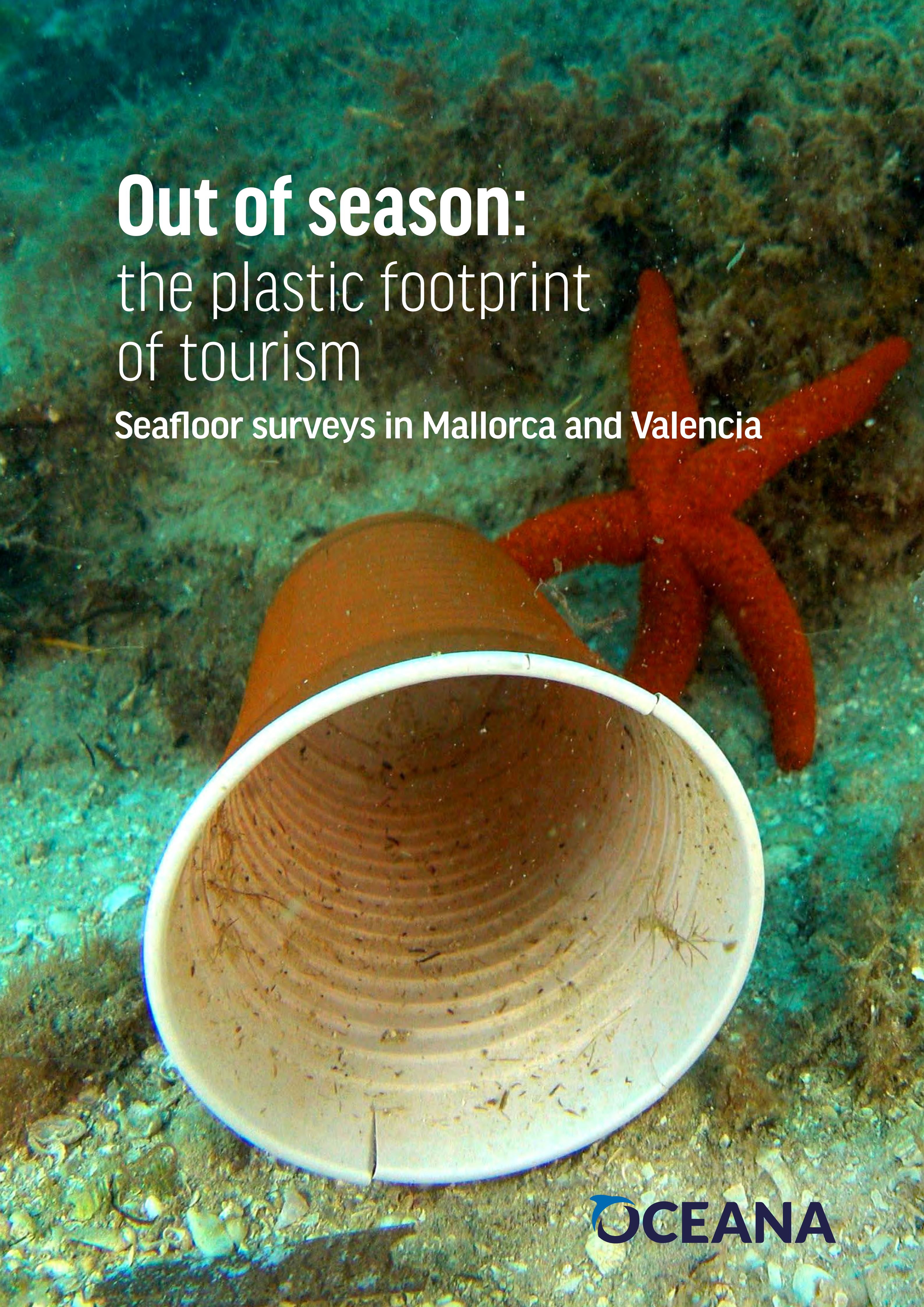
Out of season:
the plastic footprint of tourism

Seafloor surveys in Mallorca and Valencia



OCEANA

Contents

Credits

Suggested citation: Schroeer, A., Aguilar, R., Blanco, J., Álvarez, H., Marín, P. (2021). Out of season: the plastic footprint of tourism. Seafloor surveys in Mallorca and Valencia. Oceana, Madrid, 28 pp.

