Underwater dumps:
the plastic siege on biodiversity

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Index

Credits

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Executive summary

Biogenic habitats are marine structures formed by a variety of species that provide habitat for many others. They include coral reefs or gardens, aggregations of sponges or molluscs, kelp forests, and seagrass meadows. The biological diversity associated with these environments can be enormous. However, pollution of these areas often goes unnoticed due to two factors: they comprise species that are not typically considered charismatic, and they can be found at great depths, far from visible impacts.[a]

This report reviews the damage to various types of biogenic habitats, lists international obligations to protect those with the greatest biodiversity or fragility, and outlines actions that can be taken locally to complement policies aimed at stemming the flow of waste at the source.

The vast majority of plastic in the ocean is found on the seabed. As a result, benthic biogenic habitats can be buried by accumulations of litter.

Filter-feeding animals, like corals and sponges, ingest microplastics that may be toxic to them. These harmful substances can also bioaccumulate, with filter-feeding species such as bivalves (mussels, clams, oysters) transferring them to higher levels in the food chain (fish, cephalopods, etc.).

Habitat-structuring species are susceptible to snagging and entanglement because they are sessile organisms, i.e., they live fixed to the substrate. In coral and coralligenous reefs, debris causes tissue breakage and abrasions that can lead to infections. Another possible impact being studied is the potential for invasive species to spread by attaching themselves to plastic fragments (*biofouling*) that are then displaced by currents or the wind.

Damage to all these habitat-building species affects the organisms that depend on them. Many biogenic habitats that are biodiversity hotspots are under threat and their conservation is therefore a priority. This situation is reflected in various instruments of international conventions, as well as in European Union legislation.

The ubiquity of marine litter calls for decisive action. It is necessary to develop public policies that encourage reduction and reuse, in order to minimise the amount of waste reaching the sea.

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Black scorpionfish (*Scorpaena porcus*) entangled in a trammel net. (Ratón de Guetaria, Basque Country, Spain).

The strategies Oceana proposes to address the problem of plastics in marine biodiversity hotspots include a first phase of data collection, accompanied by restrictions on activities in the area and, where feasible, removal of the waste, taking care not to damage the habitat.

[a] The lack of knowledge about the seriousness of seabed litter was highlighted in a previous Oceana report, which warned that geohabitats (geological structures in which certain organisms live) such as canyons and seamounts are becoming "plastic traps".

Introduction

Plastic pollution threatens marine biodiversity around the world. It is estimated that between 4.8 and 12.7 million tonnes of plastic are dumped into the ocean each year,[1] 80% of which is from land-based sources,[2] with serious impacts on the stability of ecosystems and the health of a multitude of species. More recent studies have even suggested that the figure is as high as 15 million tonnes of plastic per year.[3]

(See p. 7:
infographic *Origin of marine plastic pollution)*

Although plastic is known to be very widespread and has already reached the most distant areas of the ocean, including the deepest waters,[4] the true extent of its impact on the sea is unknown. To a greater or lesser extent, plastic negatively –even lethally– affects most impacted marine species. The way in which this happens varies depending on the characteristics of the plastic (e.g., size, shape, and colour), as well as the nature of the species themselves (e.g., feeding strategies, habitat, and physical conditions).

The majority of studies focus on disturbances in higher vertebrates known as marine ‘flagship species’, such as turtles, cetaceans, and birds, which act as ‘bio-indicators’ of the state of the sea. Data from such studies show that, at present, 100% of turtle species, 66% of mammal species, and 50% of bird species have ingested or become entangled in plastics.[5]

Recently, it has become clear that less iconic invertebrate animals are also heavily affected. These organisms play a key role in marine ecosystems because they form biogenic habitats, including coral reefs and sponge aggregations The same is true for marine plant species and algae, other organisms that form structures that enable other species to proliferate, creating areas of high biodiversity concentration, or biodiversity hotspots.

These less iconic species can be affected in multiple ways (entanglement, abrasion, ingestion, laceration, uprooting, etc.), both by macroplastics (>5 mm) and by micro- or nanoplastics (0.1-5000 µm and 0.001-0.1 µm, respectively).[6,7] A number of characteristics that are shared among many or all of these species are associated with significant problems and may make them particularly vulnerable to this type of pollution. These common characteristics and the main impacts arising from them are described below:

Seabed accumulation

Most of the species that form biogenic habitats on the seabed grow fixed to the substrate: they are mainly epibenthic, sessile species, such as corals, sponges, bivalves, algae, or seagrasses. The habitats they form coincide with the place where 94% of the plastic that ends up in the sea accumulates,[2] so their associated species coexist with large concentrations of plastic of various types and sizes (especially for those species that inhabit deep-sea ecosystems), and are therefore at high risk of suffering negative impacts.

These large accumulations are mainly of two types, which differ in terms of the size of the plastic pieces:

- **Fragmented plastic in the form of nano- or microplastic that forms part of the sediment.** It should be noted that the deep sea is the main sink for microplastics and is home to many of habitat-forming species.[8,9]
- **Macroplastic that tends to accumulate in submarine topographical formations** (canyons, trenches, and escarpments), where it remains trapped by the seabed morphology.[10] As one example, up to 167,540 pieces of plastic per square kilometre were found in a single sample in the Cap de Creus canyon, mostly from domestic waste (72%) and fishing nets (17%).[11] Over time, macroplastic items are degraded by environmental and oceanographic agents until they are reduced to microplastics.

Ingestion of toxins

While it is true that many species mistake plastic objects for their usual prey (e.g., plastic bags are mistaken for jellyfish by turtles and for squid by sperm whales), in the case of biogenic habitat-forming species, ingestion occurs at the level of nano- or microplastics, as a result of their feeding strategy.

These suspension-feeding fauna (such as sponges, corals, and bryozoans) live erect on the substrate in areas of strong currents, and either actively or passively filter out particles (organic matter, plankton, bacteria, etc.) from the water to obtain food.

Microplastics are similar in size and morphology to these particles, and thus are ingested by many species, as they have a limited or non-existent capacity to select what they eat.[12] As they cannot be digested, plastics cause a series of physical impacts ranging from accumulation in the digestive tract to their distribution through the circulatory system, becoming lodged in different tissues and cells[13] and potentially having more serious consequences:

- **Bioaccumulation:** once lodged in tissues, ingested microplastics can be transmitted to higher trophic levels. This is known as 'bioaccumulation'.[14,15] It occurs because filter-feeding species are generally found at the bottom of the food chain.

  This phenomenon also extends to commercial species, including fish, molluscs, and crustaceans,[13] therefore representing not only an environmental hazard, but also a danger for the end consumer.[16] For example, microplastics have been detected in human faeces[17] and placentas.[18]

- **Toxicity:** filter-feeding species are also at risk of harmful effects from toxins associated with plastics. Substances such as heavy metals, styrene, phthalates, bisphenol A, polychlorinated biphenyls and polycyclic aromatic hydrocarbons are added to plastics during the manufacturing process, to give them certain industrial properties.

  In addition, due to their chemical and physical properties, plastics can bind to a number of other chemicals present in the ocean, including so-called persistent organic pollutants (POPs) and other toxic and bioaccumulative substances.[19] This entails a more serious threat than accumulation, as some substances are carcinogenic or endocrine disruptors, which can have a series of detrimental effects on the biological processes of these species. They can affect, among other variables, development, reproduction, and behaviour, and can even cause death.[20]

  As in the previous case, the bioaccumulation of toxic substances, such as endocrine

The buoyancy of plastics. Why do they tend to accumulate on the seabed?

Plastic bottle fragment beside a spiny starfish (*Marthasterias glacialis*). (Arenillas, Cantabria, Spain).

In addition to oceanographic characteristics, the factor that determines whether a plastic floats or sinks is its specific gravity, i.e., its density in relation to water. In general, plastics such as polyvinyl chloride (PVC) and polyethylene terephthalate (PET) have a higher specific gravity than water, and so they tend to sink to the seabed, increasing the rate of plastic sedimentation.[29]

Although plastics with a lower specific gravity, such as polyethylene (PE) and polypropylene (PP), initially float in the water column,[30] they undergo various biological processes whereby organic material and/or bacteria adhere to them. This process is known as 'bioincrustation' or 'biofouling'[31] and it can increase the size and density of plastic particles, making them more likely to sink and increasing their accessibility to bottom-dwelling species.

disrupting chemicals (EDCs), has been documented in numerous marine species including birds, turtles, sharks and fish, as well as in humans.[21] Recent studies on humans have detected the presence of microplastics in the blood,[22] and recommended limiting the consumption of certain commercial species by vulnerable groups such as pregnant women and infants due to the potential toxicity of microplastics and associated contaminants.[23]

Breakage and abrasion

Many biogenic habitat-forming species are considered structuring or engineering species, as they produce predominantly calcium carbonate frameworks that serve as a substrate for many other species. These structures, in the form of gardens, reefs, aggregations, and so on, are used as refuges or breeding, nursery, feeding, or resting sites, attracting other species and in some cases becoming habitats with high levels of biodiversity.[24]

These formations are very susceptible to physical impacts and may be broken or abraded by plastic debris, especially in the case of arborescent species whose branches are easily entangled by litter. Taxa with more complex branching morphologies, such as corals, gorgonians, sponges, hydrocorals, macroalgae, and seagrasses, are the most severely affected by such impacts.[25] In some cases, species produce a protective mucus that coats the exoskeleton. This can be damaged simply by rubbing against plastic (abrasion), leaving an exposed area prone to attack by bacteria or other pathogens.

Because of their high ecological value, some of these habitats and species are protected at the regional, national, or local level, as are the areas where they typically occur (see p.16 *Biodiversity Hotspots: Frameworks of protection*). The formations most conducive to the proliferation of these habitats are canyons, seamounts, and escarpments, given their rocky substrates and the presence of strong currents. Unfortunately, these formations coincide with the so-called "plastic traps", areas where plastics tend to accumulate, such that biodiversity hotspots are also plastic hotspots.[4]

Dispersal of exotic species

Studies have shown that benthic and sessile species can use plastic debris as a substrate to which they can attach. However, the true extent of this problem and its potential impact on the organisms, such as changes in their integrity, longevity, and resilience, are currently unknown.[26,27]

What has been found to be detrimental is the role that plastic, given its buoyancy and availability in the sea, can play as a vector for invasive species. In fact, more than 80% of exotic species in the Mediterranean may either have arrived on floating waste or used waste to further expand their distributions.[28] The dispersal of such species can lead to ecosystem imbalances and poses a threat to local marine biodiversity.

Fishing gear: the most lethal plastic

Fishing gear is primarily made of plastic and it comprises up to 10% of marine plastic litter.[32] Lost and abandoned gear continues to catch fish indiscriminately, causing severe damage with highly lethal consequences for pelagic species, as well as breaking and lacerating benthic taxa, including corals, gorgonians, hydrocorals, sponges, and algae.[25,33]

Furthermore, it has been shown that the impact of fishing gear (as well as other plastics) can be even more harmful in ecosystems dominated by sessile species like corals or sponges; once snagged gear causes a breakage, the plastic object is free to become entangled again on another individual.[25,34,35] Oceana has observed this phenomenon on the steep slopes of seamounts, where plastics, lines, and nets move vertically, leaving a trail of colonies showing evidence of impacts, and continuing with the process of destruction further down the slope.


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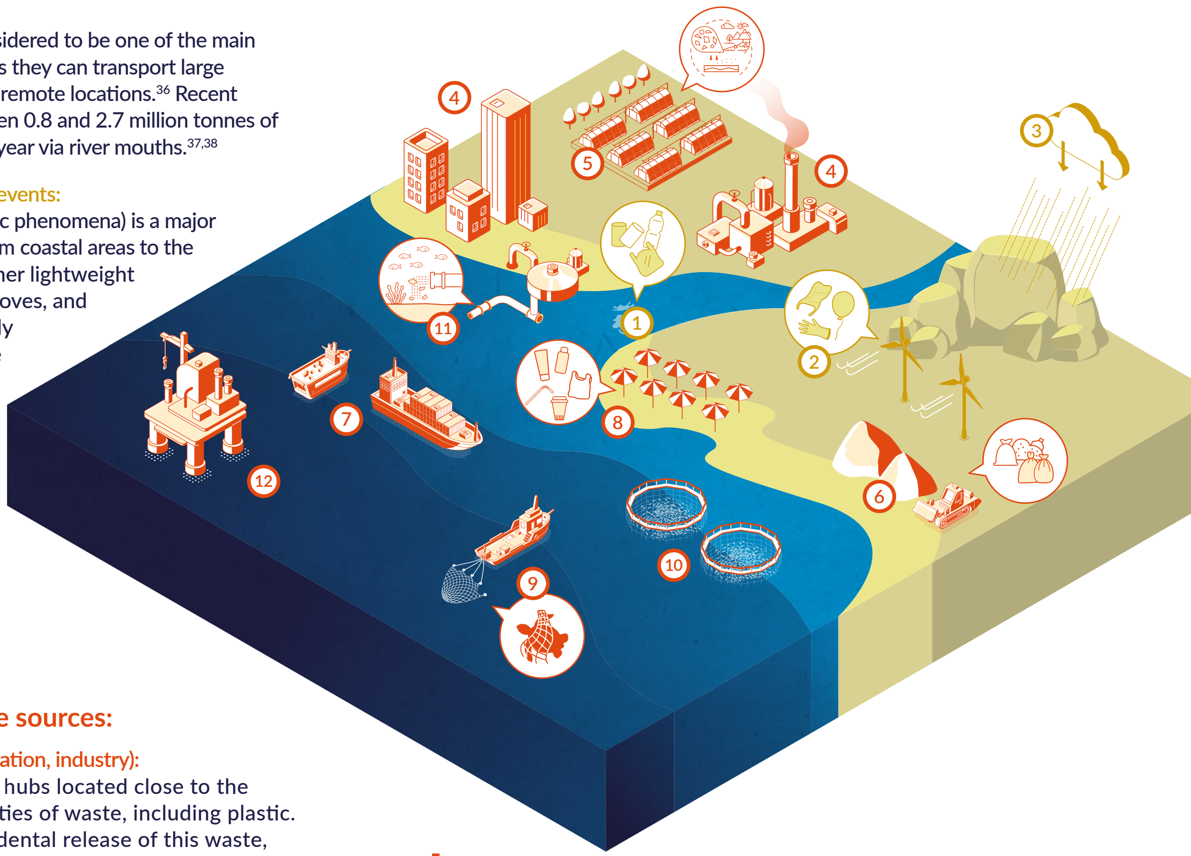
Origin of marine plastic pollution

The first step in tackling the problem of plastic in the ocean is to identify its sources, both land-based and marine, as well as the vectors that carry the waste from its origins to marine ecosystems.

