PLASTIC BUSTERS

IMPACT OF MARINE LITTER ON MEDITERRANEAN BIODIVERSITY

- Provide a thorough analysis on plastics and microplastics as vectors of chemical pollutants
- Overview of tested protocols on monitoring microplastics in biota

UNIVERSITÀ DI SIENA 1240

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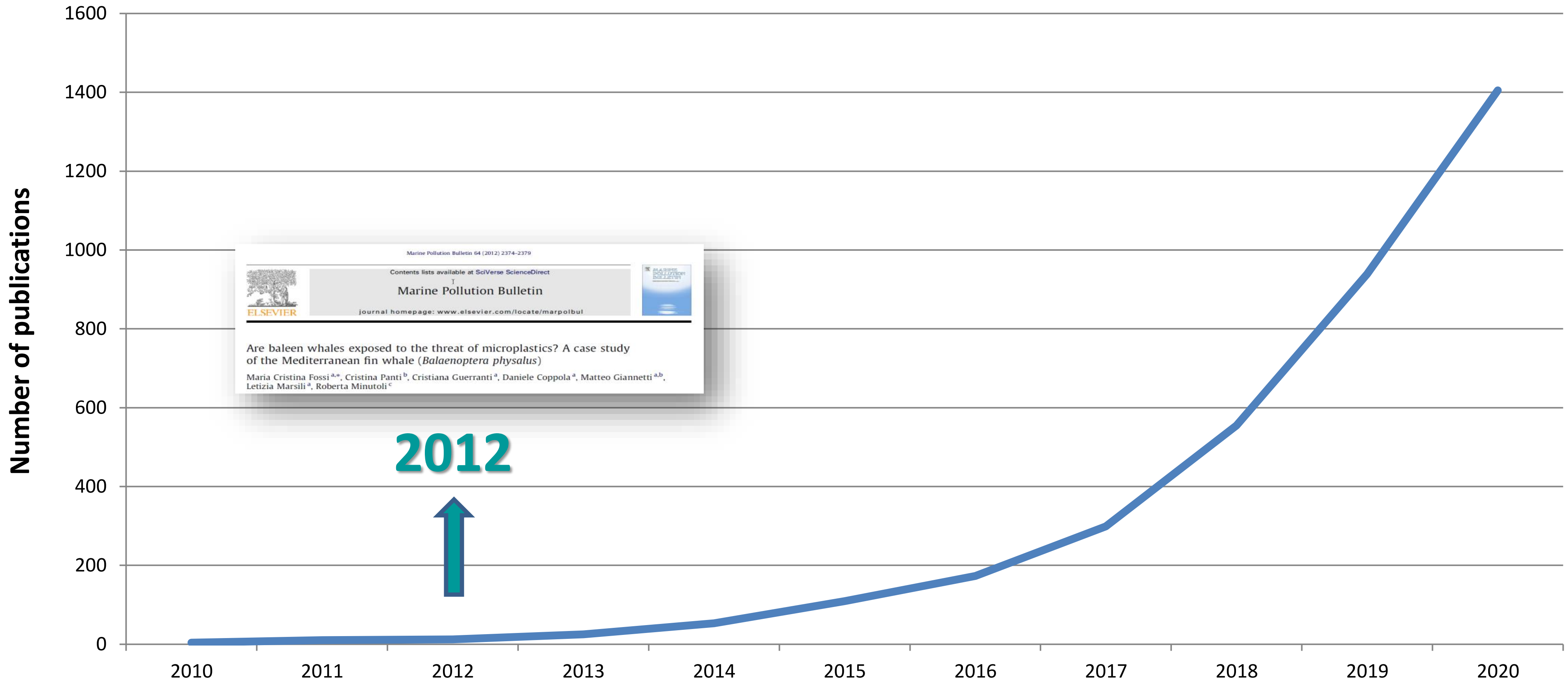
SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK
A GLOBAL INITIATIVE FOR THE UNITED NATIONS
Mediterranean


cima

Microplastics publications in the last 10 years



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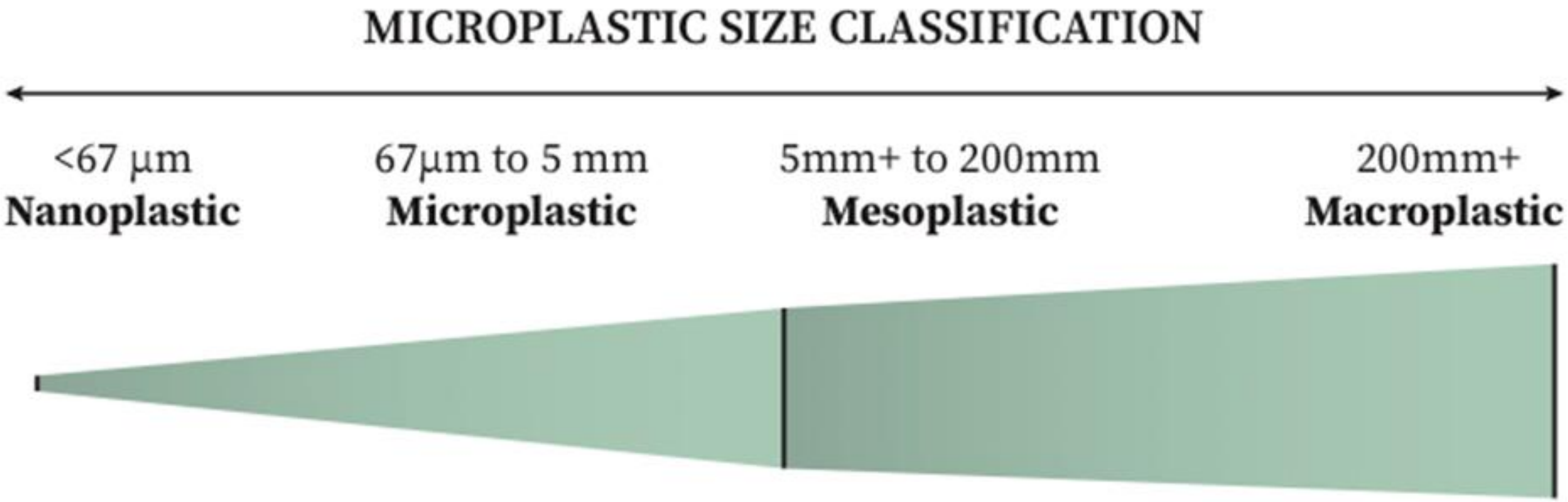
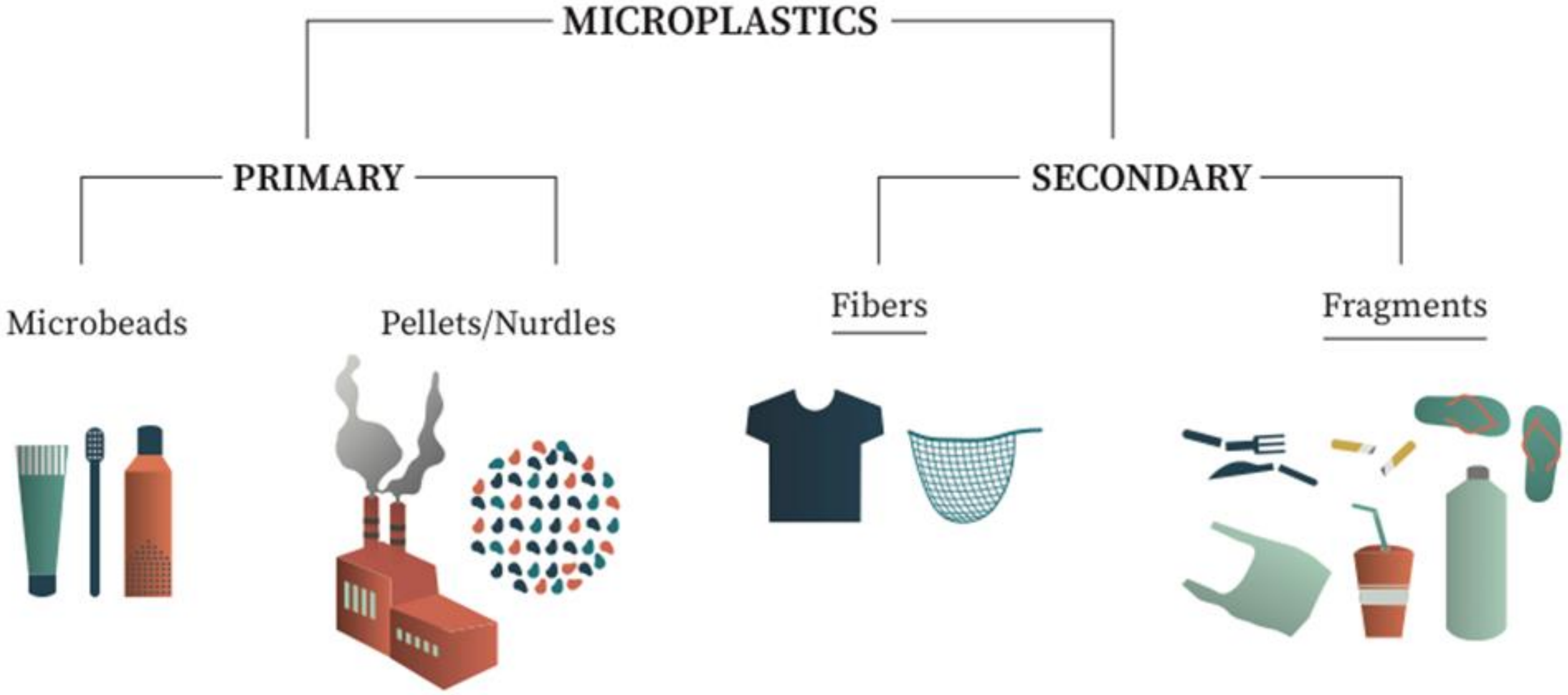
Document results (Scopus) from 2010 to 2021

PLASTIC BUSTERS

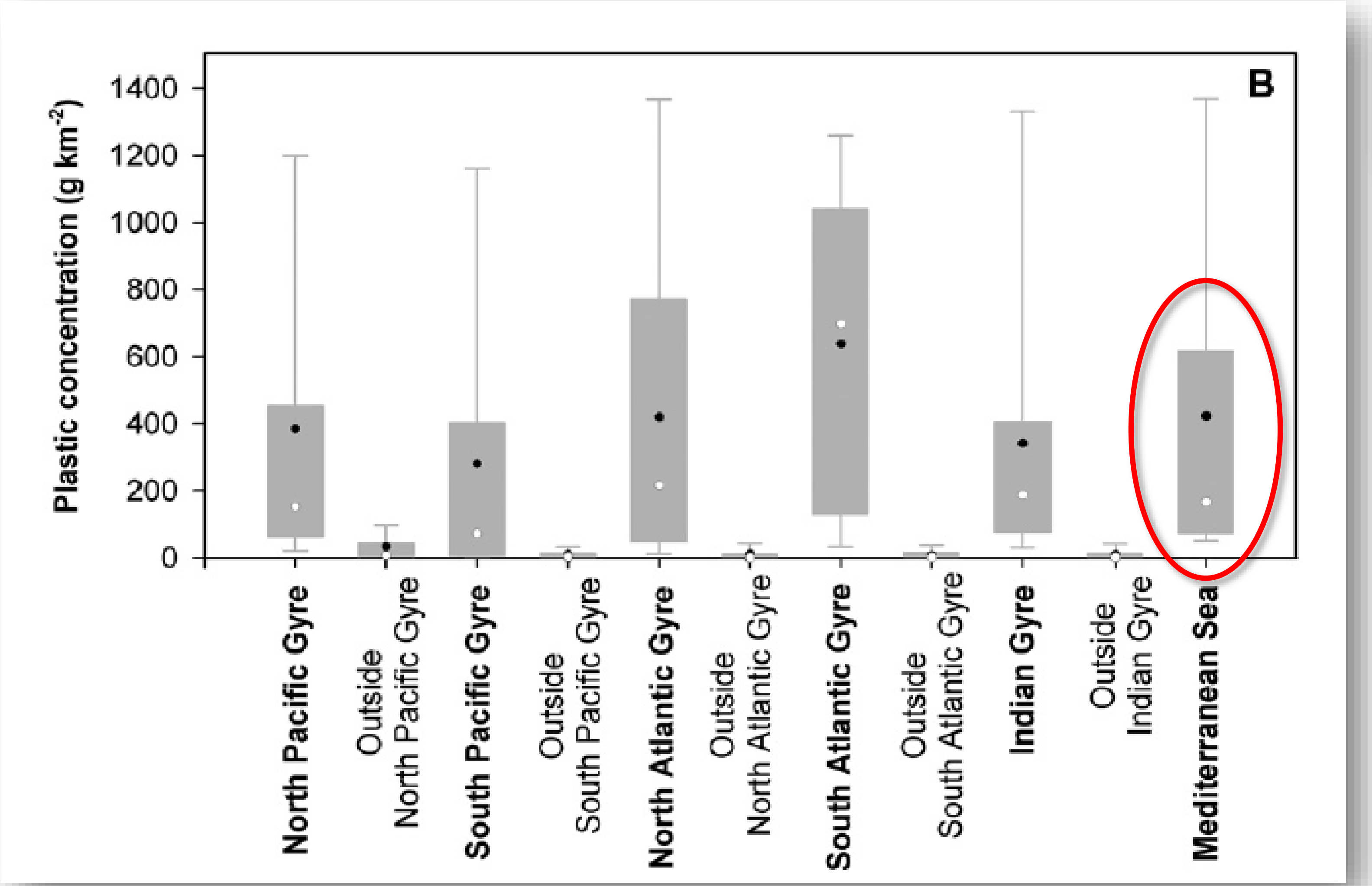
Microplastics



Microplastics



Word microplastics distribution:
Mediterranean sea is one of the “hot spot areas”



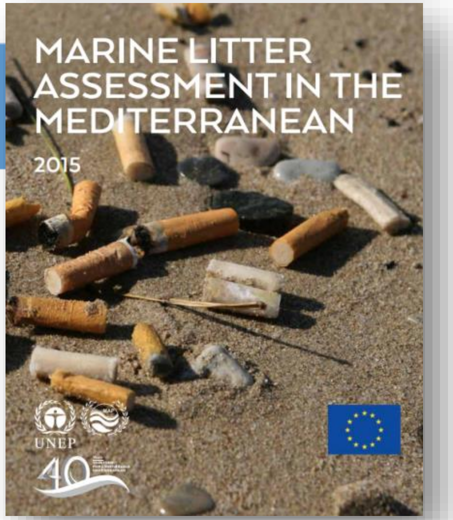
PLOS | ONE

RESEARCH ARTICLE

Plastic Accumulation in the Mediterranean Sea

Andrés Cózar[1]*, Marina Sanz-Martín[2,3], Elisa Martí[1], J. Ignacio González-Gordillo[1], Bárbara Ubeda[1], José Á. Gálvez[1], Xabier Irigoien[4], Carlos M. Duarte[2,4]

MARINE LITTER IN THE MEDITERRANEAN SEA



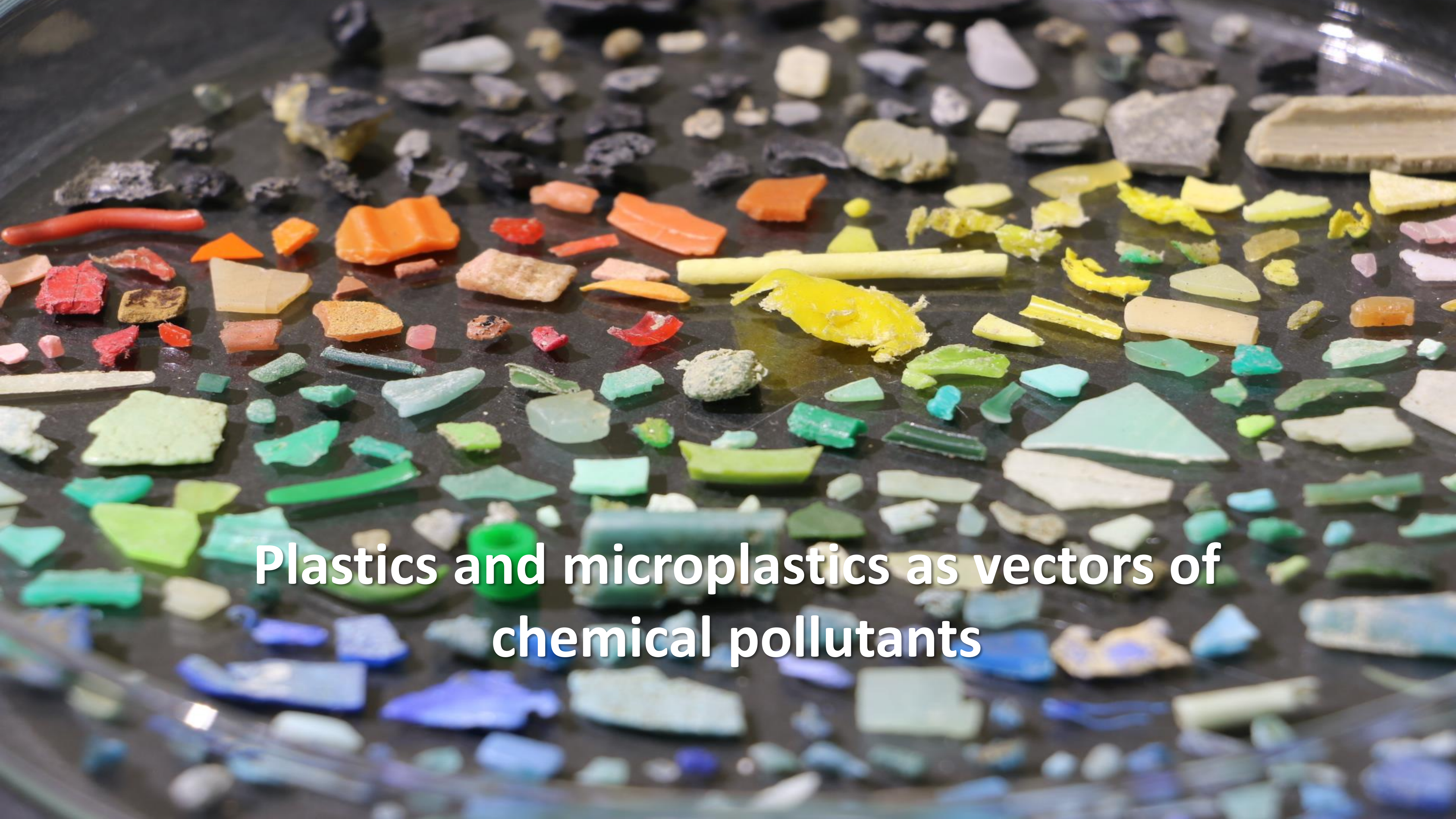
- An highly urbanized and developped coastline
- A closed basin
- 30% of the maritime traffic
- A touristic destination
- Large rivers (Rhône, Nile, Po)

THE MOST AFFECTED AREA WORLWIDE FOR MARINE LITTER

- Some of the largest amounts of Municipal Solid Waste (MSW) are generated annually per person in the Mediterranean Sea (208 – 760 kg/Year)
- An estimated 731 tons of plastic is littered every day, with important differences depending on country
- Cigarette butts may reach 40% of stranded litter
- the highest densities of marine litter stranded on the sea floor, up to 100,000 items / km² (French Coast) are found in the Mediterranean Sea
- the highest densities of floating microplastics , up to 4680,000 items / km² (Southern Adriatic) are found in the Mediterranean Sea

