



A Mediterranean full of plastic

Research on plastic pollution, impacts and solutions

GREENPEACE

**LESS PLASTIC,
MORE MEDITERRANEAN**



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1. Plastic pollution in the oceans

Plastic materials were developed in the 1930s and 1940s and mass production began in the 1950s. Since then, the popularity of and uses for different plastics have continued to increase and projections suggest that the trend will continue. In 2015, world production of plastic materials was 269 million tonnes, with China being the largest producer of plastic materials (27.8%) followed by Europe (18.5%) and NAFTA (18.5%). European demand reached 49 million tonnes in that same year, the highest proportion of which (39.9%) was used for packaging (Plastics Europe, 2016). But this lightweight, durable, convenient and versatile material has a downside that was not predicted. Many plastic items are intended to be used just once, which is generating a mountain of waste. Discarded plastic may end up in landfills, be incinerated or recycled. But some ends up in waterways and the ocean through urban drainage, runoff or 'leachate' from landfill sites, through the deliberate dumping of garbage, accidental spillage from ships, or in effluents from sewage and wastewater treatment plants (Derraik, 2002). As a consequence, plastic debris has become ubiquitous in the world's oceans. It floats on the surface, is present in the water column and is buried in the sediment of every ocean (GESAMP, 2015). The presence of marine plastic litter in our oceans is due not only to the increasing use of plastics but also from poor waste management.

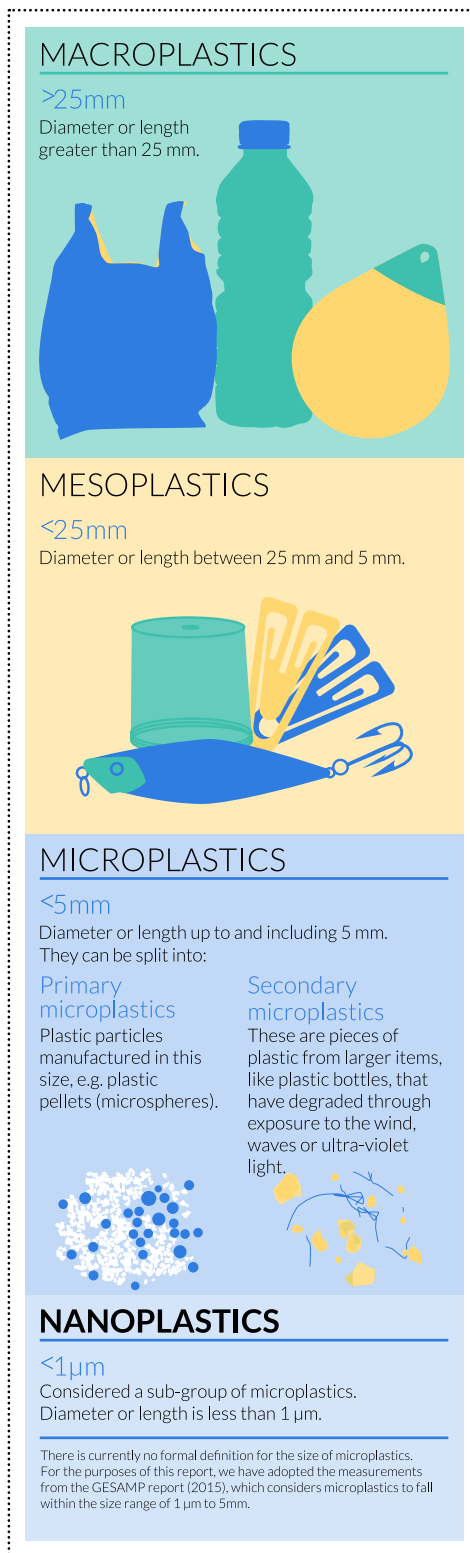
Globally, **plastics comprise 60-80% of all marine litter** (Derraik, 2002) or even 90% in some beach litter surveys (Pasternak et al., 2017). No definitive figure on the abundance of plastic in the world's oceans exists,

but a quantitative theoretical model estimates that there are **5.25 trillion pieces of plastic debris weighing in the region of 268,940 tons floating in the sea, not including pieces on the seabed or on beaches** (Eriksen et al., 2014). **More recent studies put the estimates even higher, at perhaps more than 50 trillion pieces** (van Sebille et al., 2015), though in practice any estimates are impossible to verify with accuracy.