Vectors

1. River mouths : Rivers are considered to be one of the main sources of plastic in the sea, as they can transport large quantities of waste from very remote locations.[36] Recent estimates suggest that between 0.8 and 2.7 million tonnes of plastic enter the ocean every year via river mouths.[37,38]
2. Wind and other atmospheric events: Wind (and related atmospheric phenomena) is a major vector that carries plastics from coastal areas to the sea.[1] Balloons, along with other lightweight plastic items such as bags, gloves, and packaging, are the most easily transported by wind, and are among the most deadly to marine wildlife.[39,40]
3. Rainfall and runoff



Land-based and marine sources:

4. Coastal development (urbanisation, industry): Cities, towns and industrial hubs located close to the coast generate large quantities of waste, including plastic. The intentional and/or accidental release of this waste, together with poor waste management, make these sites major sources of plastic pollution, as it can be transported to the sea by wind and runoff, as well as by other more intense weather events such as heavy rainfall or flooding.[41]
5. Agricultural plastics: Globally, 6.1 million tonnes of plastic are used annually in the agricultural industry (e.g., greenhouses, mulch, liners, tree protectors, etc.), and demand is expected to increase by 50% by 2030, rising to a total of 9.5 million tonnes.[44] This large volume of plastic creates a pollution problem, as it decomposes into microplastics that accumulate in agricultural soils, damaging human health and the environment.[45]
6. Landfills
7. Maritime traffic
8. Tourism: Coastal tourism is one of the most significant source of marine plastic.[42] In heavily visited areas, like the Mediterranean islands, 80% of marine litter found on beaches is directly related to tourism,[43] amounting to around 40 million items per day.
9. Fisheries: Lost or discarded fishing nets account for up to 10% of marine plastic waste.[32] A recent meta-analysis estimated that around the world, 5.7% of all nets, 8.6% of all pots and 29% of all fishing lines are lost each year.[46]
10. Aquaculture
11. Sewage outlets
12. Oil platforms

Below is a literature review that compiles information on the types and major impacts of plastic on the main biogenic habitat-forming species around the world, both in shallow and deep waters. It also provides examples that have been documented during Oceana's scientific expeditions. It is followed by a guide with recommendations on how to reduce the sources of plastics and remove marine litter, to prevent it from reaching the most vulnerable areas.

Impacts of plastic on key biogenic habitats

1. True coral (scleractinian) reefs

Corals are highly diverse organisms that are all highly sensitive to external shocks. Scleractinian corals, also known as stony or hard corals, are characterised by a hard exoskeleton covered with sclerites (cells specialised in the formation of calcite) for growth and protection.

Numerous variables determine the type and degree of impact of plastic waste on coral colonies, depending on the characteristics of the particular species and the type of plastic, but their negative effects have been widely documented. These include:

Disease

Studies show that the presence of plastic debris is associated with the incidence of coral reef diseases –such as 'black band disease',[47] white syndromes, and skeletal erosion– which increase by an average of 20-80% when there is direct contact with the plastic.[48]

Massive tropical corals are at greater risk of developing diseases when in contact with plastics (98% probability) than more complex reef structures, even though the latter are more likely to come into contact with and accumulate plastic.[48]

Breakage and abrasion

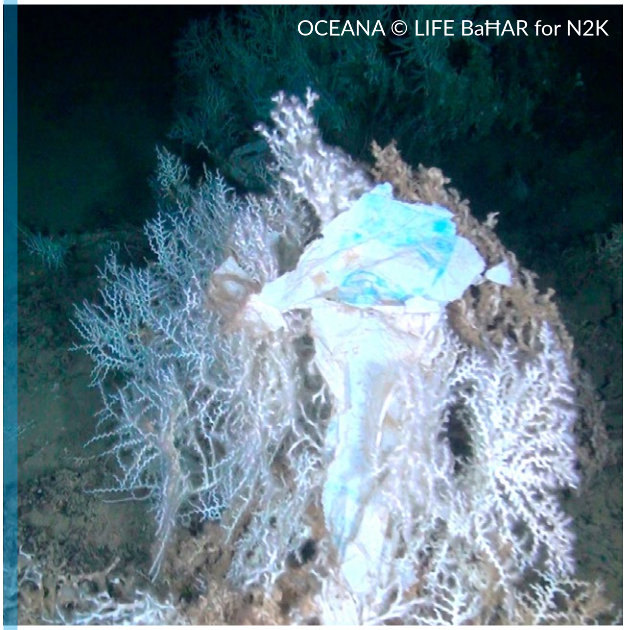
Damage to coral reefs and colonies can be caused by both macro- or microplastics, which contribute to the decline of these organisms on a global scale.[49] The most well-documented impacts caused by macroplastics are breakage of the exoskeleton and abrasion.[50,51] Along with domestic rubbish, abandoned fishing gear (including pots) poses a particular threat in this regard,[52] as it becomes snagged, entangled, occupies the substrate and other available space, and increases the incidence of disease as a result of abrasion.[34,53,54,55]

This damage can lead to rapid algal colonisation, which ultimately results in death and reduced coral cover on the substrate, with corals being displaced in favour of other benthic species.[56] The associated loss of biodiversity has negative consequences that also affect humans,[57] as reflected in a study that estimated that such changes in tropical coral habitats reduced fisheries productivity to less than one third.[58]

Ingestion of microplastics

As filter feeders, some corals may occasionally ingest microplastics.[59-63] This has a number of direct consequences including a decreased intake of the species that would adequately nourish the coral, leading to a false sense of satiety that affects feeding and therefore growth.[64] Other effects of microplastic ingestion include enhanced mucus production, increased bleaching and loss of symbiotic algae, and changes in photosynthetic efficiency.[64,65,66,67]

Piece of plastic entangled in deep-sea corals (*Madrepora oculata, Desmophyllum pertusum*). (Malta).



Corals damaged by plastics and fishing gear eventually die, resulting in reef biodiversity loss and impacts on associated fisheries.

Biological processes

The biological characteristics of coral species can influence the nature and severity of damage caused by plastic. For example, corals are particularly vulnerable to plastic pollution during early life stages, as contact with microplastics can affect gametes and larvae, fertilisation, embryo survival, and even settlement and attachment to the seabed.[68,69,70]

Damage to deep-sea habitats

The negative effects of plastic have been described not only on tropical corals, but also those in the deep sea. Recent studies have analysed the impact of macro- and microplastics on deep-sea corals, such as *Desmophyllum pertusum*, one of the main habitat-forming species in cold waters.[64] These effects include reduced skeletal growth rates, increased energy use by polyps for feeding, decreased success in capturing prey, and reduced calcification rates, which threatens the resilience of reefs and their associated biodiversity. Effects on other deep-sea corals and gorgonians have also been detected, for example partial necrosis.[5,33]

Although information on cold-water corals is limited compared to tropical reefs, during marine expeditions conducted by Oceana, plastic debris has been observed on many deep-sea scleractinian coral species that are essential for habitat formation. These species include *Dendrophyllia cornigera*, *D. ramea*, *Desmophyllum pertusum* and *Madrepora oculata*.

Focus: "Plastic trap" on a *Madrepora oculata* reef

In the course of research around the islands of the Maltese archipelago, Oceana documented an area inhabited by a dense reef of *Madrepora oculata* (white coral). In addition to these corals, which serve as an important refuge for fish species such as blackspot seabream (*Pagellus bogaraveo*) and the deep-sea cardinalfish *Epigonus constanciae*, and crustaceans like Norwegian krill (*Meganyctiphanes norvegica*), a plethora of plastic waste was found, some of a clearly domestic and/or tourist nature, such as bags and disposable cups. Being remote (about 20 nm from the coast) and deep (about 540 m), this reef provides a clear example of a 'plastic trap' and its detrimental effects. Oceana documented numerous plastics entangled on the coral, as well as sections of detached coral adjacent to the colonies, suggesting breakage caused by snagging and/or abrasion.

White coral (*Madrepora oculata*) reef with garbage, at 540 metres depth. (Malta).

2. Gardens of black corals, gorgonians, sea pens and soft corals

In a similar way to scleractinian corals, plastics and fishing gear debris cause damage to black corals (antipatharians) and octocorals, which include gorgonians, sea pens, and soft corals. These corals form gardens on both soft and hard seabeds, and their associated fauna constitute valuable communities.

Data show that when these species come into contact with plastic pollution, they are more vulnerable to parasitism,[71,72] as well as other negative effects such as suffocation and tissue abrasion, which causes partial or complete mortality of individuals and colonies.[26,73,74,75] As filter feeders, they are also vulnerable to microplastic ingestion, which has been documented in gorgonians[76] and sea pens.[77]

More and more studies reflect the frequency of finding plastic (mostly fishing gear debris) entangled on these corals around the world.[78,79] The number of species known to be affected is increasing as more research is conducted on antipatharians and octocorals and as deeper and more remote waters are studied. At the Condor Seamount in the North Atlantic, litter has been observed entangled in gorgonians including *Dentomuricea* cf. *meteor* and *Viminella flagellum* at depths of up to 1092 m[80], while in the Mediterranean, there are various examples of black coral and gorgonian colonies damaged by plastics.[33,81-85] Research has revealed lacerations, increased epibionts, and mortality, which may lead to the local disappearance of these underwater forests. This may even jeopardise the existence of some species, especially if their distributions are limited. This is the case of the soft coral *Dendronephthya australis*, which acts as a refuge for many individuals, including juveniles of important commercial species.[86]

Oceana's observations in the Atlantic, Mediterranean, and North Sea have verified and documented these impacts on both gorgonian and black coral species, such as *Antipathes dichotoma*, *Callogorgia verticillata*, *Elisella paraplexauroides*, *Eunicella* spp., *Isidella elongata*, *Leiopathes glaberrima*, *Narella* sp., *Paramuricea clavata*, and *Viminella flagellum*.

Focus: Fishing lines in gorgonian gardens

Seco de Palos seamount is located approximately 30 nm east of Cabo de Palos (Region of Murcia), and is a proposed Site of Community Importance (SCI) within the Natura 2000 Network.

Given the general lack of knowledge about seamounts and the high biological diversity associated with them,[87] Oceana carried out an expedition to Seco de Palos. In addition to a highly productive ecosystem, lost fishing lines and plastic gear were commonly observed, especially in the area of the escarpments, presumably as a result of the fishing for large pelagic species that takes place in the area. These gears were directly affecting the colonies of *Callogorgia verticillata* gorgonians, which showed clear evidence of breakage and lacerations as a result.[88]

Fishing lines entangled in deep-sea gorgonians. (Seco de Palos, Murcia, Spain).

3. Hydrocoral gardens

Hydrocorals are hydrozoans that have a calcareous exoskeleton similar to that of true corals. Knowledge of the impact of plastic pollution on these organisms in Europe is virtually non-existent, as they are less common species and tend to live in deep, cold waters or under specific oceanographic conditions.

However, some data do exist on the presence of plastic debris from fishing gear in colonies of *Errina aspera* in the Strait of Messina (Italy); it has not been possible to analyse its impacts, although it is known that this hydrocoral colonises fishing gear debris.[89]

In contrast, studies carried out in shallower waters on coral reefs of the Florida Keys have documented the impact of litter and lost fishing gear on hydrocoral species such as *Millepora alcicornis* and *M. complanata*.[26] As with other sessile organisms, this pollution causes tissue abrasion and partial or complete mortality of individuals and colonies.

4. Sponge aggregations

Along with corals and hydrocorals, sponges appear to be among the organisms most commonly affected by lost or abandoned fishing gear and other marine debris.[26] The most obvious effect is abrasion produced by this debris, which can lead to tissue loss or even the death of the animal.

