JPI OCEANS

Microplastics in the marine environment

Research projects 2020 - 2023

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Vision: Enabling the transformation to a sustainable blue economy whilst fostering the health and productivity of seas and oceans.

Mission: Facilitating the efficient provision of expert knowledge and innovative solutions to enable informed policy delivery and economic development ensuring sustainably healthy and productive seas and oceans.

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Introduction

Plastics in the marine environment have become a major concern because of their persistence at sea and adverse consequences to marine life. According to estimates from Eunomia (2016) between 27–67 million tons of plastic could be found in the world's ocean as of 2016. However, knowledge and understanding about smaller microplastic particles (from 10 µm to even smaller particles - nanoparticles) is still limited.

Building on the results from the first JPI Oceans transnational call "Ecological aspects of microplastics in the marine environment" and recent scientific findings a second call was launched by thirteen JPI Oceans member countries together with Latvia and Brazil in November 2018. After evaluation, six new JPI Oceans projects were selected for funding to conduct research on sources of microplastics, methods for identifying smaller micro- and (nano-) plastics and monitoring their circulation in marine systems and their effects thereon:

ANDROMEDA - Analysis techniques for quantifying nano-and microplastic particles and their degradation in the marine environment – Coordinator: Dr Richard Sempéré, Université d'Aix-Marseille, France

HOTMIC - Horizontal and vertical oceanic distribution, transport, and impact of microplastics – Coordinator: Dr Aaron Beck, GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Germany

FACTS - Fluxes and Fate of Microplastics in Northern European Waters – Coordinator: Prof Jes Vollertsen, Aalborg University, Denmark

microplastiX - Integrated approach on the fate of MicroPlastics (MPs) towards healthy marine ecosystems - Prof Luca Brandt KTH, Royal Institute of Technology, Sweden

i-plastic - Dispersion and impacts of micro- and nano-plastics in the tropical and temperate oceans: from regional land-ocean interface to the open ocean – Coordinator: Prof Patrizia Ziveri, Universitat Autònoma de Barcelona, Spain

RESPONSE - Toward a risk-based assessment of microplastic pollution in marine ecosystems - Coordinator: Prof Francesco Regoli, Polytechnic University of Marche, Italy

This booklet provides an overview introducing the new projects and their participants.

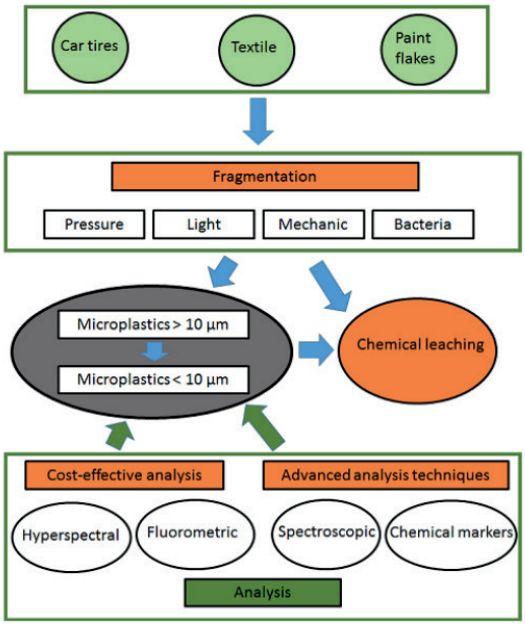
ANDROMEDA

Analysis techniques for quantifying nano-and microplastic particles and their degradation in the marine environment

Project Description

Coordinator: Dr Richard Sempéré, Université d'Aix-Marseille, France

The Andromeda project brings together an international research partnership that combines the expertise and competencies of 15 international research institutes. The project aims to gain knowledge about the degradation of microplastics while further advancing in-field of analyses of both; micro- and nanoplastics. The cost-effectiveness of analyses as well as the need for advanced analysis techniques will be considered, and challenging types of microplastics, such as microfibers, tyre wear particles, and paint flakes among others, will be assessed.