UNEP
UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

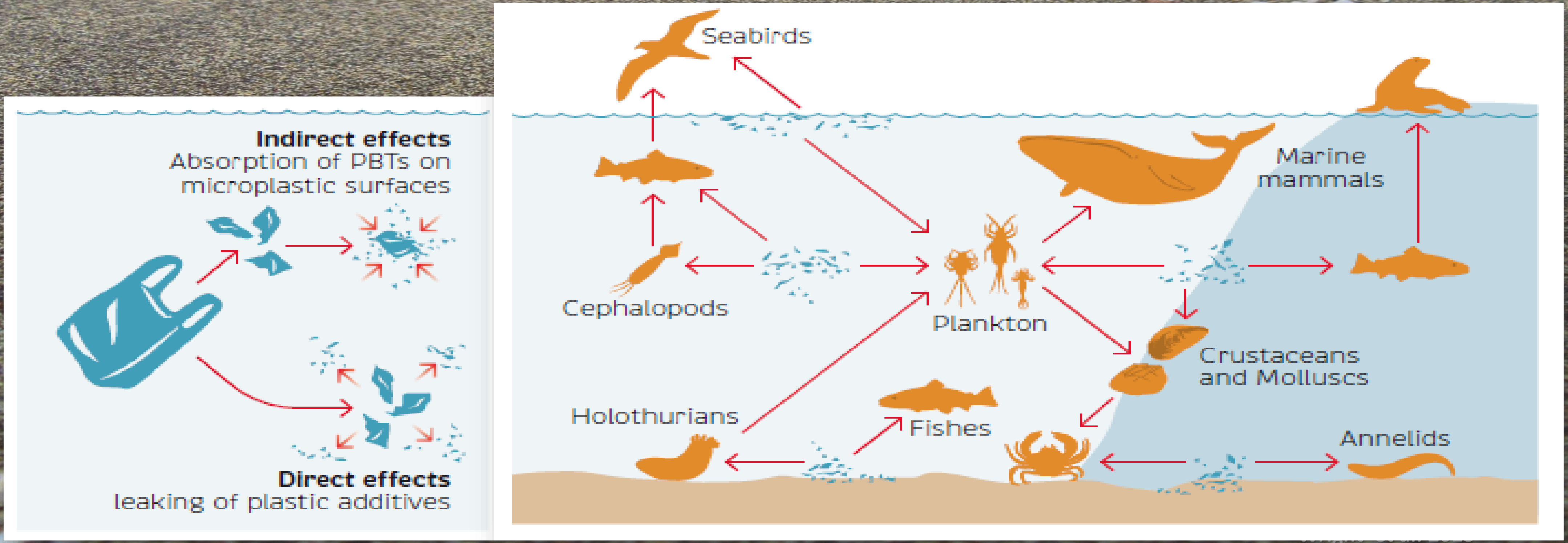
Plastics and microplastics as vectors of chemical pollutants



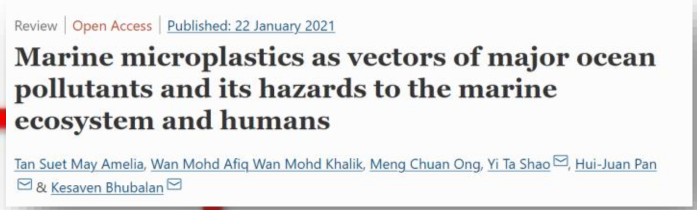
Impact of microplastics on marine organisms

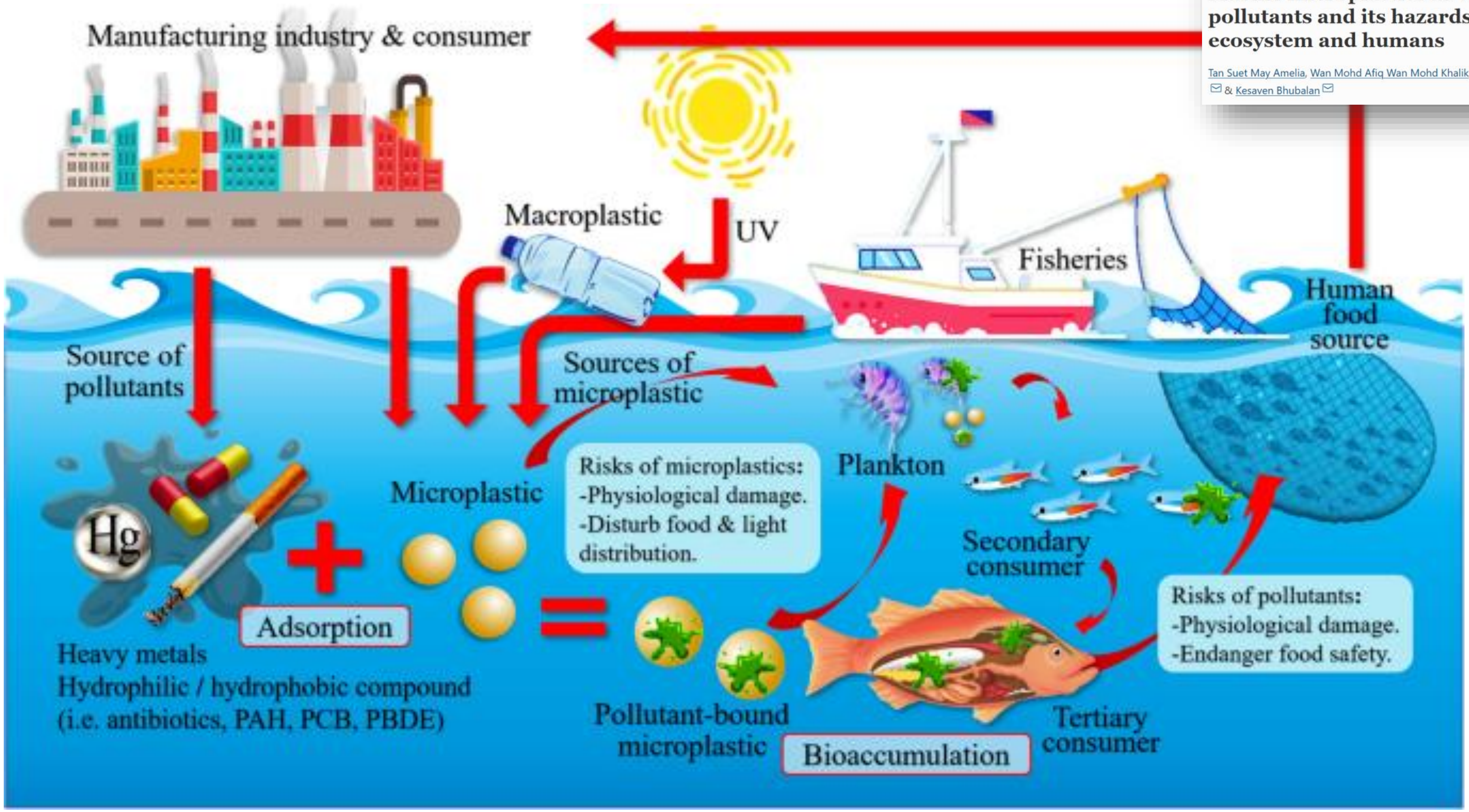
1 - transport of persistent, bioaccumulating toxic (PBT) substances from plastics
2 - leaching of additives from the plastics such as phthalates
3 - physical harm
4 - virus and bacteria ?

Multiple Stress

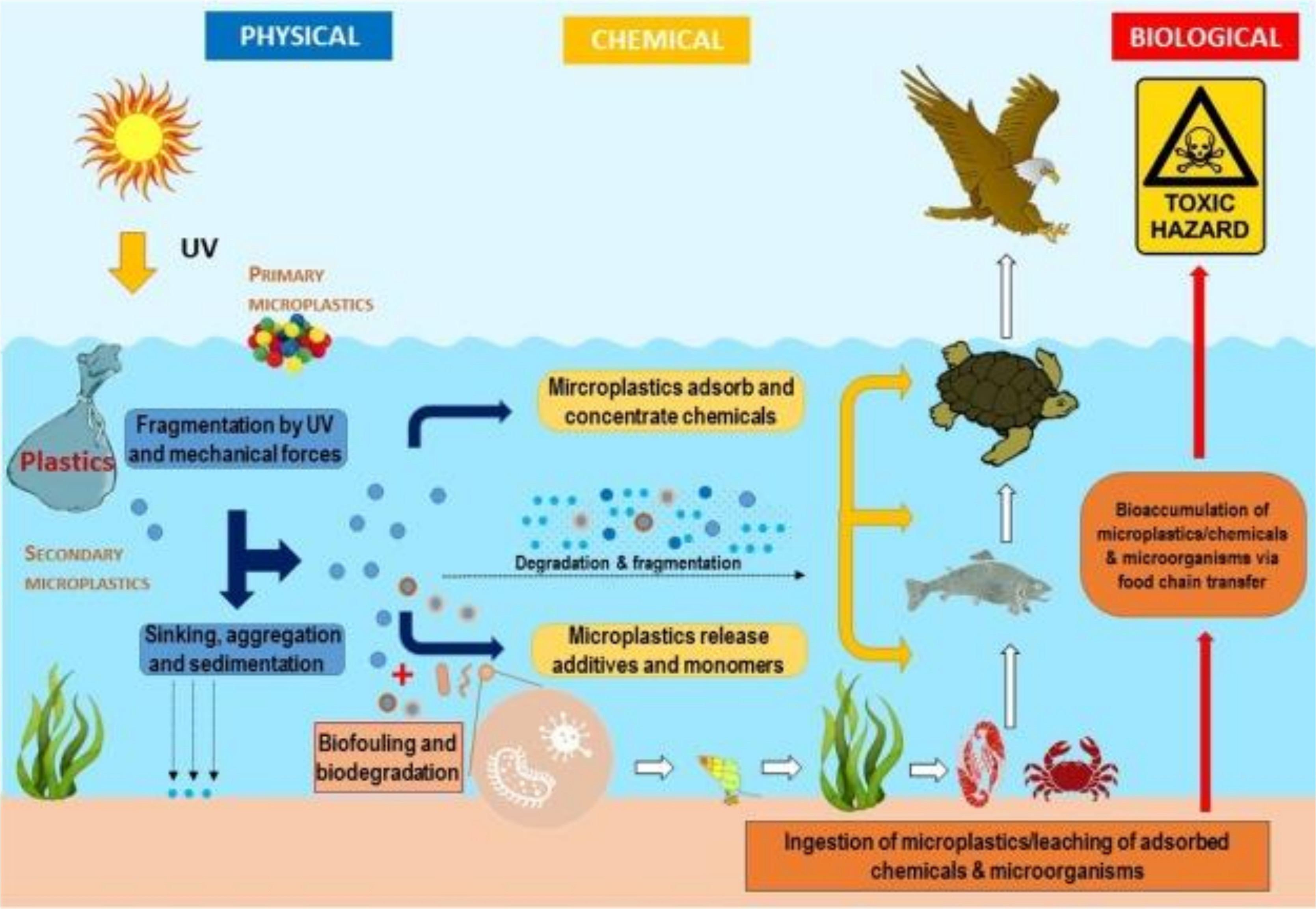


Plastics and microplastics as vectors of chemical pollutants

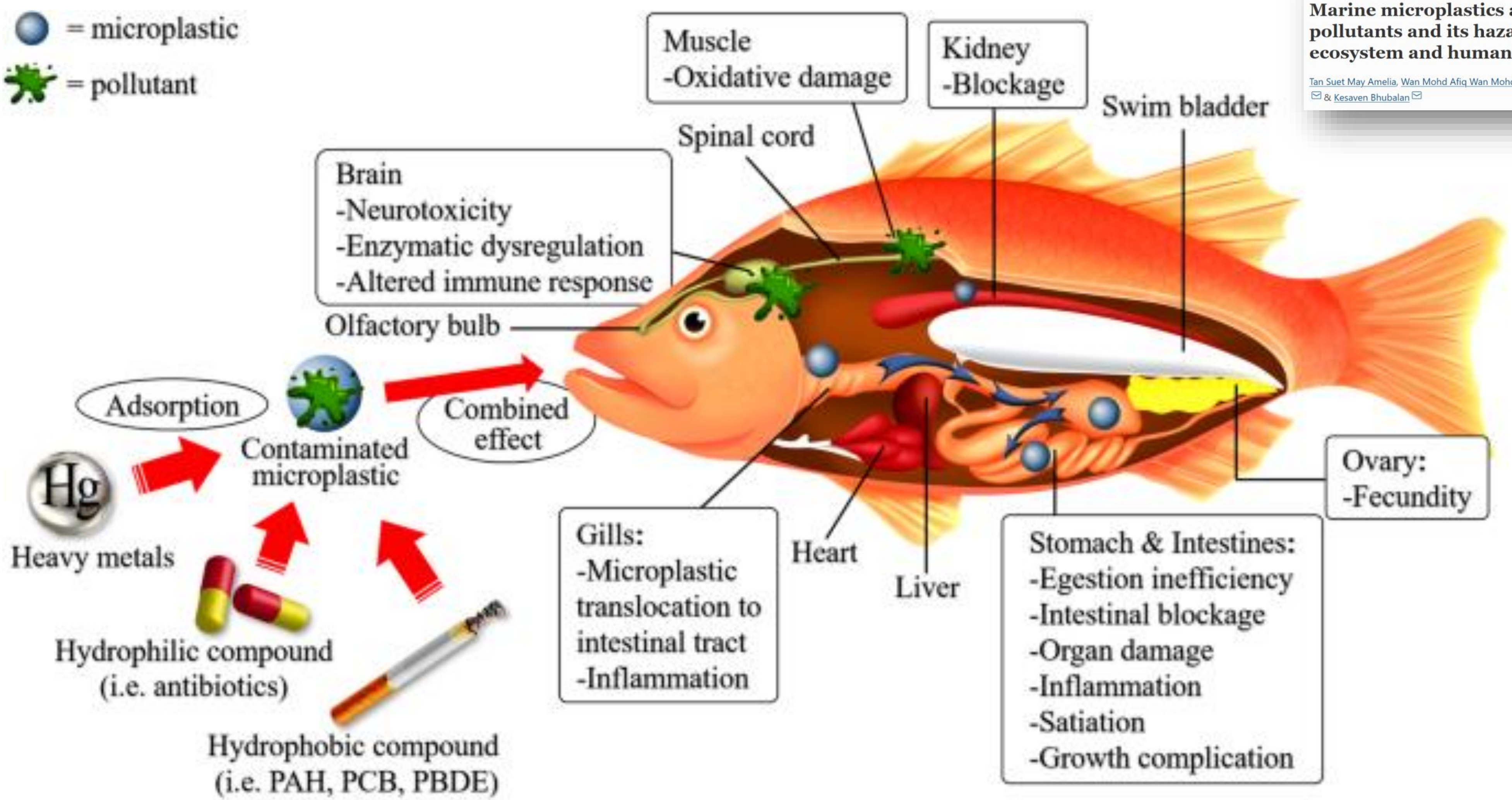




Plastics and microplastics as vectors of chemical pollutants



Plastics and microplastics as vectors of chemical pollutants



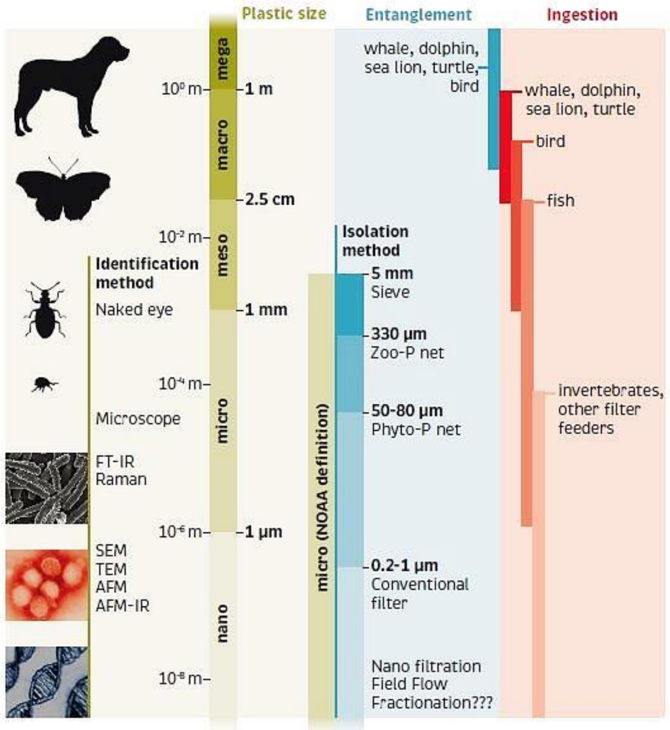

Review | Open Access | Published: 22 January 2021

Marine microplastics as vectors of major ocean pollutants and its hazards to the marine ecosystem and humans

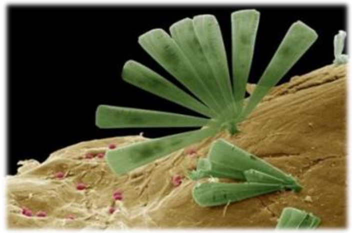
Tan Suet May Amelia, Wan Mohd Afiq Wan Mohd Khalik, Meng Chuan Ong, Yi Ta Shao, Hui-Juan Pan & Kesaven Bhubalan

ECOLOGICAL IMPACT OF PLASTIC LITTER

- **Habitat destruction**
- **Introduction and spread of invasive species**
- **Entanglement/entrapment**
- **Ingestion**
- **Transport of chemicals**



GESAMP



Transport of Chemicals

This raises concerns regarding:

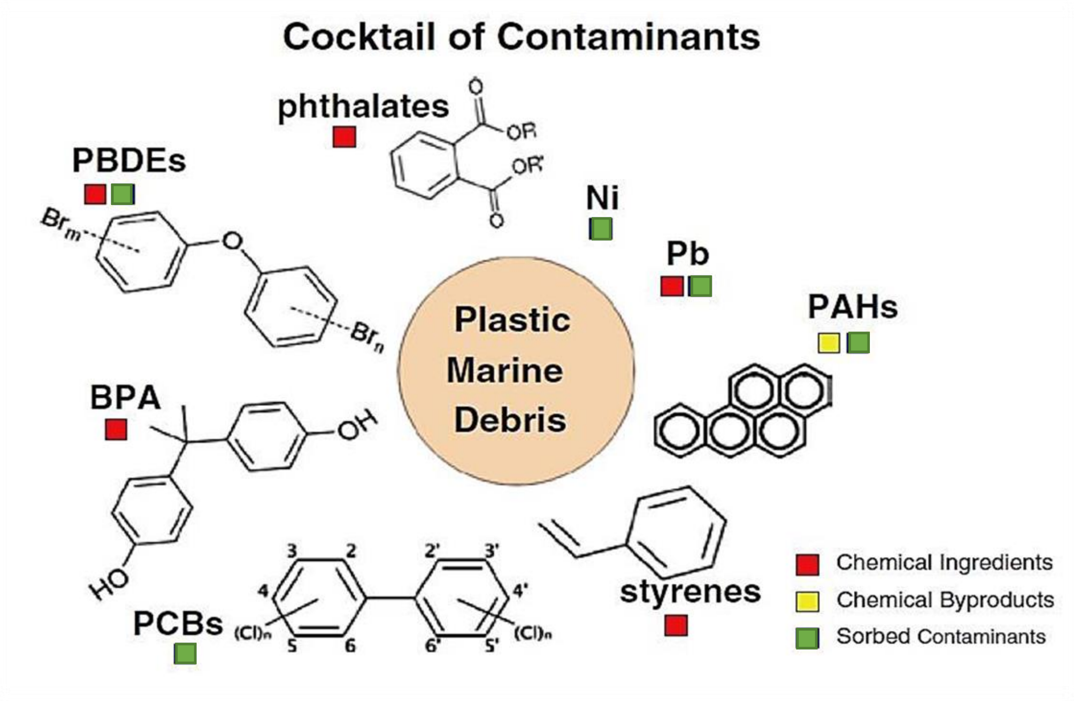
✓the **complex mixture of chemical** substances associated with marine plastic debris;

✓the **environmental fate** of these chemicals **to and from plastics** in our **oceans**;

✓how this **mixture affects wildlife**, as hundreds of species ingest this material in nature.

Transport of Chemicals

Because of their **physical** and **chemical properties** marine **plastic** debris are associated with a **‘cocktail of chemicals’**, including those that are **ingredients of the plastic material** (e.g. **monomers and additives**) and those **present** in the **marine environment** that **absorbs on plastic** when it becomes marine debris (e.g. persistent, bioaccumulative and toxic substances (PBTs)).