Sponges are one of the least studied taxa in relation to microplastic ingestion.[90,91] However, they are presumed to be potential indicators for detecting and estimating the density of microplastics in the sea,[92] given their widespread occurrence in marine ecosystems and their high filtering potential (up to 35 mL of water per minute and per cm^3 of sponge).[93] In particular, collections stored in museums are being analysed to elucidate a historic reference point for the onset of plastic interaction with biological organisms, as well as a history of their areas and levels of greatest accumulation in the tissues of marine biota.[94]

Some effects detected in sponges after ingesting microplastics include altered contraction patterns in the presence of phthalates; this may have important repercussions for feeding in sponges.[95] In some areas, such as the Mediterranean, plastic damage in filter-feeding species appears to be widespread. Among Mediterranean sponge species listed as Vulnerable on the International Union for Conservation of Nature Red List, up to 73% are affected by plastics.[96]

The effects of plastics are most noticeable in larger sponges. In particular, evidence of plastic damage has been repeatedly found in glass sponges (Hexactinellida), even in areas as remote as the deep Arctic,[97] as well as in the Pacific,[98] where microplastics have also been detected in these sponges. Nevertheless, the effect of these plastics has also been found in small individuals, such as the carnivorous sponge *Cladorhiza gelida*.[99]

Oceana has also documented macroplastics and fishing gear debris trapped in sponges of the genera *Geodia* and *Axinella*, and in lithistids such as *Leiodermatium pfeifferae*,[100] as well as in deep-sea hexactinellid specimens from the Atlantic and Mediterranean, such as *Asconema setubalense* and *Pheronema carpenter*.

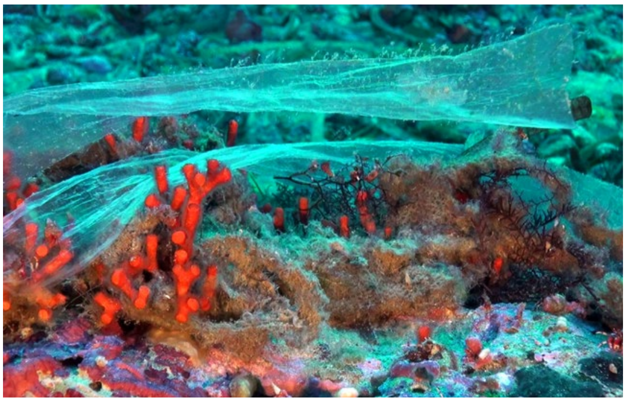
Glass sponge (*Pheronema* sp.) with plastic debris. (Punta de Tejeda, El Hierro, Canary Islands, Spain).

Focus: Remains of fishing gear on glass sponges

Together with the University of the Algarve, Oceana carried out an expedition in the submarine canyons off Cabo de São Vicente (Portugal), where large volumes of plastic waste were documented at densities of 3.31 items per 100 metres sampled.[101] The majority of this waste came from fishing activities, including debris from fishing gears such as nets and lines. The species most impacted by this debris were glass sponges (*Geodia* sp., *Asconema setubalense*), which were observed in contact with fishing lines and with evident structural damage.

Glass sponges (*Asconema setubalense*) and fishing lines at 424 metres depth. (São Vicente Canyon, Algarve, Portugal).

5. Bryozoan aggregations



Plastic on false coral (*Myriapora truncata*), rhodoliths, algae, and sponges. (Port of Mahón, Menorca, Balearic Islands, Spain).

Many species of bryozoans form large three-dimensional structures and can potentially suffer from the impacts of plastic, similar to those observed in hard corals and gorgonians.

Oceana has been able to document some of the impacts of macroplastics on bryozoan species, like *Myriapora truncata*, *Pentapora* spp. and *Schizoporella errata*, and even the growth of others, such as *Adeonella calveti*, over the remains of fishing gear.

6. Bivalve aggregations

Bivalve molluscs are an extensive group of species, various of which form vast aggregations that create habitats with high levels of biodiversity. They are also important due to the fundamental role they play at the base of the food chain, as well as their commercial value.[102] For these reasons, and because they are filter feeders, there has been extensive research on how these organisms can accumulate a considerable quantity of pollutants, including those related to the ingestion of microplastics in many species.[103]

Bed of blue mussels (*Mytilus* sp.). (Øresund Bridge, Central Sound, Sweden).

Mussels

One of the most studied cases is that of mussels (Mytilidae), which suffer from microplastic contamination, as has been demonstrated in many areas across Europe. For example, on the Baltic coasts of Denmark and in the North Sea in Belgium, France, and the Netherlands, averages of 0.2-1.5 microplastic particles per gram wet weight have been detected;[104,105,106] while on the coasts of northern Spain, observed average densities are as high as 2.55 microplastic particles per gram wet weight.[107]

Among the negative effects on mussels, major impacts include digestive tract inflammation,[108] reduced filtering activity,[109] and even decreased adherence of these molluscs to rocks.[110]

Other bivalves, both colonial (mytilids) and non-colonial (scallops), also show effects stemming from the presence of microplastics, including the blockage of their feeding appendages.[111,112]

Oysters

Many other bivalve species are also affected by microplastic ingestion, including oysters. The Pacific giant oyster *Magallana gigas* suffers reduced reproductive potential (e.g., variation in oocyte number and size in females, and sperm velocity in males) when exposed to concentrations of polystyrene microbeads. Research indicates that these effects may inhibit fertilisation, reduce larval survival, and impair offspring growth.[113] Other adverse effects observed include reduced egg size and decreased hatching success.[114] Pearl oysters (*Pinctada margaritifera*) also exhibit negative effects on feeding and reproduction as a result of plastic pollution, such as reductions in assimilation efficiency and in their overall energy balance.[115]

Oceana's footage of bivalve aggregations has verified the presence of plastics and fishing gear in oysters such as *Neopycnodonte cochlear* and *N. zibrowii*, in both the Atlantic Ocean and the Mediterranean Sea.

7. Algal forests

So-called 'algal forests' represent extremely important habitats in the marine environment, as they are home to a large number of species and play a major role at the base of the food chain. As such, they are susceptible to absorbing microplastics from the environment and can transfer this pollution to predatory organisms.

Brown algae

Various studies have investigated the role of a range of algae as vectors for introducing plastics into the food chain.[116,117] This occurrence has already been described in the alga *Fucus vesiculosus*, from which microplastics are transferred to higher trophic levels via one of its predators, the common periwinkle *Littorina littorea*.[116]

Phthalates have also been found to accumulate in brown algae such as *Sargassum* spp.[118] These pollutants, which are directly related to the ingestion of plastics such as PVC, affect animals and plants,[119] and the possibility that they may also hinder the reproduction of aquatic plants is currently being investigated.[120] Other species, like *Padina* sp. and *Sargassum ilicifolium*, have also been documented to contain traces of microplastics, but the side effects are still unknown.[121]

Algal (*Laminaria* sp.) forest.
(Karmøy, Norwegian Trench, Norway).

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Green algae

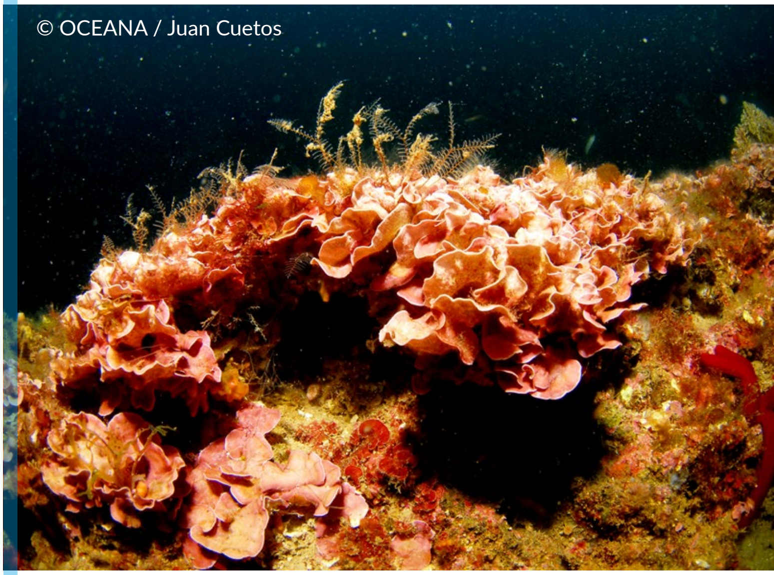
In the case of green algae, plastic contamination can affect photosynthesis, leading to reduced nutrient uptake and promoting the production of reactive oxygen species,[122] this is often indicative of stress from external agents that are harmful to the organism.[123,124] These alterations can damage proteins, lipids, and DNA, even leading to cell death.[124,125]

Red algae

The impact of macroplastics on ecologically important algal habitats, such as calcareous red algal aggregations, is noteworthy. Coralligenous and maërl-forming algae create calcium carbonate bioconstructions, referred to as reef formations, which play a similar role in the ecosystem to that of corals. These structures are very fragile and susceptible to abrasion or breakage from discarded plastics and fishing gear, which can become caught in them and affect both the algae and the other organisms that make up this unique habitat.[126,127]

Surveys by Oceana have found plastics among various types of algal communities, including maërl beds, coralligenous reefs, fucoids, kelps, and chlorophytes.

Red calcareous algal reef.
(Isla de las Palomas, Murcia, Spain).



Plastics can enter the food chain through algae. The reef formations of calcareous red algae are very fragile.

Focus: Ghost fishing in coralligenous habitat

The area of Fort d'en Moreu (Balearic Islands) comprises a vast expanse of coralligenous habitat located to the east of the Cabrera archipelago, featuring gardens of red gorgonians (*Paramuricea clavata*) growing on a thick reef of calcareous algae and a forest of Mediterranean kelp. Today the area is included in the extended area of Cabrera National Park, which is extremely rich in biodiversity. During multiple expeditions, Oceana has documented, in addition to the richness of this important habitat, a large quantity of fishing gear debris covering the calcareous algae reef formations, affecting their structures and being colonised by various epibionts.[128]

Lost trawl net on coralligenous seabed with violescent sea-whip (*Paramuricea clavata*). (Fort d'en Moreu, Cabrera, Balearic Islands, Spain).

8. Seagrass meadows

Seagrass meadows play a similar ecosystem role to that of kelp forests, and also suffer from the effects of micro- and macroplastic pollution. To date, microplastics and fibres have been found in meadows of various seagrass species, including *Cymodocea rotundata*,[128] *Enhalus acoroides*,[129] *Posidonia oceanica*,[130] *Thalassia hemprichii*,[129] *T. testudinum*[131] and *Zostera marina*.[132]

Microplastics

Large seagrasses are the most susceptible to accumulating greater quantities of epiphytes and microplastics. As in the case of algae, there is a possibility that these pollutants are transferred up the food chain via herbivorous species that feed on the leaves or the epiphytes that grow on them.[133,134] In addition, toxic substances associated with microplastics are likely to function as inhibitors and disruptors of photosynthesis and growth processes in seagrasses.[135]

Macroplastics

Plastic becomes trapped in leaf litter and other plant debris that washes ashore, helping to reduce the amount of litter in the sea.[136] However, this does not prevent seagrasses from being affected by macroplastics in different ways. In the Mediterranean, it has been shown that plastic bags, even biodegradable ones, can increase competition for resources in mixed meadows of *Cymodocea nodosa* and *Zostera noltii*.[137] In coastal marshes, there is evidence of how macroplastics prevent plants from obtaining the necessary amount of light and how they cover areas from which vegetation disappears (screening),[138,139] and modify bottom microcurrents;[140] all of these factors are important for photosynthetic species that need to attach to the bottom by retaining sediment.

Seagrasses are also at risk of snagging by fishing gear, which can reduce leaf density in species like *Thalassia testudinum* and *Syringodium filiforme*.[141] The damage caused may persist for months after removal of the object.[142]

Plastic fork among *Posidonia oceanica* leaves. (Magaluf, Mallorca, Balearic Islands, Spain).

Focus: Plastic litter in seagrass meadows

In 2019, Oceana documented certain areas of the Mallorcan coast (Balearic Islands, Spain) to investigate the relationship between locations with heavy tourism, considered one of the main sources of single-use plastic waste,[143] and the presence of those plastics in adjacent marine ecosystems. A high concentration of plastics –from domestic or tourism-related sources– was found in seagrass meadows (*Posidonia oceanica*) off the coast of Magaluf, one of the most important tourist resorts in the Balearic Islands.[144]

Plastic bottle in *Posidonia oceanica* meadow. (Magaluf, Mallorca, Balearic Islands, Spain).

9. Other habitat-forming organisms

In addition to those mentioned above, there are many other habitat-forming species that also suffer from the effects of marine plastics. For many of them, there is still a large information gap, especially for species living in deeper areas. However, this does not mean that the threat should be ignored. Several examples are described below:

- Barnacles: Some studies point to entanglement and the detrimental effects of microplastics on sessile crustaceans, such as acorn barnacles and goose barnacles.[145,146,147] These studies refer to species that are very important in the formation of deep-sea habitats,[148] such as *Pachylasma giganteum*,[89] in addition to key species in coastal ecosystems, like *Balanus amphitrite*.[146]

Ascidian and marine litter.
(Punta Entinas-Sabinar, Almeria, Andalusia, Spain).