To date, very little is known about the degradation processes of microplastics. It is therefore the aim of the Andromeda project to develop UV, hydrolytic, and thermo-oxidative methodologies to study accelerated plastic degradation in the laboratory, which will in turn establish a collection of partially degraded reference materials for further research applications. Comprehensive degradation studies will be undertaken to examine the mechanisms of UV and microbial degradation of microplastics in seawater and in marine sediments. Furthermore, the influence of parameters such as temperature, acidity and hyperbaric pressure will be investigated, with special attention being given to the leaching of chemical additives. To facilitate this, microplastic material will be immersed in coastal waters at a depth of 2000 meters for up to 12 months, and the resulting degraded materials will be distributed to project partners for further analyses and physicochemical characterisation. At the same time, hyperbaric conditions will be simulated under laboratory conditions to study the leaching of chemical additives. Chemical compounds will also play a key role in the development of a cost-effective methodological toolbox. Chemical markers that are suitable to replace the invasive sampling of organisms will be identified, consequently avoiding the sacrificing of animals in testing. Metals and organic additives will be tested as potential tracers.

Partners specialised in communication, dissemination, and data management will ensure strong stakeholder involvement and efficient outreach of the project results. Communication activities will include the provision of factsheets to schools, social media engagement, a project website, and participation at national and international conferences.

Interaction with the general public will take place via a smartphone app, which will be developed to engage citizens in the mapping of meso- and microplastics. Moreover, as another way of detecting mesoplastics and large microplastics at the water surface, hyperspectral imaging will be combined with the use of aerial drone imaging.

Consortium

Organisation	Acronym	Country
Université d'Aix-Marseille - Mediterranean Institute of Oceanography	AMU-MIO	FRANCE
Flanders Research Institute for Agriculture and Fisheries	ILVO	BELGIUM
French Research Institute for Exploitation of the Sea	Ifremer	FRANCE
SINTEF Ocean AS	SINTEF	NORWAY
Norwegian Institute for Air Research	NILU	NORWAY
Flanders Marine Institute	VLIZ	BELGIUM
University of Malta	UM	MALTA
University of Gothenburg	/	DENMARK
Helmholtz-Centre for Environmental Research	UFZ	GERMANY
University College Cork	UCC	IRELAND
Instituto Español de Oceanografía	IEO	SPAIN
Tallinn University of Technology	TalTech	ESTONIA
McGill University	/	CANADA
Wageningen University	WUR	THE NETHERLANDS
Merinov	/	CANADA

HOTMIC

Horizontal and vertical oceanic distribution, transport and impact of microplastics

Project Description

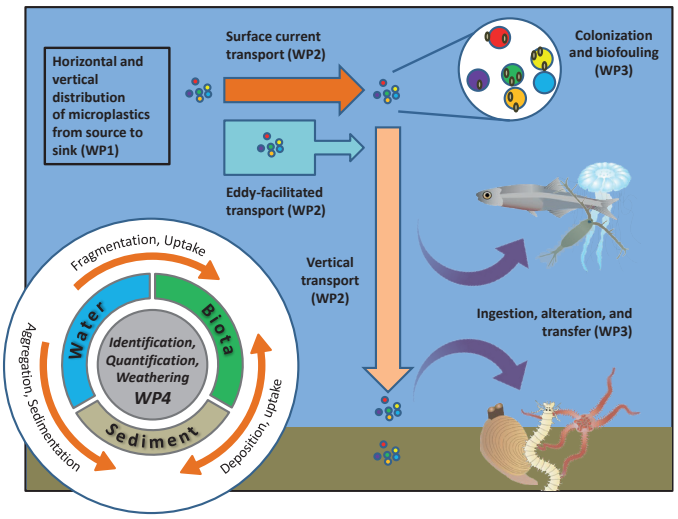
Coordinator: Dr. Aaron Beck
GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany

Less than 10% of the total amount of plastics entering the oceans can currently be accounted for, likely due to its fragmentation into small microplastics, still unquantified by modern techniques, or export from the ocean surface. It is unknown how much plastic debris actually floats at the ocean surface, which mechanisms control plastic transportation and its fate from land to the deep sea, and what ecological impact these may have.

