**Water and Environment Support**
in the ENI Southern Neighbourhood region

# RE-2-REG

## Regional training on microplastics

### Amounts, types, sources and effects of plastics and microplastics in the Mediterranean marine environment Overview of microplastics monitoring approaches & knowledge gaps and research needs

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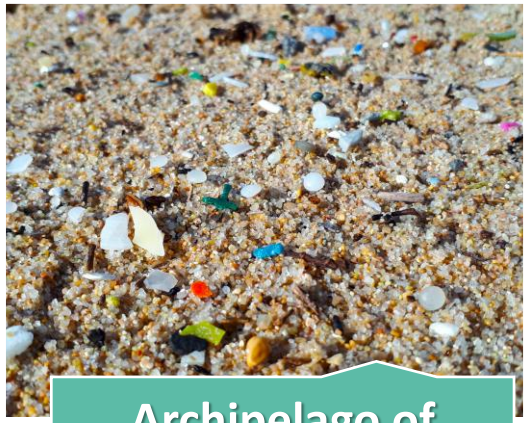
This Project is funded by the European Union

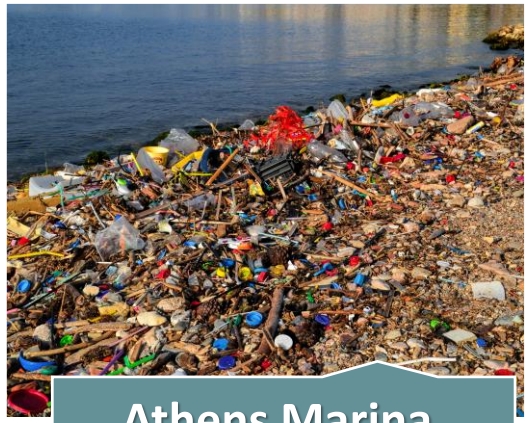
# MARINE LITTER & MARINE PLASTIC POLLUTION IN THE MEDITERRANEAN

**The Mediterranean Sea is one of the most affected areas by marine litter worldwide!**

Port of Izmir, Turkey



Archipelago of Lavezzi, France



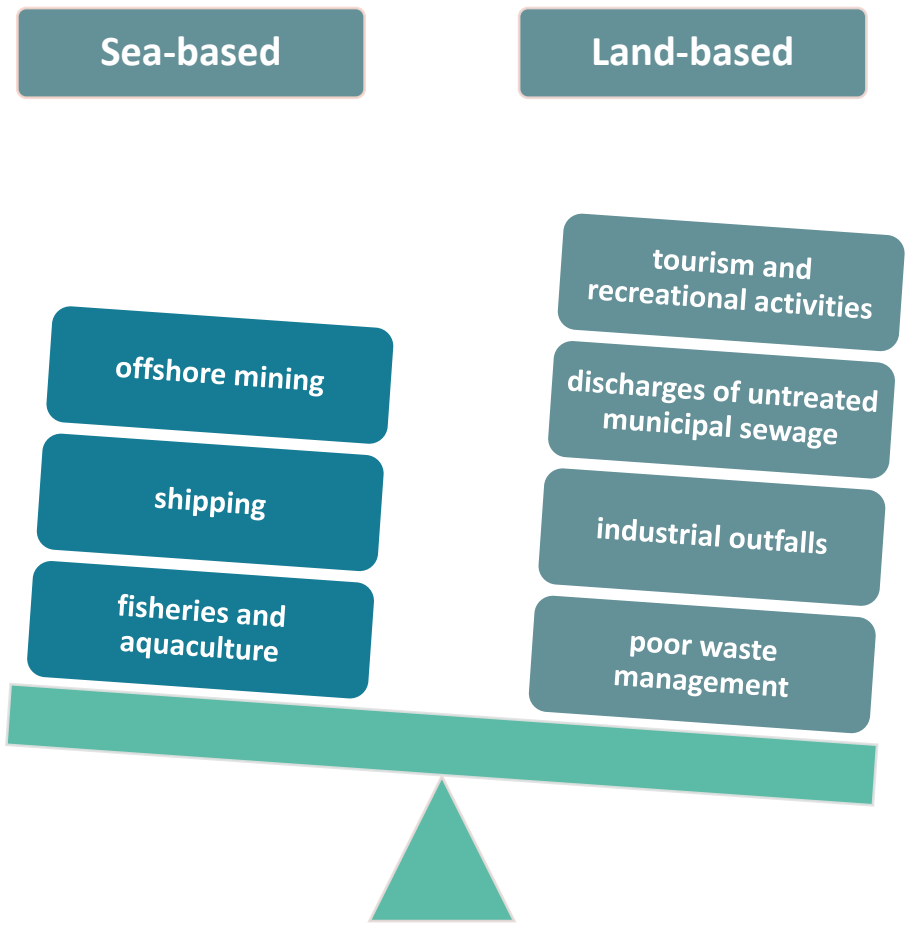
Athens Marina, Greece

Tangier, Morocco

Milazzo, Italy

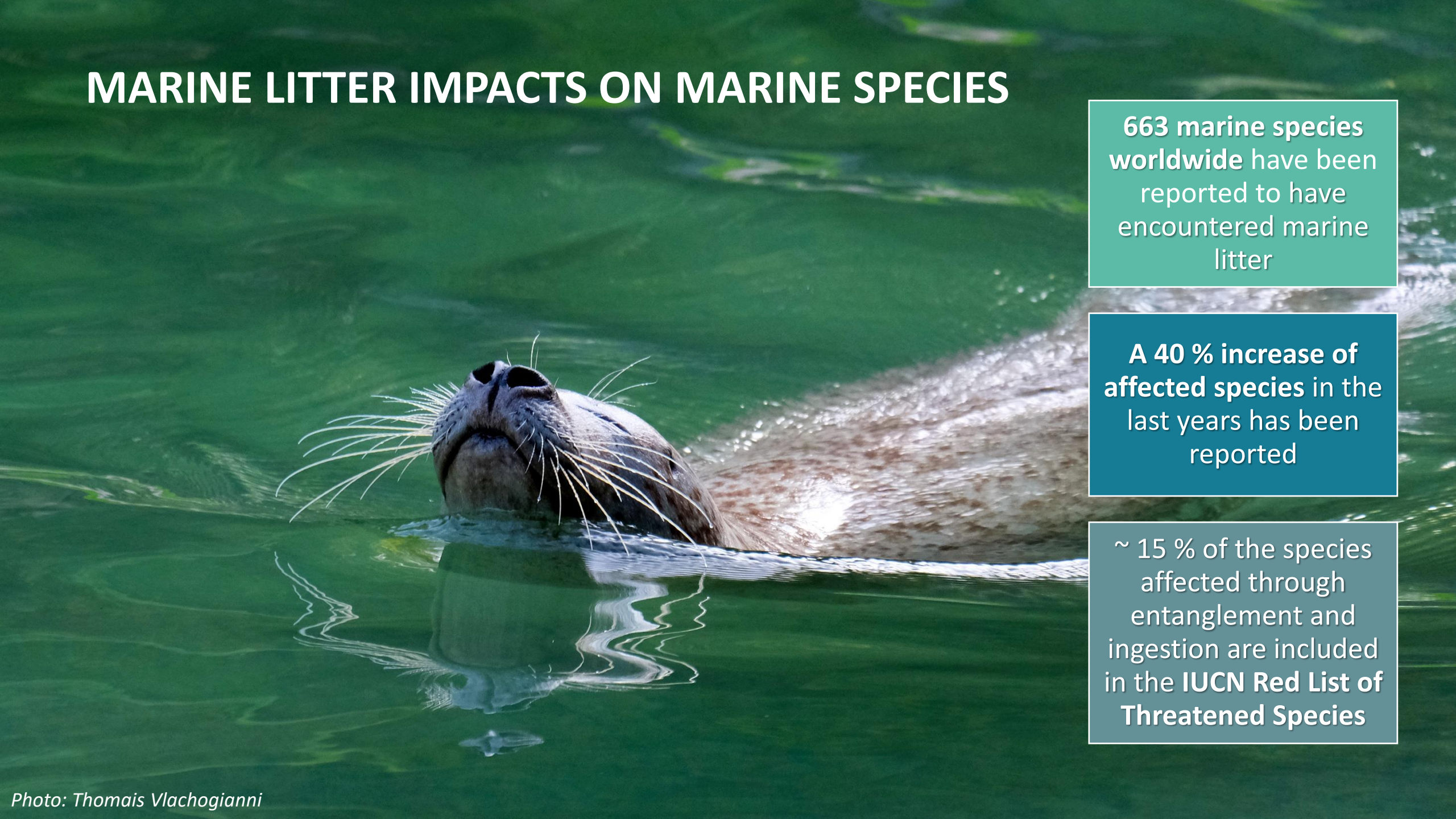
# MARINE LITTER & MARINE PLASTIC POLLUTION SOURCES

- **Assessing the relative importance of the different sources is challenging** given that a considerable percentage of litter items cannot be attributed to a specific source.
- **Beach litter research results are biased towards reflecting marine litter inputs from tourism and recreational activities** as most beach litter surveys are carried out in tourism destinations.
- **The origin (transboundary effect) of marine litter** is difficult to be determined.
- **The riverine inputs of marine litter are substantial**.




*It has been calculated that total annual plastic input in the Mediterranean basin is equal to 100,000 tons, and of these 50% originates from various land-based sources, 30% from rivers and 20% is from sea-based sources (Cincinelli et al., 2019)*

# MARINE LITTER IMPACTS ON MARINE SPECIES



**663 marine species worldwide** have been reported to have encountered marine litter

**A 40 % increase of affected species** in the last years has been reported

~ 15 % of the species affected through entanglement and ingestion are included in the **IUCN Red List of Threatened Species**

*Photo: Thomais Vlachogianni*

# MARINE LITTER IMPACTS

- **Uncertainties remain regarding the extent of harm caused to marine species by ingestion** of microplastics and their exposure to hazardous chemicals leaching from or adsorbed on microplastics.
- **Currently there is no evidence to support or refute potential bio-magnification** of particles or associated chemicals.
- **Basic toxicological data on the consumption of microplastics and nanoplastics by humans** for a food risk safety assessment are lacking.
- **Measuring the full economic cost of marine litter** e.g. including the inhibition of the proper functioning of marine ecosystems is not possible.