- Tunicates: Microplastics have been documented in both the digestive tract and the circulatory system of ascidians (sea squirts).[149,150] One study found that ascidians are capable of retaining up to 0.62 microplastics per gram of tissue, which is five times greater than in animals with a higher filtering capacity such as the bivalves *Magallana gigas* (0.11 microplastics/g); *Mytilus galloprovincialis* (0.05 microplastics/g), and *Anomia ephippium* (0.12 microplastics/g).[16] Toxic additives from plastic production, such as phthalates, have also been detected in these organisms.[151]

During its expeditions, Oceana has documented multiple marine ecosystems that highlight the ubiquity of plastic in the sea and its serious impacts on numerous species, in addition to those cited in this report. Those ecosystems include bamboo coral gardens, beds of giant foraminifera, crinoid fields, and brachiopod beds.

Biodiversity hotspots: frameworks of protection

Many of the biogenic habitats described in this report are considered conservation priorities in Europe. Either because of their associated biological diversity, their productive capacity, their importance for endemic species, or their fragility to external impacts, they are included on lists of protected features and/or are the subject of specific action plans regulated by national, European or regional instruments. This is evidence of their importance from a conservation point of view and is a clear sign of the need to avoid the impacts of plastic pollution on them.

Among the relevant regulatory tools, the European Union's Habitats Directive is one of the most important,[152] as its main objective is the conservation of natural habitats and wild species in the EU. On the other hand, many of these habitats are also included in the lists of threatened and/or endangered species and habitats of different regional conventions (OSPAR,[153] HELCOM,[154] Barcelona Convention UNEP-MAP[155]), for which, in some cases, Action Plans have been developed.[156,157,158] The inclusion of habitats on these lists means that countries must take binding measures for their conservation and protection.

When it comes to impacts on the ocean, the Marine Strategy Framework Directive is particularly relevant, as its main objective is to prevent, protect and conserve the marine environment from the pressures and impacts of harmful human activities.[159] In fact, one of the eleven descriptors used to assess 'Good Environmental Status' is 'Marine Litter' (Descriptor D10), in which plastic plays a prominent role, as it is one of the main types of waste found both in the sea and on the coast.

Plastics from a greenhouse. (Almería, Spain).

Plastic bag fragment with zebra seabream (*Diplodus cervinus*). (Arenillas, Cantabria, Spain).

Biogenic formations of conservation interest are included within all the habitat types affected by plastic waste described in this report. The category that includes almost all of these habitats is that listed by the Habitats Directive as habitat of Community interest "1170 - Reef". This covers all types of biogenic reefs, which are defined as "*encrusting, coralligenous concretions and bivalve beds comprising both live animals and their remains*"; the associated interpretation manual extends this to a large number of bioconstructors and algae. The same Directive also covers the habitat "1120 - Posidonia beds", which is included in the habitat described here as "seagrass meadows".

In addition to these instruments, the European Red List of Habitat Types classifies terrestrial, marine, and coastal habitats according to five criteria used to assess their risk of collapse.[160] Habitats considered threatened are classified according to three categories: Critically Endangered, Endangered, and Vulnerable, and with threat levels differentiated for the different European seas. Among those habitats most likely to be threatened by plastic marine litter are those consisting of forests or aggregations of algae, such as *Fucus* spp. or maërl, seagrass meadows, and aggregations of molluscs, such as the iconic ocean quahog (*Arctica islandica*) (**Table 1**).

In the Mediterranean and Atlantic regions, the habitats on these lists that are most frequently cited as being affected by plastics are those consisting of true corals, gorgonians, black corals, soft corals, and sponge aggregations, as well as algal forests and seagrass meadows. In contrast, in the Baltic region, HELCOM restricts its Red List of habitats to sea pen gardens, kelp forests and mollusc aggregations, in line with the habitats that proliferate in this are.

Table 1: Biogenic habitats of conservation concern affected by plastics.
CR: Critically Endangered; **EN:** Endangered; **VU:** Vulnerable (likely to become an endangered habitat).

	EUROPEAN FRAMEWORK		REGIONAL FRAMEWORK		
BIOGENIC HABITATS	HABITATS DIRECTIVE (HABITAT TYPE))	EUROPEAN RED LIST OF MARINE HABITATS	OSPAR	UNEP-MAP	HELCOM
Scleractinian coral reefs	1170 Reefs		✓	✓	
Black coral gardens	1170 Reefs		✓	✓	
Gorgonian gardens	1170 Reefs		✓	✓	
Soft coral gardens	1170 Reefs		✓	✓	
Sea pen gardens	1170 Reefs		✓		EN[b]
Hydrocoral gardens	1170 Reefs				
Sponge aggregations	1170 Reefs		✓	✓	
Bivalve aggregations	1170 Reefs	EN[c,d,e]	✓		CR[f]; VU[g]
Bryozoan aggregations	1170 Reefs			✓	
Algal forests/aggregations	1170 Reefs	EN[h,i]; VU[j]	✓	✓	EN[k,l,m,n,o,p]
Seagrass meadows	1120 Posidonia beds	CR[q]; VU[r,s]	✓	✓	

b Baltic: Aphotic muddy sediment characterised by sea pens
c Northeast Atlantic: Mussel beds in the littoral zone
d Mediterranean: Mussel beds in the infralittoral zone
e Mediterranean: Oysters beds in the infralittoral zone
f Baltic: Aphotic muddy sediment dominated by ocean quahog (*Arctica islandica*)
g Baltic: Aphotic sand dominated by ocean quahog (*Arctica islandica*)
h Mediterranean: Photophilic communities with kelp forests on infralittoral and upper circalittoral rocks
i Mediterranean: Algal-dominated communities on infralittoral sediment
j Northeast Atlantic: Maërl beds
k Baltic: Photic mixed substrate dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)
l Baltic: Photic mud dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)
m Baltic: Photic coarse sediment dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)
n Baltic: Photic sand dominated by stable aggregations of unattached *Fucus* spp. (dwarf form)
o Baltic: Photic maërl beds (unattached particles of coralline red algae)
p Baltic: Aphotic maërl beds (unattached particles of coralline red algae)
q Northeast Atlantic: Meadows on infralittoral sandy seabeds (non-Macaronesia)
r Northeast Atlantic: Meadows on infralittoral sandy seabeds (Macaronesia)
s Mediterranean: Posidonia beds in the infralittoral zone

Marine habitats are damaged by activities such as fishing with bottom-contacting gears (e.g., trawl nets, dredges, etc.), mining or hydrocarbon extraction, as well as other impacts like the spread of invasive species or acidification, for example. Plastic represents an additional threat that makes it even more difficult to manage these habitats, as it usually originates in areas far from where the impact occurs.

The costs of this pollution for society, the environment, and the economy have already been assessed,[161] although further research is required on its negative consequences on marine species.[162,163] Also unknown is the cumulative effect that plastic can have on a habitat that is subject to other stressors, which is often the case in the marine environment.

Enormous quantities of plastic enter the ocean, and it is distributed ubiquitously. This makes it virtually impossible to remove, especially when it has reached areas far from the coast and/or great depths. The solution is therefore to eradicate the problem at the source, which would prevent this waste from coming into contact with biogenic habitats of conservation concern. Below are guidelines on how to prevent plastic from reaching these areas of great importance for the marine environment, and how to remove the plastic that is already present without damaging habitats.

Guidelines for plastic-free biogenic seabeds

1. Gather information

To define the measures that can be applied in a particular area, it is necessary to carry out a preliminary study to identify the oceanographic and biological characteristics of the site, as well as the level of pollution. For this purpose, the following variables should be analysed:

- **Ocean currents:** Currents play an important role in distributing plastic in the ocean. They transport plastic from its (predominantly terrestrial) sources, carrying it long distances and/or aggregating it in specific areas, such as within oceanographic gyres.[164] Numerous scientific studies have developed models to determine how marine currents distribute litter both globally[165] and regionally –as in the case of the heavily polluted Mediterranean[166,167,168] – and which are the most likely places where it concentrates (e.g., in coastal areas).[169]

  The concentration of plastics can also vary depending on the characteristics of bodies of water, such as temperature and density. This can be seen in plumes formed at river mouths and on coastal fronts, where increased suspended organic particles favour the retention of floating plastics.[170]

- **Vulnerable habitats and 'plastic traps':** The types of ecosystems present in an area are among the most important factors when determining both the potential impacts of marine pollution and the most appropriate measures to minimise them. The existence of one or more biogenic habitats increases the likelihood of certain types of damage (see p.8 *Impacts of plastic on key biogenic habitats*), which has implications for the marine life that depends on them. Identifying and mapping the distribution of biogenic habitats within an area is therefore key to understanding their vulnerability to plastic pollution.

  Vulnerability also depends on the complexity of the habitat: the extent of three-dimensional structures, with branching and erect individuals, hard structures, etc.. For example, deep-sea biogenic habitats such as coral reefs and sponge aggregations could serve as indicators of macroplastic damage; they tend to be highly vulnerable to such impacts because they are sessile, very fragile species with life spans of hundreds or thousands of years and very slow growth rates. In the case of microplastics, filter-feeding species such as sponges and bivalves can indicate the levels of pollution in the area.[92]

  Of the habitats vulnerable to plastic pollution, some are more susceptible to waste accumulation for other reasons. Certain geological formations where biogenic habitats are typically found (submarine canyons, escarpments, seamounts, depressions and caves) can act as areas that concentrate marine litter and become 'plastic traps'.[10]

  These areas need to be identified, and the vulnerability to plastic exposure of the species that inhabit them needs to be assessed. The potential threat varies depending on whether the species are densely or sparsely distributed in the habitat, whether they are perennial or have annual cycles, and whether they are slow- or fast-growing.

- ***In-situ* macroplastic pollution:**

  To some extent, plastics carry clues that can reveal their origin or allow them to be categorised. For example, sunscreen containers are linked to recreational activities, fishing gear to fishing activities, and diving masks to underwater activities. In some cases it may be possible to identify whether they have a local or remote origin, which, together with the study of currents, is essential for identifying the main sources of plastic waste affecting an area. For example, a study on the Dutch island of Texel found that 42% of the plastics detected originated within the Netherlands, while the rest came from both neighbouring countries and from locations as distant as Canada and China.[171]

  Further classification allows categories to be established according to object, type of plastic, and chemical composition. These characteristics reveal crucial information about how an object will behave once it reaches the ocean (its buoyancy, erosion, decomposition, etc.), as well as determining the type of impact and injury it may cause to various biogenic habitat-forming species, as described earlier. Currently, there are guidelines available for classifying the different types of marine plastic debris found both on shore and in the ocean.[172,173,174]

- **Other impacts:**

  It is common for a particular area to be affected by more than one environmental impact at the same time, and biogenic habitats may be more vulnerable due to this synergy. It is important to be aware of all the stressors to which an area is subjected, in order to consider potential cumulative effects along with those associated with the plastic.

Checklist

- ☑ *Analysis of both surface and bottom currents, as well as water bodies and the levels of plastics they contain.*
- ☑ *Mapping of the seabed to identify the distribution of vulnerable habitats and potential plastic traps.*
- ☑ *Census of plastics in the area and their origin (e.g., local/remote origin, brand, etc.).*
- ☑ *Classification of plastics according to marine litter types as well as the degree of risk they pose to the types of habitat present.*
- ☑ *Assessment of the potential risk of each habitat identified to exposure to the type of plastic present, in conjunction with other stressors to which it is subjected.*
- ☑ *Selection of indicator species based on their vulnerability to contact with plastics, either through entanglement or lacerations (e.g., corals, sponges) or their tendency to bioaccumulate these contaminants (e.g., bivalves).*

Plastic sunscreen tube in the sand. (Carmen beach, Barbate, Cadiz, Spain).

2. Actions

At the regional level, actions have been laid out in Marine Litter Action Plans under both the Barcelona Convention (UNEP/MAP Decision IG.21/7)[175] and OSPAR[176], with the aim of achieving environmental targets in their respective geographical areas. Within the Interreg MED programme, the Plastic Busters MPAs project (https://plasticbustersmpas.interreg-med.eu/) has extensively studied the effects of litter in marine protected areas, and developed guidelines and best practices to address this issue in the Mediterranean.

Below is a series of recommendations to complement those plans and contribute to the reduction of plastics in biodiversity hotspots.

› Reduce sources of plastic close to biodiversity hotspots:

As mentioned above, pollution may originate from distant sources, as ocean currents can even carry plastic waste over intercontinental distances. This problem needs to be addressed through legislation and public policies to minimise the use of unnecessary plastics and their uncontrolled dumping.

Below is a table of recommendations for mitigating pollution from activities carried out in the vicinity of biogenic habitats.