The HOTMIC project seeks to address these knowledge gaps. To do so, it focuses on the North Atlantic as a model region and investigates the pathways of plastic coming from the continent into the North Atlantic Ocean gyre. The objective of HOTMIC is to map the distribution of microplastics - including particles smaller than 10 micrometer and microfibers - in water, sediment, and organisms from the coastal ocean to the open ocean gyre and into the deep sea. The project will quantify processes controlling lateral and vertical transportation of microplastics, including biofouling, (bio)aggregation, and deposition, for incorporation into global ocean models.

To understand the fate of microplastics in the ocean, HOTMIC will examine microplastics weathering signatures during ocean transportation, and evaluate the predominant mechanisms that create such weathering signature, including biological effects of bioshredding and ingestion.

These objectives will be supported by a diverse suite of analytical techniques. In order to achieve comprehensive detection of microplastic particles smaller than 10 micrometer and microfibers, HOTMIC will develop and optimize novel analytical methods based on a combination of non-destructive (Raman & FT-IR spectrometry, microscopy), and destructive techniques (hydrolytic depolymerization, HPLC, Py-GC/MS, EGA/MS).



In addition, HOTMIC will develop Raman spectroscopy techniques for automated detection of microplastics, including particles smaller than 10 micrometer and microfibers, to greatly increase sample throughput, and 2D & 3D imaging of microplastics in biota. HOTMIC will use field and experimental measurements to understand the transportation and fate of small microplastics and microfibers, and to evaluate the risks of these contaminants for marine environments and organisms.

Consortium

Organisation	Acronym	Country
GEOMAR Helmholtz Centre for Ocean Research Kiel	GEOMAR	GERMANY
Ghent University, Department of Marine Biology	UGENT	BELGIUM
University of Southern Denmark, Department of Biology	SDU	DENMARK
University of Tartu, Estonian Marine Institute	UT	ESTONIA
Institute of Hydrochemistry, Technical University of Munich, Department of Chemistry	IWC/TUM	GERMANY
University of Pisa, Department of Chemistry and Industrial Chemistry	UNIPI	ITALY
Portuguese Institute for the Sea and the Atmosphere, Division of Oceanography and Marine Environment	IPMA	PORTUGAL
Marine and Environmental Sciences Centre	MARE	PORTUGAL