DOI: 10.5281/zenodo.5709912

Text: Anne Schroeer, Ricardo Aguilar, Jorge Blanco, Helena Álvarez, Pilar Marín

Review: Allison Perry, Natividad Sánchez, Vera Coelho

Editorial Support: Ángeles Sáez, Irene Campmany

Design: Yago Yuste

Cover photo: Red starfish (*Echinaster sepositus*) and plastic cup in Mallorca. @ Oceana / Enrique Talledo

November 2021

Oceana acknowledges the generous support of

Life BancaMarch

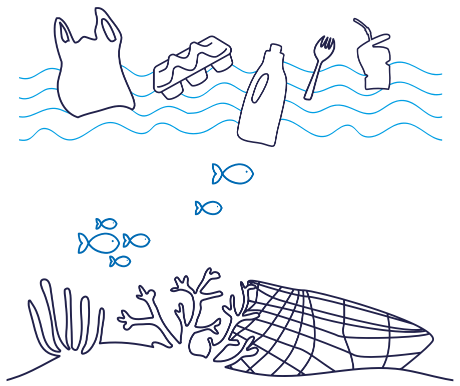
1. Executive summary

Plastic pollution on the seafloor has an irreversible impact on marine ecosystems and can seriously affect the health and behavior of wildlife. Such waste transforms seafloor habitats that are rich in flora and fauna into marine landfills, where plastics accumulate yet can go unnoticed because they are not visible from shore.

This problem can be particularly pronounced in places where large quantities of single-use plastics are used and discarded close to the sea, such as in coastal locations that are popular with tourists.

As part of a global project to investigate the extent of seabed plastics in biodiverse sites with high levels of tourism, Oceana scientists and divers surveyed a dozen different habitat types (including corals, sandy bottoms, and algal forests) along the coast of Valencia, and in six marine habitats off the island of Mallorca. The underwater surveys were conducted outside the tourist season and, in the case of Valencia, during the Covid-19 pandemic. Despite this, we found large quantities of plastic waste in every habitat type documented.

The most frequently observed items were single-use plastics, such as bags, food wrappers, packaging, cutlery, and drinking containers, as well as abandoned fishing gear.



Healthcare items, such as disposable masks and gloves, were also observed, in addition to other types of garbage. Wildlife, including several threatened species, was filmed in plastic-polluted areas, at risk of ingesting plastic fragments, growing upon them, or entangled in plastic debris. In other cases, species were settled on moving plastic pieces that can be transported outside their habitats.

© OCEANA / Enrique Talledo

Mallorca, Spain
Piece of plastic bag in the seabed.

Overall, our findings demonstrate that the excessive use of plastics is directly impacting delicate underwater habitats and the species that live in them. Our results add urgency to the need for plastic-free coastal regions, restaurants, and tourist resorts, and for significant reductions in the production of single-use plastics (SUPs).