LOCAL SOURCES OF PLASTIC	RECOMMENDATIONS
Professional and recreational fishing	• Eliminate fixed gear in sensitive areas • Establish zoning to reduce the loss of nets • Promote the use of biodegradable gear, fish boxes and bait packets • Avoid the use of fishing gear made of low-quality materials (e.g., plastic bottles used as buoys) • Establish a system for reporting losses of fishing gear
Diving	• Establish a system for reporting objects lost while diving • Promote the collection of plastic by divers and establish clean-up days • Conduct educational programmes for instructors and divers
Boating	• Monitor illegal dumping of waste from boats • Report debris encountered while sailing to the authorities • Promote educational programmes in marinas and sailing clubs
Other vessels	• Keep a register of vessels engaged in professional and recreational activities in or near the area • Monitor the real-time positions of vessels engaged in professional and recreational activities in or near the area and equipped with geographic positioning systems
Anchorage areas	• Ensure that anchorage areas are located away from biogenic habitats • Establish environmentally sustainable anchorage systems • Prohibit anchoring of cargo ships and cruise liners • Establish penalties for vessels that dump waste in anchorage areas
Register of activities	• Establish a register of activities and their potential impacts on biogenic habitats, with special reference to those activities that are potential sources of plastic
Coastal occupation	• Ban single-use plastic in facilities and shops, and for visitors to coastal areas where biogenic habitats are located • Install adequate collection systems in coastal areas close to areas where biogenic habitats are located

Reducing plastic at the source

1. Design products bearing in mind the end of their life cycle and the likelihood that they will end up as scattered waste
2. Replace disposable items with reusable ones
3. Improve collection systems, including through deposit return systems
4. Eliminate unnecessary packaging and products that are harmful to wildlife
5. Implement gear identification systems and establish removal protocols for lost fishing gear

› Remove plastics:

To reduce the impact of plastic on biogenic habitats once it has been released into the environment or has reached the ocean from land, various collection approaches can be considered. These options are very limited for technological, economic, and environmental reasons and should therefore only be considered as a last resort.

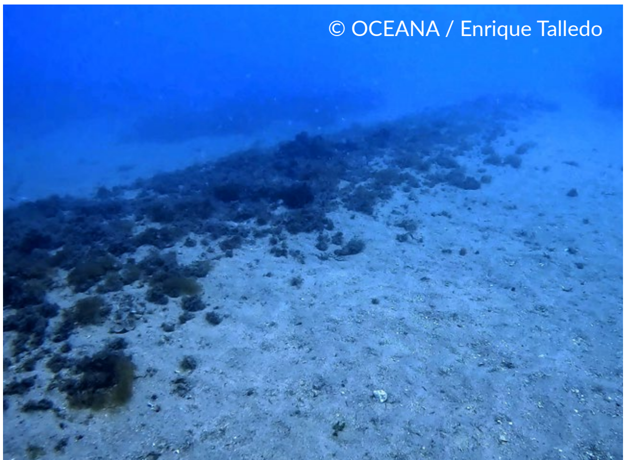
The initial assessment must take into account a number of issues:

» **Location:** the presence of litter is more noticeable in coastal and shallow areas, where removal is easier, but most ocean litter is found in deep areas, where it is difficult to reach.[9]

Depending on the depth and accessibility of the site, plastic can be removed in two ways:

- **Manual removal:** in coastal and accessible areas, manual collection is the best alternative for removing macroplastics. Collaboration of the public and non-governmental organisations can be very helpful in actions undertaken by companies or authorities, either when collecting waste directly or when using SCUBA diving equipment.
- **Mechanical removal:** for areas that are inaccessible, either because of their distance from the coast or their depth, mechanical methods can be used to collect plastic waste, such as the use of robots (*remotely operated vehicles*, ROVs). However, this involves a high cost and relies on technological development. Devices also exist for use in small areas -such as marinas- that can prevent waste from reaching the open sea at the expense of surface marine life. Bottom-trawling has also been used indirectly to remove rubbish from the seabed, although this is a non-selective method and therefore has a significant negative impact on benthic ecosystems. For this reason, Oceana does not consider the latter option as an advisable alternative for cleaning up marine plastic.

Potential trawl marks on the seabed. (Almeria, Andalusia, Spain).



- **Varieties of plastic:** the type, composition and chemicals added to the plastic, as well as its morphology, must be taken into account when setting priorities for its removal. Fishing gears (nets, lines, ropes, pots, etc.) and lightweight plastics (bags, wrappers, balloons, etc.) are the most harmful to marine wildlife and should be prioritised, given their severe impact on marine habitats.[40]

- **Habitat type:** depending on the complexity of the habitat, plastic may be more difficult to locate, for example in a seagrass meadow or algal forest, where it may be hidden among vegetation. Plastic may also become entangled in highly branched and fragile species, making it difficult to collect without damaging those organisms. It is important to establish a balance between the impact of the plastic and the impact of its removal if this involves the destruction of certain habitats.

Thus, there may be occasions when the best option is not to intervene, leaving the plastic waste where it is as an alternative to causing further damage to a particular habitat. This option may be considered in cases where the objects are badly entangled or have been colonised by slow-growing sessile species, such as true corals or gorgonians, or species that are protected or at risk of extinction. In such cases, removal would not be possible without affecting the benthic habitats.

In the event that an object cannot be removed for these reasons, but is causing a significant impact on other species (such as in the case of fishing nets and lines), Oceana considers that it is possible to reduce the damage by cutting the lines/nets to avoid ghost fishing. This also avoids potential damage by gear that is entangled in rocky substrates such as seamounts or escarpments, where nets can tumble downslope, affecting a large number of biogenic species that thrive in those environments.

Conclusions

Based on the analysis carried out, and given the multitude of impacts described in previous sections, Oceana proposes three key actions to combat the impacts of plastic:

Reduce consumption: reduce or eliminate the use of those plastic products that are most harmful to the marine environment. This action is critical to drastically reduce plastic pollution of marine habitats.

Document the area: map the marine habitats that are most vulnerable to plastic pollution, with particular attention to deep-sea habitats –where plastic pollution is less well understood– and assess the overlap of vulnerable habitats with areas of high concentration of marine litter.

Take action: develop a protocol for the removal of plastics in vulnerable marine ecosystems.

References

[1] Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768–771.

[2] Sherrington, C. (2016). Plastics in the Marine Environment. Eunomia Research & Consulting Ltd.

[3] Forrest, A., Giacovazzi, L., Dunlop, S., Reisser, J., Tickler, D., Jamieson, A., & Meeuwig, J. J. (2019). Eliminating plastic pollution: how a voluntary contribution from industry will drive the circular plastics economy. *Frontiers in Marine Science*, 6, Article 627.

[4] Chiba, S., Saito, H., Fletcher, R., Yogi, T., Kayo, M., Miyagi, S., Ogido, M., & Fujikura, K. (2018). Human footprint in the abyss: 30 year records of deep-sea plastic debris. *Marine Policy*, 96, 204–212.

[5] Kühn, S., Rebolledo, E. L. B., & Franeker, J. A. (2015). Deleterious effects of litter on marine life. In M. Bergmann, L. Gutow, & M. Klages (Eds.), *Marine Anthropogenic Litter* (pp. 75–116). Springer International Publishing.

[6] Arthur, C., Baker, J., & Bamford, H. (Eds.). (2009). *Proceedings of the International Research Workshop on the Occurrence, Effects and Fate of Microplastic Marine Debris*. NOAA Technical Memorandum NOS-OR&R-30.

[7] Commission Recommendation of 18 October on the definition of nanomaterial. (Text with EEA relevance). (2011/696/EU). *Official Journal of the European Union*, L275, 20 October 2011.

[8] Peng, G., Bellerby, R., Zhang, F., Sun, X., & Li, D. (2020). The ocean's ultimate trashcan: Hadal trenches as major depositories for plastic pollution. *Water Research*, 168, Article 115121.

[9] Woodall, L. C., Sanchez-Vidal, A., Canals, M., Paterson, G. L., Coppock, R., Sleight, V., Calafat, A., Rogers, A. D., Narayanaswamy, B. E., & Thompson, R. C. (2014). The deep sea is a major sink for microplastic debris. *Royal Society Open Science*, 1(4), Article 140317.

[10] Aguilar, R., Marín, P., Álvarez, H., Blanco J., & Sánchez, N. (2020). *Plastic in the deep: An invisible problem. How the seafloor becomes a plastic trap*. Oceana. https://eu.oceana.org/sites/default/files/oceana-plastic_in_the_deep_an_invisible_problem.pdf

[11] Tubau, X., Canals, M., Lastras, G., Rayo, X., Rivera, J., & Amblas, D. (2015). Marine litter on the floor of deep submarine canyons of the Northwestern Mediterranean Sea: The role of hydrodynamic processes. *Progress in Oceanography*, 134, 379–403.

[12] Moore, C. J. (2008). Synthetic polymers in the marine environment: A rapidly increasing, long-term threat. *Environmental Research*, 108(2), 131–139.

[13] Barboza, L. G. A., Vethaak, A. D., Lavorante, B. R., Lundebye, A. K., & Guilhermino, L. (2018). Marine microplastic debris: An emerging issue for food security, food safety and human health. *Marine Pollution Bulletin*, 133, 336–348.

[14] Kelly, B. C., Ikonomou, M. G., Blair, J. D., Morin, A. E., & Gobas, F. A. (2007). Food web-specific biomagnification of persistent organic pollutants. *Science*, *317*(5835), 236–239.

[15] Nelms, S. E., Galloway, T. S., Godley, B. J., Jarvis, D. S., & Lindeque, P. K. (2018). Investigating microplastic trophic transfer in marine top predators. *Environmental Pollution*, 238, 999–1007.

[16] Bonello, G., Varrella, P., & Pane, L. (2018). First evaluation of microplastic content in benthic filter-feeders of the Gulf of La Spezia (Ligurian Sea). *Journal of Aquatic Food Product Technology*, 27(3), 284–291.

[17] Schwabl, P., Köppel, S., Königshofer, P., Bucsics, T., Trauner, M., Reiberger, T., & Liebmann, B. (2019). Detection of various microplastics in human stool: A prospective case series. *Annals of Internal Medicine*, 171, 453–457.

[18] Ragusa, A., Svelato, A., Santacroce, C., Catalano, P., Notarstefano, V., Carnevali, O., Papa, F., Rongioletti, M. C. A., Biaocco, F., Draghi, S., S'Amore, E., Rinaldo, D., Matta, M., & Giorgini, E. (2021). Plasticenta: First evidence of microplastics in human placenta. *Environment International*, *146*, Article 106274.

[19] Stafford, C., & Wentworth, J., C. 2016. Marine Microplastic Pollution. Houses of Parliament. Parliamentary Office of Science & Technology. *POSTnote*, *528*(June 2016).

[20] Haegerbaeumer, A., Mueller, M. T., Fueser, H., & Traunspurger, W. (2019). Impacts of micro-and nano-sized plastic particles on benthic invertebrates: A literature review and gap analysis. *Frontiers in Environmental Science*, *7*, Article 17.

[21] Biamis, C., O'Driscoll, K., & Hardiman, G. (2021). Microplastic toxicity: a review of the role of marine sentinel species in assessing the environmental and public health impacts. *Case Studies in Chemical and Environmental Engineering*, *3*, Article 100073.

[22] Leslie, H. A., Van Velzen, M. J., Brandsma, S. H., Vethaak, A. D., Garcia-Vallejo, J. J., & Lamoree, M. H. (2022). Discovery and quantification of plastic particle pollution in human blood. *Environment International*, 163, 107199.

[23] Akhbarizadeh, R., Moore, F., & Keshavarzi, B. (2019). Investigating microplastics bioaccumulation and biomagnification in seafood from the Persian Gulf: A threat to human health? *Food Additives and Contaminants, Part A*, *36*(11), 1696–1708.

[24] Rossi, S., Bramanti, L., Gori, A., & Orejas, C. (Eds.). (2017). *Marine animal forests: The ecology of benthic biodiversity hotspots*. Springer International Publishing.

[25] Vegter, A. C., Barletta, M., Beck, C., Borrero, J., Burton, H., Campbell, M. L., Costa, M. F., Eriksen, M., Eriksson, C., Estrades, A., Gilardi, K. V. K., Hardesty, B. D., Sul, J. A. I., Lavers, J. L., Lazar, B., Lebreton, L., Nichols, W. J., Ribic, C. A., Ryan, P. G., Schuyler, Q. A., Smith, S. D. A., Takada, H., Townsend, K. A., Wabnitz, C. C. C., Wilcox, C., Young, L. C., Hamann, M., & Ivar do Sul, J. A. (2014). Global research priorities to mitigate plastic pollution impacts on marine wildlife. *Endangered Species Research*, *25*, 225–247.

[26] Chiappone, M., Dienes, H., Swanson, D. W., & Miller, S. L. (2005). Impacts of lost fishing gear on coral reef sessile invertebrates in the Florida Keys National Marine Sanctuary. *Biology Conservation*, 121, 221–230.

[27] Smith, S. D. A., & Hattori, H. (2008). Corals versus monofilament: Corals fight back in Savusavu Bay, Fiji. *Coral Reefs*, *27*, 321.

[28] Galgani, F., Barnes, D. K. A., Deudero, S., Fossi, M. C., Ghiglione, J.F., Hema, T., Jorissen, F. J., Karapanagioti, H.K., Katsanevakis, S., Klasmeier, J., von Moos, N., Pedrotti, M. L., Raddadi, N., Sobral, P., Zambianchi, E., & Briand, F. (2014). Executive Summary. In F. Brand (Ed.), *Marine litter in the Mediterranean and Black Seas* (pp. 7–20). CIESM Workshop Monograph No. 46. CIESM Publisher.

[29] Wright, S. L., Thompson, R. C., & Galloway, T. S. (2013). The physical impacts of microplastics on marine organisms: A review. *Environmental Pollution*, *178*, 483–492.