FACTS

Fluxes and Fate of Microplastics in Northern European Waters

JPI OCEANS

Project factsheet

Project Description

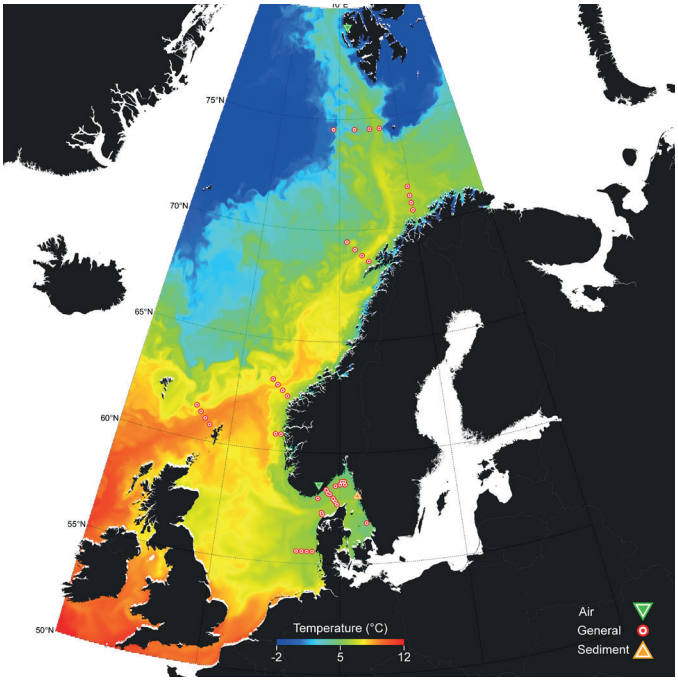
FACTS

Coordinator: Prof. Jes Vollertsen
Aalborg University, Denmark

FACTS has the objective to create new knowledge and improve our mechanistic understanding on the sources, transport, occurrence, and fate of small microplastics in the northern marine waters. It addresses the geographical issue of microplastics transport from the temperate waters of the southern North Sea to the arctic waters of the Barents Sea. FACTS includes the physical distribution of microplastics on different temporal and spatial scales and their vertical transport in the water column. In addition, FACTS targets new challenges of determining and quantifying nanoplastics and tyre particles in the marine environment. It combines state-of-the-art analytical, monitoring and modelling approaches in feedback cycles to describe transport and geographical sources of microplastics contamination as well as sinks from the temperate waters of the southern North Sea to the Arctic waters of the Barents Sea.

FACTS analyses the distribution of microplastics in the water column and quantifies Skagerrak as a major sink zone. Investigated transport processes range from drift scenarios to air transport to aggregation and sinking processes. FACTS also zooms in on the geographic scale to study microplastic transport and fate in a semi enclosed fjord system. The goal is to address the question of how microplastics move vertically in the water column with time under comparatively well-defined hydrodynamic conditions.

FACTS is structured around a set of sampling campaigns reaching from the German Bight to Svalbard, where samples are collected from large research vessels, smaller research vessels, fishery vessels and land based boats. The sampling and analysis addresses microplastics particles of all shapes. The sampling targets to represent the whole water column from the interface with the atmosphere to the sediments. At



a limited number of sites, benthic fish are caught wild and atmospheric deposition is sampled and analysed down to the nanometre range. The sea surface microlayer and larger rapidly sinking particle aggregates (marine snow) are sampled to improve the understanding of the role of these conditions and processes on the 3-dimensional transport of microplastics and nanoplastics.

Plastic particle concentrations obtained from the proposed sampling campaigns are implemented into oceanographic models. The modelling approach is used to integrate release and transport scenarios, and the likelihood and timescale for particle pathways is estimated based on sinking, defragmentation, and beaching rates, obtained from observations.

The reliability of reported data on small microplastics has improved significantly since more emphasis is put on contamination control, chemical identification of polymer particles, and removal of human biases by automation.

Chemical imaging methods such as μ-FTIR and Raman microscopy with particle detection limits of 10 and 1 micrometre are now routinely applied. Based on these and emerging methods with even lower detection limits, FACTS delivers a more complete description of sources, transport and fate of small microplastics. FACTS also tackles the current challenges of nanoplastics and tyre wear particle detection in marine samples. Both particle types are currently not accessible for mass balances of marine plastics contamination.

Consortium

Organisation	Acronym	Country
Aalborg University	AAU	DENMARK
Alfred-Wegener-Institut Helmholtz-Zentrum für Polar und Meeresforshung	AWI	GERMANY
Norwegian Institute of Air research	NILU	NORWAY
Institute for Chemistry and Biology of the Marine Environment, University of Oldenburg	ICBM	GERMANY
National Research Council of Italy	CNR	ITALY
Institute of Marine Research	IMR	IRELAND
Norwegian Research Center	UCC-MaREI	NORWAY
GEOMAR Helmholtz Zentrum für Ozeanforschung	GEOMAR	GERMANY
University of Gothenburg	GU	DENMARK
Technische Universität Berlin	TU Berlin	GERMANY
Sigray	/	USA
Universitet i Bergen	UiB	NORWAY
Continental Reifen Deutschland GmbH	/	GERMANY
Ocean Scientific International Limited	OSIL	UNITED KINGDOM
Heriot-Watt University	/	UNITED KINGDOM

MicroPlastiX

Integrated approach to the fate of Microplastics (MPs) towards healthy marine ecosystems