A primary reason for the extent of litter in the ocean is mismanaged waste – that is, anthropogenic litter that has been deliberately dumped or irresponsibly disposed of – and the problem is extensive and global. Jambeck et al. (2015) estimated that in 2010, 4.8 to 12.7 million metric tonnes of plastic entered the ocean from 192 coastal countries across the world. Should waste management strategies remain unchanged, the team predicts that the amount of plastic entering the oceans from those 192 countries will increase by an order of magnitude by 2025.

Over the past two decades, research papers, environmental reports and campaigns have highlighted the impact made by plastic debris **on marine animals**. Examples of **the effects of macroplastics** (items >25mm in length or width that are clearly visible to the naked eye, such as plastic bags, fishing nets and bottles) **are entanglement, choking, strangulation and malnutrition** and typically involve marine mammals, seabirds and sessile fauna such as corals.

Microplastics also have a negative impact on marine life. These tiny pieces of plastic, measuring less than 5mm in length or diameter, **have the potential to be ingested by a greater number**



of organisms than macroplastics. Microplastics could also adsorb and subsequently desorb toxic contaminants (adsorb is the term used when a plastic attracts a chemical compound that 'sticks' to the plastic; desorption occurs when the plastic 'releases' the adsorbed chemical) or leach chemicals that have been added during the manufacturing process. Microplastics can be spheres, fragments or filaments and are either primary (they were manufactured that size, such as the pre-production plastic pellets known as 'nurdles') or secondary (they have been degraded in size from larger pieces by exposure to the elements, such as wind, waves and ultraviolet light). As more plastics are thrown away, more waste can enter the world's water systems. And because large items of plastic degrade into even smaller pieces, each piece of macroplastic floating at sea can give rise to hundreds, if not thousands, of pieces of microplastic.

The **Mediterranean Sea** is a semi-enclosed basin with a surface area of 2.6 million km² and access to the Atlantic Ocean through the Strait of Gibraltar. The water in the basin has a residency time of around 100 years (Ramirez-Llodra et al., 2013; Cózar et al., 2015; Tubau et al., 2015). The Mediterranean Sea is recognized for

its rich biodiversity and supports about 7.5% of known marine species (Ramirez-Llodra et al., 2013). **The region's coastal zones are densely populated with 427 million inhabitants** (approximately 7% of the world's population), **attracts a large number of tourists during the summer months (25% of the international annual tourist trade)** and has a significant level of commercial and recreational marine traffic (**30% of global shipping traffic passes through the Mediterranean Sea**) (UNEP/MAP, 2011; Eurostat, 2017). The high activity in the region has led to the accumulation of anthropogenic debris such as plastic, glass, wood and rubber in the Mediterranean Sea – litter has been found in the water column, on beaches and on the deep sea floor. The topography of the region and the extent of anthropogenic activities mean that the likelihood of pollution by plastic and other types of man-made litter is high. The flow of water between the Mediterranean and the Atlantic Ocean is limited, which leads to the accumulation of floating litter in the Mediterranean basin.

This report presents a selection of the available data that has been published over the past decade on the presence and impacts of plastic litter in the Mediterranean Sea.



2. Status of plastic pollution in the Mediterranean

The Mediterranean Sea is one of the most investigated maritime regions of the world but data on marine litter are still incomplete for the region, which is why **estimates relating the mass or quantity of plastic litter differ widely**. The disparity in estimated plastic load is because of the different computer model formulations. For this reason, estimates, particularly the higher figures, should be treated with caution. Eriksen et al. (2014) estimate that the mass of surface plastic litter in the Mediterranean Sea to be 23,150 tonnes. Van Sebille et al. (2015) calculate the mass of microplastic in the Mediterranean Sea as varying from 4.8 to 30.3 thousand metric tonnes. The estimated figures from Eriksen et al. (2014) and Van Sebille et al. (2015) contrast with Cózar et al. (2015), who estimate that in the region 756 to 2,969 tons of plastic are floating on the surface of the Mediterranean Sea.