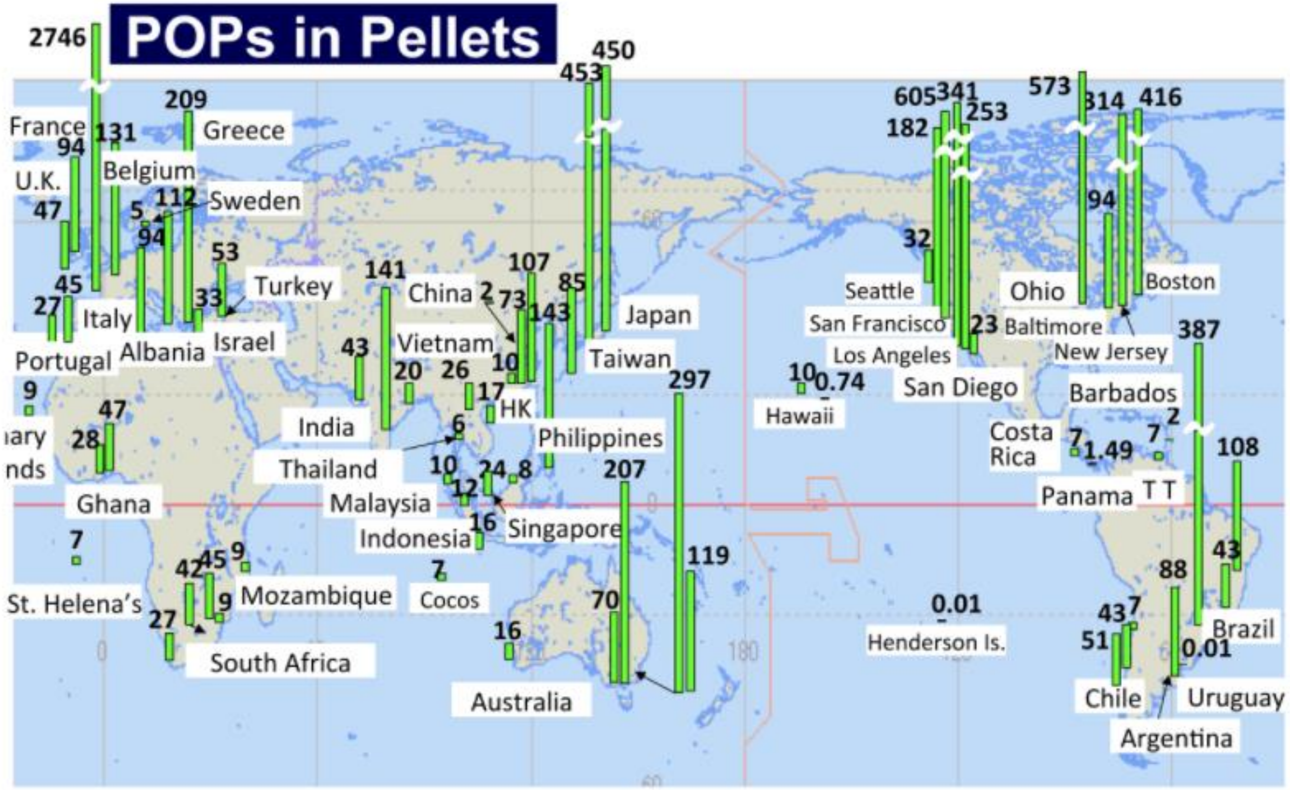


TRANSPORT OF CHEMICALS: PBTS

- Because of their **physical and chemical properties**, plastics accumulate a complex **mixture of chemical contaminants present in the surrounding seawater** adding to the cocktail of chemicals already present from manufacturing.
- As a result of **widespread global contamination of chemical contaminants** and plastic debris, **marine plastic debris** are recovered globally with **measurable amounts of persistent bioaccumulative and toxic substances (PBTs)**: e.g. **polychlorinated biphenyls (PCBs)**, **PAHs** and **PBDEs**. **PBTs** generally have a **low water-solubility** thus, when PBTs encounter plastic debris they **tend to sorb to this material**.
- The risks of plastic contributing to availability and transfer of chemicals are **still not clear**.

TRANSPORT OF CHEMICALS: PBTS

Plastic pellets, a recognizable component of marine debris, are now **used to examine the global pattern of PBTs**, **acting as passive samplers** and providing baseline information **regarding PBT contamination in the ocean**. International Pellet Watch leads this effort, collecting plastic pellets globally and measuring the concentrations of various PBTs sorbed to plastic debris.



PCB concentrations in beached plastic resin pellets (ng/g)

International Pellet Watch

http://pelletwatch.org/

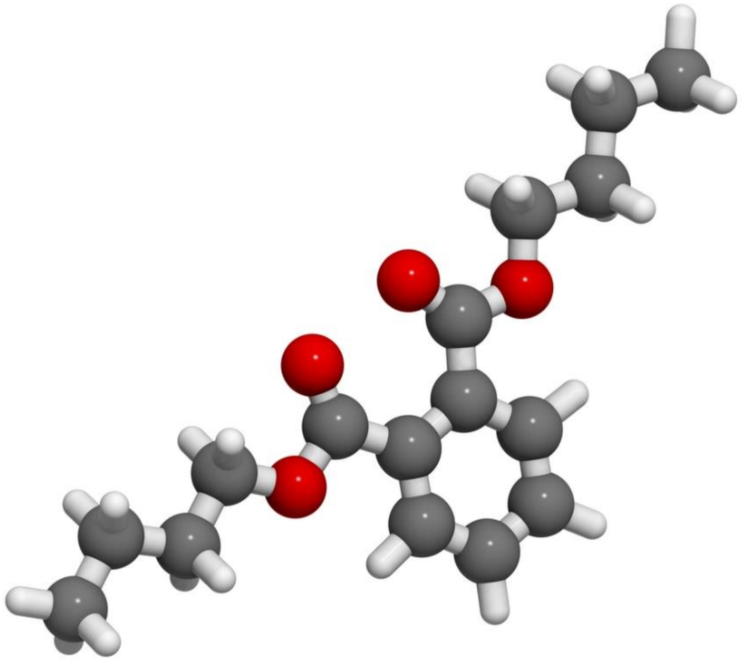
TRANSPORT OF CHEMICALS: PLASTIC ADDITIVES

- There are several **different types of plastics** manufactured into a **diversity of products**. These are **made using solvents and other chemicals** that may be used as initiators and catalysts.
- In addition, **several additives** (e.g. flame retardants, stabilizers, pigments and fillers) are included to give the plastic certain characteristics (e.g. flexibility, strength and color).
- Such **chemicals** can potentially migrate from plastic products to the medium in contact with them and **be released during production**, **use and disposal** of the product, **several** of which can be **harmful**.

TRANSPORT OF CHEMICALS: PLASTIC ADDITIVES

PHTHALATES

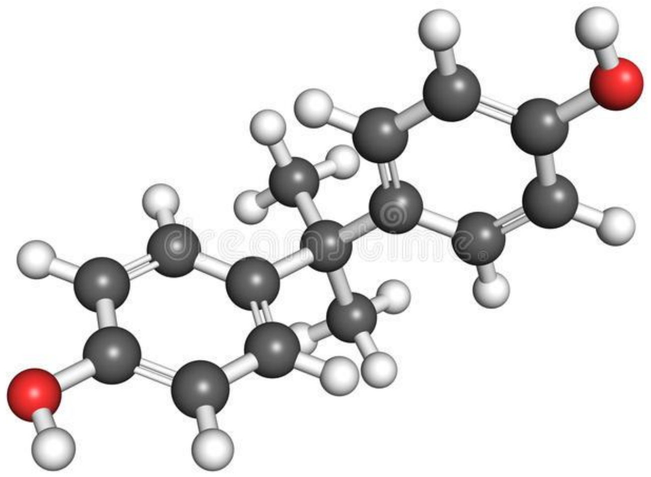
- Phthalic acid esters or phthalates are a family of additives used as **plasticisers**, mainly in PVC production. They **add fragrance to products and make them more pliable**. PVC can contain 10%-60% phthalates by weight. They can e**asily leach into the environment during manufacturing, use and disposal**.
- Some **phthalates** have been defined **as endocrine disruptors, even at low concentrations** since they interfere with the production of androgen (testosterone), a hormone critical in male development and relevant to females as well.
- **Di(2-ethylexyl) phthalate (DEHP) was the most commonly used** representing 37% of the global plasticiser market. However, DEHP has gradually been replaced by diisononyl phthalate (DiNP), diisodecyl phthalate (DiDP) and di(2-Propyl Heptyl) phthalate (DPHP), which represented 57% of plasticiser consumption in Europe in 2015.



TRANSPORT OF CHEMICALS: PLASTIC ADDITIVES

BISPHENOLS

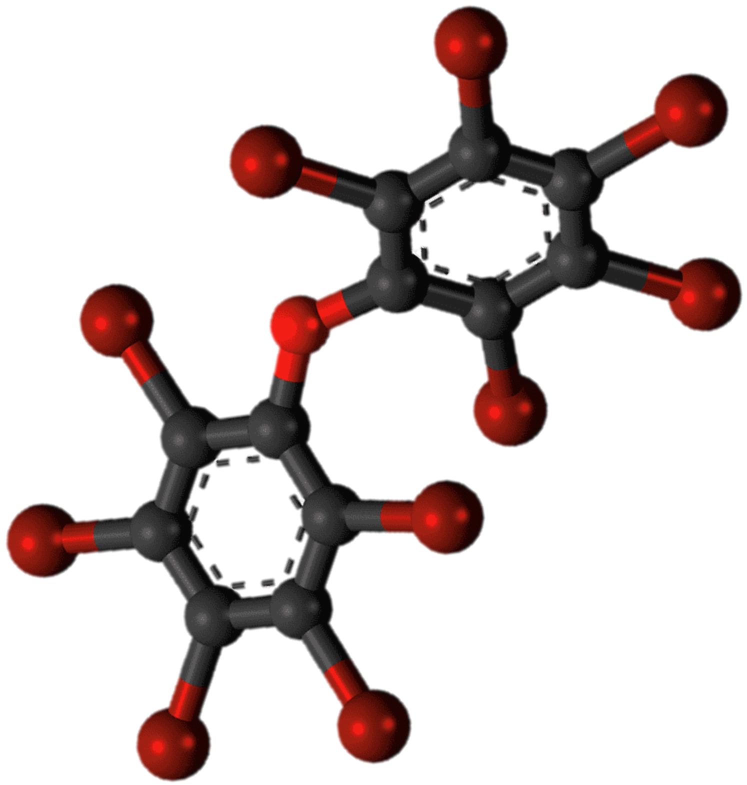
- Bisphenols are a group of chemical compounds with two hydroxyphenyl functionalities. They are present in **many polycarbonate plastic products** (including **water bottles, food storage containers and packaging, sports equipment**), **epoxy resin liners of aluminium cans**, and also bisphenols are frequently used as a developer in thermal paper such as cash register receipts.
- **Bisphenol A (BPA) is the most representative chemical** of the bisphenol group and is one of the most commonly produced chemicals worldwide, with over **three million tons produced annually**.
- BPA can be used as an **antioxidant or as a plasticiser** in some polymers such as **PP, PE and PVC**. **Leaching of BPA** can occur, leading to **release from food and drink packaging, a source of exposure for humans**.



TRANSPORT OF CHEMICALS: PLASTIC ADDITIVES

FLAME RETARDANTS

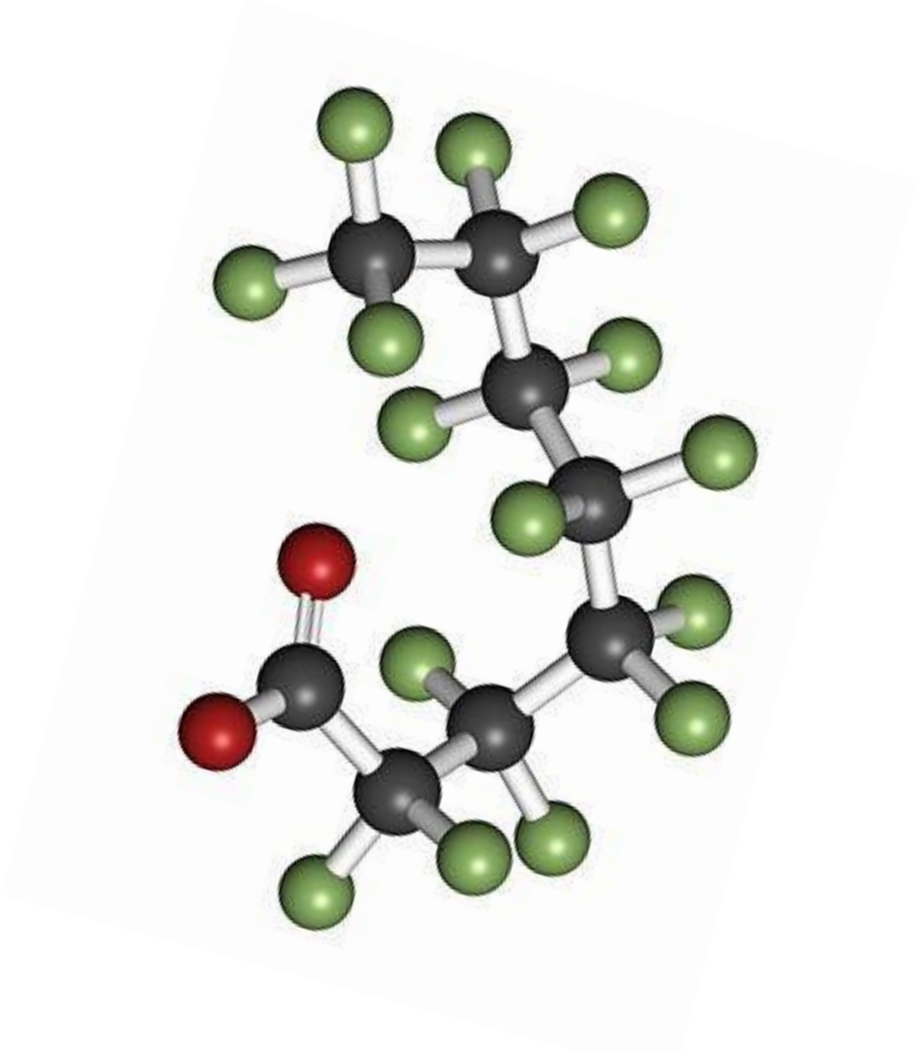
- Flame retardants are a class of additives used in plastic and other polymer products to **reduce flammability and to prevent the spread of fire**. The main retardants used in plastics include **brominated flame retardants (BFRs)** with antimony (Sb) as synergist (e.g. polybrominated diphenyl ethers (PBDEs)).
- PBDEs are **hydrophobic substances** that were produced as three commercial formulations (**commercial penta-BDE**, **commercial octa-DBE** and **commercial deca-BDE**). They are **ubiquitous, toxic, and persistent, they bioaccumulate,** and **they are of great concern for human health.**



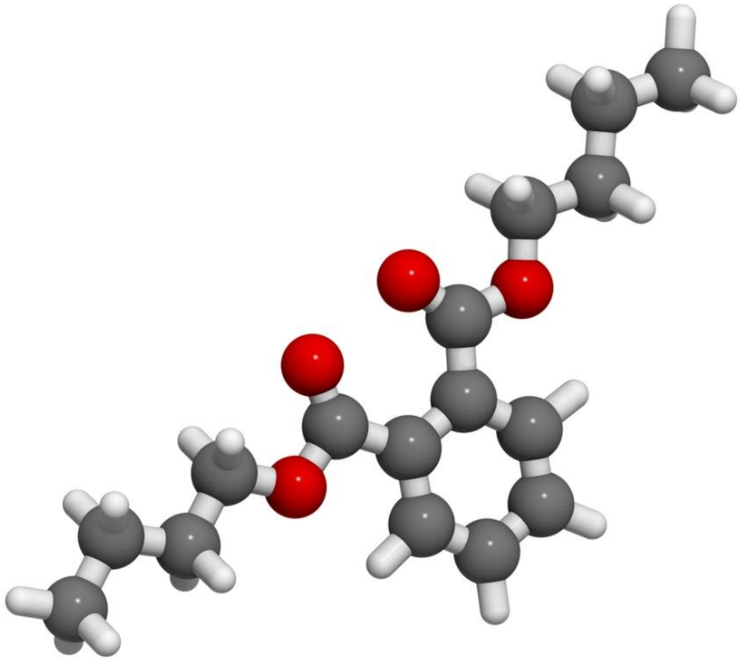
TRANSPORT OF CHEMICALS: PLASTIC ADDITIVES

PERFLOURINATED CHEMICALS

- PFOS and related substances have been **listed under the Stockholm Convention since 2009**, and PFOA and related substances are suggested for listing in the current COP. PFOS and PFOA **do not follow the pattern of a classic POP** — they do **not accumulate in fatty tissues but instead binds to proteins**.
- They therefore accumulate mainly in organs such as the liver, kidney, brain and spleen. In animal studies **PFOS causes cancer, neonatal mortality, delays in physical development, and endocrine disruption**.



TRANSPORT OF CHEMICALS:
PLASTIC ADDITIVES



Plastic Additives Analysis: Phthalates

MECHANICAL SHAKING

ULTRASONIC EXTRACTION

PURIFICATION

Dispersive SPE

CONCENTRATION

Stream of nitrogen

Agilent 5977B GC/MS

11 phthalates	CAS
Dimethyl phthalate	131-11-3
Diethyl phthalate	84-66-2
Diallyl phthalate	131-17-9
Dipropyl phthalate	131-16-8
Diisobutyl phthalate	84-69-5
Dibutyl phthalate	84-74-2
Benzyl butyl phthalate	85-68-7
Dicyclohexyl phthalate	84-61-7
Bis(2-ethylhexyl) phthalate	117-81-7
Diisononyl phthalate	28553-12-0
Di-n-octyl phthalate	117-84-0

Listed as reprotoxic category 1B substances under EU Regulation (EC) 1272/2008

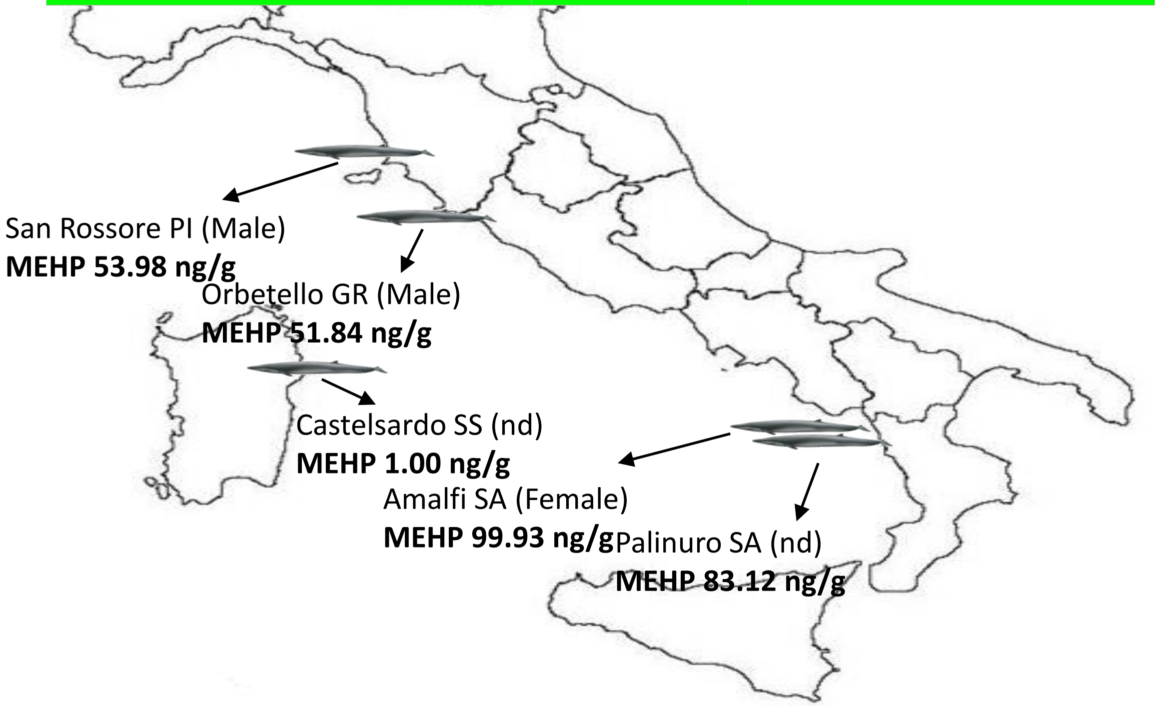
Interreg Mediterranean
PLASTIC BUSTERS MPAs
Project co-financed by the European Regional Development Fund


Could Microplastics Affect
Filter-Feeding Megafauna?