**Stomach contents of sea turtles that were dissected at the Talamone Sea Turtles Rescue Centre located in south Tuscany**

# SOCIOECONOMIC IMPLICATIONS OF MARINE PLASTIC POLLUTION


**Impacting negatively vital economic sectors:**

- Tourism
- Fisheries
- Aquaculture
- Navigation

**Bringing losses to:**

- Individuals
- Enterprises
- Communities

# EXAMPLE OF THE DIRECT & INDIRECT COSTS OF MARINE PLASTIC POLLUTION

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- For the fisheries sector the average annual cost of marine litter per vessel reaches **€ 5,400** (cost of repairs of damages, loss of revenue due to the smaller catch, loss of time spent on clearing and repairing nets, etc.). Given this, the total losses to the fisheries sector in the Adriatic-Ionian macroregion were calculated to be € 18.19 million per year, which represents one third of the marine litter costs to the EU fishing fleet.
- On average, the annual direct and indirect marine litter related costs for the aquaculture sector were assessed to be **€ 3,200** per aquaculture farm unit.
- The total annual cost of managing marine litter reported by 38 harbours and marinas in the Adriatic-Ionian macroregion was **€ 323,500** with an average annual cost of **€ 8,500** per harbour.
- The average annual amount per tourism related business of varying size and type was calculated to be **€ 5,700** per year, which can be considered as a substantial expense.
- The total cost of removing beach litter reported by the 32 municipalities was € 6,724,530 per year, with an average of **€ 217,000** per year per municipality. On average, the municipalities spent some 5% of their budget for marine litter cleanup operations.

# MARINE LITTER COMPOSITION

- Plastics are ubiquitous in the coastal and marine environment accounting for some **70-90%** of all litter items found. Leakage' of plastics into the ocean can occur at all stages of the production-use-disposal cycle.
- A large amount of litter items found in the Mediterranean are **single-use plastic items**.
- **Fishing and aquaculture related items account for some 37.5%** of total items recorded in certain areas of the Mediterranean (Vlachogianni et al., 2018).
- There are **no reliable estimates of the microplastics** quantities entering the marine environment.
- **Microplastics greatly outnumber large plastic items in marine systems**. Even if all releases of plastic to the environment were to cease immediately, the number of microplastics in the ocean would be expected to continue to increase as a result of continuing fragmentation.

# MICROLITTER STUDIES IN THE MEDITERRANEAN

The Mediterranean Sea is one of the most studied regions in the world in terms of microplastic contamination


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# MICROLITTER MONITORING APPROACHES


Beach sediments

Sea surface


Seafloor sediments

Biota

# MICROLITTER STUDIES IN MEDITERRANEAN BEACH SEDIMENTS

| Location | Size | Sampling | | | Extraction | | | | | Identification | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Beach zone | n | Depth (cm) | Drying duration/ Temp | Extraction process | Stirring time/ speed | Settling time | Repeat extractions | | |
| **Slovenian coast** | 250µm-5mm | Entire beach | 3 | 5 | 24 h/60 °C | 1.2 kg/L NaCl | 2 min manually | 30 min | 2 | Visual (microscope) | Laglbauer et al., 2014 |
| **Slovenian coast** | 250 µm-5mm | Sublittoral zone | 3 | ND | 24 h/60 °C | 1.2 kg/L NaCl | 2 min manually | 30 min | 2 | Visual (microscope) | Laglbauer et al., 2014 |
| **North-western Adriatic coast, Italy** | ≤5mm | High tide mark | 6 | 5 | 48 h/50 °C | Optical | - | - | - | FTIR-ATR | Munari et al., 2017 |
| **Mediterranean coastline, Morocco** | 1.25-4.75 mm | Entire beach | 3 | 5 | 1 h/65 °C | Optical | - | - | - | - | Alshawafi et al., 2017 |
| **Northern coast of Crete isl.** | ≥2mm | Entire beach | 12-18 | 10 | - | Optical | - | - | - | - | Karkanorachaki et al., 2018 |
| **Mediterranean Sea (Esp, Fr, It, Gr, Tr, Is)** | 0.3- 5mm | High tide line | 5 | 5 | 48 h/60 °C | 1.2 kg/L NaCl | 2 min/ 900 rpm | 8 h | 3 | Visual (microscope) and Raman spectroscopy | Lots et al., 2017 |
| **Northern Tunisian coast** | ≥1mm | ND | 3 | 2-3 | air | 1.2 kg/L NaCl | 5 min manually | ND | ND | FTIR-ATR | Abidli et al., 2018 |
| **Kea isl., Aegean Sea** | 1-2 mm | Upper beach | 3-4 | 3 | ND | 1.2 kg/L NaCl | ND | ND | ND | FTIR-ATR | Kaberi et al., 2013 |
| **Kea isl., Aegean Sea** | 2-4 mm | Upper beach | 3-4 | 3 | ND | Optical | - | - | - | Visual and FTIR-ATR | Kaberi et al., 2013 |
| **Samos isl., Greece** | ≥1.2 µm | Beach and sublittoral zone | 27 | 0-5, 5-10, 10-15 cm | ND | 1.2 kg/L NaCl | ND | ND | ND | ND | De Ruijter et al., 2018 |

*Source: Vlachogianni, et al., 2018. State-of-the-art methods to monitor marine litter and its impacts on biodiversity. Interreg Med Plastic Busters MPAs project.*