Despite the variation in estimates described above, the Mediterranean Sea can be considered as a zone in which floating plastic debris accumulates. Monitoring suggests that the average **density of plastic in the Mediterranean basin is 1 item 4 m⁻², which is comparable to the accumulation of plastic litter in the five subtropical gyres** (Cózar et al., 2015) which are accumulation zones that are happening for example in the Pacific Ocean.

Van Sebille et al. (2015) estimate the amount and distribution of small floating plastic particles in the global ocean. In the paper they explain that they used the largest dataset to date and compared three different ocean circulation models. Using the three models, their calculated estimation of the global mass of floating marine microplastic varies substantially from 93,000 to 236,000 metric tonnes, and the estimated mass of microplastic in the Mediterranean Sea varies from 4,800 to 30,300 metric tonnes. They add that three models predict **somewhere between 21% and 54% of all global microplastic particles (equating to 5-10% of global mass) are in the Mediterranean basin**.

Litter in the Mediterranean Sea has widespread impacts such as to marine biodiversity, ecosystem

Somewhere between 21% and 54% of all global microplastic particles in the world are in the Mediterranean basin

services, social and visual, and economic value.

Plastics have been reported in the Mediterranean Sea sediment (Blaškovič et al., 2017), on the rocky seafloor (Melli et al., 2017), on beaches (Pasternak et al., 2017) in the water column (Suaria et al., 2016), ingested by marine organisms (Casale et al., 2016; Alomar & Deudero, 2017) and entangled with cold-water corals (Orejas et al., 2009).

Temporary trends indicate that plastic abundance in the Mediterranean is increasing. Ruiz-Orejón et al. (2016) report that plastics were responsible for 96.87% of all floating debris in the Mediterranean Sea in net trawls conducted in 2011 and 2013. **The authors note that this percentage is higher than previous estimates and suggest that microplastic abundance in the region studied is increasing.**

Litter is not evenly distributed in the Mediterranean Sea. Litter tends to accumulate near coasts, particularly urbanized developments, shipping lanes or recreational boat traffic, and in submarine canyons (Pham et al., 2014; Ruiz-Orejón et al., 2016).

FROM THE BEACH TO THE SEAFLOOR: FINDINGS FROM SURVEYS

Surveys employ different methods to attempt to quantify Mediterranean marine litter on the sea floor, surface water and beaches. Surface seawater samples are typically collected using a net that is dragged behind or alongside a ship; on beaches, litter is collected by hand; and on the



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seabed trawlers collect and remote operated vehicles assess litter that has accumulated.

PLASTIC ON BEACHES:

Several research groups have carried out beach litter surveys. As well as affecting flora and fauna, beach litter deters tourists and can have a negative impact on the income generated by a country or region's tourist industry.

Published data from beach litter surveys report that, in general, plastic litter dominates, though percentage values differ. At the higher end of the scale as much as 90% on Israeli beaches (Pasternak et al., 2017) and 81.1% on beaches in eastern Italy (Munari et al., 2016) of the collected litter was plastic. Others found a slightly lower proportion was plastic, with percentages of 64% in Slovenia (Laglbauer et al., 2014); and 43% in 2006 and 51% in 2007 on Greek beaches (Kordella et al., 2013). Of the plastic beach litter, cigarette filters are often reported to be the most abundant form (Laglbauer et al., 2014; Munari et al., 2016). Other common items found on beach litter surveys in Europe include plastic fragments, plastic cups and lids, polystyrene, plastic bags, string, packets and wrappers, cotton buds, glass, ceramic pieces and bottles (EEA, 2015)

PLASTIC IN SURFACE WATERS:

The Mediterranean Sea is thought to have a particularly high proportion of floating microplastic debris. Cózar et al. (2015) found that **83% of plastic items in samples collected from the Mediterranean Sea were microplastics.**

Suaria & Aliani (2014) carried out visual surveys on 167 transits across the central and west Mediterranean Sea to assess floating debris. Of the litter sighted, 78% was anthropogenic (82% was plastic, 13.6% was Styrofoam, and 4.4% comprised other man-made items).