[30] Corcoran, P. L. (2015). Benthic plastic debris in marine and fresh water environments. *Environmental Science: Processes & Impacts*, *17*(8), 1363–1369.

[31] Botterell, Z. L., Beaumont, N., Dorrington, T., Steinke, M., Thompson, R. C., & Lindeque, P. K. (2019). Bioavailability and effects of microplastics on marine zooplankton: A review. *Environmental Pollution*, *245*, 98–110.

[32] Macfadyen, G., Huntington, T., & Cappell, R. (2009). *Abandoned, lost or otherwise discarded fishing gear*. UNEP Regional Seas Reports and Studies No. 185; FAO Fisheries and Aquaculture Technical Paper No. 523. United Nations Environment Programme/Food and Agriculture Association.

[33] Consoli, P., Romeo, T., Angiolillo, M., Canese, S., Esposito, V., Salvati, E., Scotti, G., Andaloro, F., & Tunesi, L. (2019). Marine litter from fishery activities in the Western Mediterranean Sea: The impact of entanglement on marine animal forests. *Environmental Pollution*, *249*, 472–481.

[34] Donohue, M. J., Boland, R. C., Sramek, C. M., & Antonelis, G. A. (2001). Derelict fishing gear in the northwestern Hawaiian Islands: Diving surveys and debris removal in 1999 confirm threat to coral reef ecosystems. *Marine Pollution Bulletin*, *42*, 1301–1312.

[35] Abu-Hilal, A., & Al-Najjar, T. (2009). Marine litter in coral reef areas along the Jordan Gulf of Aqaba, Red Sea. *Journal of Environmental Management*, *90*, 1043–1049.

[36] Al-Zawaidah, H., Ravazzolo, D., & Friedrich, H. (2021). Macroplastics in rivers: present, knowledge, issues and challenges. *Environmental Science: Processes & Impacts*, *23*(4), 535–552.

[37] Lebreton, L. C., van der Zwet, J., Damsteeg, J.-W., Slat, B., Andrady, A., & Reisser, J. (2017). River plastic emissions to the world's oceans. *Nature Communications*, 8, Article 15611.

[38] Meijer, L. J. J., van Emmerik, T., van der Ent, R., Schmidt, C., & Lebreton, L. (2021). More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. *Science Advances*, *7*, Article eaaz5803.

[39] Wilcox, C., Mallos, N. J., Leonard, G. H., Rodriguez, A., & Hardesty, B. D. (2016). Using expert elicitation to estimate the impacts of plastic pollution on marine wildlife. *Marine Policy*, *65*, 107–114.

[40] Roman, L., Schuyler, Q., Wilcox, C., & Hardesty, B. D. (2020). Plastic pollution is killing marine megafauna, but how do we prioritize policies to reduce mortality? *Conservation Letters*, *14*(2), Article e12781.

[41] Axelsson, C., & van Sebille, E. (2017). Prevention through policy: Urban macroplastic leakages to the marine environment during extreme rainfall events. *Marine Pollution Bulletin*, *124*(1), 211–227.

[42] Wilson, S. P., & Verlis, K. M. (2017). The ugly face of tourism: Marine debris pollution linked to visitation in the southern Great Barrier Reef, Australia. *Marine Pollution Bulletin*, *117*(1-2), 239–246.

[43] Grelaud, M., & Ziveri, P. (2020). The generation of marine litter in Mediterranean island beaches as an effect of tourism and its mitigation. *Scientific Reports*, *10*, Article 20326.

[44] FAO. (2021). Assessment of agricultural plastics and their sustainability. A call for action. FAO. https://www.fao.org/3/cb7856en/cb7856en.pdf

[45] Dahl, M., Bergman, S., Björk, M., Diaz-Almela, E., Granberg, M., Gullström, M., Leiva-Dueñas, C., Magnusson, K., Marco-Méndez, C., Piñeiro-Juncal, N., & Mateo, M.A. (2021). A temporal record of microplastic pollution in Mediterranean seagrass soils. *Environmental Pollution*, *273*, Article 116451.

[46] Richardson, K., Hardesty, B. D., & Wilcox, C. (2019). Estimates of fishing gear loss rates at a global scale: A literature review and meta-analysis. *Fish and Fisheries*, *20*(6), 1218–1231.

[47] Glas, M. S., Sato, Y., Ulstrup, K. E., & Bourne, D. G. (2012). Biogeochemical conditions determine virulence of black band disease in corals. *ISME Journal*, *6*, 1526–1534.

[48] Lamb, J.B., Willis, B. L., Fiorenza, E. A., Couch, C. S., Howard, R., Rader, D. N., True, J. D., Kelly, L. A., Ahmad A., Jompa, J., & Harvell, C. D. (2018). Plastic waste associated with disease on coral reefs. *Science*, *359*, 460–462.

[49] Sweet, M., Stelfox, M., & Lamb, J. (2019). *Plastics and shallow water coral reefs. Synthesis of the science for policy-makers*. United Nations Environment Programme.

[50] Sweet, M., & Bythell, J. (2015). White Syndrome in Acropora muricata: Nonspecific bacterial infection and ciliate histophagy. *Molecular Ecology*, *24*(5), 1150–1159.

[51] Sweet, M. J., & Séré, M. G. (2016). Ciliate communities consistently associated with coral diseases. *Journal of Sea Research*, *113*, 119–131.

[52] Lewis, C. F., Slade, S. L., Maxwell, K. E., & Matthews, T. R. (2009). Lobster trap impact on coral reefs: Effects of wind-driven trap movement, New Zealand. *Journal of Marine and Freshwater Research*, *43*(1), 271–282.

[53] Angiolillo, M., & Canese, S. (2018). Deep gorgonians and corals of the Mediterranean Sea. In C. Duque Beltran, & E. Tello Camacho (Eds.), *Corals in a Changing World* (pp. 29–49). IntechOpen.

[54] Ferrigno, F., Appolloni, L., Russo, G. F., & Sandulli, R. (2017). Impact of fishing activities on different coralligenous assemblages of Gulf of Naples (Italy). *Journal of Marine Biology Association of the United Kingdom*, *98*, 1–10.

[55] Mueller, J., Bill, N., Reinach, M., Lasut, M., Freund, H., & Schupp, P. (2022). A comprehensive approach to assess marine macro litter pollution and its impacts on corals in the Bangka Strait, North Sulawesi, Indonesia. *Marine Pollution Bulletin*, *175*, Article 113369.

[56] Schleyer, M. H., & Tomalin, B. J. (2000). Damage on South African coral reefs and an assessment of their sustainable diving capacity using a fisheries approach. *Bulletin of Marine Science*, *67*(3), 1025–1042.

[57] Worm, B., Barbier, E. B., Beaumont, N., Duffy, J. E., Folke, C., Halpern, B. S., Jackson, J. B. C., Lotze, H. K., Micheli, F., Palumbi, S. R., Sala, E., Selkoe, K. A., Stachowicz, J. J., & Watson, R. (2006). Impacts of biodiversity loss on ocean ecosystem services. *Science*, *314*(5800), 787–790.

[58] Rogers, A., Blanchard, J. L., & Mumby, P. J. (2014). Vulnerability of coral reef fisheries to a loss of structural complexity. *Current Biology*, *24*(9), 1000–1005.

[59] Allen, A. S., Seymour, A. C., & Rittschof, D. (2017). Chemoreception drives plastic consumption in a hard coral. *Marine Pollution Bulletin*, *124*, 198–205.

[60] Hall, N. M., Berry, L. E., Rintoul, L., & Hoogenboom, M. O. (2015). Microplastic ingestion by scleractinian corals. *Marine Biology*, *162*, 725–732.

[61] Axworthy, J. B., & Padilla-Gamiño, J. L. (2019). Microplastics ingestion and heterotrophy in thermally stressed corals. *Scientific Reports*, *9*, Article 18193.

[62] Hankins, C., Duffy, A., & Drisco, K. (2018). Scleractinian coral microplastic ingestion: Potential calcification effects, size limits, and retention. *Marine Pollution Bulletin*, *135*, 587–593.

[63] Berry, K. L. E., Epstein, H. E., Lewis, P. J., Hall, N. M., & Negri, A. P. (2019). Microplastic contamination has limited effects on coral fertilisation and larvae. *Diversity*, *11*(12), Article 228.

[64] Chapron, L., Peru, E., Engler, A., Ghiglione, J. F., Meistertzheim, A. L., Pruski, A. M., Purser, A., Vétion, G., Galand, P. E., & Lartaud, F. (2018). Macro- and microplastics affect cold-water corals growth, feeding and behaviour. *Scientific Reports*, *8*(1), Article 15299.

[65] Rotjan, R. D., Sharp, K. H., Gauthier, A. E., Yelton, R., Baron Lopez, E. M., Carilli, J., Kagan, J.C., & Urban-Rich, J. (2019). Patterns, dynamics and consequences of microplastic ingestion by the temperate coral, *Astrangia poculata*. *Proceedings of the Royal Society B*, *286*, Article 20190726.

[66] Reichert, J., Schellenberg, J., Schubert, P., & Wilke, T. (2018). Responses of reef building corals to microplastic exposure. *Environmental Pollution*, *237*, 955–960.

[67] Reichert, J., Arnold, A. L., Hoogenboom, M. O., Schubert, P., & Wilke, T. (2019). Impacts of microplastics on growth and health of hermatypic corals are species-specific. *Environmental Pollution*, *254*, Article 113074.

[68] Jones, R., Ricardo, G. F., & Negri, A. P. (2015). Effects of sediments on the reproductive cycle of corals. *Marine Pollution Bulletin*, *100*, 13–33.

[69] Berry, K. L. E., Hoogenboom, M. O., Brinkman, D. L., Burns, K. A., & Negri, A. P. (2017). Effects of coal contamination on early life history processes of a reef-building coral, *Acropora tenuis*. *Marine Pollution Bulletin*, *114*(1), 505–514.

[70] Ricardo, G. F., Jones, R. J., Negri, A. P., & Stocker, R. (2016). That sinking feeling: Suspended sediments can prevent the ascent of coral egg bundles. *Scientific Reports*, *6*, Article 21567.

[71] Carreiro-Silva, M., Braga-Henriques, A., Matos, V., Porteiro, F. M., & Ocaña, O. (2011). *Isozoanthus primnoidus*, a new species of zoanthid (Cnidaria: Zoantharia) associated with the gorgonian *Callogorgia verticillata* (Cnidaria: Alcyonacea). *ICES Journal of Marine Science*, *68*(2), 408–415.

[72] Ricardo, G. F., Jones, R. J., Clode, P. L., Humanes, A., & Negri, A. P. (2016). Suspended sediments limit coral sperm availability. *Scientific Reports*, *5*, Article 18084.

[73] Asoh, K., Yoshikawa, T., Kosaki, R., & Marschall, E. A. (2004). Damage to cauliflower coral by monofilament fishing lines in Hawaii. *Conservation Biology*, *18*, 1645–1650.

[74] Bavestrello, G., Cerrano, C., Zanzi, D., & Cattaneo-Vietti, R. (1997). Damage by fishing activities to the gorgonian coral *Paramuricea clavata* in the Ligurian Sea. *Aquatic Conservation*, *7*, 253–262.

[75] Yoshikawa, T., & Asoh, K. (2004). Entanglement of monofilament fishing lines and coral death. *Biological Conservation*, *117*, 557–560.

[76] Corinaldesi, C., Canensi, S., Dell'Anno, A., Tangherlini, M., Di Capua, I., Varrella, S., Willis, T. J., Cerrano, C., & Danovaro, R. (2021). Multiple impacts of microplastics can threaten marine habitat-forming species. *Communications Biology*, *4*, Article 431.

[77] Taylor, M. L., Gwinnett, C., Robinson, L. F., & Woodall, L. C. (2016). Plastic microfiber ingestion by deep-sea organism. *Scientific Reports*, *6*, Article 33997.

[78] June, J. (1990). Type, source, and abundance of trawl-caught marine litter off Oregon, in the Eastern Bering Sea, and in Norton Sound in 1988. In R. S. Shomura & M. L. Godfrey (Eds.), *Proceedings of the Second International Conference on Marine Debris* (pp. 279–301). NOAA Technical Memo NMFS-SWFSC-154. U.S. Department of Commerce.

[79] Mordecai, G., Tyler, P. A., Masson, D.G., & Huvenne, V. A. I. (2011). Litter in submarine canyons off the west coast of Portugal. *Deep-Sea Research Part II: Topical Studies in Oceanography*, *58*, 2489–2496.

[80] Pham, C. K., Gomes-Pereira, J. N., Isidro, E. J., Santos, R. S., & Morato, T. (2013). Abundance of litter on Condor seamount (Azores, Portugal, Northeast Atlantic). *Deep-Sea Research Part II: Topical Studies in Oceanography*, *98*, 204–208.

[81] Fabri, M. C., Pedel, L., Beuck, L., Galgani, F., Hebbeln, D., & Freiwald, A. (2014). Megafauna of vulnerable marine ecosystems in French Mediterranean submarine canyons: Spatial distribution and anthropogenic impacts. *Deep-Sea Research Part II: Topical Studies in Oceanography*, *104*, 184–207.

[82] Bo, M., Bava, S., Canese, S., Angiolillo, M., Cattaneo-Vietti, R., & Bavestrello, G. (2014). Fishing impact on deep Mediterranean rocky habitats as revealed by ROV investigation. *Biological Conservation*, *171*, 167–176.