# MICROLITTER STUDIES IN THE MEDITERRANEAN SEA SURFACE



Photo: Thomais Vlachogianni

| Location | Sampling | | | | | | Identification | References |
|---|---|---|---|---|---|---|---|---|
| | Compartment | Net | Mesh size | Mouth | Vessel speed | Time | | |
| **North Western Mediterranean Sea Tuscan coast** | Sea surface/Water column | Surface samples: Manta-net Vertical hauls: WP2 plankton net | Manta trawl net: 330 µm WP2 net: 200 µm | Manta trawl: 0.5 × 0.25 m WP2: 0.57 m diameter | Manta trawl: 2 – 3 knots WP2: 0 knots | Manta trawl: 20 min WP2: up to 100 m | FTIR | Baini et al., 2018 |
| **Western Mediterranean Sea PelagosSanctuary** | Sea surface | Manta-net | 330 µm | 0.5 × 0.25 m | 3 – 4 knots | 30 min | FTIR | Fossi et al., 2017 |
| **Western Mediterranean SeaGulf of Lion** | Sea surface | Manta-net | 780 µm | 0.5 x 0.15 m | 2.5 knots | 20 min | Visual (microscope) | Schmidt et al., 2017 |
| **Aegean-Levantine Sea, Turkish** | Sea surface | Manta-net | 333 µm | 0.4 x 0.2 m | - | - | FTIR | Güven et al., 2017 |
| **Aegean-Levantine Sea** | Sea surface | Manta-net | 333 µm | 0.2 × 0.6 m | 2 knots | 15 min | Visual (microscope) | van der Hal et al., 2017 |
| **Western Mediterranean Sea (Ligurian Sea)** | Sea surface | Neuston net | 200 µm | 0.6 x 0.2 m | 2.5 knots | 60 min | FTIR | Pedrotti et al., 2016 |
| **Western Mediterranean Sea and Adriatic Sea** | Sea surface | Neuston net | 200 µm | 1 × 0.5 m | 1.5 – 2 knots | 5 min | FTIR-ATR | Suaria et al., 2016 |
| **Whole Mediterranean** | Sea surface | Manta-net | 333 µm | 0.6 x 0.25 m | 3.13 knots | 15 - 30 min | Visual (microscope) | Ruiz-Orejón et al., 2016 |
| **Adriatic Sea** | Sea surface | Neuston net | 300 µm | 0.6 × 0.15 m | 3 knots | 20 min | Chemical analysis | Gajšt et al., 2016 |
| **Western Mediterranean Sea** | Sea surface | Neuston net | 200 µm | 0.6 x 0.25 m | 1.5 knots | 20 min | Visual (microscope) | Fossi et al., 2016 |
| **Aegean-Levantine Sea Turkey** | Sea surface | Manta-net | 333 µm | 0.6 × 0.25 m | 2 knots | 20 min | Visual (microscope) | Gündoğdu and Çevik, 2017 |
| **Western Mediterranean Sea AsinaraNational Park PelagosSanctuary** | Sea surface | WP2 | 200 µm | 57 cm diameter | 0.772 m/s | 20 min | Visual (microscope) | Panti et al., 2015 |
| **Whole Mediterranean** | Sea surface | Neuston net | 200 µm | 1.0 × 0.5 m | 2 – 3 knots | 15 min | Visual (microscope) | Cózar et al., 2015 |
| **Western Mediterranean Sea** | Sea surface | Manta-net | 330 µm | 0.6 × 0.15 m | 1.4 m/s | 45 - 90 min | Visual (microscope) | Faure et al., 2015 |
| **Western Mediterranean Sea (Corsica)** | Sea surface | WP2 0.2 mm | 200 µm | 0.6 x 0.25 m | 2.5 km/h | 20 min | Visual (microscope) | Collignon et al., 2014 |
| **Western Mediterranean Sea (Sardinian coast)** | Sea surface | Manta-net | 500 µm | - | 2 knots | 20 min | Visual (microscope) | de Lucia et al., 2014 |
| **Adriatic and Ionian Seas** | Sea surface | Manta-net | 330 µm. | 0.6 × 0.24 m | < 3 knots | 30 min | Visual (stereomicroscope); ATR-FTIR spectroscopy | Zeri et al., 2018 |

*Source: Vlachogianni, et al., 2018. State-of-the-art methods to monitor marine litter and its impacts on biodiversity. Interreg Med Plastic Busters MPAs project.*