Plastic additives in fin whales


Contents lists available at SciVerse ScienceDirect
Marine Pollution Bulletin
journal homepage: www.elsevier.com/locate/marpolbul
Are baleen whales exposed to the threat of microplastics? A case study of the Mediterranean fin whale (*Balaenoptera physalus*)
Maria Cristina Fossi [a,*], Cristina Panti [b], Cristiana Guerranti [a], Daniele Coppola [a], Matteo Giannetti [a,b], Letizia Marsili [a], Roberta Minutoli [c]

MEHP concentration in stranded fin whales		
SPECIES	TISSUE	Mean MEHP (ng/g)
Balaenoptera physalus	Blubber	**57.97**



MEHP concentrations (ng/g) in blubber samples of five **stranded fin whales** collected along the Italian coasts during the period July 2007 – June 2011 in five different locations.

Contents lists available at ScienceDirect
Marine Environmental Research
journal homepage: www.elsevier.com/locate/marenvrev

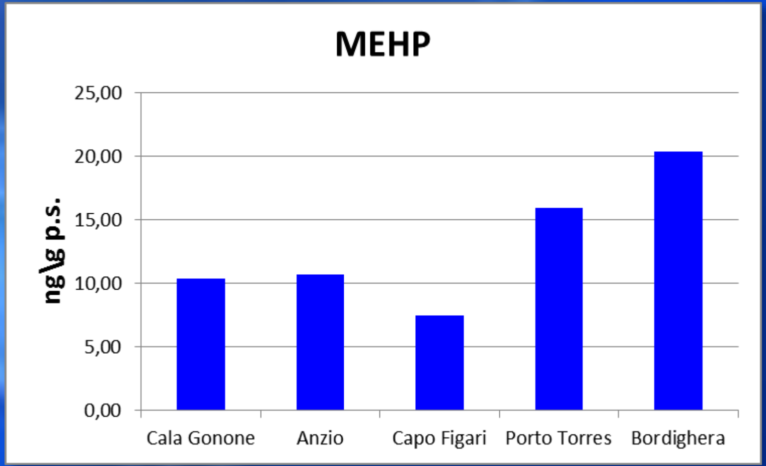
Large filter feeding marine organisms as indicators of microplastic in the pelagic environment: The case studies of the Mediterranean basking shark (*Cetorhinus maximus*) and fin whale (*Balaenoptera physalus*)

Maria Cristina Fossi [a,*], Daniele Coppola [a], Matteo Baini [a], Matteo Giannetti [a,b], Cristiana Guerranti [a], Letizia Marsili [a], Cristina Panti [a], Eleonora de Sabata [c], Simona Clò [c,d]

[a] Department of Physical, Earth and Environmental Sciences, University of Siena, Via P.A. Mattioli 4, 53100 Siena, Italy
[b] Department of Life Sciences, University of Siena, Via A. Moro 2, 53100 Siena, Italy
[c] MedSharks, Via Ruggero Fauro 82, 00197 Rome, Italy
[d] CTS, via Albalonga 3, 00183 Roma, Italy

MEHP concentration in basking sharks

SPECIES	TISSUE	Mean MEHP (ng/g)
Basking sharks	muscle	12.97



Phthalates as plastic tracer ?

…one of the largest filter fedeers in the sea

8 h/day feeding at the surface

Based on open mouth internal heights, the estimated total open mouth area was **2035 cm^2** for shark A (622cm TL), **1841 cm^2** for shark B (593cm TL),

PLASTIC BUSTERS

PCB levels in skin biopsy


Comparative Biochemistry and Physiology, Part C

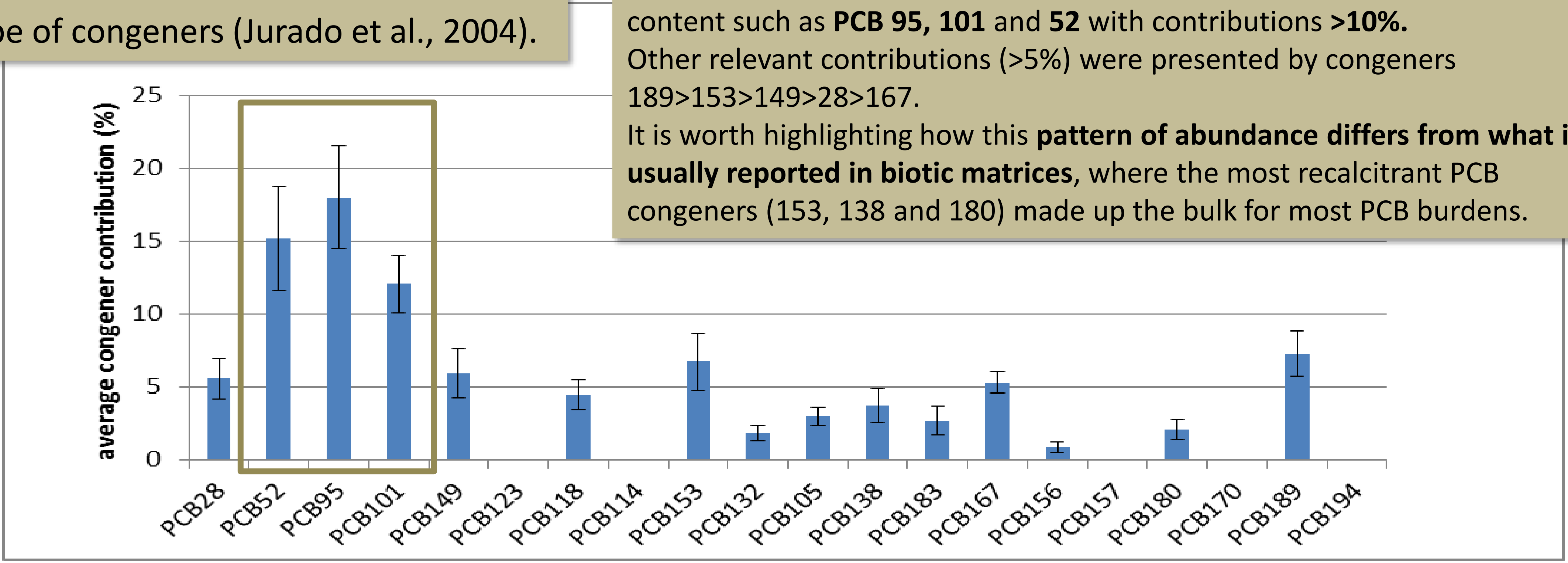
journal homepage: www.elsevier.com/locate/cbpc

Are whale sharks exposed to persistent organic pollutants and plastic pollution in the Gulf of California (Mexico)? First ecotoxicological investigation using skin biopsies

Maria Cristina Fossi [a], Matteo Baini [a,*], Cristina Panti [a], Matteo Galli [a], Begoña Jiménez [b], Juan Muñoz-Arnanz [b], Letizia Marsili [a], Maria Grazia Finoia [c], Dení Ramírez-Macías [d]

Surface oceans are enriched in this type of congeners (Jurado et al., 2004).

PCB content was mostly dominated by congeners with medium-low chlorine content such as **PCB 95, 101** and **52** with contributions **>10%.**
Other relevant contributions (>5%) were presented by congeners 189>153>149>28>167.
It is worth highlighting how this **pattern of abundance differs from what is usually reported in biotic matrices**, where the most recalcitrant PCB congeners (153, 138 and 180) made up the bulk for most PCB burdens.

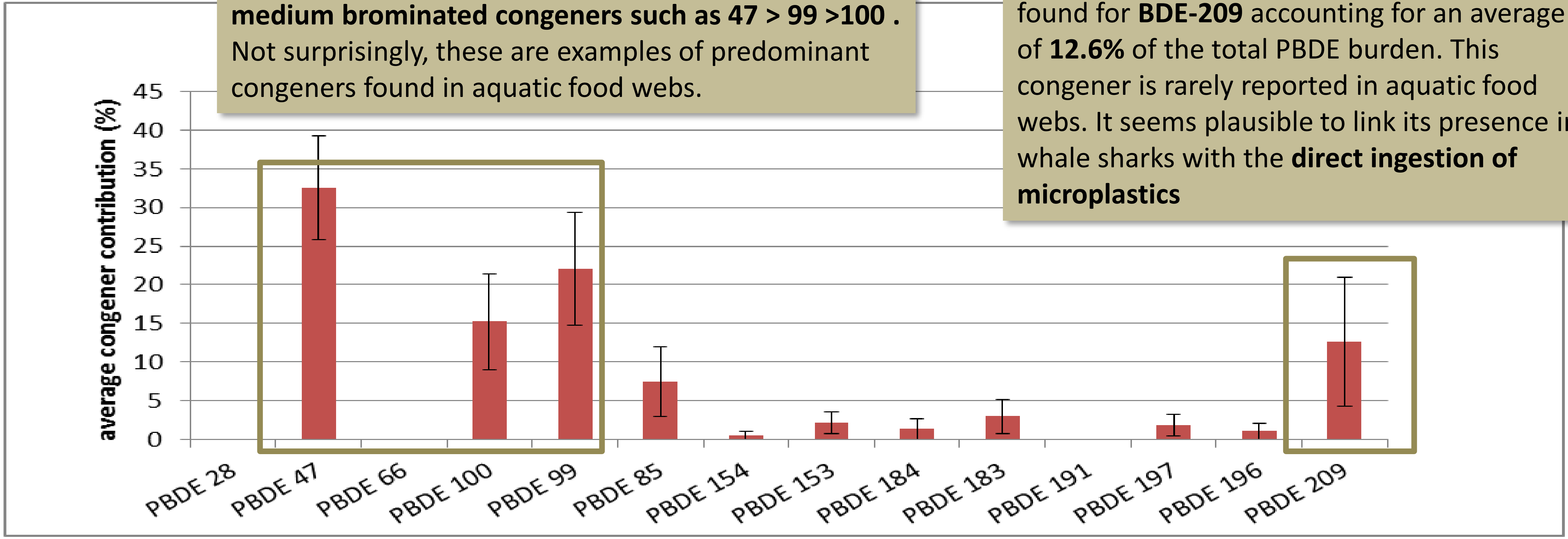


Average PCB congener profile in skin biopsies of whale sharks. Error bars represent standard errors (SE).

PBDE levels in skin biopsy

As with PCBs, **PBDE content was dominated by lower-medium brominated congeners such as 47 > 99 >100 .** Not surprisingly, these are examples of predominant congeners found in aquatic food webs.

Unexpected, was the important contribution found for **BDE-209** accounting for an average of **12.6%** of the total PBDE burden. This congener is rarely reported in aquatic food webs. It seems plausible to link its presence in whale sharks with the **direct ingestion of microplastics**



Average PBDE congener profile in skin biopsies of whale sharks. Error bars represent standard errors (SE).

Plastic Litter: POPs and EDCs


Gallo et al. Environ Sci Eur (2018) 30:13
https://doi.org/10.1186/s12302-018-0139-z

Environmental Sciences Europe

DISCUSSION Open Access

CrossMark

Marine litter plastics and microplastics and their toxic chemicals components: the need for urgent preventive measures

Frederic Gallo[1*], Cristina Fossi[2], Roland Weber[3*], David Santillo[4], Joao Sousa[5], Imogen Ingram[6], Angel Nadal[7] and Dolores Romano[8]

2018

Synergies

- Persistent plastics, with an estimated lifetime for degradation of hundreds of years in marine conditions, can break up into micro- and nanoplastics over shorter timescales, thus facilitating their uptake by marine biota throughout the food chain.
- **These polymers may contain chemical additives and contaminants, including some known endocrine disruptors that may be harmful at extremely low concentrations for marine biota, thus posing potential risks to marine ecosystems, biodiversity and food availability.**
- Although there is still need to carry out focused scientific research to fill the knowledge gaps about the impacts of plastic litter in the marine environment (Wagner et al. in Environ Sci Eur 26:9, 2014), **the food chain and human health**, existing scientific evidence and concerns are already sufficient to support actions by the scientific, industry, policy and civil society communities to curb the ongoing flow of plastics and the toxic chemicals they contain into the marine environment.
- This document was prepared by a working group of **Regional Centres of the Stockholm and Basel Conventions** and related colleagues intended to be a background document for discussion in the 2017 Conference of the Parties (COP) of the Basel Convention on hazardous wastes and the Stockholm Convention on persistent organic pollutants (POPs).

PLASTIC BUSTERS

Monitoring Microplastics in Biota


How can
Marine litter
impact on
Mediterranean
marine
life?

IMPACTS OF MARINE DEBRIS

INGESTION
Animals mistakenly eat plastic and other debris.

ENTANGLEMENT & GHOSTFISHING
Marine life gets caught and killed in ghost nets, trapped in derelict gear, and entangled in plastic bands and other marine debris.

HABITAT DAMAGE
Heavy marine debris crushes sensitive habitat, such as coral reefs and sea grass.

NON-NATIVE SPECIES
Marine debris transports alien and invasive species from one region to another.

Marine litter impact: what happens in the Mediterranean sea?

7 plastic items in the stomach

145 plastic items in the stomach

22 Kg of plastic in the stomach

More than 130 marine species affected
by marine litter in the Mediterranean basin


Environmental Pollution xxx (2017) 1–18

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

ELSEVIER

Bioindicators for monitoring marine litter ingestion and its impacts on Mediterranean biodiversity☆

Maria Cristina Fossi[a,b], Cristina Pedà[c], Montserrat Compa[d], Catherine Tsangaris[e], Carme Alomar[d], Francoise Claro[f], Christos Ioakeimidis[g], Francois Galgani[h], Tatjana Hema[g], Salud Deudero[d], Teresa Romeo[c], Pietro Battaglia[c], Franco Andaloro[c], Ilaria Caliani[a,b], Silvia Casini[a,b], Cristina Panti[a,b,*], Matteo Baini[a,b]

Marine Litter impact: two points of view…

Detect the impact of marine litter on Mediterranean species

..and/or

Bioindicators of impact of marine litter on Mediterranean sea


Impact on whales?
Balaenoptera physalus

THE MEGAFAUNA AND MPs STORY

2012

Marine Pollution Bulletin 64 (2012) 2374–2379
Contents lists available at SciVerse ScienceDirect
Marine Pollution Bulletin
journal homepage: www.elsevier.com/locate/marpolbul

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2014

Marine Environmental Research 100 (2014) 17–24
Contents lists available at ScienceDirect
Marine Environmental Research
journal homepage: www.elsevier.com/locate/marenvrev

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2016

Environmental Pollution 209 (2016) 68–78
Contents lists available at ScienceDirect
Environmental Pollution
journal homepage: www.elsevier.com/locate/envpol

Fin whales and microplastics: The Mediterranean Sea and the Sea of Cortez scenarios

Maria Cristina Fossi[a], Letizia Marsili[a], Matteo Baini[a], Matteo Giannetti[a,b], Daniele Coppola[a], Cristiana Guerranti[a], Ilaria Caliani[a], Roberta Minutoli[c], Giancarlo Lauriano[d], Maria Grazia Finoia[d], Fabrizio Rubegni[e], Simone Panigada[f], Martine Bérubé[g], Jorge Urbán Ramírez[h], Cristina Panti[a,*]

2018

Trends in Ecology & Evolution

Science & Society

Microplastics: No Small Problem for Filter-Feeding Megafauna

Elitza S. Germanov,[1,2,*,@] Andrea D. Marshall,[2,@] Lars Bejder,[3,4,@] Maria Cristina Fossi,[5] and Neil R. Loneragan[1,@]

Microplastic pollution can impact filter-feeding marine megafauna, namely mobulid rays, filter-feeding sharks, and baleen whales. Emerging research on these flagship species highlights potential exposure to microplastic contamination and plastic-associated toxins. Research and its wide communication are needed to understand the magnitude of the issue and improve marine stewardship.

BBC NEWS

The Guardian — International edition

INDEPENDENT

Whale and shark species at increasing risk from microplastic pollution – study

Large filter feeders, such as baleen whales and basking sharks, could be particularly at risk from ingesting the tiny plastic particles, say scientists

2017

Plastic Debris Occurrence, Convergence Areas and Fin Whales Feeding Ground in the Mediterranean Marine Protected Area Pelagos Sanctuary: A Modeling Approach

Maria Cristina Fossi[1], Teresa Romeo[2], Matteo Baini[1], Cristina Panti[1*], Letizia Marsili[1], Tommaso Campan[1], Simonepietro Canese[2], François Galgani[3], Jean-Noël Druon[4], Sabina Airoldi[5], Stefano Taddei[6], Maria Fattorini[6,7], Carlo Brandini[6,7] and Chiara Lapucci[6,7]

2017

Comparative Biochemistry and Physiology, Part C xxx (2017) xxx–xxx
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journal homepage: www.elsevier.com/locate/cbpc

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PLASTIC BUSTERS


Impact on sea turtles?
Caretta caretta

MSFD-D10 Sentinel species for marine litter in Mediterranean sea


Marine Pollution Bulletin 74 (2013) 225–230

Contents lists available at SciVerse ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Presence of plastic debris in loggerhead turtle stranded along the Tuscany coasts of the Pelagos Sanctuary for Mediterranean Marine Mammals (Italy)

Tommaso Campani[a], Matteo Baini[a,*], Matteo Giannetti[a,d], Fabrizio Cancelli[b], Cecilia Mancusi[c], Fabrizio Serena[c], Letizia Marsili[a], Silvia Casini[a], Maria Cristina Fossi[a]

2013


Environmental Pollution 230 (2017) 199–209

Contents lists available at ScienceDirect

Environmental Pollution

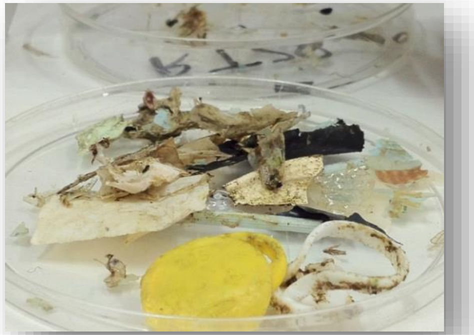
journal homepage: www.elsevier.com/locate/envpol

Loggerhead sea turtles (*Caretta caretta*): A target species for monitoring litter ingested by marine organisms in the Mediterranean Sea☆

Marco Matiddi[a,*], Sandra Hochsheid[b], Andrea Camedda[c], Matteo Baini[d], Cristiano Cocumelli[e], Fabrizio Serena[f], Paolo Tomassetti[a], Andrea Travaglini[b], Stefano Marra[c], Tommaso Campani[d], Francesco Scholl[e], Cecilia Mancusi[f], Ezio Amato[a], Paolo Briguglio[g], Fulvio Maffucci[b], Maria Cristina Fossi[d], Flegra Bentivegna[c], Giuseppe Andrea de Lucia[c]

2017

Found 483 pieces of marine litter with a total mass of 62.37g

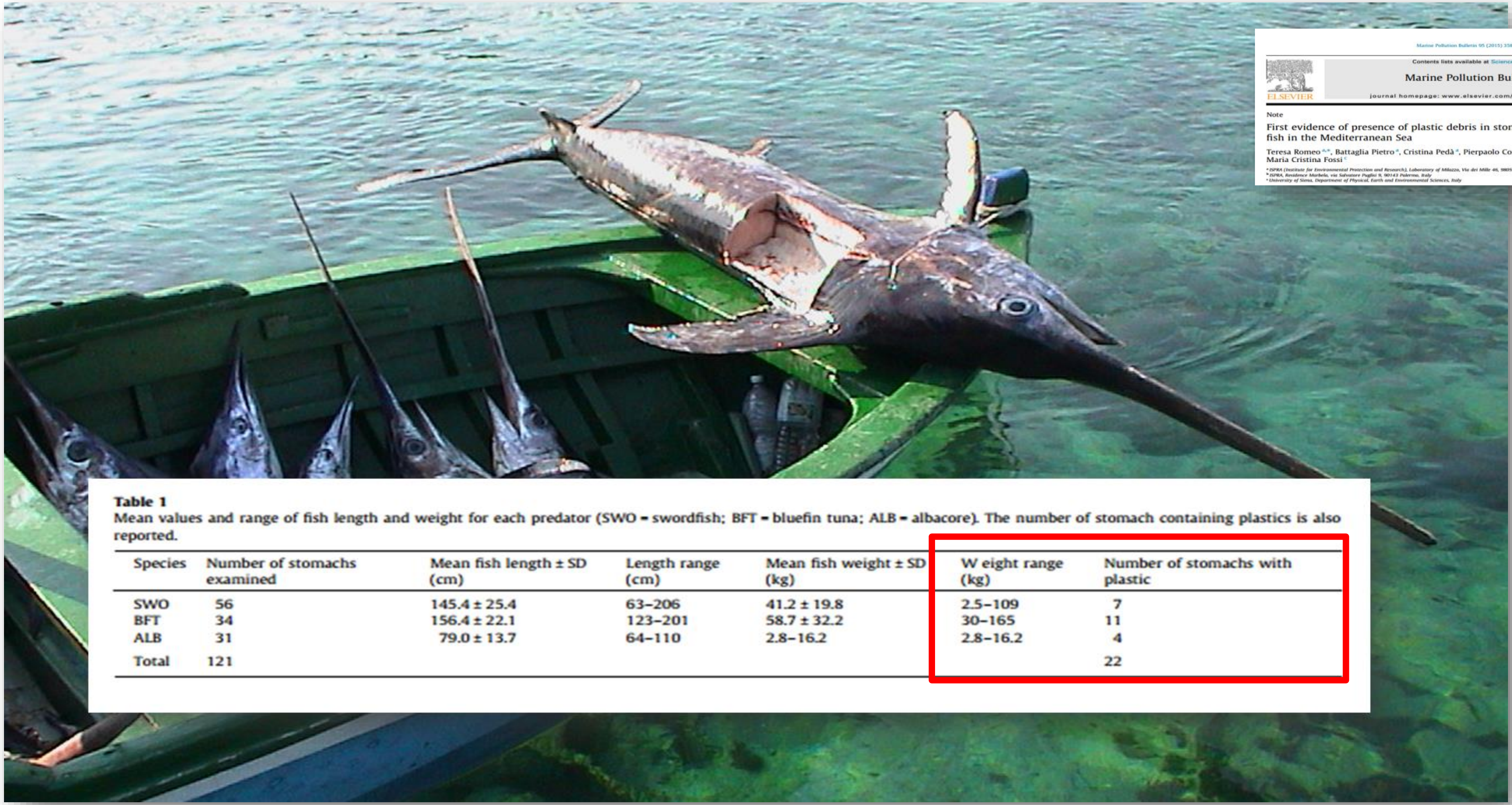


22 loggerhead turtles out of 31 animals had ingested marine debris (71%)

PLASTIC BUSTERS


Impact on fish species?