JPI OCEANS

Project Description

Coordinator: Dr. Luca Brandt
Royal Institute of Technology (KTH), Sweden

MicroplastiX is an international interdisciplinary project bringing together 15 partners from 7 countries. The main goal of the project is to improve our understanding of the degradation mechanisms that affect microplastics (MPs) in environmental conditions, an issue of pressing urgency on which there is still relatively scarce information. MicroplastiX focuses on how weathering and degradation affect plastic materials, causing them to fragment into smaller pieces. Because degradation processes are not uniform, addressing this issue is particularly relevant to assess, estimate and monitor microplastics abundances, hot-spots, distribution patterns and pathways from land sources to the ocean. The line of thought in MicroplastiX is to identify the "missing plastics" in the environment by sampling water (surface and column), sediments (intertidal and benthic) and biota (pelagic, demersal and benthic) in different habitats and geographical areas. To advance this research field, MicroplastiX intends to establish a methodological framework based on field and laboratory experiments to gather data which will be modelled through mathematical links.

The United Nations (UN) and the Group of Seven (G7) have recognized anthropogenic marine litter and microplastics particles as items with negative effects on aquatic wildlife, on marine and freshwater ecosystems, on local economies and potentially on human health. The impact of these microscopic items on the natural environment is inducing concerns within the scientific community on the urgency of reducing the sources of continental pollution, which represent about 80% of the overall marine litter in our oceans. The progressive fragmentation of microplastics, due to processes of biocolonisation and weathering, makes their quantification and qualification in the aquatic environment even more complicated. Since plastic has the ability to adsorb persistent pollutants and act as a transport vector for invasive species, an additional goal is that of designing models to understand how pollutant adsorption and colonization rate by different species might contribute to changes in the physical-chemical behaviour of plastics.

MicroplastiX will develop a comprehensive approach that combines field data and laboratory experiments to evaluate degradation, fragmentation and interaction of microplastics with biota. All data gathered will be used in multiscale prediction models, to provide detailed information to stakeholders on the fate and pathways from rivers to the sea.

The project covers a significant area in the North and South Atlantic oceans. The research team is already working along the North-eastern, Eastern and South-eastern coast of Brazil, the North Western and South Western coasts of Africa, in the Western coast of Ireland and the Mediterranean Sea. This is a wide geographical area of ecological and economic relevance.

Part of the project time and costs will be devoted to outreach activities and dissemination actions to educate and raise awareness among the general public on the impact and dynamics of marine litter and microplastics in the marine environment. This project therefore aims to directly contribute to healthy marine ecosystems by addressing the UN Sustainable Development Goals 4 (Quality education) and 14 (Life below water), and descriptor 10 (marine litter) of the EU Marine Strategy Framework Directive.

Consortium

Organisation	Acronym	Country
Royal Institute of Technology	KTH	SWEDEN
Chalmers University of Technology	CTH	SWEDEN
Universidade Federal de Pernambuco, Centro de Estudos e Ensaios em Risco e Modelagem Ambiental	UFRPE-CEERMA	BRAZIL
Universidade Federal de Pernambuco, Laboratório de Zooplâncton	UFPE- LABZOO	BRAZIL
Instituto Oceanográfico da Universidade de São Paulo	IOUSP	BRAZIL
Universidade Federal do Rio de Janeiro	UFRJ	BRAZIL
Universidade Federal do Rio Grande do Sul	UFRGS	BRAZIL
Universidade Federal do Pernambuco-PLANKTON	PLANKTON	BRAZIL
Sorbonne Université	SORBONNE	FRANCE
Mediterranean Institute of Oceanography, Toulon University	MIO	FRANCE
Leibniz Institute of Polymer Research Analytics	IPF	GERMANY
Leibniz Centre for Tropical Marine Research	ZMT	GERMANY
Marine and Freshwater Research Centre, Galway-Mayo Institute of Technology	MFRC - GMIT	IRELAND
Stazione Zoologica Anton Dohrn	SZN	ITALY
Universidade da Coruña	UDC	SPAIN

i-plastic

Dispersion and impact of micro and nano plastics in the tropical and temperate oceans: from regional land-ocean interface to the open ocean

JPI OCEANS

Project factsheet

Project Description

Coordinator: Prof. Patrizia Ziveri
Catalan Institution for Research and Advanced Studies (ICREA), Institute of Environmental Sciences and Technologies (ICTA), Autonomous University of Barcelona (UAB), Spain

About

The recent acceleration of microplastics pollution has increased the need to develop novel collaborative tools for synergistic problems affecting coastal and oceanic ecosystems. One of the main hurdles is the lack of standardized, comparable and integrated information on smaller size (micro- and nano-) plastics pollution, including their abundance, sources, regional hotspots of accumulation, fragmentation, and transport at the land-sea interface.