# INDICATIVE FLOATING MICROPLASTICS DENSITIES

| Location | Habitat | Date | Density | References |
|---|---|---|---|---|
| North Western Mediterranean Sea Tuscan coast | Sea surface/Water column | 2013-2014 | Surface: 69,161.3 ± 83,243.9 items/km$^2$<br>Vertical: 0.16 ± 0.47 Items/m$^3$ | Baini et al., 2018 |
| Western Mediterranean Sea Pelagos Sanctuary | Sea surface | 2014 | 82,000 ± 79,000 items/km$^2$ | Fossi et al., 2017 |
| Western Mediterranean Sea (Ligurian Sea) | Sea surface | 2013 | 125,930 ± 132,485 Items/km$^2$ ± SD | Pedrotti et al., 2016 |
| Western Mediterranean Sea and Adriatic Sea | Sea surface | 2013 | 400,000 ± 740,000 items/km$^2$<br>1.00 ± 1.84 Items/m$^3$ | Suaria et al., 2016 |
| Adriatic Sea- Slovenian coastal waters | Sea surface | 2014 | 472,000 ± 201,000 Items/km$^2$ ± SD | Gajšt et al., 2016 |
| Gulf of Trieste | Sea surface | 2014- 2015 | 444,182 ± 563,190 items/km$^2$ | Zeri et al., 2018 |
| Western Mediterranean Sea | Sea surface | 2012 | 0.31 ± 1.17 Items/m3 ± SD | Fossi et al., 2016 |
| Western Mediterranean Sea, Asinara National Park, Pelagos Sanctuary | Sea surface | 2012–2013 | 0.17 ± 0.32 Items/m$^3$ ± SD | Panti et al., 2015 |
| Whole Mediterranean | Sea surface | 2013 | 243,853 Items/km$^2$ | Cózar et al., 2015 |
| Western Mediterranean Sea (Sardinian coast) | Sea surface | 2013 | 0.15 ± 0.11 Items/m$^3$ | de Lucia et al., 2014 |
| Ligurian and Sardinian Sea | Sea surface | 2011 | 0.62 ± 2.00 Items/m$^3$ ± SD | Fossi et al. 2012 |
| Western Mediterranean Sea | Sea surface | 2010 | 116,000 Items/km$^2$ | Collignon et al., 2012 |
| Archipelago of Zadar | Sea surface | 2015 | 127,135 ± 294,847 particles/km$^2$ | Palatinus et al., 2019 |

# COMPOSITION OF FLOATING MICROPLASTICS

The detected plastic types are diverse but some are predominant on the sea surface because of their widespread use and their buoyancy:

- poly(ethylene) (PE) frequent in food packaging (e.g. in films and bottle caps)
- poly(propylene) (PP), used as packaging material and plastic parts in various industries
- poly(amides) (PA) and poly(styrene) (PS)