[83] Bo, M., Angiolillo, M., Bava, S., Betti, F., Canese, S., Cattaneo-Vietti, R., Cau, A., Priori, C., Sandulli, R., Santangelo, G., Tunesi, L., & Bavestrello, G. (2015). Fishing impact on Italian coral gardens and management of Vulnerable Marine Ecosystems. In H. Langar, C. Bouafif, & A. Ouerghi (Eds.), *Proceedings of the 1st Mediterranean Symposium on the conservation of Dark Habitats* (pp. 21–26). UNEP/MAP–RAC/SPA.

[84] Angiolillo, M., di Lorenzo, B., Farcomeni, A., Bo, M., Bavestrello, G., Santangelo, G., Cau, A., Mastascusa, V., Cau, A., Sacco, F., & Canese, S. (2015). Distribution and assessment of marine debris in the deep Tyrrhenian Sea (NW Mediterranean Sea, Italy). *Marine Pollution Bulletin*, *92*, 149–159.

[85] Consoli, P., Sinopoli, M., Deidun, A., Canese, S., Berti, C., Andaloro, F., & Romeo, T. (2020). The impact of marine litter from fish aggregation devices on vulnerable marine benthic habitats of the central Mediterranean Sea. *Marine Pollution Bulletin*, *152*, Article 110928.

[86] Smith, S. D. A., & Edgar, R. J. (2014). Documenting the density of subtidal marine debris across multiple marine and coastal habitats. *PLOS ONE*, *9*(4), e94593.

[87] Morato, T., Hoyle, S. D., Allain, V., & Nicol, S. J. (2010). Seamounts are hotspots of pelagic biodiversity in the open ocean. *Proceedings of the National Academy of Sciences*, *107*(21), 9707–9711.

[88] Marín, P., Aguilar, R., García, S., & Pardo, E. (2011). Montes submarinos del Mediterráneo: Seco de Palos. Propuesta de protección. Oceana. https://europe.oceana.org/sites/default/files/reports/oceana_montes_submarinos_del_mediterraneo_seco_de_palos.pdf

[89] Battaglia, P., Consoli, P., Annemdolia, G., D'Alessandro, M., Bo, M., Vicchio, T. M., Pedà, C., Cavallaro, M., Andaloro, F., & Romero, T. (2019). Colonization of floats from submerged derelict fishing gears by four protected species of deep-sea corals and barnacles in the Strait of Messina (Central Mediterranean Sea). *Marine Pollution Bulletin*, *148*, 61–65.

[90] De Sá, L. C., Oliveira, M., Ribeiro, F., Lopez Rocha, T, & Futter, M. N. (2018). Studies of the effects of microplastics on aquatic organisms: What do we know and where should we focus our efforts in the future? *Science of The Total Environment*, *645*, 1029–1039.

[91] Bråte, I. L. N., Huwer, B., Thomas, K. V., Eidsvoll, D. P., Halsband, C., Almroth, B. C., & Lusher, A. (2017). *Micro- and macro-plastics in marine species from Nordic waters*. TemaNord 2017:549. Nordic Council of Ministers.

[92] Girard, E., Lasut, M., & Wörheide, G. (2018, September 5-7). *Microplastic mapping in sponges: Potential bioindicators?* [Poster session]. 5th Young Reef Scientists Meeting. Munich, Germany.

[93] Weisz, J. B., Lindquist, N., & Martens, C. S. (2008). Do associated microbial abundances impact marine demosponge pumping rates and tissue densities? *Oecologia*, *155*, 367–376.

[94] Modica, L., Lanuza, P., & García-Castrillo, G. (2020). Surrounded by microplastic, since when? Testing the feasibility of exploring past levels of plastic microfibre pollution using natural history museum collections. *Marine Pollution Bulletin*, *151*, Article 110846.

[95] Goldstein Ascer, L., & Reis Custodio, M. (2017). Plastic additive changes contraction patterns in Hymeniacidon heliophila: a changepoint analysis. In B. Picton & C. Morrow (Eds.), *10th World Sponge Conference* (pp. 125–126). National University Ireland, Galway.

[96] Deudero, S., & Alomar, C. (2018). Revising interactions of plastics with marine biota: Evidence from the Mediterranean. In F. Brand (Ed.), *Marine litter in the Mediterranean and Black Seas* (pp. 79–85). CIESM Workshop Monograph No. 46. CIESM Publisher.

[97] Tekman, M. B., Krumpen, T., & Bergmann, M. (2017). Marine litter on deep Arctic seafloor continues to increase and spreads to the North at the Hausgarten observatory. *Deep-Sea Research Part I: Oceanographic Research Papers*, *120*, 88–99.

[98] Zhang, D., Liu, X., Huang, W., Li, J., Wang, C., Zhang, D, & Zhang, C. (2020). Microplastic pollution in deep-sea sediments and organisms of the Western Pacific Ocean. *Environmental Pollution*, *259*, Article 113948.

[99] Kühn, S., Bravo Rebolledo, E. L., & van Franeker, J. A. (2015). Deleterious effects of litter on marine life. In M. Bergmann, L. Gutow, & M. Klages (Eds.), *Marine Anthropogenic Litter* (pp. 75–116).). Springer International Publishing.

[100] Maldonado, M., Aguilar, R., Blanco, J., García, S., Serrano, A., & Punzón, A. (2015). Aggregated clumps of lithistid sponges: A singular, reef-like bathyal habitat with relevant paleontological connections. *PLOS ONE*, *10*(5), Article e0125378.

[101] Oliveira, F., Monteiro, P., Bentes, L., Sales Henriques, N., Aguilar, R., & Gonçalvez, J. M. S. (2015). Marine litter in the upper São Vicente submarine canyon (SW Portugal): Abundance, distribution, composition and fauna interactions. *Marine Pollution Bulletin*, *97*(1-2), 401–407.

[102] Farrell, P., & Nelson, K. (2013). Trophic level transfer of microplastic: Mytilus edulis (L.) to Carcinus maenas (L.). *Environmental Pollution*, *177*, 1–3.

[103] Ward, J. E., Rosa, M., & Shumway, S. E. (2019). Capture, ingestion, and egestion of microplastics by suspension-feeding bivalves: A 40-year history. *Anthropocene Coasts*, *2*, 39–49.

[104] Agersnap, S. (2013). *Mikroplastik i havmiljøet – Metode til kvantificering af mikroplastik i havvand, blåmusling og fisk.* [BSc Thesis, Aarhus University].

[105] De Witte, B., Devriese, L., Bekaert, K., Hoffman, S., Vandermeersch, G., Cooreman, K., & Robbens, J. (2014). Quality assessment of the blue mussel (*Mytilus edulis*): Comparison between commercial and wild types. *Marine Pollution Bulletin*, *85*, 146–155.

[106] Van Cauwenberghe, L., Claessens, M., Vandegehuchte, M. B., & Janssen, C. R. (2015). Microplastics are taken up by mussels (*Mytilus edulis*) and lugworms (*Arenicola marina*) living in natural habitats. *Environmental Pollution*, *199*, 10–17.

[107] Reguera, P., Viñas, L., & Gago, J. (2019). Microplastics in wild mussels (*Mytilus* spp.) from the north coast of Spain. *Scientia Marina*, *83*(4), 337–347.

[108] Ivar do Sul, J. A., & Costa, M. F. (2014). The present and future of microplastic pollution in the marine environment. *Environmental Pollution*, *185*, 352–364.

[109] Wegner, A., Besseling, E., Foekema, E. M., Kamermans, P., & Koelmans, A. A. (2012). Effects of nanopolystyrene on the feeding behavior of the blue mussel (*Mytilus edulis* L.). *Environmental Toxicology and Chemistry*, *31*(11), 2490–2497.

[110] Green, D. S., Colgan, T. J., Thompson, R. C., & Carolan, J. C. (2018). Exposure to microplastics reduces attachment strength and alters the haemolymph proteome of blue mussels (*Mytilus edulis*). *Environmental Pollution*, *246*, 423–434.

[111] Browne, M. A., Dissanayake, A., Galloway, T. S., Lowe, D. M., & Thompson, R. C. (2008). Ingested microscopic plastic translocates to the circulatory system of the mussel, *Mytilus edulis* (L.). *Environmental Science and Technology*, *42*, 5026–5031.

[112] Brillant, M. G. S., & MacDonald, B. A. (2000). Postingestive selection in the sea scallop, *Placopecten magellanicus* (Gmelin): The role of particle size and density. *Journal of Experimental Marine Biology and Ecology*, *253*(2), 211–227.

[113] Sussarellu, R., Suquet, M., Thomas, Y., Lambert, C., Fabioux, C., Pernet, M. E. J., Le Goïc, N., Quillien, V., Mingant, C., Epelboin, Y., Corporeau, C., Guyomarch, J., Robbens, J., Paul-Pont, I., Soudant, P., & Huvet, A. (2016). Oyster reproduction is affected by exposure to polystyrene microplastics. *Proceedings of the National Academy of Sciences*, *113*(9), 2430–2435.

[114] Suquet, M., Arsenault-Pernet, E.-J., Goic, N. L., Soudant, P., Mingant, C., Sussarellu, R., Boulais, M., Epelboin, Y., Robbens, J., & Huvet, A. Microplastics are love-killers for pacific oysters! (2014). In A.-L. Cassone & P. Soudant (Eds.), *International Workshop: Fate and Impact of Microplastics in Marine Ecosystems* (p. 42). Micro2014.

[115] Gardon, T., Reisser, C., Soyez, C., Quillien, V., & Le Moullac, G. (2018). Microplastics affect energy balance and gametogenesis in the pearl oyster *Pinctada margaritifera*. *Environmental Science and Technology*, *52*, 5277–5286.

[116] Gutow, L., Eckerlebe, A., Giménez, L., & Saborowski, R. (2016). Experimental evaluation of seaweeds as a vector for microplastics into marine food webs. *Environmental Science and Technology*, *50*, 915–923.

[117] Sundbæk, K. B., Due Würtzner Koch, I., Greve Villaro, C., Rasmussen, N. S., Løvstad Holdt, S., & Hartmann, N. B. (2018). Sorption of fluorescent polystyrene microplastic particles to edible seaweed *Fucus vesiculosus*. *Journal of Applied Phycology*, *30*(5), 2923–2927.

[118] Chan, H. W., Lau, T. C., Ang, P. O., Wu, M., & Wong, P. K. (2004). Biosorption of di(2-ethylhexyl) phthalate by seaweed biomass. *Journal of Applied Phycology*, 16, 263–274.

[119] Ma, T., Christie, P., Teng, Y., & Luo, Y. (2013). Rape (*Brassica chinensis* L.) seed germination, seedling growth, and physiology in soil polluted with di-n-butyl phthalate and bis(2-ethylhexyl) phthalate. *Environmental Science and Pollution Research*, *20*, 5289–5298.

[120] Yokota, K., Waterfield, H., Hastings, C., Davidson, E., Kwietniewski, E., & Wells, B. (2017). Finding the missing piece of the aquatic plastic pollution puzzle: Interaction between primary producers and microplastics. *Limnology and Oceanography Letters*, *2*(4), 91–104.

[121] Seng, N., Lai, S., Fong, J., Saleh, M. F., Cheng, C., Cheok, Z. Y., & Todd, P. A. (2020). Early evidence of microplastics on seagrass and macroalgae. *Marine and Freshwater Research*, *71*(8), 922–928.

[122] Bhattacharya, P., Lin, S., Turner, J. P., & Ke, P. C. (2010). Physical adsorption of charged plastic nanoparticles affects algal photosynthesis. *Journal of Physical Chemistry C*, *114*, 16556–16561.

[123] Pérez-Pérez, M. E., Lemaire, S. D., & Crespo, J. L. (2012). Reactive oxygen species and autophagy in plants and algae. *Plant Physiology*, *160*(1), 156–164.

[124] Huang, H., Ullah, F., Zhou, D. X., Yi, M., & Zhao, Y. (2019). Mechanisms of ROS regulation of plant development and stress responses. *Frontiers in Plant Science*, *10*, Article 800.

[125] Apel, K., & Hirt, H. (2004). Reactive oxygen species: Metabolism, oxidative stress, and signal transduction. *Annual Review of Plant Biology*, *55*, 373-399.

[126] Oceana. (2007). *Estudio bionómico de Cabrera: Estudio bionómico de los ecosistemas profundos del parque nacional marítimoterrestre del archipiélago de Cabrera y sus alrededores*. Oceana.

[127] Ferrigno, F., Appolloni, L., Donnarumma, L., Di Stefano, F., Rendina, F., Sandulli, R., & Russo, G. F. (2021). Diversity loss in coralligenous structuring species impacted by fishing gear and marine litter. *Diversity*, *13*, Article 331.

[128] Datu, S. S., Supriadi, & Tahir, A. (2019). Microplastic in *Cymodocea rotundata* seagrass blades. *International Journal of Environment, Agriculture and Biotechnology*, *4*(6), 1758–1761.

[129] Sawalman, R., Werorilangi, S., Ukkas, M., Mashoreng, S., Yasir, I., & Tahir, A. (2018). Microplastic abundance in sea urchins (*Diadema sitosum*) from seagrass beds of Barranglompo Island, Makassar, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *763*, Article 012057.