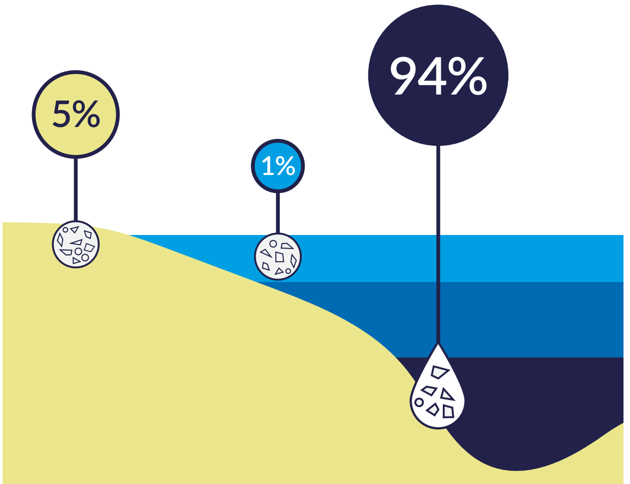
2. Introduction

Much of our planet is swimming in discarded plastic. Coastal regions, as well as the hotel and tourism industries, have a key role to play in addressing this problem. Since most of the plastics used in the tourism sector are made to be thrown away, and with hotels, restaurants, and takeaways often located directly on the seafront, these industries are responsible for large amounts of single-use plastics reaching the ocean.

At the same time as the tourism industry is one of the major contributors to plastic pollution,[1] it also depends heavily upon our planet's natural beauty. Increasing ocean plastic pollution in coastal areas represents a growing threat to the tourism industry itself, as holidaymakers are very sensitive to beaches and scenic areas being littered with plastic. With many local authorities lacking adequate infrastructure to keep up with plastic pollution, tourism is impacted as pristine areas are increasingly overwhelmed by plastic litter.

To make matters worse, the visible plastic litter on beaches barely hints at the magnitude of what lies hidden at the bottom of the sea. The bulk of all plastics that litter marine and coastal environments can be found below the surface.

Plastic littering the seafloor can be harmful to a wide range of species[3] and can disrupt sensitive ecosystems for centuries as it never degrades. Instead, it breaks into smaller and smaller plastic pieces, called 'microplastics'.



It is estimated that only 1% of plastics are in surface waters, 5% wash up on beaches, and the remaining 94% end up on the seafloor,[2] where they accumulate in underwater structures like seamounts, canyons, and escarpments.

To make the problem of plastic on the seafloor visible and to better understand its extent – specifically in tourist areas located in some of the world's most important biodiversity hotspots – Oceana documented seafloor plastics and their apparent impacts on ecosystems, using an underwater drone.

As part of this global project, we documented litter on the seafloor in the waters of coastal cities and holiday areas with high biodiversity, such as the island of Mallorca and the Valencian seaside in the Mediterranean. The coastal area close to Valencia has been identified as a hotspot of marine plastic pollution[4] and, at the same time, the site of a large variety of marine habitats that are representative of the broader Mediterranean. This combination allowed us to study a wide range of plastic impacts.[5] In Mallorca, the at-sea research focused on waters close to heavily frequented tourist areas.

While the problem of plastics on beaches and in floating debris is well known and documented, Oceana's research focused on determining the amount and types of plastic on the seafloor, close to beaches, and noting their apparent impacts on seafloor habitats and species.

In our seafloor plastic surveys, we answered questions such as: How much litter is on the seafloor? What types of plastic items are on the seafloor? What are the apparent impacts on marine animals and ecosystems? Our recommendations help to answer the critical question: what must be done to stop the rising tide of plastic?

Plastic pollution in the Mediterranean

The Mediterranean is the most plastic-contaminated sea in the world[6] due to its depth, its semi-enclosed nature, and the presence of many underwater topographical elements that act as plastic traps and facilitate the accumulation of garbage on the seabed.[7] Once plastic waste reaches the ocean, it can remain there for centuries, either as macroplastics (larger plastics), or as microplastics (fragmented pieces). Regardless of its size, plastic is transported by wind across the surface of the sea, carried by currents, and displaced to deep areas where it becomes trapped in various marine habitats.