PLASTIC IN THE SEAFLOOR:

Ramirez-Llodra et al. (2013) conducted **a deep-sea survey and found litter at all depths sampled, ranging from 900–3,000m, on a trans-Mediterranean survey. Plastics were present in 92.8% of the samples collected.**

There was a higher mass of litter collected from the seafloor at locations closer to the shore than further out to sea in trawler studies of ten sites across the west, central and eastern Mediterranean by Pham et al. (2014). The authors note that distribution of marine litter is affected by factors





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including wind and wave action, currents and weather systems such as storms.

Other research conducted in specific areas in the Mediterranean has also found Tubau et al. (2015) found that the sea floor of two canyons (La Fonera and Cap de Creus) in the northwest Mediterranean Sea have mean litter densities greater than 8,000 items km⁻².

Strafella et al. (2015) collected marine litter over a period of two years from the central and northern Adriatic Sea. The study used trawler studies and found that there was a higher mass of all types of litter on the seabed at locations closer to the shore than at greater depths out to sea. To a depth of 50m, plastic was the most abundant category of litter found on the seabed.

Angiolilli et al. (2015), assessing the rocky bottom of the seabed in the Tyrrhenian Sea around Campania, Sicily and Sardinia, found a high incidence of anthropogenic debris on the rocky sea bottom of the Tyrrhenian Sea.

PLASTIC IN ECOLOGICALLY IMPORTANT AREAS:

Microplastics were found in the sediment in the marine protected area of the Cabrera Archipelago National Maritime-Terrestrial Park off the Balearic islands in the

western Mediterranean by Alomar et al. (2016). The majority of the plastic particles were plastic fragments. The authors comment that strong currents or wind may transport plastic litter from its source to the MPA. Contrary to expectations, the study found more microplastics in the MPA than in the urban site sampled.

Blašković et al. (2017) analysed litter in the sediment in different areas of the Natural Park of Telašćica bay, Croatia. The study found microplastic in 88.71% of all sediment samples and mesoplastic in 11.29% of all sediment samples.

Melli et al. (2017) surveyed a site along the coast of the Tegnùe of Chioggia in the EU Site of Community Interest in the north-west Adriatic and found a mean density of litter from all sections of 3.3 items per 100m². The paper concludes that the SCI studied, which is a sanctuary of marine biodiversity, is heavily polluted by marine litter, particularly discarded fishing gear.

Plastics were present in 92,8% of the samples collected in a deep-sea survey

3. Impact of plastic pollution on marine species

There are diverse examples in which a particular species can be affected by marine litter. For example, ingestion can lead to transfer of microplastic through the food chain, macro- or meso-size debris can smother or entangle, and in other examples a species (usually a microorganism) 'hitch-hikes' on an item of debris and be transported to an area outside of its usual habitat.

A review by the Alfred Wegener Institute's Litterbase project analysed published reports and found that globally **an estimated 1,341 species have interacted with marine litter, by colonisation, ingestion, entanglement, smothering or other** (Tekman et al., 2017).

Another review of 340 original research papers found that **92% of reported encounters between marine litter and organisms were with plastic**. 71% of the entanglement incidents were between individual organisms and plastic rope or netting, and 37% of ingestion incidents were between individual organisms and plastic fragments. Approximately **17% of species that had ingested or become entangled in marine debris were listed on the International Union for Conservation of Nature Red List of Threatened Species** (Gall & Thompson, 2015).