Microplastic impact in top predator fish



Marine Pollution Bulletin 95 (2015) 358–361

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Note

First evidence of presence of plastic debris in stomach of large pelagic fish in the Mediterranean Sea

Teresa Romeo [a,*], Battaglia Pietro [a], Cristina Pedà [a], Pierpaolo Consoli [a], Franco Andaloro [b], Maria Cristina Fossi [c]

[a] ISPRA (Institute for Environmental Protection and Research), Laboratory of Milazzo, Via dei Mille 46, 98057 Milazzo, ME, Italy
[b] ISPRA, Residence Marbela, via Salvatore Puglisi 9, 90143 Palermo, Italy
[c] University of Siena, Department of Physical, Earth and Environmental Sciences, Italy

2015

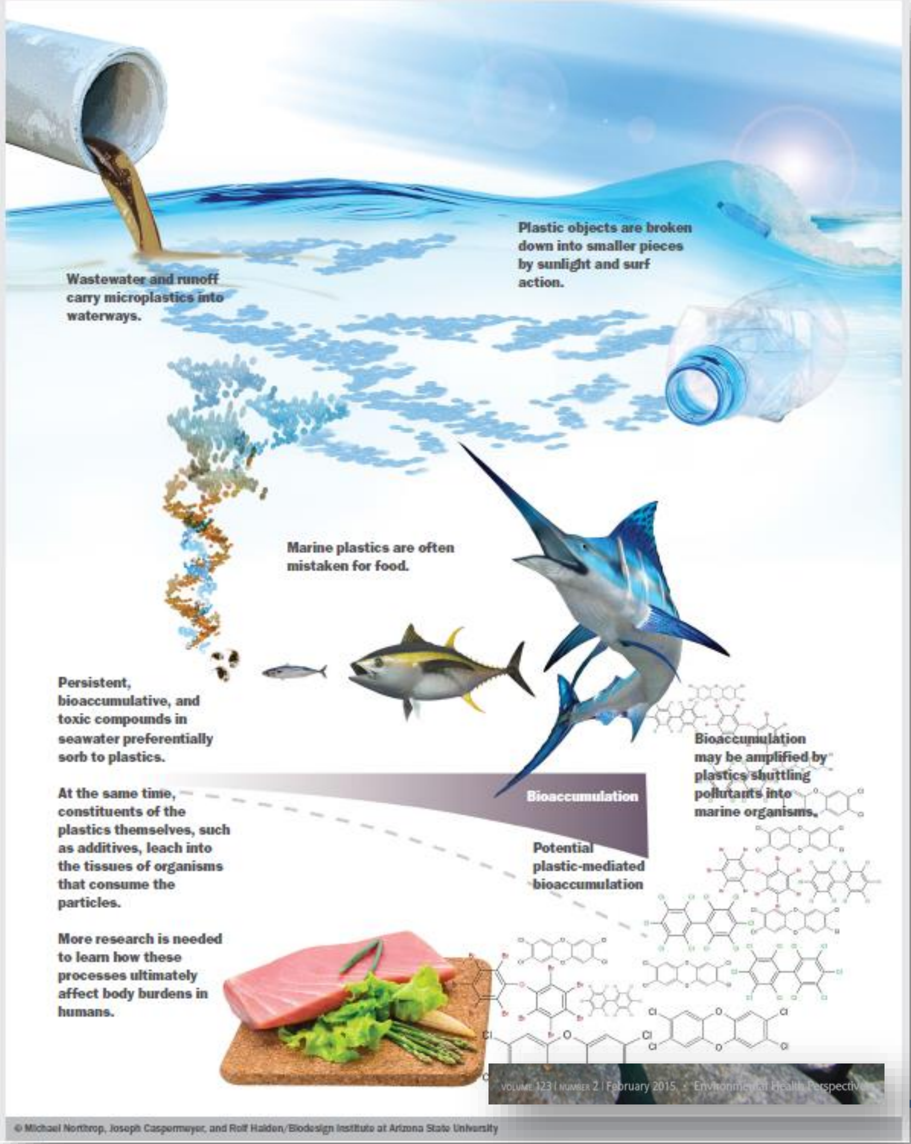
Table 1
Mean values and range of fish length and weight for each predator (SWO = swordfish; BFT = bluefin tuna; ALB = albacore). The number of stomach containing plastics is also reported.

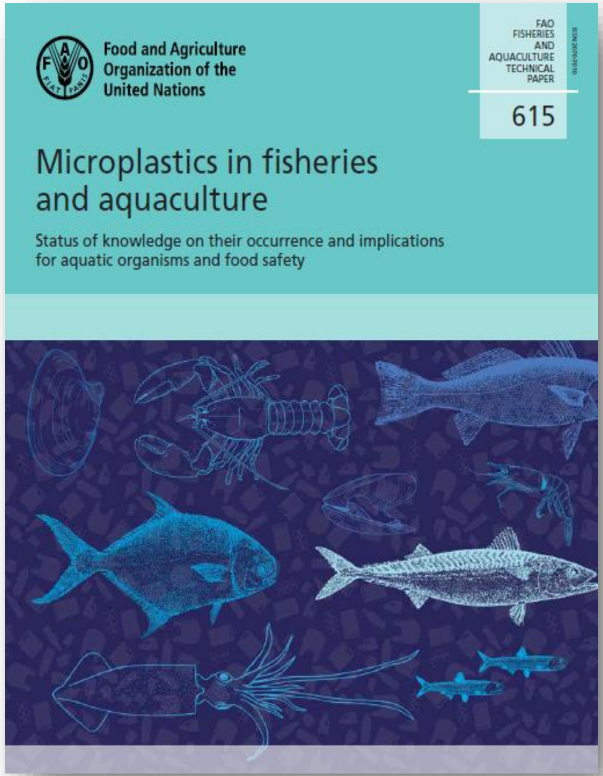
Species	Number of stomachs examined	Mean fish length ± SD (cm)	Length range (cm)	Mean fish weight ± SD (kg)	W eight range (kg)	Number of stomachs with plastic
SWO	56	145.4 ± 25.4	63–206	41.2 ± 19.8	2.5–109	7
BFT	34	156.4 ± 22.1	123–201	58.7 ± 32.2	30–165	11
ALB	31	79.0 ± 13.7	64–110	2.8–16.2	2.8–16.2	4
Total	121					22

PLASTIC BUSTERS

Microplastic impact in the food chain?

Marine Plastic and seafood safety

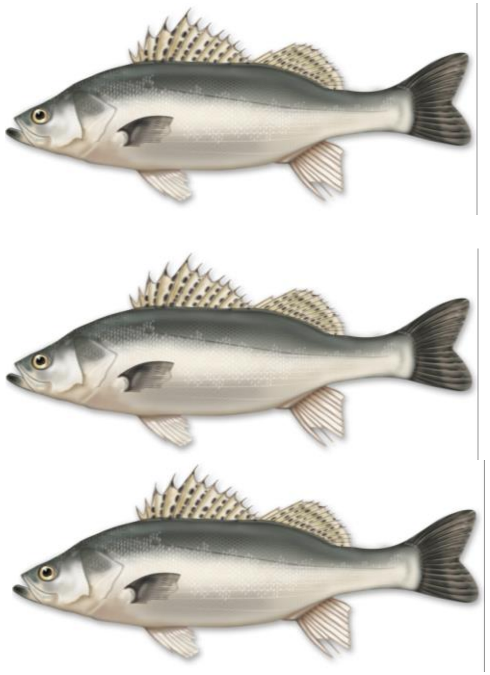


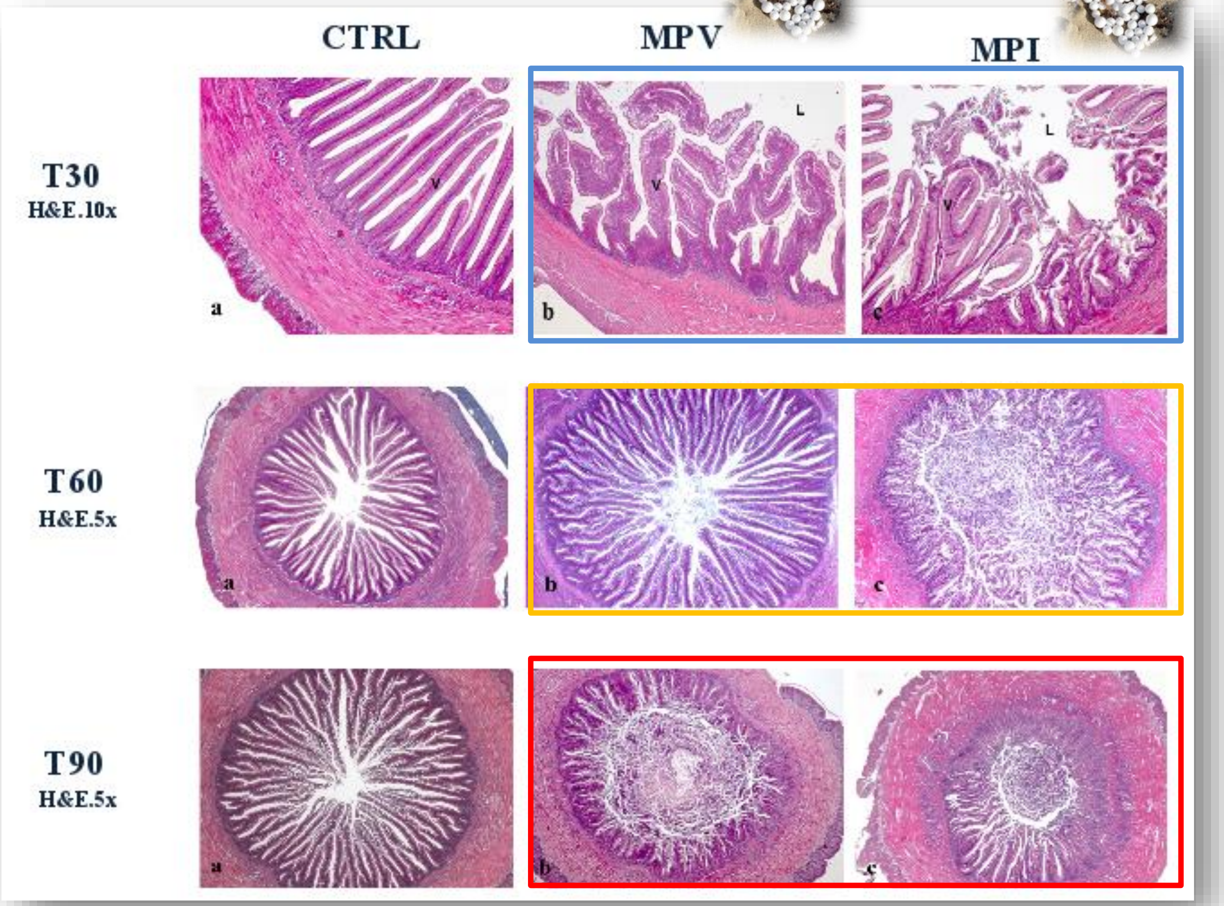


...Whereas the overall human health risks posed by microplastics in seafood at present appear to be low, it is important to consider the unavoidable increase of micro- and nanoplastics in the future as a result of degradation of plastics already released in the environment as well as future inputs.

PLASTIC BUSTERS

Microplastic impact in edible fish species





Environmental Pollution 212 (2016) 251–256
Contents lists available at ScienceDirect
Environmental Pollution
journal homepage: www.elsevier.com/locate/envpol

Short communication

Intestinal alterations in European sea bass *Dicentrarchus labrax* (Linnaeus, 1758) exposed to microplastics: Preliminary results☆

Cristina Pedà [a,*], Letteria Caccamo [b], Maria Cristina Fossi [c], Francesco Gai [d], Franco Andaloro [e], Lucrezia Genovese [b], Anna Perdichizzi [b], Teresa Romeo [a], Giulia Maricchiolo [b]

[a] ISPRA, (Institute for Environmental Protection and Research) - Laboratory of Milazzo, Via dei Mille 46, 98057 Milazzo, ME, Italy
[b] IAMC (Institute for Coastal Marine Environment), CNR, U.O.S. Messina, Spianata S. Raineri, 86, 98122 ME, Italy
[c] University of Siena, Department of Physical, Earth and Environmental Sciences, Via P.A. Mattioli 4, 53100 Siena, Italy
[d] Institute of Science of Food Production, CNR, U.O.S. Torino, Largo Braccini 2, 10095 Grugliasco, Italy
[e] ISPRA, Residence Marbela, Via Salvatore Puglisi 9, 90143 Palermo, Italy

2016

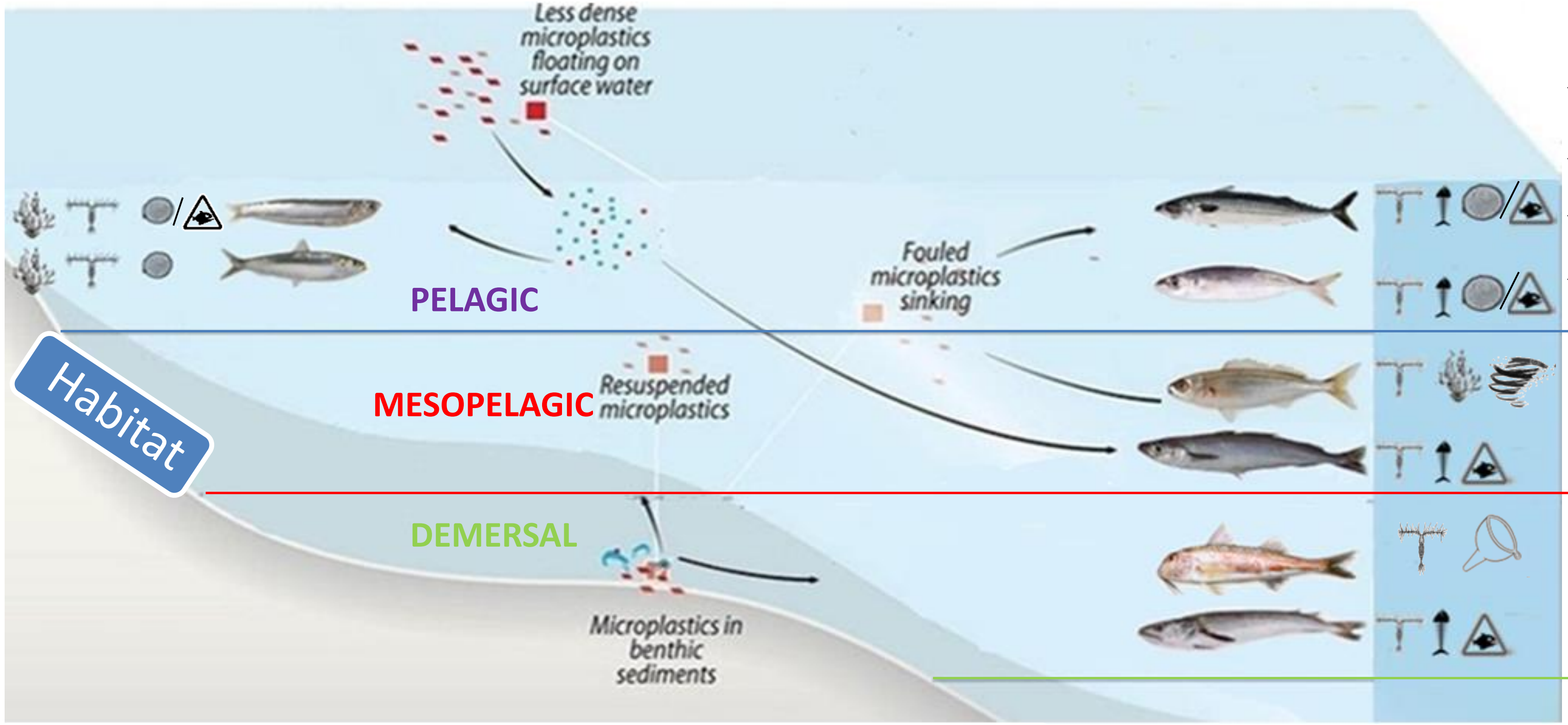
L
Intestinal alteration

M
Intestinal alteration

H
Intestinal alteration

PLASTIC BUSTERS

MPs in edible species: species selection criteria



- European anchovy (*Engraulis encrasicolus)*
- European pilchard (*Sardina pilchardus)*
- Atlantic mackerel (*Scomber scombrus)*
- Atlantic horse mackerel (*Trachurus trachurus)*

- Bogue (*Boops boops)*
- Blue whiting (*Micromesistius poutassou)*

- Red mullet (*Mullus barbatus)*
- European hake (*Merluccius merluccius)*

Trophic level (main prey) Stergiou&Karpouzi 2002

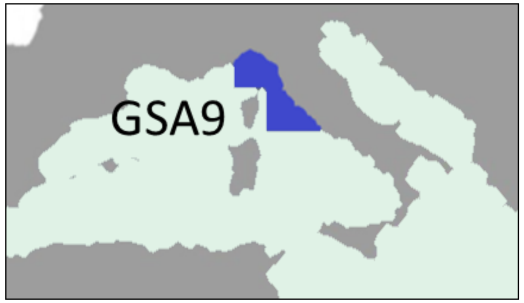
Ichthyophagus Fitoplanctophagus Zooplanctophagus

Feeding habits

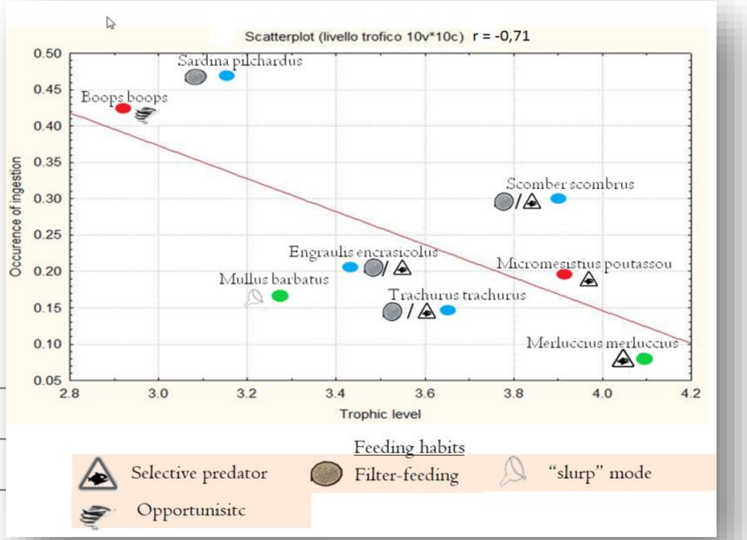
Selective predator Filter-feeding "slurp" mode

