocean to open ocean gyre to deep sea.
2. **Understand the processes** controlling lateral and vertical transport of MP, to improve global ocean MP models and identify the missing ocean plastic pool
3. Further **develop the analytical tools** required to measure MP particles, especially those <10 µm in size, in marine environmental matrices

A. Synthesis and data management for **seamless integration into oceanographic transport models** such as OceanParcels

B. Availability of HOTMIC data through repositories such as Pangaea and Ocean Science Information System (OSIS) at GEOMAR

C. Training opportunities for postdoctoral researchers and students at all levels

D. Inform policy and management strategies for reducing the impact of MP on the ocean

WP5: Outreach, Training, Stakeholder Engagement

Popular and industry

BRIGHT 2019
LA NOTTE DEI RICERCATORI IN TOSCANA

EUROPEAN RESEARCHER'S NIGHT
NOTTE EUROPEA DEI RICERCATORI
ERN ITALY

COREPLA

Multi-level Education

IMBRSea

GAME
GLOBAL APPROACH BY MODULAR EXPERIMENTS

Erasmus+

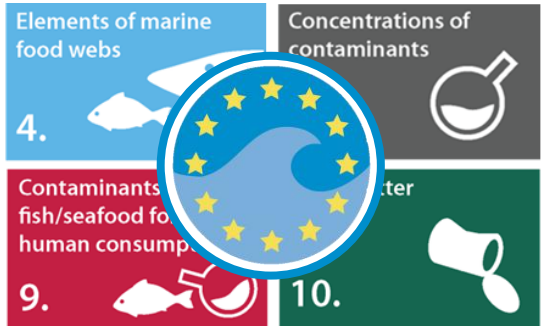
IPMA Escolas

TUMlab im Deutschen Museum

Oceans & Lakes

CIÊNCIA VIVA

Government and Policy



SUSTAINABLE DEVELOPMENT GOALS
14 LIFE BELOW WATER

DAM
GERMAN MARINE RESEARCH ALLIANCE

REPUBLIC OF ESTONIA
MINISTRY OF THE ENVIRONMENT

HOTMIC