Globally there are hundreds of species that are affected by marine litter (Kühn et al., 2015). The authors report that examples from 100% of all seven species of marine turtle, 67% of seals (22 of 33 species), 31 % of whales (25 of 80 species) and 25% of seabirds (103 of 406) have been reported entangled in marine litter. The chapter includes a list of 557 marine species that are reported in the literature to have been affected by marine debris. **The ingestion of marine debris can be a direct cause of death to different marine species, but at sub-lethal levels ingestion can cause dietary dilution and reduced energy intake** (Lazar & Gra an, 2011).

FISH AND CETACEANS Analysis of 121 individual fish drawn from the commercial species *Xiphias gladius* (swordfish), *Thunnus thynnus* (Atlantic bluefin tuna) and *Thunnus alalunga* (albacore tuna) from the Central Mediterranean Sea found plastic debris in 18.2% samples (Romeo et al., 2015a). Atlantic bluefin tuna



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and albacore tuna are listed as Endangered and Near Threatened (respectively) by the International Union for Conservation of Nature.

Plastic particles were found by Anastasopoulou et al. (2013) in the stomach contents of *Pagellus bogaraveo* (blackspot seabream) from the Ionian Sea, listed as Near Threatened by the IUCN.

Microplastics were found in 21 of 125 individual blackmouth catshark (*Galeus melastomus*) fish that were caught off the coast of Mallorca, Balearic islands, Spain (Alomar & Deudero, 2017).

Fossi et al. (2014) looked at the toxicological effects of microplastics in filter-feeding megafauna in the Mediterranean Sea off the coast of Italy – the Mediterranean basking shark (*Cetorhinus maximus*) and fin whale (*Balaenoptera physalus*) – and concluded that both organisms are chronically exposed to persistent and emerging contaminants associated with microplastic ingestion and ingestion of contaminated plankton prey.

Fin whales have a long lifespan and are also listed as Vulnerable on the IUCN Red List of Threatened Species because the number of individuals is declining. The area of the Mediterranean in which they congregate in the summer months is a Specially Protected Area of Mediterranean Importance and has been shown to have a high concentration of microplastic in the water.



Shoal ROV video frames showed abandoned fishing debris and a severely damaged coral community.

Angiolilli et al. (2015) surveyed the Tyrrhenian Sea around Campania, Sicily & Sardinia using an ROV and found that fishing gear was the litter type with the highest abundance. Anthropogenic debris had a major impact on benthic communities, particularly gorgonians and corals. More than half of the recorded debris items negatively affected benthic organisms by covering or abrading their tissues.

TURTLES The loggerhead sea turtle (*Caretta caretta*) is an indicator species used to monitor trends in spatial and temporal marine litter. The species is listed as Vulnerable on the IUCN Red List of Threatened Species. **An 11-year study of 567 loggerhead turtles inhabiting the central Mediterranean found that 201 animals had ingested marine litter.** The team reported an increase in debris ingestion from the start of the study in 2005 to its conclusion in 2015. User **plastics accounted for 97.3% of the debris ingested by the turtles** (Casale et al., 2016).

SEALS The Mediterranean monk seal (*Monachus monachus*) is listed as Endangered on the IUCN Red List. There are an estimated 350-450 mature individual seals in the population, with fewer than 250 individuals in the eastern Mediterranean. Karamanlidis et al. (2008) report that **one of the main reasons for low population levels of Mediterranean monk seals is accidental entanglement in fishing gear.**

FLORA AND SESSILE FAUNA Abandoned or lost fishing gear can lodge on reefs and smother coral or trap marine animals (Knowlton et al., 2012).

Bo et al. (2014) assessed the impact of fishing gear on coral in the Tyrrhenian Sea using ROV surveys. They report that the Vedove Shoal site, which is 12 nautical miles off the coast of Capri in the South Tyrrhenian Sea, represented the worst case of marine fishing litter of the four sample sites. They report that 62% of the Vedove

TRANSFER TO THE FOOD WEB

The ingestion of microplastics by marine organisms is widespread. One estimate suggests that, globally, least 170 marine vertebrate and invertebrate species ingest anthropogenic debris (Vegter et al., 2014). Concerns are that plastic microparticles could transfer or accumulate within the food chain if predators ingest prey that has consumed plastic; this scenario may not be limited to marine animals if land species ingest contaminated fish or shellfish. Concerns seem to be twofold: (i) the physical presence of the microplastics; and (ii) the toxicity of plastics and associated or adsorbed chemicals.