Giani et al. (2018)

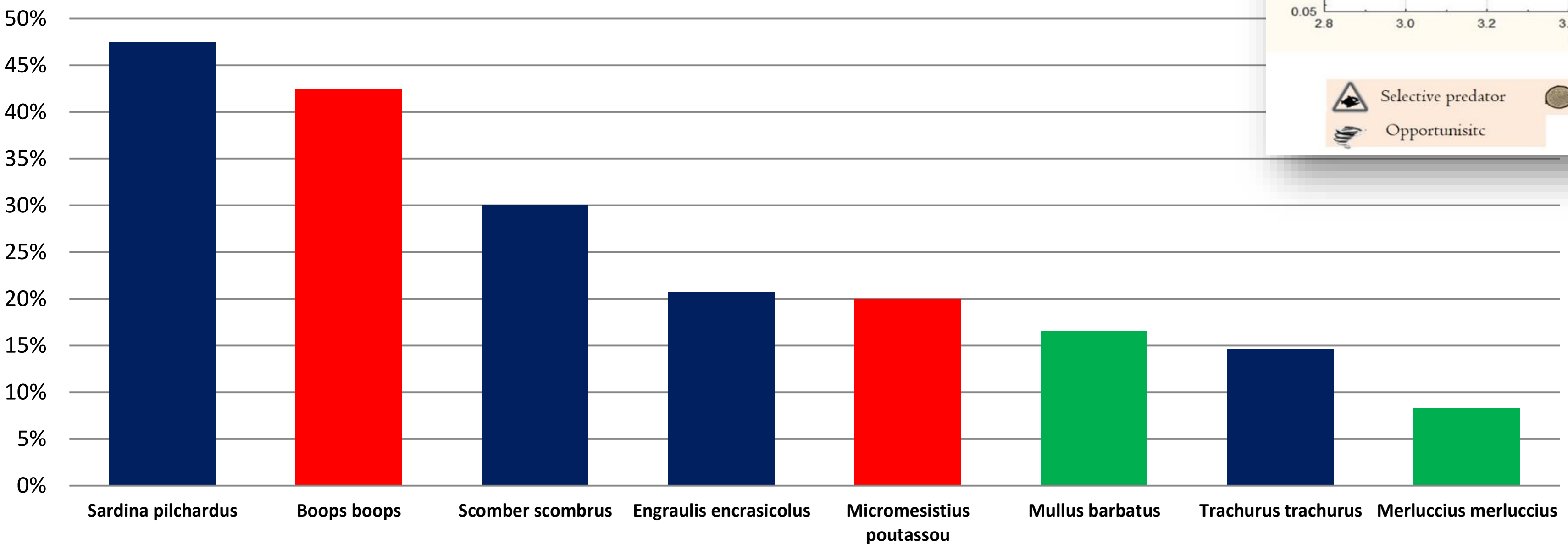
MPs in edible species: % of MPs ingestion



- ✓ Sample analyzed in GSA9 → **330**
- ✓ Total plastic items → **118**
- ✓ **Number of fish with MPs →87 (25.2%)**



PELAGIC
MESOPELAGIC
DEMERSAL



PLASTIC BUSTERS

Marine Litter impact: two points of view…

Detect the impact of marine litter on Mediterranean species

..and/or

Bioindicators of impact of marine litter on Mediterranean sea

Plastic Busters initiative

Plastic Busters on basin scale

PLASTIC BUSTERS

A crucial aspect of the marine litter issue, underlined by the **Barcelona Convention within the Regional Plan for Marine Litter** (Istanbul 2013) is that: "Marine pollution knows no border, pollution in one country affects all other 21 countries, hence there is a need for a regional approach".

Plastic Busters is the first project at basin scale that binds the Southern and Northern Mediterranean countries on the issue of Marine Litter under the umbrella of UNEP/MAP and UfM, with 10 countries already involved in the project and 12 countries endorsing the project.

Diagnosis of the problem to identified specific solutions

- Impact on Biodiversity?
- Impact on Fisheries?
- Identification of Hot spot areas?
- Impact on Human?

Project coordinator
Maria Cristina Fossi
Biomarker Laboratory, University of Siena, Italy

UNIVERSITÀ DI SIENA 1240

SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK A GLOBAL INITIATIVE FOR THE UNITED NATIONS Mediterranean

INDICIT II INDICATOR • IMPACT • TAXA

blueMed A Plastic-free healthy Mediterranean Sea: the BLUEMED R&I Pilot

SDSN-MED Flagship project

UNEP MAP 40 Years together for a sustainable Mediterranean

SUSTAINABLE DEVELOPMENT GOAL 14

SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK A GLOBAL INITIATIVE FOR THE UNITED NATIONS Mediterranean

ONU

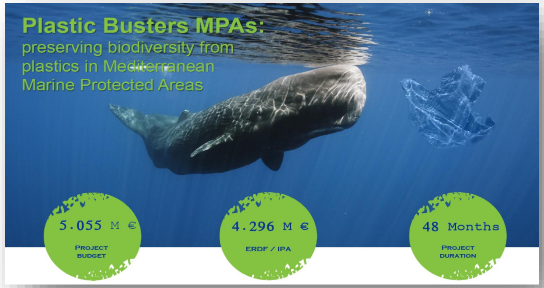
2013

UfM Labelling

Union for the Mediterranean
Union pour la Méditerranée
الإتحاد من أجل المتوسط

2016

MED-Interreg



2018

ENI -CBC

ENI CBCMED Project funded by the EUROPEAN UNION

COMMON

Plastic Busters CAP

2019 - 21

Plastic Busters MPAs:

preserving biodiversity from plastics in Mediterranean Marine Protected Areas

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

5.055 M €
PROJECT BUDGET

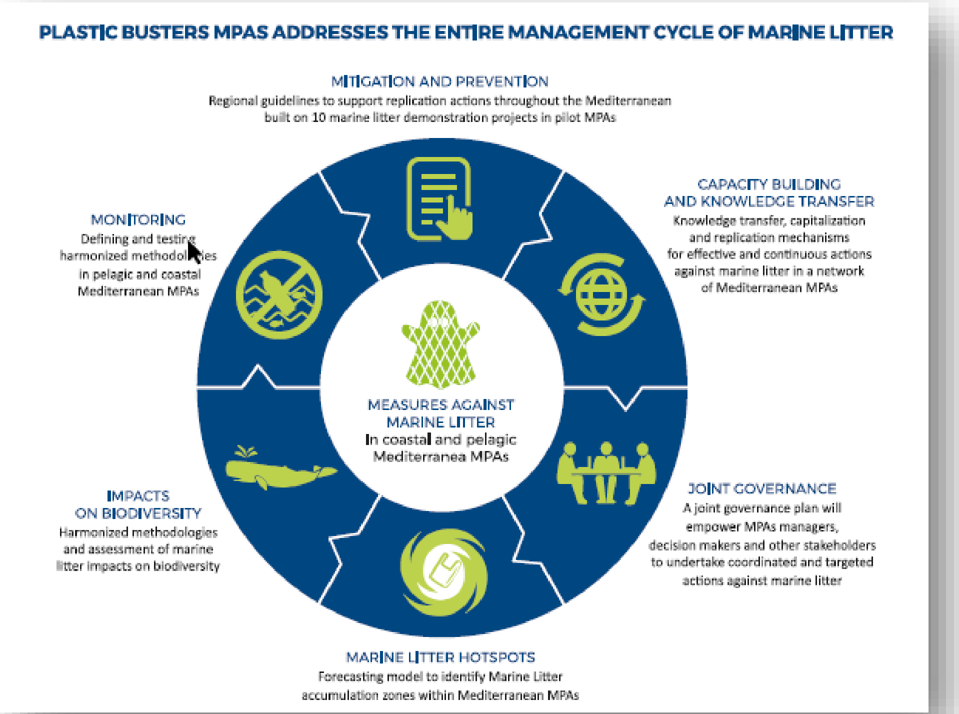
4.296 M €
ERDF / IPA

48 Months
PROJECT DURATION

Interreg Mediterranean
PLASTIC BUSTERS MPAs

Project co-financed by the European Regional Development Fund

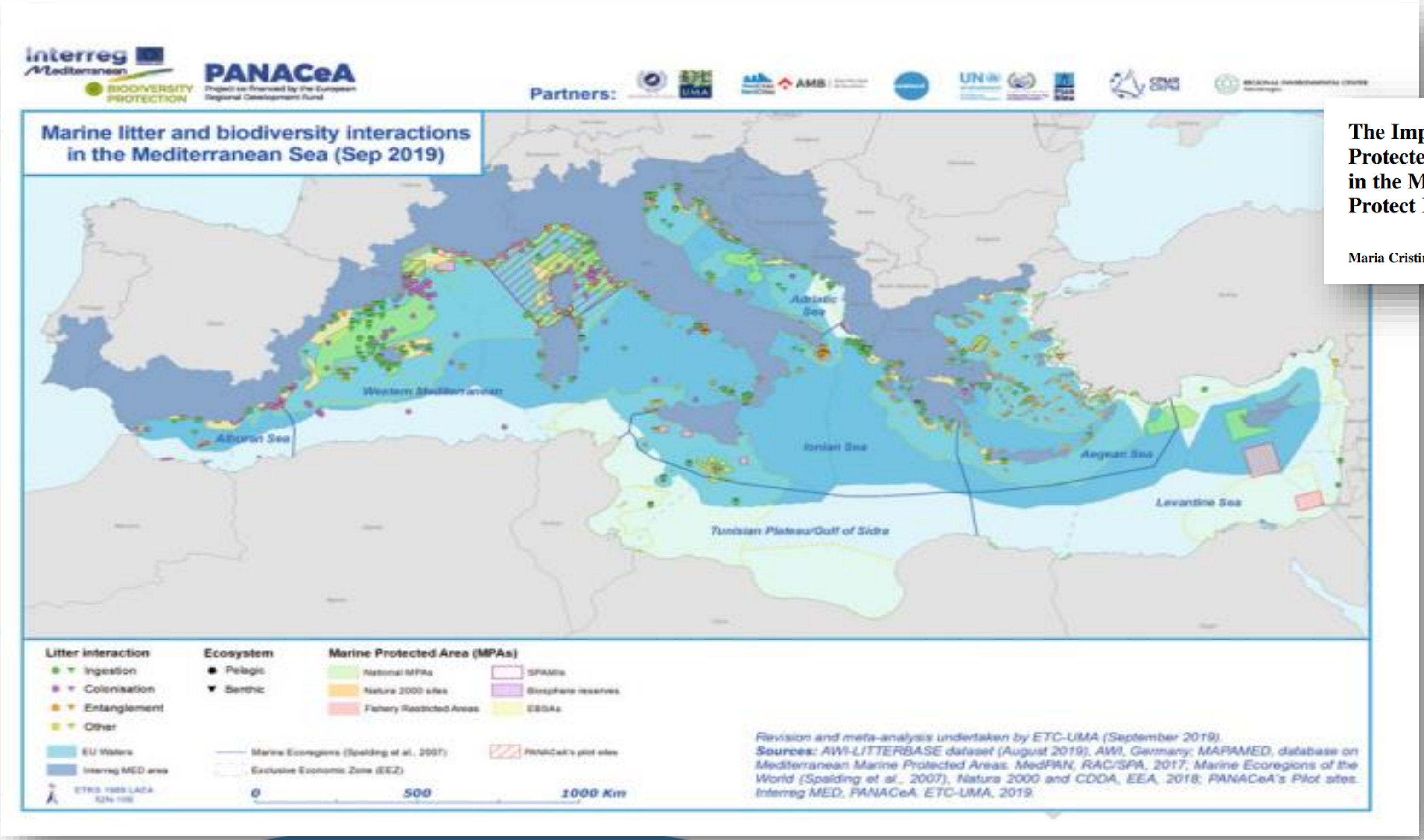
Plastic Busters MPAs general objectives
Whole Management Cycle Of Marine Litter



- **PlasticBusters MPAs**, is a 4-year-long project Interreg Mediterranean funded project aiming to contribute to **maintaining biodiversity and preserving natural ecosystems** in pelagic and coastal **marine protected areas** (MPAs), by defining and implementing a **harmonized approach against marine litter**.
- The project entails actions that address the **WHOLE MANAGEMENT CYCLE OF MARINE LITTER**, from **monitoring and assessment** to **prevention and mitigation**, as well as actions to **strengthen networking** between and among pelagic and coastal MPAs located in Italy, France, Spain, Croatia, Albania and Greece.
- The project will support the **implementation** of the **MSFD** and the Barcelona Convention **Regional Plan on Marine Litter** Management in the Med.

Interreg Mediterranean
PLASTIC BUSTERS MPAs
Project co-financed by the European Regional Development Fund

The Impact of Marine Litter in Marine Protected Areas (MPAs) in the Mediterranean Sea



The Impact of Marine Litter in Marine Protected Areas (MPAs) in the Mediterranean Sea: How Can We Protect MPAs?

Maria Cristina Fossi and Cristina Panti

In the whole Mediterranean basis <u>1231 MPAs</u> and OECMs (Other Effective area- based Conservation Measures) cover <u>179,798 km</u> for a total surface of 7.14% under a legal designation. Many of these areas are heavily subjected to marine litter pressure.

Interreg Mediterranean
PLASTIC BUSTERS MPAs

Project co-financed by the European Regional Development Fund

Plastic Busters MPAs:
Harmonized Diagnosis in Biota

- **4.1 – Coordinating WP 4**
- **4.2** Piloting harmonized ML monitoring in Med MPAs to assess ML (macro- and micro-plastics) in the coastal and pelagic environment
- **4.3** Piloting harmonized ML monitoring approaches in Med MPAs and hotspots to establish the impacts on biota, including endangered species and fishery resources
- **4.4** Testing the ML forecasting model
- **4.5** Preparation of the demo projects
- **4.6** Piloting ML prevention and mitigation measures

i) Plastic detection

Analysis of the ingested marine litter/microplastics:
- Occurrence (%)
- Abundance (n°)
- Weight (g)
- Polymer analysis

ii) Plastic tracers detection

Analysis of plastic additives:
- Phthalates
- PBDEs
- Bisphenol A

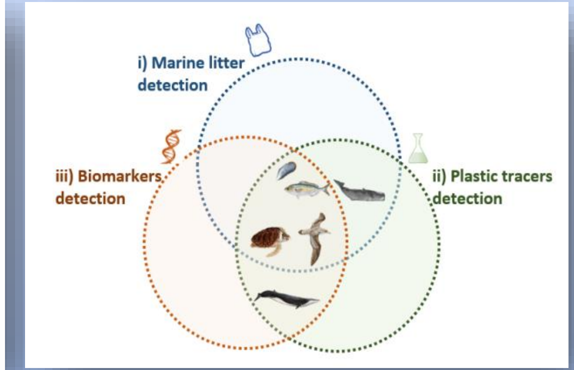
- Analysis of PBT compounds:
- PCBs
- DDTs
- PAHs
- Mercury

iii) Biomarkers detection

Effects at molecular level:
- Measure of DNA damage
- Alterations of gene expression
- Alteration of proteins

- Effects at cellular level:
- Alteration of cell functions

- Effects at tissue level:
- Histological and histopathological alterations



MARINE LITTER IMPACTS ON BIOTA

Interreg Mediterranean
PLASTIC BUSTERS MPAs
Project co-financed by the European Regional Development Fund

Identification of marine litter bioindicators


Environmental Pollution xxx (2017) 1–18

Contents lists available at ScienceDirect

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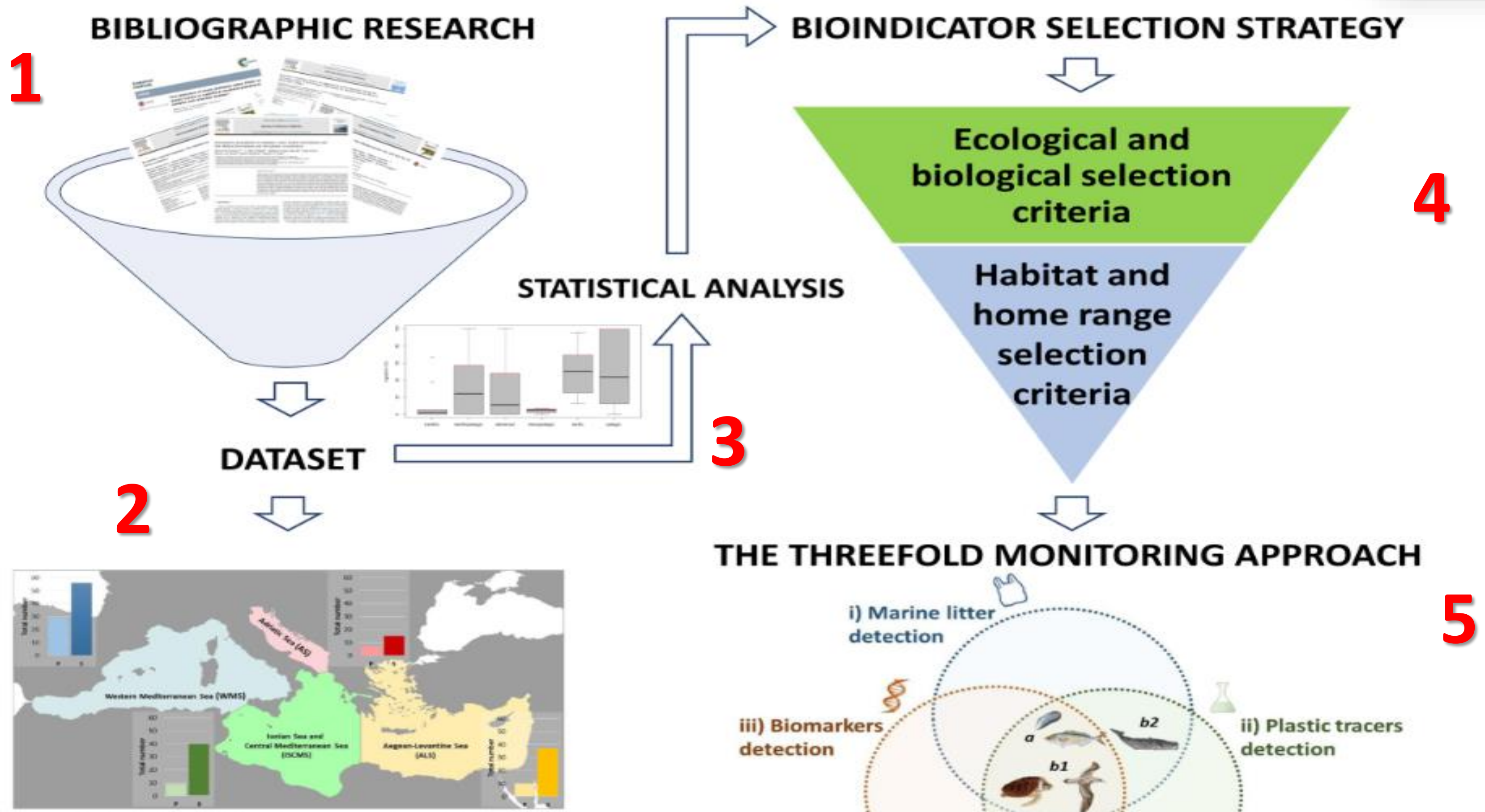
ELSEVIER

Bioindicators for monitoring marine litter ingestion and its impacts on Mediterranean biodiversity*

Maria Cristina Fossi [a,b], Cristina Pedà [c], Montserrat Compa [d], Catherine Tsangaris [e], Carme Alomar [d], Francoise Claro [f], Christos Ioakeimidis [g], Francois Galgani [h], Tatjana Hema [g], Salud Deudero [d], Teresa Romeo [c], Pietro Battaglia [c], Franco Andaloro [c], Ilaria Caliani [a,b], Silvia Casini [a,b], Cristina Panti [a,b,*], Matteo Baini [a,b]



State the of art of marine litter ingestion in Mediterranean Sea

Percentage and ranking of marine litter ingestion in the Med species calculated on the data present in literature