[130] Dahl, M., Bergman, S., Björk, M., Díaz-Almela, E., Granberg, M., Gullström, M., Leiva-Dueñas, C., Magnusson, K., Marco-Méndez, C., Piñeiro-Juncal, N., & Mateo, M. A. (2021). A temporal record of microplastic pollution in Mediterranean seagrass soils. *Environmental Pollution*, *273*, Article 116451.

[131] Goss, H., Jaskiel, J., & Rotjan, R. (2018). *Thalassia testudinum* as a potential vector for incorporating microplastics into benthic marine food webs. *Marine Pollution Bulletin*, *135*, 1085–1089.

[132] Jones, K. L., Hartl, M. G. J., Bell, M. C., & Capper, A. (2020). Microplastic accumulation in a *Zostera marina* L. bed at Deerness Sound, Orkney, Scotland. *Marine Pollution Bulletin, 152*, Article 110883.

[133] Sora Datu, S., Supriadi, S., & Tahir, A. (2019). Microplastic in *Cymodocea rotundata* Seagrass Blades. *International Journal of Environment, Agriculture and Biotechnology, 5*(6), 1758–1761.

[134] Tahir, A., Samawi, M. F., Sari, K., Hidayat, R., Nimzet, R., Wicaksono, E. A., Asrul, L., & Werorilangi, S. (2019). Studies on microplastic contamination in seagrass beds at Spermonde Archipelago of Makassar Strait, Indonesia. *Journal of Physics: Conference Series, 1341*, Article 022008.

[135] Gerstenbacher, C. M., Finzi, A. C., Rotjan, R. D., & Novak, A. B. (2022). A review of microplastic impacts on seagrasses, epiphytes, and associated sediment communities. *Environmental Pollution, 303*, Article 119108.

[136] Sanchez-Vidal, A., Canals, M., de Haan, W. P., Romero, J., & Veny, M. (2021). Seagrasses provide a novel ecosystem service by trapping marine plastics. *Scientific Reports, 11*, Article 254.

[137] Balestri, E., Menicagli, V., Vallerini, F., & Lardicci, C. (2017). Biodegradable plastic bags on the seafloor: A future threat for seagrass meadows? *Science of the Total Environment, 605-606*, 755-763.

[138] Uhrin, A. V., & Schellinger, J. (2011). Marine debris impacts to a tidal fringing-marsh in North Carolina. *Marine Pollution Bulletin, 62*(12), 2605–2610.

[139] Viehman, S., Vander Pluym, J. L., & Schellinger, J. (2011). Characterization of marine debris in North Carolina salt marshes. *Marine Pollution Bulletin, 62*(12), 2771–2779.

[140] Pibot, A., & Claro, F. (2012). *Pressions et impacts - Méditerranée Occidentale. Pressions physiques et impacts associés. Autres perturbations physiques. Impacts écologiques des déchets marins*. Ministère de l'Écologie, du Développement durable et de l'Énergie, Agence des aires marine protégées & Ifremer.

[141] Uhrin, A. V., Matthews, T. R., & Lewis, C. (2014). Lobster trap debris in the Florida Keys National Marine Sanctuary: Distribution, abundance, density and patterns of accumulation. *Marine and Coastal Fisheries, 6*(1), 20–32.

[142] Uhrin, A.V., Fonseca, M. S., & DiDomenico, G. P. (2005). Effect of Caribbean spiny lobster traps on seagrass beds of the Florida Keys National Marine Sanctuary: Damage assessment and evaluation of recovery. *American Fisheries Society Symposium, 41*, 579–588.

[143] Grelaud, M., & Ziveri, P. (2020). The generation of marine litter in Mediterranean island beaches as an effect of tourism and its mitigation. *Scientific Reports, 10*, Article 20326.

[144] Schroeer, A., Aguilar, R., Blanco, J., Álvarez, H., & Marín, P. (2021). Fuera de temporada: la huella de plástico del turismo. Estudios del lecho marino en Mallorca y Valencia. Oceana. https://europe.oceana.org/sites/default/files/oceana_fuera_de_temporada_-_la_huella_de_plastico_del_turismo.pdf

[145] Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A. W. G., McGonigle, D., & Russell, A. E. (2004). Lost at sea: Where is all the plastic? *Science, 304*, 838.

[146] Thushari, G. G. N., Senevirathna, J. D. M., Yakupitiyage, A., & Chavanich, S. (2017). Effects of microplastics on sessile invertebrates in the eastern coast of Thailand: An approach to coastal zone conservation. *Marine Pollution Bulletin, 124*(1), 349–355.

[147] Goldstein, M. C., & Goodwin, D. S. (2013). Gooseneck barnacles (*Lepas* spp.) ingest microplastic debris in the North Pacific Subtropical Gyre. *PeerJ, 1*, Article e184.

[148] Angeletti, L., Montagna, P., Schembri, P. J., & Taviani, M. (2011, April 11-15). *Giant sessile barnacles contribute to the construction of cold-water coral habitats south of Malta (Mediterranean Sea)* [Conference paper]. 2nd Annual Meeting HERMIONE, Malaga, Spain.

[149] Dewar-Fowler, V. H. (2013). *Microplastic Study: Ingestion and translocation of microplastics in the Ecteinascidia diaphanis*. Invertebrates of the Coral Sea. The University of Queensland. https://www.gbri.org.au/SpeciesList/Ecteinascidiadiaphanis|VictoriaDewarFowler.aspx?PageContentID=4506

[150] Dewar-Fowler, V. H. (2017). *Uptake and biological impacts of microplastics and nanoplastics in sea squirts*. [Master's thesis, University of Exeter]. University of Exeter Repository. https://ore.exeter.ac.uk/repository/bitstream/handle/10871/32658/FowlerV.pdf

[151] Vered, G., Kaplan, A., Avisar, D., & Shenkar, N. (2019). Using solitary ascidians to assess microplastic and phthalate plasticizers pollution among marine biota: A case study of the Eastern Mediterranean and Red Sea. *Marine Pollution Bulletin, 138*, 618–625.

[152] Council Directive 92/42/EEC of 21 May 1992 on the conservation of natural hábitats and of wild fauna and flora. Official Journal of the European Communities, *L206, 22* July 1992.

[153] OSPAR Commission. (2019). *List of Threatened and/or Declining Species and Habitats*. https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats

[154] Helsinki Commission (HELCOM). (2013). *Red List of Baltic Sea underwater biotopes, habitats and biotope complexes*. Baltic Sea Environmental Proceedings No. 138. HELCOM. https://www.helcom.fi/wp-content/uploads/2019/10/BSEP138.pdf

[155] UNEP/MAP-SPA/RAC. (2018). *SPA/BD Protocol Annex II: List of endangered or threatened species*. United Nations Environment Programme/Mediterranean Action Plan. Specially Protected Areas Regional Activity Centre (SPA/RAC). https://www.rac-spa.org/sites/default/files/annex/annex_2_en_20182.pdf

[156] UNEP/MAP-RAC/SPA. (2015). *Action Plan for the conservation of habitats and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemo-synthetic*

phenomena in the Mediterranean Sea. (Dark Habitats Action Plan). United Nations Environment Programme/Mediterranean Action Plan. Regional Activity Centre for Specially Protected Areas (RAC/SPA). https://www.rac-spa.org/sites/default/files/action_plans/dark_habitats_ap.pdf

157 UNEP/MAP-RAC/SPA. (2008). *Action plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea*. United Nations Environment Programme/Mediterranean Action Plan. Regional Activity Centre for Specially Protected Areas (RAC/SPA). https://www.rac-spa.org/sites/default/files/action_plans/pacoralligene.pdf

158 UNEP/MAP-RAC/SPA. *Action plan for the conservation of marine vegetation in the Mediterranean Sea*. United Nations Environment Programme/Mediterranean Action Plan. Regional Activity Centre for Specially Protected Areas (RAC/SPA). https://www.rac-spa.org/sites/default/files/action_plans/ap_marine_vegetation_en_fr.pdf

159 Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). *Official Journal of the European Union, L164*, 25 June 2008.

160 Gubbay, S., Sanders, N., Haynes, T., Janssen, J. A. M., Rodwell, J. R., Nieto, A., García Criado, M., Beal, S., Borg, J., Kennedy, M., Micu, D., Otero, M., Saunders, G., & Calix, M. (2016). *European Red List of Habitats. Part 1. Marine habitats*. European Union. https://ec.europa.eu/environment/nature/knowledge/pdf/Marine_EU_red_list_report.pdf

161 DeWit, W., Towers Burns, E., Guinchard, J.-C., & Ahmed, N. (2021). *Plastics: The costs to society, the environment and the economy*. WWF. https://europe.nxtbook.com/nxteu/wwfintl/tcops/index.php#/p/2

162 Boucher, J., & Bilard, G. (2020). The Mediterranean: Mare plasticum. IUCN. https://portals.iucn.org/library/node/49124

163 Azoulay, D., Villa, P., Arellano, Y., Gordon, M., Moon, D., Miller, K., & Thompson, K. (2019). *Plastic & Health: The Hidden Costs of a Plastic Planet. CIEL*. https://www.ciel.org/wp-content/uploads/2019/02/Plastic-and-Health-The-Hidden-Costs-of-a-Plastic-Planet-February-2019.pdf

164 van Gennip, S. J., Dewitte, B., Garçon, V., Thiel, M., Popova, E., Drillet, Y., Ramos, M., Yannicelli, B., Bravo, L., Ory, N., Luna-Jorquera, G., & Gaymer, C. F. (2019). In search for the sources of plastic marine litter that contaminates the Easter Island Ecoregion. *Scientific Reports*, *9*, Article 19662.

165 Chassignet, E. P., Xu, X., & Zavala-Romero, O. (2021). Tracking marine litter with a global ocean model: Where does it go? Where does it come from? *Frontiers in Marine Science*, *8*, Article 667591.

166 Mansui, J., Darmon, G., Ballerini, T., van Canneyt, O., Ourmieres, Y., & Miaud, C. (2020). Predicting marine litter accumulation patterns in the Mediterranean basin: Spatio-temporal variability and comparison with empirical data. *Progress in Oceanography*, *182*, Article 102268.

167 Soto-Navarro, J., Jordá, G., Deudero, S., Alomar, C., Amores, A., & Compa, M. (2020). 3D hotspots of marine litter in the Mediterranean: A modeling study. *Marine Pollution Bulletin*, *155*, Article 111159.

168 Guerrini, F., Mari, L., & Casagrandi, R. (2021). The dynamics of microplastics and associated contaminants: Data-driven Lagrangian and Eulerian modelling approaches in the Mediterranean Sea. *Science of The Total Environment*, *777*, Article 145944.

169 Onink, V., Jongedijk, C. E., Hoffman, M. J., van Sebille, E., & Laufkötter, C. (2021). Global simulations of marine plastic transport show plastic trapping in coastal zones. *Environmental Research Letters*, *16*(6), Article 064053.

170 van Sebille, E., Aliani, S., Law, K. L., Maximenko, N., Alsina, J. M., Bagaev, A., Bergmann, M., Chapron, B., Chubarenko, I., Cózar, A., Delandmeter, P., Egger, M., Fox-Kemper, B., Garaba, S. P., Goddijn-Murphy, L., Hardesty, B. D., Hoffman, M. J., Isobe, A., ... Wichmann, D. (2020). The physical oceanography of the transport of floating marine debris. *Environmental Research Letters*, *15*, Article 023003.

171 van Franeker, J. A. (2005). Schoon Strand Texel 2005: *Onderzoeksresultaten van de schoonmaakactie van het Texelse strand op 20 april 2005*. Alterra speciale uitgave 2005/09. Alterra - Texel.

172 Veiga, J. M., Fleet, D., Kinsey, S., Nilsson, P., Vlachogianni, T., Werner, S., Galgani, F., Thompson, R. C., Dagevos, J., Gago, J., Sobral, P., & Cronin, R. (2016). *Identifying Sources of Marine Litter. MSFD GES TG Marine Litter Thematic Report*. JRC Technical Report. EUR 28309.

173 GESAMP. (2019). *Guidelines for the monitoring and assessment of plastic litter and microplastics in the ocean* (Kershaw, P.J., Turra, A., & Galgani, F. (Eds.). GESAMP Report No. 99. IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP/ISA Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. http://www.gesamp.org/publications/guidelines-for-the-monitoring-and-assessment-of-plastic-litter-in-the-ocean

174 Galgani, F., Deidun, A., Liubartseva, S., Gauci, A., Doronzo, B., Brandini, C., & Gerigny, O. (2019). *Monitoring and assessment guidelines for marine litter in Mediterranean MPAs*. Technical report of the Interreg/MED/AMARE project. IFREMER/AMARE. https://archimer.ifremer.fr/doc/00487/59840/

175 United Nations Environment Programme/Mediterranean Action Plan (UNEP/MAP). (2013). *Regional Plan on Marine Litter Management in the Mediterranean in the Framework of Article 15 of the Land Based Sources Protocol* (Decision IG.21/7). https://www.unep.org/unepmap/meetings/cop-decisions/cop18-outcome-documents

176 OSPAR Commission. (2014). *Marine Litter Regional Action Plan*. https://www.ospar.org/documents?v=34422

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