The impact on health should humans consume microplastics is unclear. In addition, there is currently no regulatory framework

concerning the presence of microplastics in seafood (EFSA, 2016). In drawing the conclusion in its recent report that microplastics in seafood do not currently represent a human health risk, a major review by UNEP (2016) nonetheless also highlights the limitations to data and the uncertainties that remain, stressing in particular that there is insufficient evidence to assess the potential for transfer of contaminants to the fish flesh, and hence be made available to predators, including humans. UNEP's review goes on to conclude that our understanding of the fate and toxicity of microplastics in humans constitutes a major knowledge gap, as well as noting the potential for microplastics to act as surfaces for the transport and dispersal of pathogens relevant to human diseases.

4. Solutions and ways forward



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The Mediterranean Sea urgently needs measures to be put in place to address plastic pollution in its waters. Governments and businesses in the region should embrace the following measures to keep plastic and its value in the economy and out of the ocean:

★ **Legislative bans and restrictions for unnecessary and damaging products or activities**, starting where viable substitutes already exist - e.g. for single use packaging and cutlery, plastic film packaging in supermarkets, plastic microbeads in cosmetics, and plastic blasting in shipyards (see alternatives/substitutes that already exist listed below) .

★ **Extended Producer Responsibility (RAP)**: Use EPR to internalise costs and avoid certain types of marine litter, most notably single-use packaging items.

Use legislative reuse targets to drive investment.

★ **Research into product and (for packaging) delivery systems design to facilitate reuse, repair, remanufacture**, and complement this by providing more information on the plastic composition of products and how long the type of plastic takes to degrade in the marine environment..

★ **Economic incentives targeting consumption**: Make greater use of economic incentives to make market signals part of the solution - i.e. ensure that plastic has a price and is therefore more widely recognised as a valuable resource – e.g. apply deposit-refunds to bottles, incentivise deposit return for refill rather than recycling, and charges/taxes to plastic bags, disposable cutlery, and other one-use items.

★ **Awareness-raising and attitude shifting:** Raise awareness among consumers to better inform purchasing habits to increase demand for sustainable substitutes and generally changing attitudes towards **non acceptance of throwaway culture** - e.g. multiuse bottles and bags, cosmetic products not containing microbeads.

★ **Right To Know and design legislation:** Provide clear definitions of polymers, waste and secondary raw materials. Manufacturers need to design their products and packaging to fit into existing/future reuse and existing recycling systems.

★ **Transparency and labelling:** Improve transparency on the chemicals contained in plastics – to help with decisions on remanufacture and recycling. In addition, transparency on where personal care and cosmetic products (PCCPs) do and/or do not contain plastics.

In addition the following are important for river and marine sources:

★ **Reducing the flow of plastics for recycling to China**

and other regions where there is high leakage by prioritising refill and reuse systems of plastics items.

★ **Waste management measures:** Invest in waste collection infrastructure and services (at ports), wastewater treatment facilities, and waste management infrastructure using community-based zero waste approaches to avoid dispersion of litter into the marine environment - particularly in coastal areas or near rivers.

★ **Improved implementation:** In addition, there is a need for better implementation of existing legislation on the release of litter, from terrestrial sources and at sea – e.g. The MARPOL Convention, Waste Framework Directive, Directive on Port Reception Facilities, Water Framework Directive and, Marine Strategy Framework Directive.

One of the keys to solving plastic pollution is to change the mindsets around our throw-away culture



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Plastics account 60-80% of global marine litter. In the Mediterranean basin the density is 1 item 4 m⁻², comparable to that of the tropical gyres



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