The i-plastic project assembles a multidisciplinary consortium of European and Brazilian experts from five institutes and four countries. Together they will assess the dispersion and impacts of microplastics and nanoplastics in the tropical and temperate oceans, from the regional land-ocean interface to the open ocean, by:

- quantifying the seasonal transport and dispersion in three selected estuaries (hotspots of plastic sources) and adjacent coastal waters and shorelines under distinct flow and climate regimes (i.e., tropical and temperate systems);
- performing in-situ monitoring in the selected system of the eastern and western Atlantic Ocean and Mediterranean Sea;
- addressing, through in-situ observations and laboratory experiments, the impacts on distinct commercially valuable species (as part of the human diet) from target regions;
- implementing new approaches to detect and characterize nano-plastics in environmental matrices (i.e.: water, short-term sediment trap, sediment and biota) and ascertain processes of macro-plastics fragmentation;
- using the data generated to feed regional models for the dispersion of micro- and nano-plastics, which in turn will be used to elaborate a model of their dispersion at the Atlantic scale.

Impact

The scientific products of i-plastic will provide key knowledge concerning one of the main pathways of plastics to the ocean, their fate at the land-sea interface and the effects of smaller plastics on the ecosystems of different areas worldwide, by making projections to understand the impacts and dispersion of microplastics and nanoplastics in the next decades of the Anthropocene.

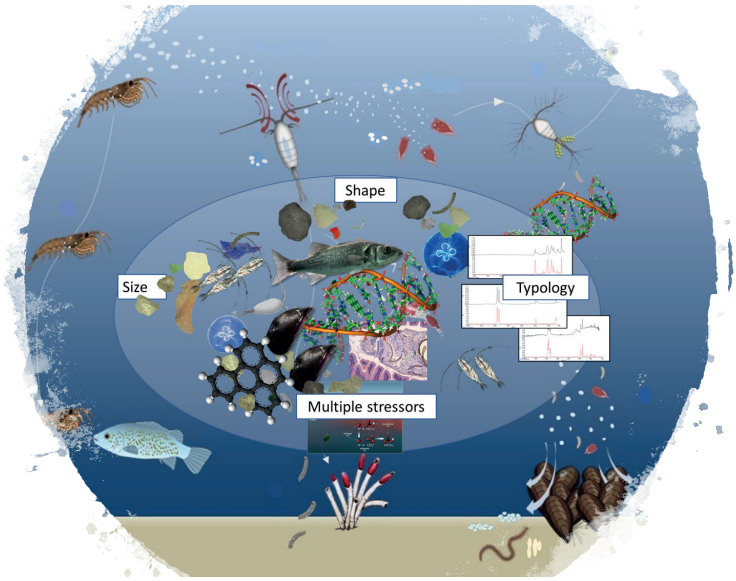
In transfering the outcomes and knowledge to stakeholders i-plastic will provide communication and education (Massive Open Online Course - MOOC) on the role of estuaries on the dispersion of plastic to different ocean basins. The project further aims to open the discussion and provide concrete knowledge to improve guidelines for plastic management to drastically improve the reduction of plastic litter in the marine environment.

Consortium

Organisation	Acronym	Country
Catalan Institution for Research and Advanced Studies, Institute of Environmental Sciences and Technologies, Autonomous University of Barcelona	ICREA/ICTA/UAB	SPAIN
Institute of Sea Science, Federal University of Ceará	LABOMAR	BRAZIL
Department of Biological and Environmental Sciences and Technologies, University of Salento	DISTeBA	ITALY
Association for Innovation and Development of the Faculty of Science and Technology, Nova de Lisboa	NOVA.ID.FCT	PORTUGAL
Division of Chemistry and Pollution of the Marine Environment, Hydrographic Institute	IH	PORTUGAL

RESPONSE

Towards a risk-based assessment of microplastic pollution in marine ecosystems



Project Description

Coordinator: Prof. Francesco Regoli
Polytechnic University of Marche - Ancona, Italy

Multidisciplinary studies which combine chemical and biological measurements, represent an added value to monitoring and management protocols, as also recommended by recent European Directives. However, the combination of multiple typologies of investigations is often hampered by the lack of common metrics and standardized procedures for the interpretation and the integration of complex datasets of heterogeneous results, which typically require various expert judgements.