A study that was carried out to support the implementation of the EU Marine Strategy Framework Directive found that 52% of the single-use plastics found on Mediterranean beaches come directly from coastal and beach tourism, while an additional 9% are from recreational fishing and boating.[8]

A scientific study from 2020 found that 86% of the marine litter found on Mediterranean island beaches in July-August is generated by tourists and the accumulation of garbage can be up to 4.7 times higher during the peak tourist season than at other times of year.[1]

Other research has shown that among European seas, Mediterranean waters are the most heavily polluted by plastics.[9] In one study, the most commonly found items on Mediterranean beaches included plastic cutlery, trays, and straws (17%, with an average frequency of more than one item per meter of beach), followed by cigarette butts (14%), plastic caps/lids (14%), plastic drink bottles (12%), shopping and other plastic bags (11%), and plastic bottles (4%).[10]

Most of the time, plastic is transported from land to the coast or the marine environment through the sewage system, via storm drains, or is carried by the wind from landfills or urban developments. Spain's most populous coastal areas and its most important rivers are the main origins of marine plastic waste found in its waters.

According to the European Union Single-Use Plastic Impact Assessment[11] and a 2018 study by Eunomia,[12] plastic waste brings high economic costs to coastal municipalities that seek to keep their streets and beaches clear of litter. In Spain alone, municipalities must pay up to €744 million per year to remove waste, of which €529 million are needed to remove beverage containers containing plastic.[11] Additionally, there are wider implications for tourism and recreation, as litter puts tourists off from visiting and participating in sea-based activities.

3. Methodology

Oceana carried out two expeditions in Spanish waters, in 2019 and 2020. We documented the amount and types of plastic pollution on the seafloor, together with apparent effects on marine life on the west coast of Mallorca (in 2019) and near the coastal city of Valencia (in 2020). The 2019 expedition was done using a dive boat, while the 2020 expedition was carried out with Oceana's research catamaran, the *Ranger*.

Survey areas were selected in both expeditions using a stratified sampling method. The study area was divided into classes based on habitat type, and then, using a hexagonal grid, each class was further subdivided in hexagonal cells with sides of 100 m length (and area of 25980.8 m^2). Cells of each habitat class were then randomly selected for surveying.

Surveys were carried out using a combination of sampling methodologies, primarily through visual, non-destructive surveys with a remotely operated vehicle (ROV). Additionally, we carried out SCUBA dives to take still images and videos in higher resolution. In the case of the 2020 expedition, in soft bottom areas, infauna was documented through grab sampling.

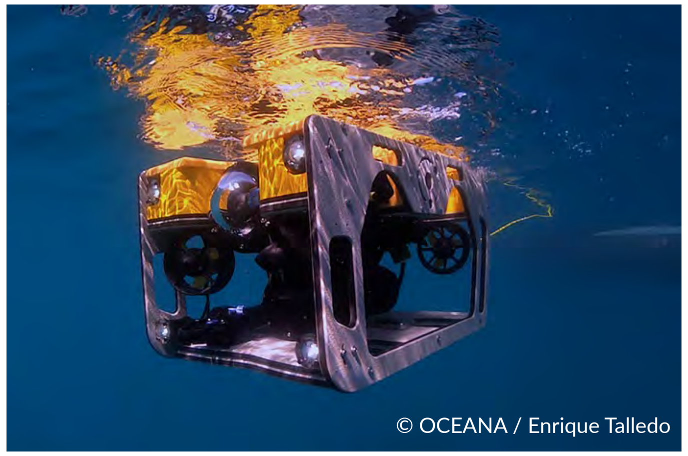
ROV surveys

In the 2019 expedition, images were recorded using a Geneinno T1 ROV drone, equipped with a full HD camera with 160° wide-angle lens and 1/2.5 inch CMOS image sensor that can capture 4K 30fps video and 1080 photograph resolution. Images were recorded in both high definition (to film specific features of interest) and low resolution (for the total duration of the surveys), along with position, depth, and time.

In 2020, a Nido Robotics Sibiu Pro ROV was used, equipped with a high-definition video camera of 1920x1080 resolution (2.24 MP), 1/2.9 inch sensor, minimum scene illumination of 0.01 lux, and a focal length of 2.97mm. Images were recorded in high and low definition, and simultaneously documented position, depth, course, and time.