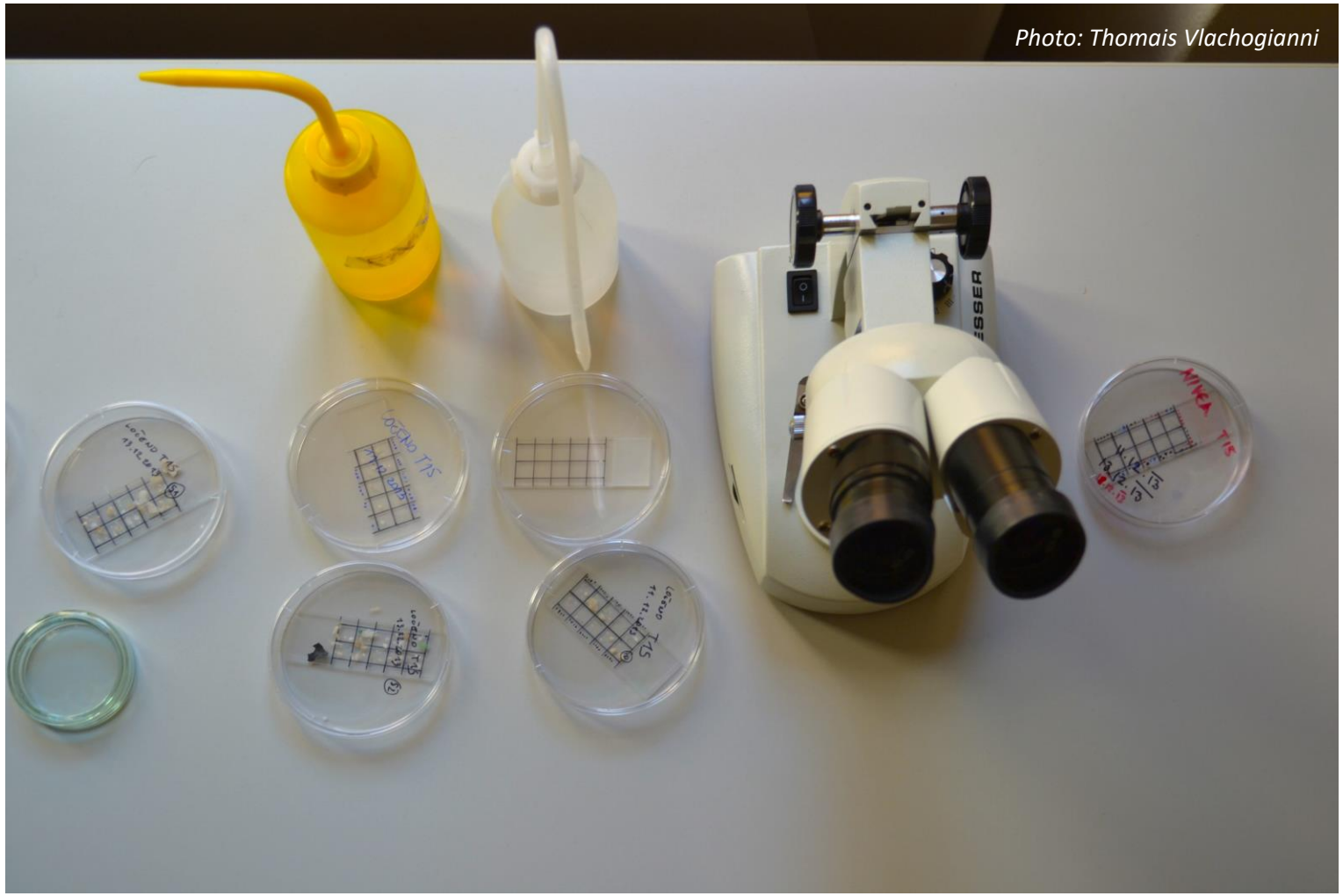


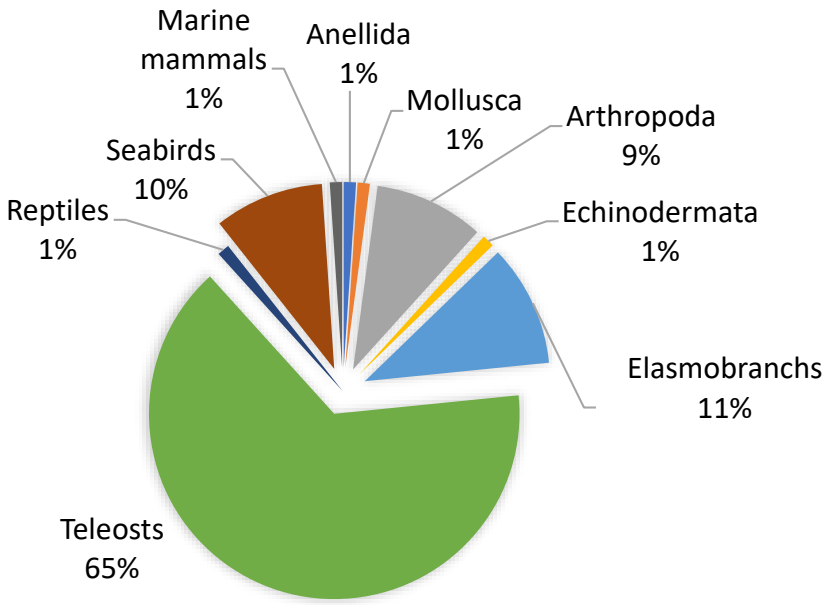
Photo: Thomais Vlachogianni

# MICROLITTER STUDIES IN MEDITERRANEAN SEAFLOOR SEDIMENTS

| Location | Sampling | Depth | Laboratory analysis | References |
|---|---|---|---|---|
| 32"22.90 N 31"43.130 E | 25 $cm^2$ Core sampling, 1-5mm | 1176-4848 | Density (NaCl) separation, visual counts, 4 categories (fibres, pellets, films, spherical) | Van cauwernberghe et al., 2013 |
| NW basin, canyons & slope | Canyons/slopes/abyssal plain, ROV/core sampling, 0.32-5mm | 300-3500 | Density (NaCl) separation, visual counts, fibers & particles separation, FTIR analysis | Woodall et al., 2014 |
| Eolian Islands | Undisturbed sediment (5 cm depth) collected by scientific scuba divers, using wide mouth glass jars | 30 | Surface sediment, sieving, visual observation, MSFD categories (5) | Fastelli et al., 2016 |
| Malta | 0.1-m2 van Veen grab at eight sampling stations | 4-22 | Density (NaCl) separation, visual counts, 3 categories (fibrous, rounded and irregular) | Romeo et al., 2015 |
| Croatia | sediment collected by scientific scuba divers, using wide mouth glass jars in 10 sites. Three replicates for each site | 3-15 | Density (NaCl) separation of sieved fractions, MSFD categories (5) | Blăsković et al., 2017 |
| Balearic Islands | Superficial core sampling (0-3.5 cm) with scuba diving, 1- 5 mm | 8-10 m | Density (NaCl) separation of sieved fractions, MSFD categories (5) | Alomar et al., 2016 |

*Source: Vlachogianni, et al., 2018. State-of-the-art methods to monitor marine litter and its impacts on biodiversity. Interreg Med Plastic Busters MPAs project.*