% of ingestion

Species	% of ingestion
Balaenoptera physalus (Linnaeus, 1758)	100.00%
Calonectris diomedea (Scopoli, 1769)	95.92%
Siganus luridus (Rüppell, 1829)	86.67%
Cetorhinus maximus (Gunnerus, 1765)	83.33%
Pagrus pagrus (Linnaeus, 1758)	77.78%
Physeter macrocephalus Linnaeus, 1758	77.78%
Argyrosomus regius (Asso, 1801)	74.51%
Puffinus yelkouan (Acerbi, 1827)	70.97%
Mullus surmuletus Linnaeus, 1758	70.59%
Puffinus mauretanicus Lowe, 1921	69.57%
Diplodus annularis (Linnaeus, 1758)	68.75%
Boops boops (Linnaeus, 1758)	67.71%
Pagellus acarne (Risso, 1827)	67.31%
Serranus cabrilla (Linnaeus, 1758)	66.67%
Pelates quadrilineatus (Bloch, 1790)	65.19%
Trachurus mediterraneus (Steindachner, 1868)	62.13%
Saurida undosquamis (Richardson, 1848)	55.56%
Pomadasys incisus (Bowdich, 1825)	55.17%
Nemipterus randalli Russell, 1986	54.81%
Dermochelys coriacea (Vandelli, 1761)	50.00%
Scomber japonicus Houttuyn, 1782	47.73%
Upeneus moluccensis (Bleeker, 1855)	44.44%
Sparus aurata Linnaeus, 1758	43.64%
Liza aurata (Risso, 1810)	43.59%
Upeneus pori Ben-Tuvia & Golani, 1989	41.03%

Species	% of ingestion
Trigla lucerna Linnaeus, 1758	37.50%
Mullus barbatus Linnaeus, 1758	36.03%
Lithognathus mormyrus (Linnaeus, 1758)	34.78%
Larus michahellis J.F. Naumann, 1840	33.33%
Trachyrincus scabrus (Rafinesque, 1810)	33.33%
Polyprion americanus (Bloch & Schneider, 1801)	32.35%
Caretta caretta (Linnaeus, 1758)	31.10%
Dentex gibbosus (Rafinesque, 1810)	28.57%
Schedophilus ovalis (Cuvier, 1833)	28.57%
Trachinotus ovatus (Linnaeus, 1758)	24.35%
Trachurus trachurus (Linnaeus, 1758)	24.00%
Pagellus erythrinus (Linnaeus, 1758)	22.39%
Squalus acanthias Linnaeus, 1758	21.05%
Sardina pilchardus (Walbaum, 1792)	20.41%
Naucrates ductor (Linnaeus, 1758)	18.00%
Nettastoma melanurum Rafinesque, 1810	16.67%
Coryphaena hippurus Linnaeus, 1758	14.34%
Balistes capriscus Gmelin, 1789	14.00%
Larus audouinii Payraudeau, 1826	13.33%
Thunnus alalunga (Bonnaterre, 1788)	12.90%
Thunnus thynnus (Linnaeus, 1758)	12.67%
Morus bassanus (Linnaeus, 1758)	12.50%
Xiphias gladius Linnaeus, 1758	12.28%
Stenella coeruleoalba (Meyen, 1833)	11.67%
Tursiops truncatus (Montagu, 1821)	11.17%
Cataetyx laticeps Koefoed, 1927	10.00%

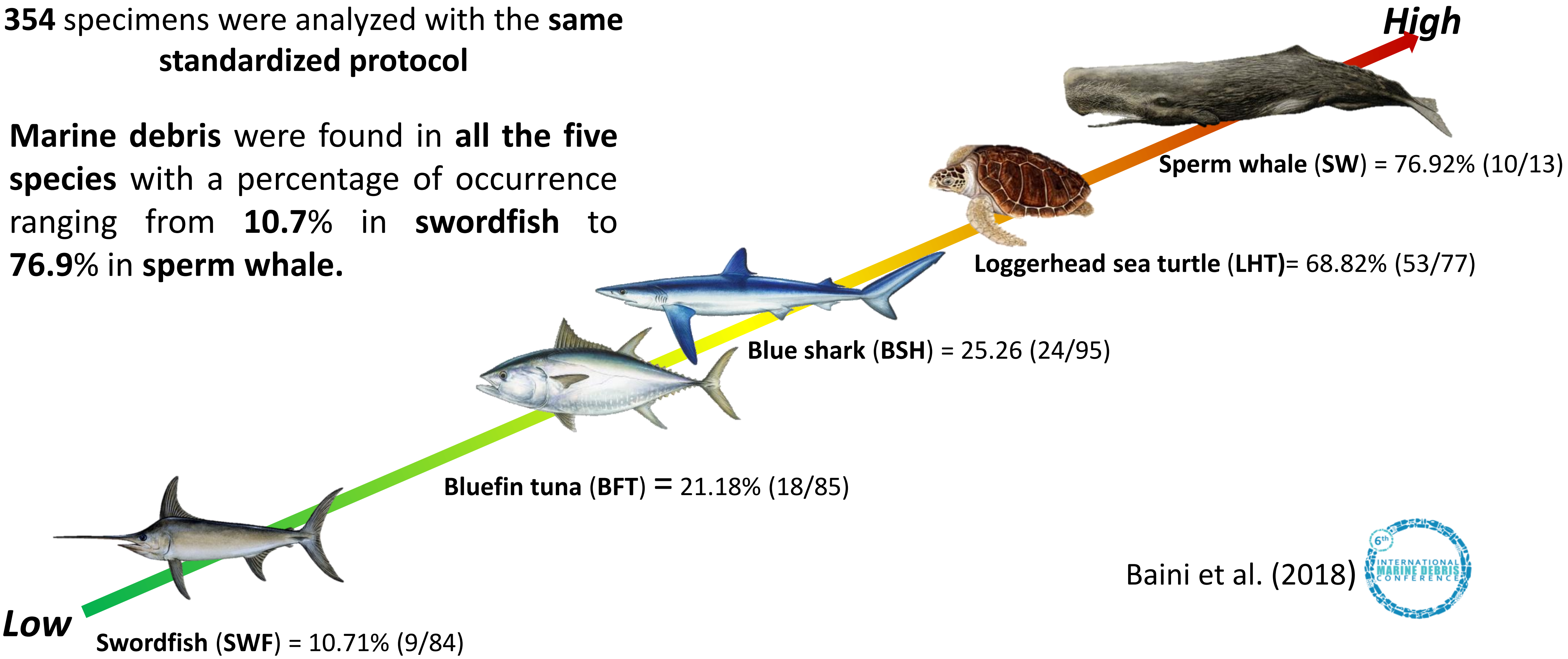
Species	% of ingestion
Mora moro (Risso, 1810)	9.09%
Etmopterus spinax (Linnaeus, 1758)	8.82%
Merluccius merluccius (Linnaeus, 1758)	7.69%
Galeus melastomus Rafinesque, 1810	7.11%
Hygophum benoiti (Cocco, 1838)	6.85%
Electrona risso (Cocco, 1829)	6.10%
Myctophum punctatum Rafinesque, 1810	4.23%
Centroscymnus coelolepis Barbosa 1864	2.99%
Solea solea (Linnaeus, 1758)	2.27%
Seriola dumerili (Risso, 1810)	2.00%
Citharus linguatula (Linnaeus, 1758)	1.92%
Pagellus bogaraveo (Brünnich, 1768)	1.67%
Squalus blainville (Risso, 1827)	1.33%
Trachurus picturatus (Bowdich, 1825)	1.00%
Helicolenus dactylopterus (Delaroche, 1809)	0.42%
Diaphus metopoclampus (Cocco, 1829)	0.34%
Alepocephalus rostratus Risso, 1820	0.00%
Brama brama (Bonnaterre, 1788)	0.00%
Conger conger (Linnaeus, 1758)	0.00%
Molva macrophthalma (Rafinesque, 1810)	0.00%
Phycis blennoides (Brünnich, 1768)	0.00%
Raja oxyrinchus Linnaeus, 1758	0.00%

PLASTIC BUSTERS

Percentage and ranking of marine litter ingestion in Med species calculated on the field data

354 specimens were analyzed with the **same standardized protocol**

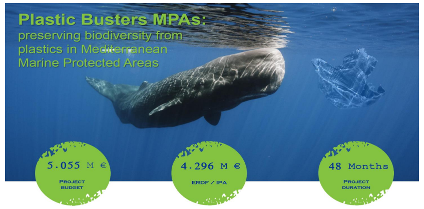
Marine debris were found in **all the five species** with a percentage of occurrence ranging from **10.7%** in **swordfish** to **76.9%** in **sperm whale.**



Baini et al. (2018)

Bioindicator selection in relation to habitat and home range

Basin Scale

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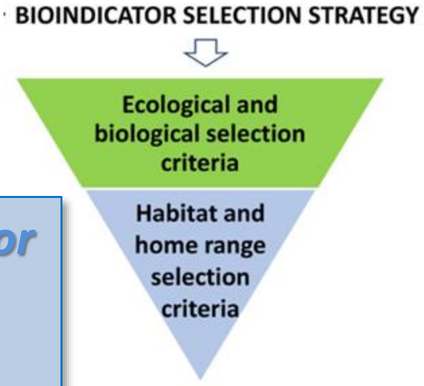
	SEA SURFACE	COASTAL WATERS	OPEN WATERS	SEAFLOOR	COAST LINE AND BEACH SEDIMENT
BASIN SCALE *(Mediterranean Sea)*	*Calonectris diomedea, Puffinus yelkouan*	*Calonectris diomedea, Puffinus yelkouan*	*Balaenoptera physalus; Cetorhinus maximus Xiphias gladius; Thunnus thynnus Xiphias gladius; Thunnus thynnus Caretta caretta Physeter macrocephalus*		
MEDIUM-SCALE *(Mediterranean UN Environment/MAP sub-regions)*			*Thunnus alalunga Coryphaena hippurus Caretta caretta Thunnus alalunga*		
SMALL-SCALE *(FAO GSA)*		*Boops boops Trachinotus ovatus*	*Maurolicus muelleri Engraulis encrasicolus Sardina pilchardus* Myctophids	*Mullus barbatus Nephrops norvegicus. Galeus melastomus, Merluccius merluccius, Solea spp. Galeus melastomus, Scyliorhinus canicula*	
LOCAL SCALE				Holoturians	*Mytilus galloprovincialis Arenicola marina* Decapods *(e.g. Carcinus sp.)*

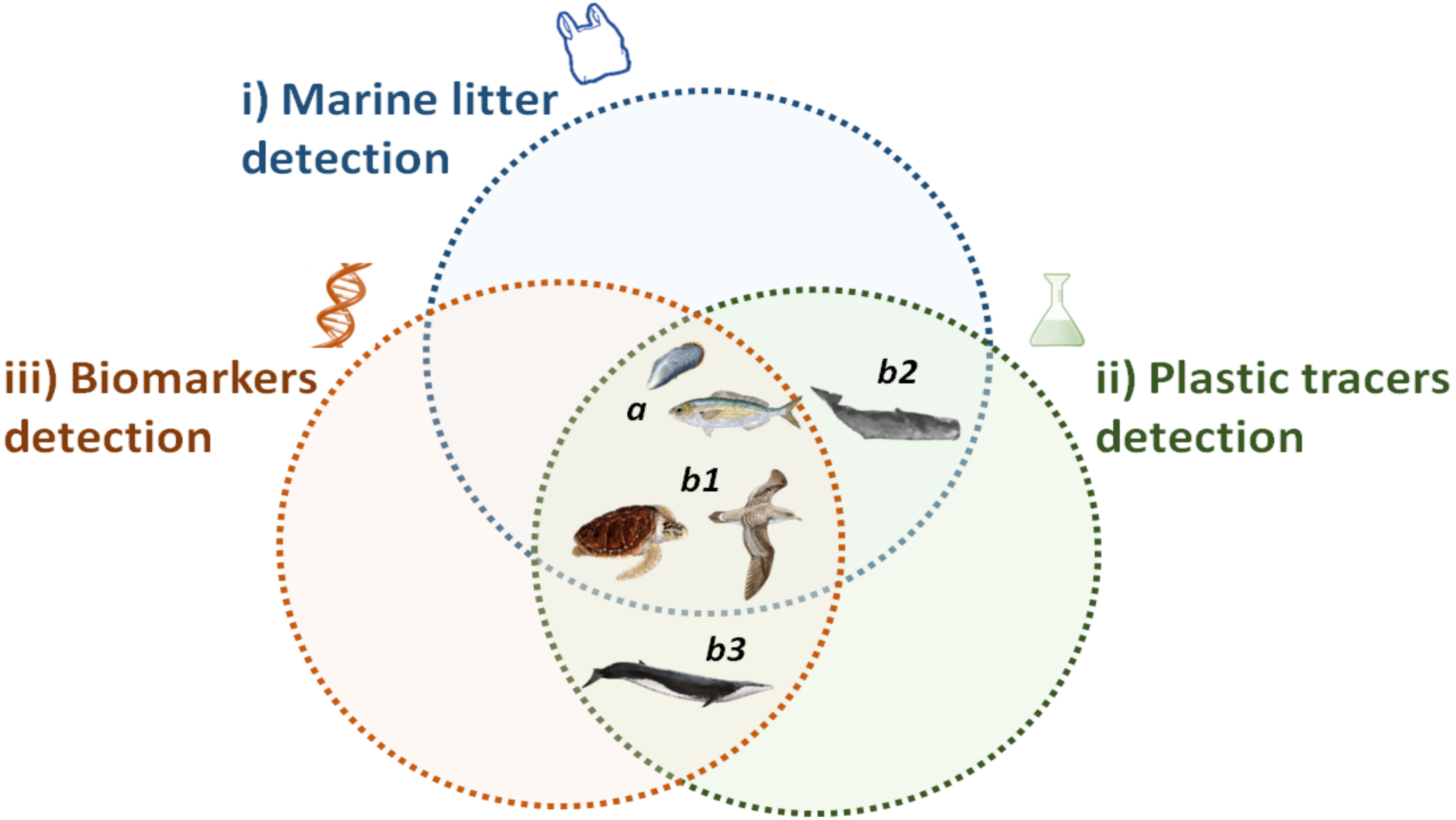
BLUE: ***biondicator for macrolitter***

RED: ***bioindicator for microplastics***



Local Scale

THE THREEFOLD MONITORING APPROACH



PLASTIC BUSTERS

18.5.2017 EN Official Journal of the European Union L 125/43

COMMISSION DECISION (EU) 2017/848

of 17 May 2017

laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU

D10C3 -The amount of litter and micro-litter ingested by marine animals is at a level **that does not adversely affect the health of the species concerned**

Descriptor 10

Properties and quantities of marine litter do not cause harm to the coastal and marine environment

DOES ML ADVERSELY AFFECT THE HEALTH OF THE SPECIES ?

The quantification of marine litter ingestion is not enough… we need to investigate ecotoxicological effects

PLASTIC BUSTERS

THE THREEFOLD MONITORING APPROACH


Environmental Pollution xxx (2017) 1-18

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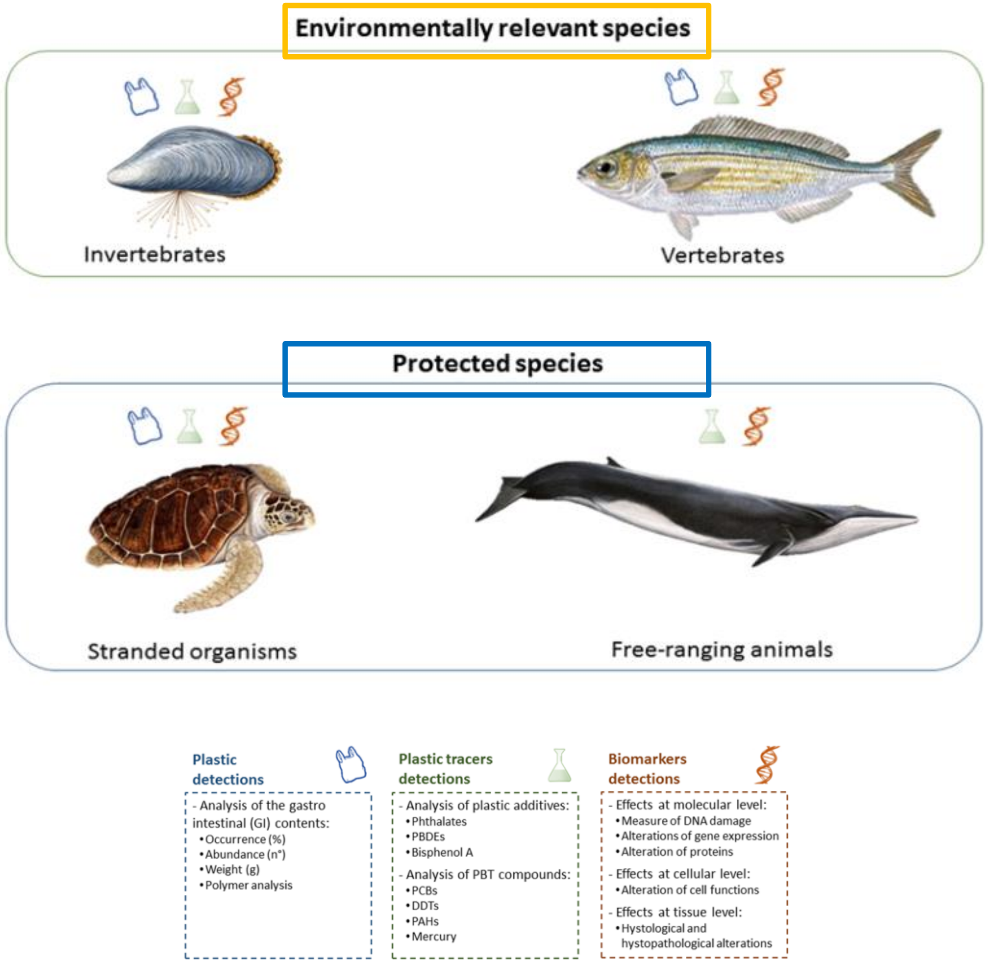


The simultaneous investigation in bioindicator species of:

A) the analysis of **gastro-intestinal content** to evaluate the **marine litter** ingested by the organisms;

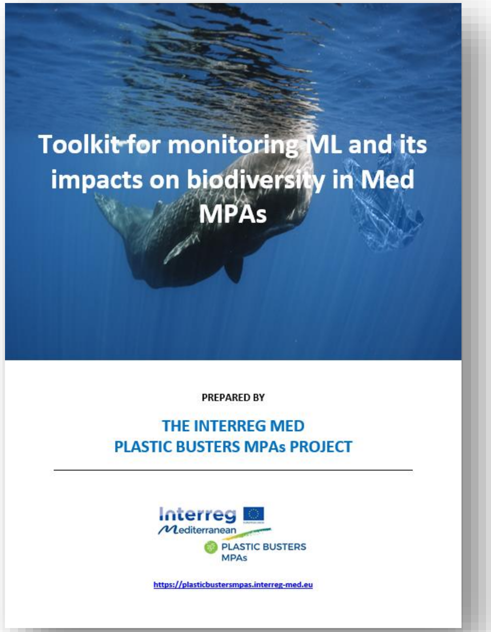
B) the analysis of **plastic additives** and PBT compounds used as plastic tracers;

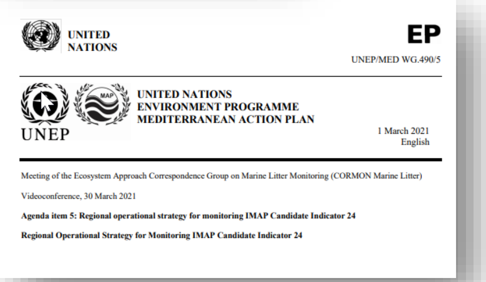
C) the analysis of the effects by **biomarkers responses** at different level of biological organization

… will allow a **more complete assessment of the real impact** related to plastic debris ingestion by marine organisms.