A total of 35 ROV transects were surveyed during the two expeditions (16 in Mallorca and 19 in Valencia).

Mallorca, Spain. ROV used in the 2019 expedition.



Valencia, Spain. ROV used in the 2020 expedition.

SCUBA dives

Visual data were gathered by a team of two professional SCUBA divers: one videographer and one safety diver. A total of 22 dives were carried out (5 in Mallorca and 17 in Valencia), and the videographer filmed high-definition videos and still images.

Aerial view of the Ranger in the port of La Puebla de Farnals.

Infaunal sampling

In the case of the 2020 Valencia expedition, benthic infaunal community composition was examined using a 12 L Van Veen grab sampler. A total of eight grab samples were taken. Oceana scientists analyzed these specimens during and following the expeditions. Specimens retained on 0.5 mm, 1 mm, 3.15 mm, and 10 mm mesh sieves were kept and identified to the finest taxonomic resolution possible. Those samples that could not be identified definitively while on board were preserved and identified following the expeditions.

The grab under the water.

Data analyses

Following the expedition, Oceana scientists analyzed the ROV and SCUBA dive videos and still images. They counted and classified all the waste items found according to type and material, and identified habitats and all visible species to the finest taxonomic level possible.

Expedition leader Ricardo Aguilar checking data.

4. Survey areas

The Balearic Islands and Valencia

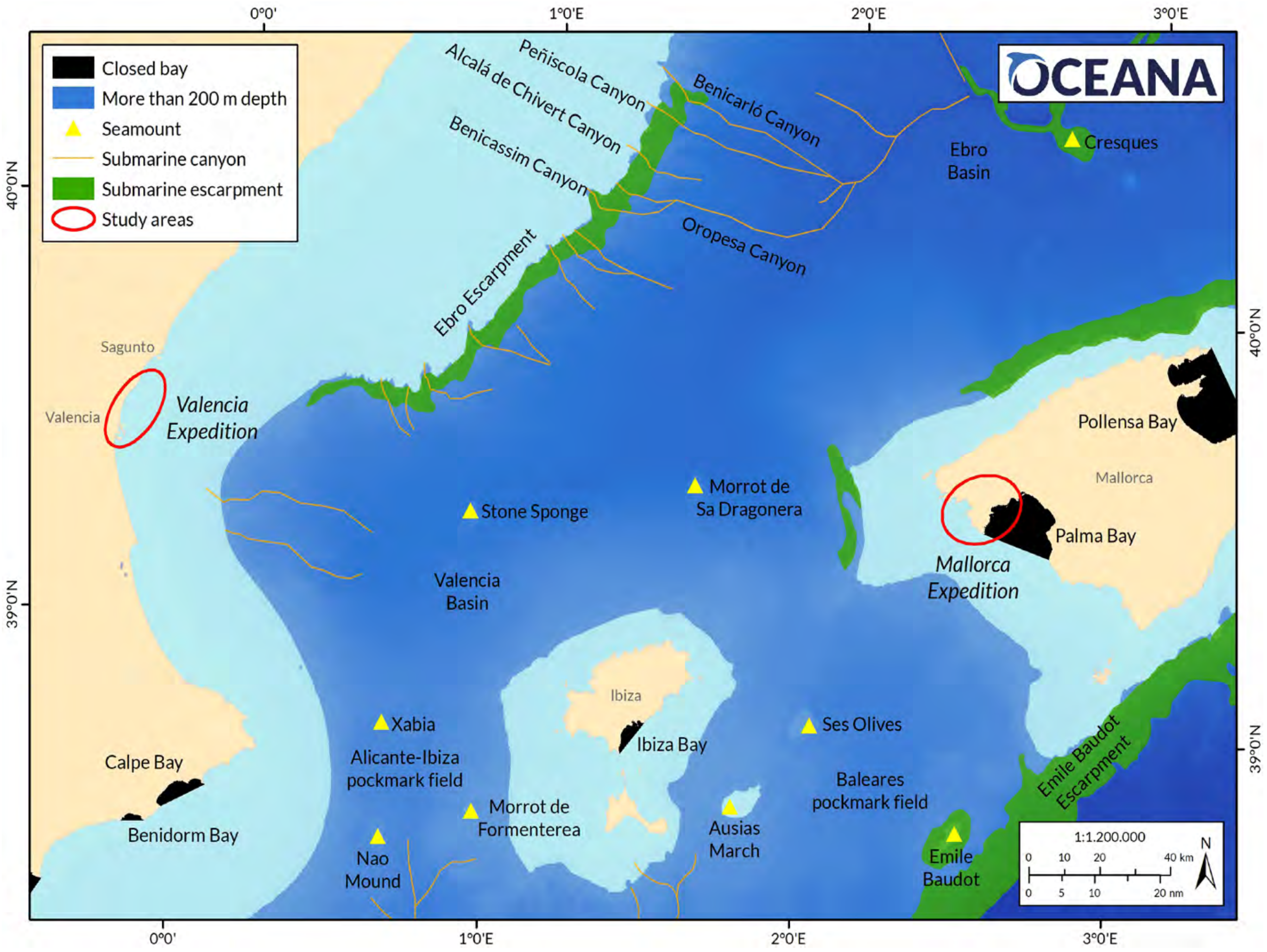


Figure 1: The two survey areas, on the coasts of Valencia and Mallorca[13-16]

The Balearic Islands and the Valencian Community are two of the most touristic regions in the Spanish Mediterranean.

In the Balearic Islands, Oceana surveyed waters off the western coast of Mallorca, including an area between Palmanova and Magaluf (Figure 1). This location draws a high number of tourists, attracted by the beach and the lively nightlife.