# PERCENTAGE OF SPECIES INVESTIGATED AMONG DIFFERENT TAXA FOR MARINE LITTER INGESTION IN THE MEDITERRANEAN SEA



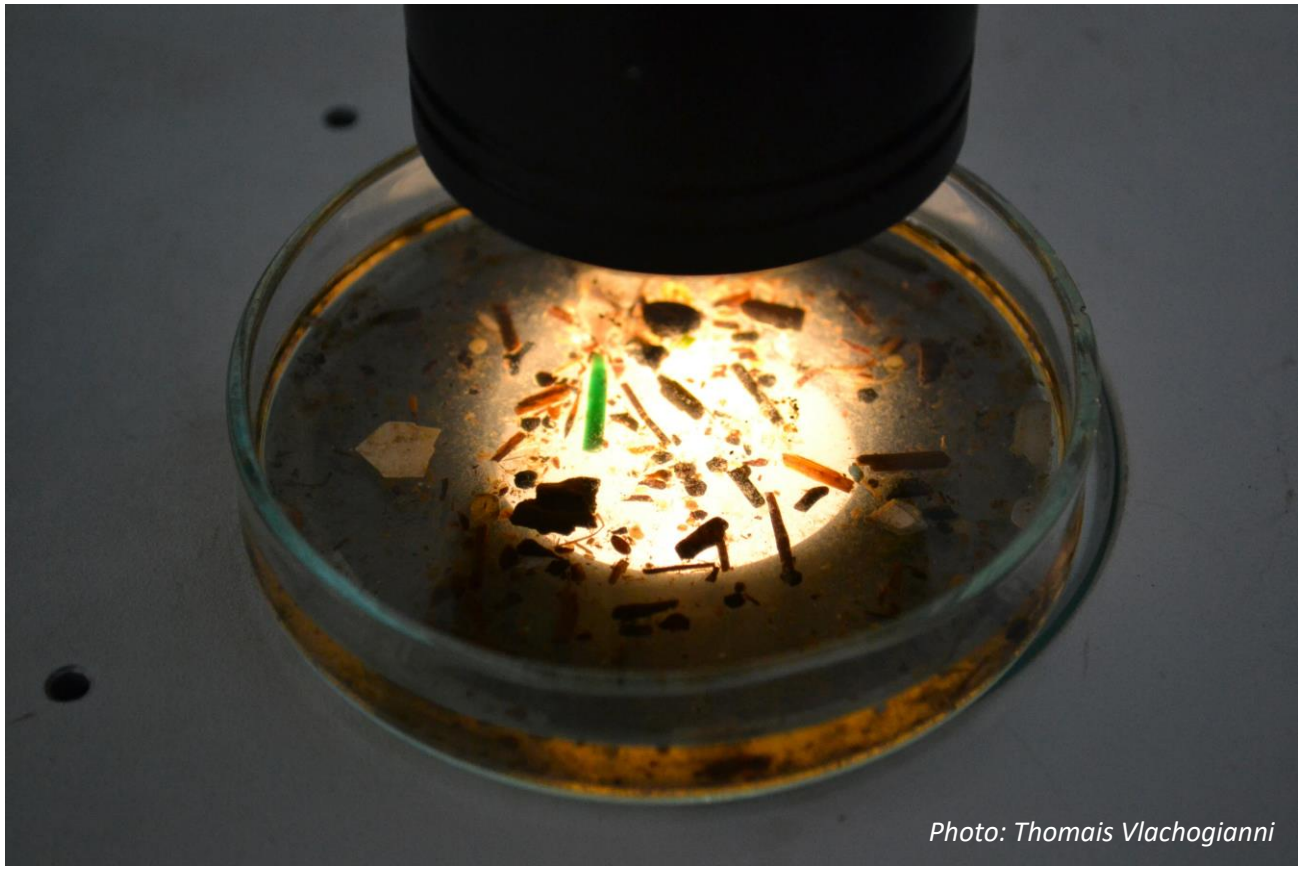



Photo: Thomais Vlachogianni

*Source: Vlachogianni, et al., 2018. State-of-the-art methods to monitor marine litter and its impacts on biodiversity. Interreg Med Plastic Busters MPAs project.*

# KNOWLEDGE GAPS AND RESEARCH NEEDS

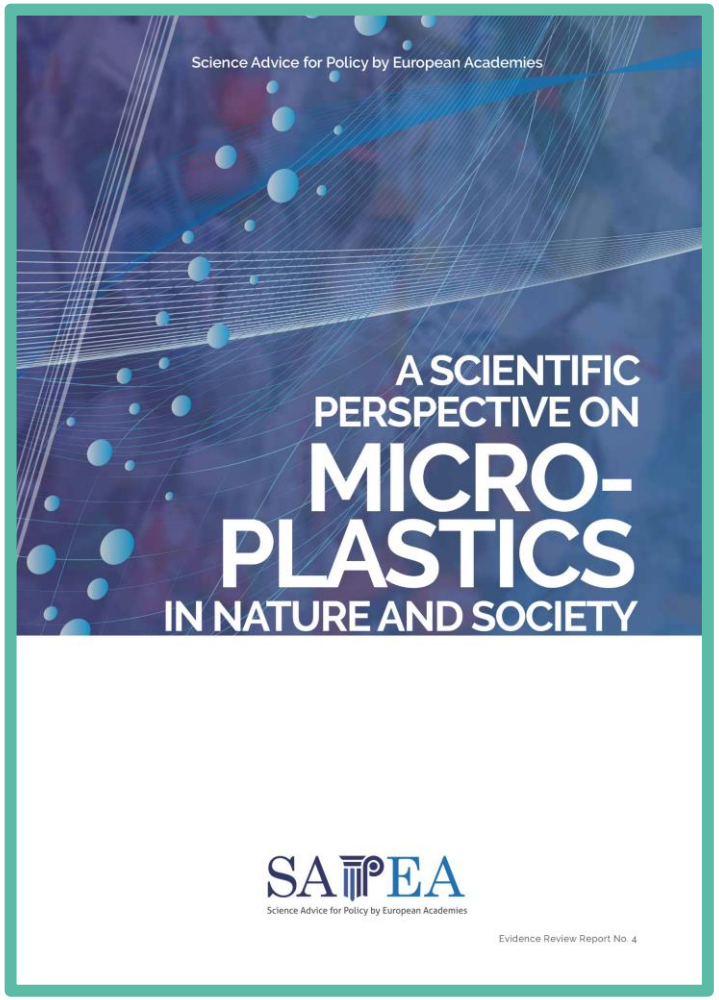
- Despite a growing number of papers, knowledge is still lacking to fully understand the distribution and concentration and chemical composition of microplastics in the Mediterranean Sea
- The different studies are uneasy to compare because of the heterogeneity of the Mediterranean Sea environment (hydrodynamic features, seasonality) and the variety of methodologies used (e.g. sampling, microplastic extraction, analysis, size classes considered, concentration units)
- Lack of quality assurance/quality control (QA/QC) instruments. No organisations to-date offer proficiency training or testing in microplastics samples processing.