The RESPONSE project integrates expertise on oceanography, environmental chemistry, ecotoxicology, experimental ecology and modelling to answer key research questions on fate and impact of microplastics (MPs) and nanoplastics (NPs). The more general objective of the project is to provide ecologically relevant strategies for assessing the distribution pathway and biological effects of plastic particles in marine ecosystems.

RESPONSE will cover a wide geographical area, including the Mediterranean, Atlantic Ocean, North Sea and Baltic Sea. Vertical distribution of plastic particles along water column down to sediments will be investigated focusing on sizes and shapes of biological relevance, to better highlight causal relationships between environmental presence of plastic particles, frequency of ingestion in key ecological species, trophic transfer, impact on pelagic food webs, benthic communities, relevant ecosystem functions and services.

Field data will be the basis to extrapolate weights and ecological thresholds for specific characteristics and typologies of microplastics in the environment.

These values will be further validated by innovative mesocosm and laboratory studies aimed to characterize rates of ingestion, tissue translocation and excretion pathways, subtle and chronic effects of microplastics induced from molecular to organism levels, their interactions with other stressors, and ecotoxicological hazard of still unexplored particles such as nanoplastics and biodegradable polymers.

Mesocosm and field manipulative experiments will provide novel insights on the role of microbial community, zooplankton and zoobenthos in the environmental fate of microplastics and nanoplastics, testing the "biological plastic pump" hypothesis and its relationship with trophic transfer and effects on benthic recruitment.

A tangible impact of the project will be the development a quantitative Weight Of Evidence (WOE) model specifically designed to elaborate huge amounts of different typologies of results, summarizing specific hazard indices and an integrated assessment of microplastics impact in the marine environment. The WOE model converted into an informatic, software-assisted tool, will represent a useful contribution to the implementation of methods and monitoring strategies.

As a technological objective, RESPONSE will set up a diffused analytical Smart Hub, which will combine a comprehensive suite of complementary and advanced instrumental facilities available in different laboratories of some partners and of an external world-leading company. The Smart Hub will share innovative technologies and application expertise for analytical needs of all the partners, also contributing to methodological improvement and training.

Particular attention will be given to validate analytical approaches for particles in the size classes of 2 - 20 µm and nanoplastics for which no validated techniques are still available.

Raising public awareness through research initiatives and science communication events will guarantee dissemination of achieved results, and sound advisory support to political and territorial agencies at both national and European levels.

Consortium

Organisation	Acronym	Country
Polytechnic University of Marche, Department of Life and Environmental Sciences	DiVSA-UNIVPM	ITALY
Tallin University of Technology	TalTech	ESTONIA
University of Bordeaux (UBx), National Institute for Scientific Research (CNRS)	EPOC	FRANCE
University of Vigo	UVIGO	SPAIN
National Institute of Aquatic Resources	DTU AQUA	DENMARK
University of Algarve, Centre of Marine and Environmental Research	UALG-CIMA	PORTUGAL
University College Cork, National University of Ireland	UCC-MaREI	IRELAND
French Research Institute for Exploitation of the Sea	IFREMER	FRANCE
Interdisciplinary Centre of Marine and Environmental Research	CIIMAR	PORTUGAL
National Research Council, Istituto per lo studio degli impatti Antropici e Sostenibilità in ambiente marino	IAS-CNR	ITALY
University of Oslo	UiO	NORWAY
University of Örebro	ORU	SWEDEN
University of Heidelberg	UH	GERMANY
University of Antwerp	UA-SPHERE	BELGIUM

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