In the case of the Spanish Levante region, the expedition on board the *Ranger* focused specifically on the waters that extend from the city of Valencia to Sagunto (Figure 1). These research spots stand out for their proximity to highly populated areas and to traditionally tourist-centered municipalities, indicators that usually coincide with areas that have high rates of plastic pollution.

5. Plastic on the seafloor in Valencia

The region of Valencia has one of the highest rates of plastic pollution in the Mediterranean Sea, with an estimated 12.9 kg of plastic waste reaching every kilometer of the coastline every day.[5] That volume is almost three times higher than the average throughout the Mediterranean, making it the third plastic hotspot in the Mediterranean, after Cilicia in Turkey and the region around Barcelona in Spain.

In addition to macroplastic pollution, the Mediterranean Sea faces microplastic contamination from car tyre dust, the washing of polyester textiles, cosmetics, and pellet loss from plastic production,[6] or from the degradation of macroplastics. Valencia is the Spanish city with the highest level of microplastic pollution (42 tons per year), and it ranks seventh among Mediterranean cities.

5.1. The survey area

The coastal area between Valencia and Sagunto is a highly populated region. Valencia is the third-largest city in Spain, with a population of nearly 800 000 people, and an additional 800 000 inhabitants in the wider urban area that includes neighboring municipalities. Tourism is one of the most important economic sectors in the Valencia region, with over 2 million visitors per year and over 4.5 million overnight stays.[24]

Oceana's research area lies between Valencia's port in the south, which is one of the largest ports in the Mediterranean, and the marina of La Pobla de Farnals in the north, with the small port of Port de Sa Platja between them (Figure 2). We surveyed an area of 889 813.96 m².

The coastal area is divided by some smaller streams and rivers, as well as numerous breakwater constructions that extend from the shore into the sea and were built to block the transport of sediments and to keep beach areas sandy. The coast in this area is dotted with smaller urban centers, agricultural areas, and industrial complexes.