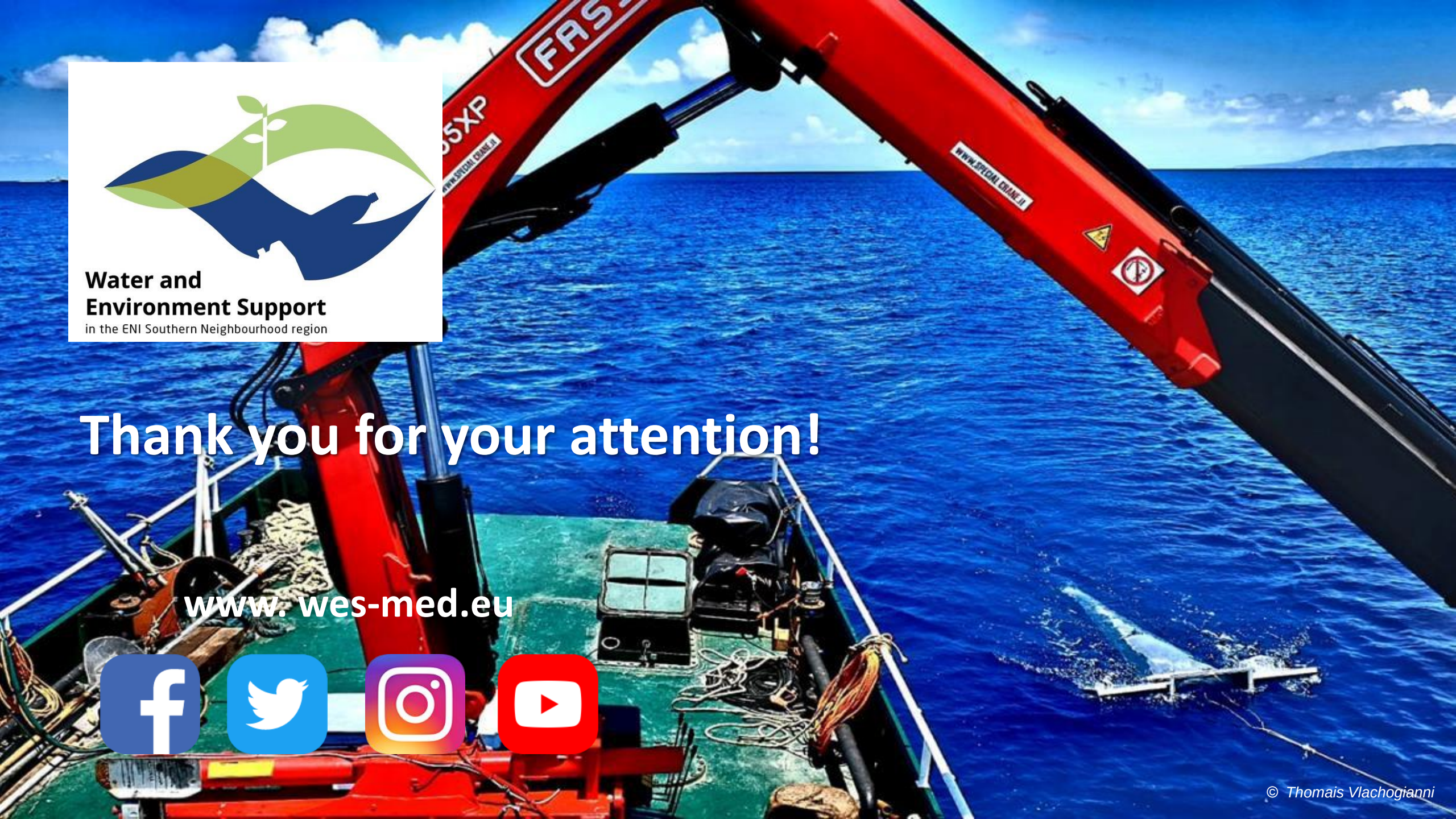

**DATA GAPS**

**ANALYTICAL METHODS RESEARCH NEEDS**

# MICROPLASTICS – WHAT DO WE KNOW?

- A lot is already known about microplastics, and more knowledge is being acquired, but some of the evidence remains uncertain and it is by its nature, complex (for instance, differences in size, shape, chemical additives, concentrations, measurements, fates, unknowns, human factors, actions).
- There is a fair knowledge of microplastics concentrations for freshwaters and the ocean surface, but little is known about concentrations and implications of microparticles below the ocean surface.
- Little is known with respect to the human health risks of microparticles; we have no evidence of widespread risk to human health from nanoparticles at present.
- Most microplastics go in and out of most organisms, and as with many chemicals, ‘the poison is in the dose’. Most effect studies are performed using concentrations that are much higher than those currently reported in the environment, or using very small microplastics for which limited exposure data exists, or using spherical ones which are not representative of real-world types of particles, or using relatively short exposure times. Currently, it is not known to what extent these conditions apply to the natural environment. This limits the reliability of the risk assessments.





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# Thank you for your attention!

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