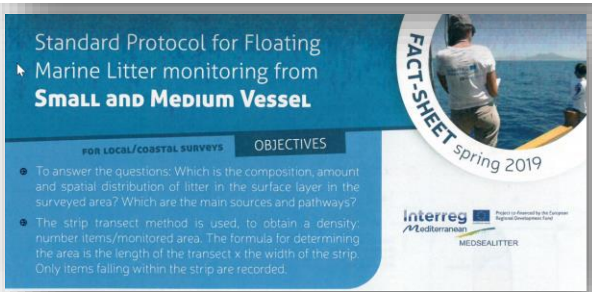
PLASTIC BUSTERS

Plastic Busters MPAs:
Toolkit – Supporting documents





INDICIT II
INDICATOR • IMPACT • TAXA



…and more

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Commercial fish species

Laboratory analysis: *Microplastics ingestion*

- Use of glass materials washed with micro-filtred water (0,45
  - One procedural blanks every tw

i) Plastic detection

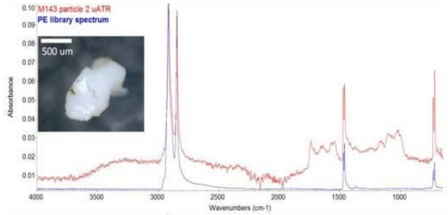
- Analysis of the ingested marine litter/microplastics:
  - Occurrence (%)
  - Abundance (n°)
  - Weight (g)
  - Polymer analysis

Digestion and filtration

- Digestion method: KOH 10% (1:5 w/
  (Rochman *et al* 2015, modified)
- Filtration with 1.6µ glass-fib

Characterization of plastics

- Shape, c of plastic particles
- Polyme IR) (10% total items)



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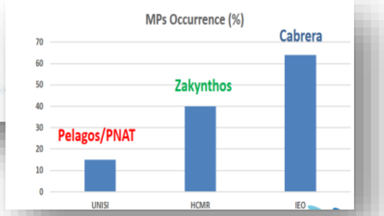
Three-Fold Monitoring Approach in Striped Red Mullet



Cabrera - IEO | **Zakynthos - HCMR** | **Pelagos/PNAT - UNISI**

i) Plastic detection

- Analysis of the ingested marine litter/microplastics:
  - Occurrence (%)
  - Abundance (n°)
  - Weight (g)
  - Polymer analysis



ii) Plastic tracers detection

- Analysis of plastic additives:
  - Phthalates
  - PBDEs
  - Bisphenol A
- Analysis of PBT compounds:
  - PCBs
  - DDTs
  - PAHs
  - Mercury

iii) Biomarkers detection

- Effects at molecular level:
  - Measure of DNA damage
  - Alterations of gene expression
  - Alteration of proteins
- Effects at cellular level:
  - Alteration of cell functions
- Effects at tissue level:
  - Hystological and hystopathological alterations

QX200™ Droplet Digital™ PCR System (Bio-Rad)

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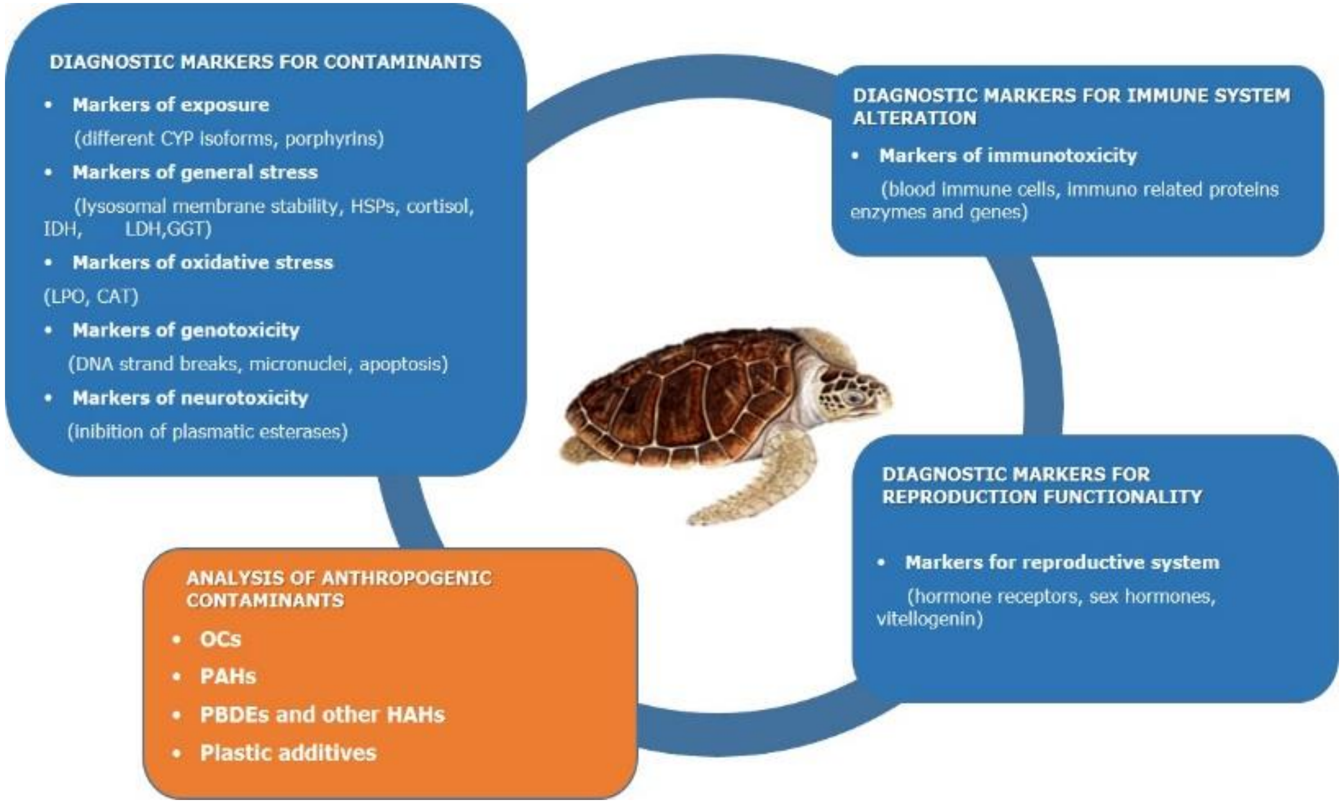
Monitoring Endangered Hospitalized Sea Turtles

Monitoring MACRO and MICROLITTER in BIOTA: ENDANGERED SPECIES



12. Methodology for monitoring MACROLITTER and MICROLITTER ingestion in biota: sea turtles

This document describes the methodological approach for monitoring macrolitter and microliter ingestion in sea turtles. It has been compiled building on the methodologies developed within the EU-funded INDICIT I project and the marine litter monitoring guidance documents of the MSFD TG10 and UNEP/MAP and it has been adapted within the framework of the Interreg Med PlasticBusters MPAs project to address the recent advances in the field.

PREPARED BY

THE INTERREG MED
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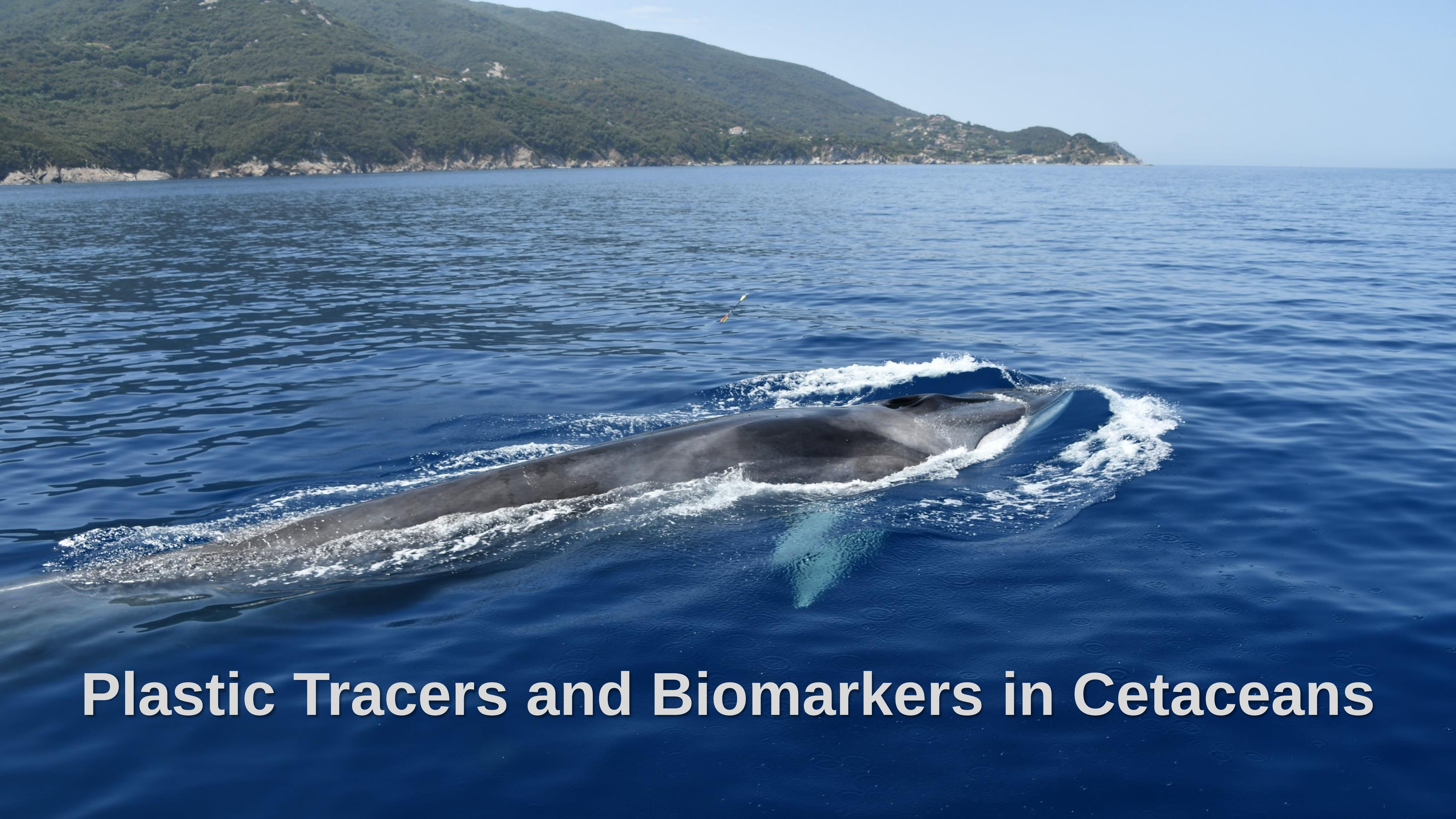
Plastic Tracers and Biomarkers in Cetaceans

Monitoring marine litter impacts in Cetacean Species

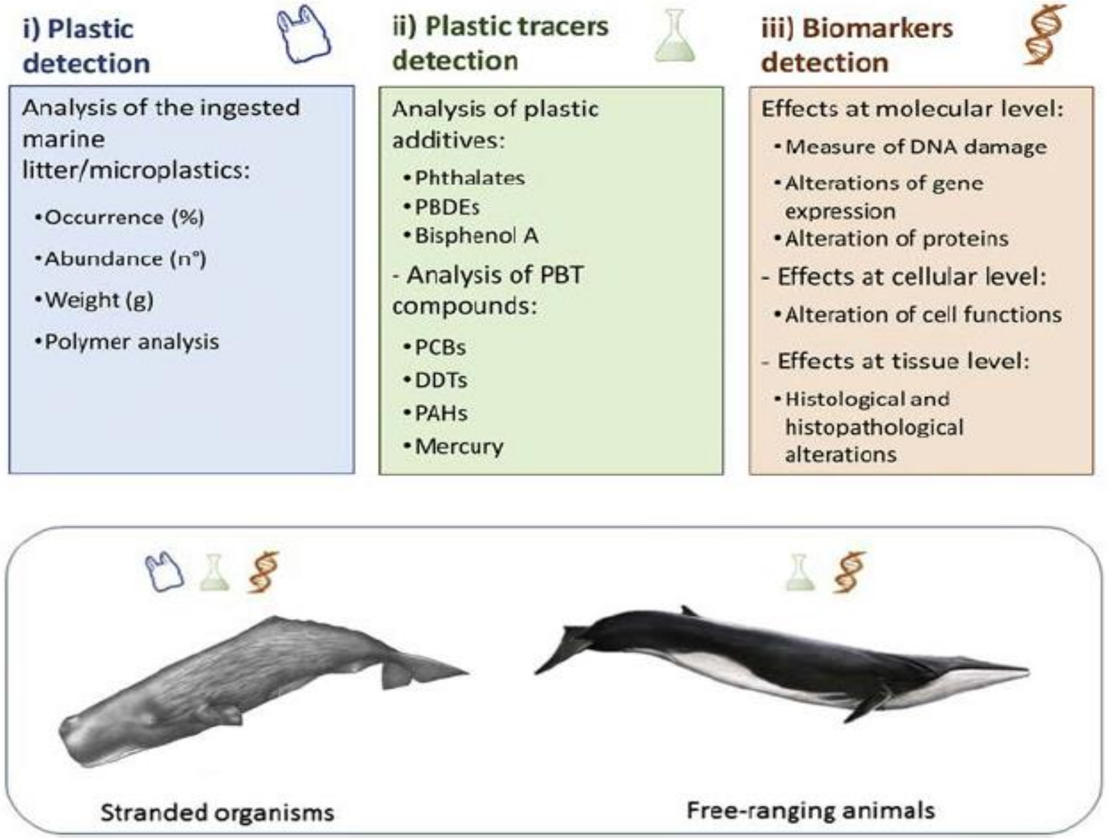

FIGURE 6.3 The threefold monitoring approach to detect marine litter presence and impact in cetacean species (stranded and free-ranging organisms).

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Monitoring Marine Litter Impacts in Cetaceans :
Stranded Organisms

i) Plastic detection

- Analysis of the ingested marine litter/microplastics:
  - Occurrence (%)
  - Abundance (n°)
  - Weight (g)
  - Polymer analysis

ii) Plastic tracers detection

- Analysis of plastic additives:
  - Phthalates
  - PBDEs
  - Bisphenol A
- Analysis of PBT compounds:
  - PCBs
  - DDTs
  - PAHs
  - Mercury

Ziphius cavirostris

A new prototype to isolate macro and microplastics in the gastrointestinal tract of stranded cetaceans
UNIVERSITY of PADOVA, IZS

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Monitoring marine litter impacts in Cetacean Species:

Skin Biopsy in Free-ranging Organisms

ii) Plastic tracers detection

- Analysis of plastic additives:
  - Phthalates
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iii) Biomarkers detection

- Effects at molecular level:
  - Measure of DNA damage
  - Alterations of gene expression
  - Alteration of proteins
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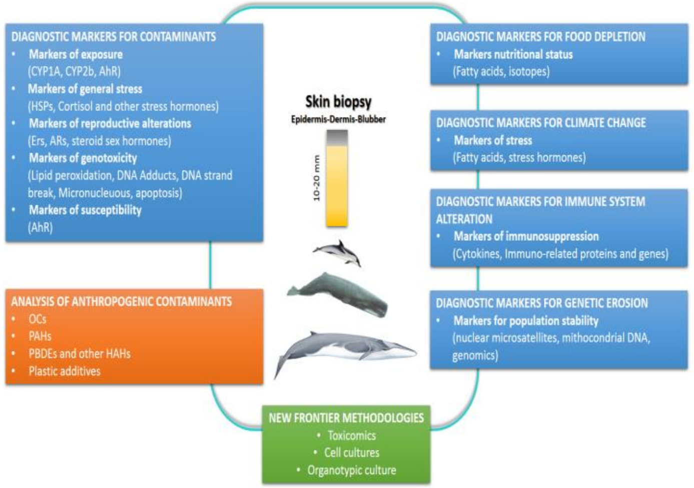
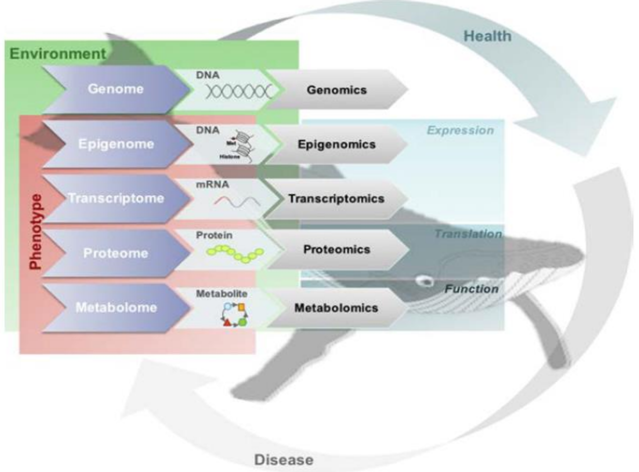
- Effects at tissue level:
  - Histological and histopathological alterations





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Thank you !

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Sistema Nazionale per la Protezione dell'Ambiente

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Collectivité Territoriale de CORSE
Cullettività Territuriale di CORSICA
Office de l'Environnement de la Corse
Uffiziu di l'Ambiente di a Corsica

Ifremer

Parco Nazionale Arcipelago Toscano

Pelagos

CONSORZIO LaMMA

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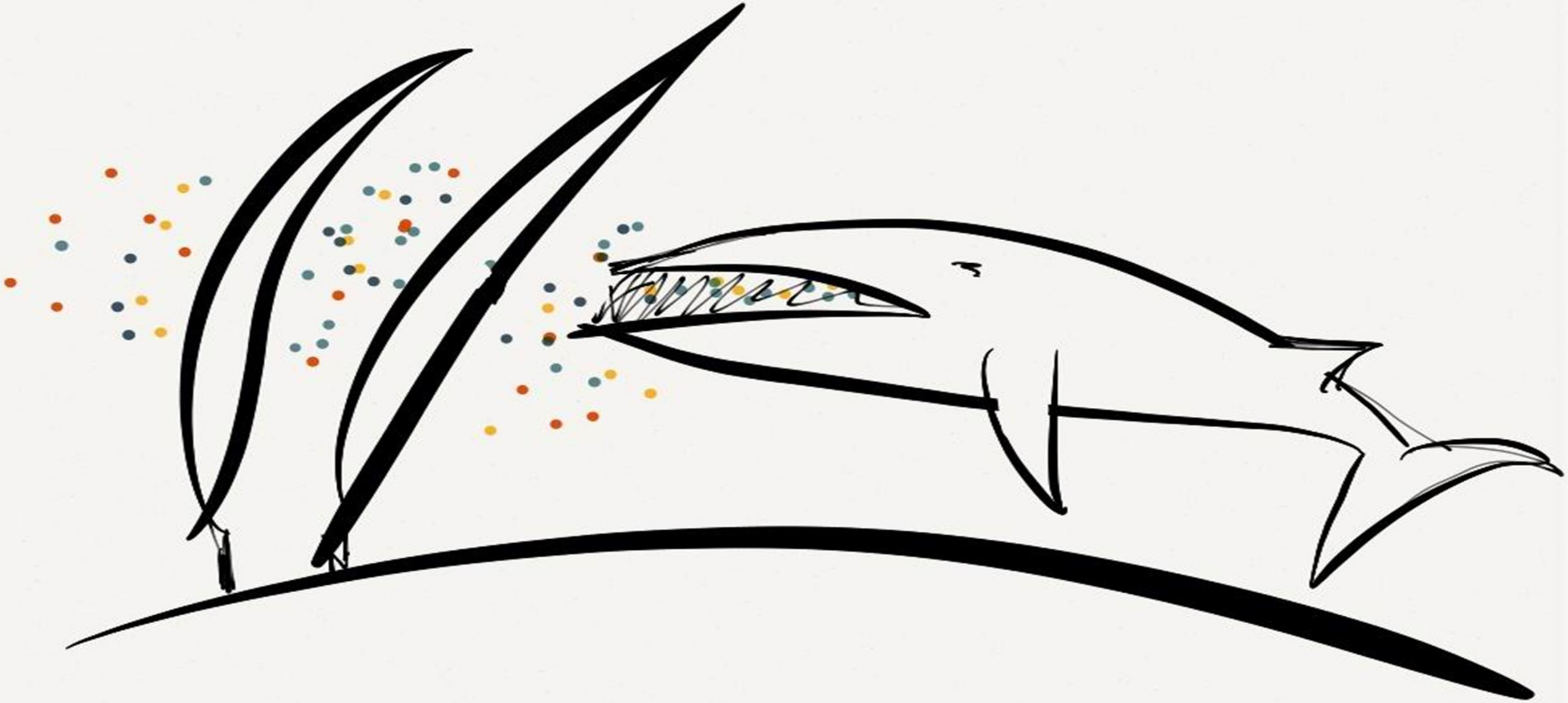

Thank you for your attention!