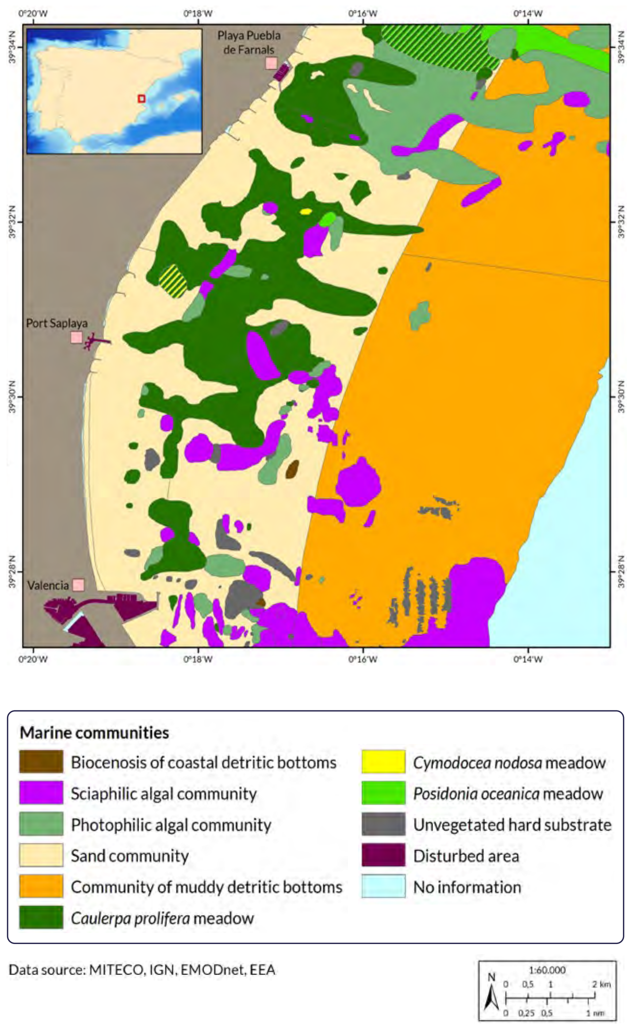


Figure 2: Sea bottom habitats in the area surveyed, close to the coast of Valencia[13-18]

5.2. Amount and types of plastic found

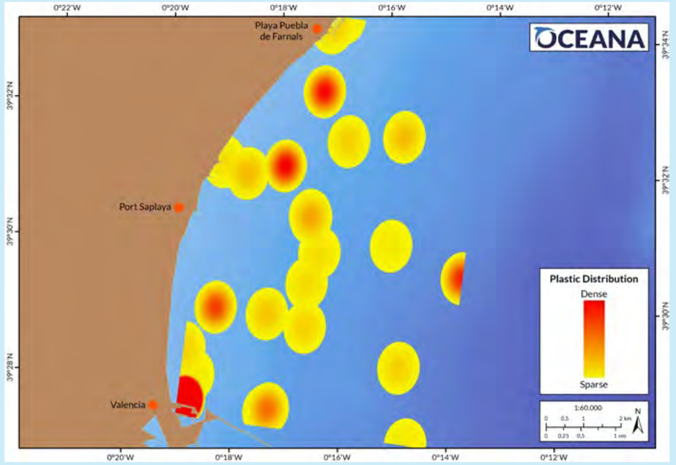


Figure 3: Plastic distribution and density on the seafloor in the Valencian survey area[13-14]

Plastic waste was widespread on the seafloor in the Gulf of Valencia. On the seafloor area surveyed, we found a total of 436 items of waste, of which 398 items (over 90%) were plastic waste. Based on our findings, we estimate a concentration of 447.3 pieces of plastic per square kilometer of seafloor for the survey area in total. Plastic was particularly abundant in the surroundings of the port of Valencia.

Almost all the plastic documented was single-use plastic from land-based sources, mostly parts of plastic film or sheets (41%) that came from packaging, bags, or plastic film used for agricultural purposes.

The second most documented items were plastic bags (32%), followed by plastic objects that could not be identified (13%), and plastic food wrappers (4.5%). 'Covid-19 waste', such as disposable masks and gloves, was also observed. A detailed overview of the items recorded is given in Table 1.

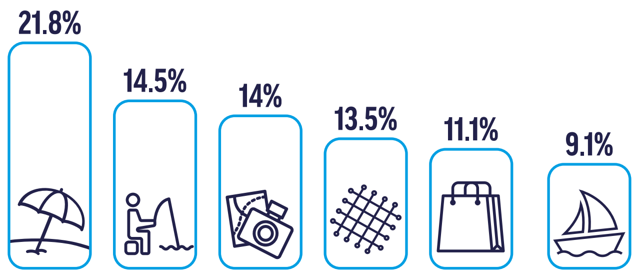
ITEMS	MATERIALS	NUMBER OF ITEMS
Film sheets	Plastic	164
Bags	Plastic	129
Other plastic objects	Plastic	54
Food wrappers	Plastic	18
Bottles	Plastic	7
Healthcare items ('Covid-19 waste')	Plastic	6
Fishing lines	Plastic	4
Boxes	Plastic	3
Tubes	Plastic	3
Other: fishing-related	Plastic	3
Fishing nets	Plastic	2
Other (gloves, shoes, etc.)	Plastic	2
Fishing traps	Plastic	1
Large plastic objects	Plastic	1
Tobacco pouches / plastic cigarette box packaging	Plastic	1
TOTAL PLASTIC ITEMS		398
Unspecified	Unspecified	24
Beverage cans	Metal	6
Non-synthetic ropes	Textile / Natural fibres	3
Bottles	Glass/ Ceramic	1
Clothing (clothes, shoes)	Textile / Natural fibres	1
Large metallic objects	Metal	1
Mooring blocks	Stone / Concrete	1
TOTAL OTHER ITEMS		38

Table 1: Plastic, fishing material, and other waste items found on the seafloor in the Valencian survey area.

Relatively few plastic bottles were found, likely because restaurants and hotels almost exclusively use refillable glass bottles for soft drinks. Plastic bottles, which are usually made of polyethylene terephthalate (PET), are sold in shops, kiosks, and take-outs. However, most of those were closed at the time of research, due to the Covid-19 pandemic.

The vast majority of the plastics we found were from land-based sources and many are used in hotels, restaurants, take-aways, and other tourism-related activities, including plastic bags, packaging, bottles, tableware, and food packaging.

Our findings are in line with observations by the Spanish government, from a study analyzing marine litter on beaches in the same area.[19] The government found that most of the identifiable marine litter corresponded to beach tourism (21.8%); recreational fishing activities (14.5%); other land-based activities (14%); fishing activities (13.5%); shops, hotels, and restaurants (11.1%); and boating (9.1%).



5.3. Marine habitats impacted by plastic

The marine area we surveyed close to the coast of Valencia is characterized by many different types of soft bottoms, especially sandy and muddy ones, which are partly covered by extensive algal meadows, including abundant green algal communities. Figure 2 shows the detailed distribution of habitat types in the area surveyed.

We documented plastic impacts in the Gulf of Valencia in a dozen seafloor habitats, including corals, seagrass meadows, sandy bottoms, and in algal forests.

Natural structures such as reefs, coral bottoms, and algal and seagrass meadows act as obstacles to the circulation of sea currents, so they accumulate plastic waste that is transported by the sea. In particular, we found that the complex structure of sea fans, sponges, bryozoans, and algae means that plastic can easily get caught on these species, and we observed that they were generally heavily impacted by plastic.[20]

One such habitat that we found to be visibly affected by plastic were sea fan (gorgonian) forests. In line with our observations, a recent study has shown that these forests' capacity to retain sediment also increases the concentration of plastics.[21] Studies on the impacts of plastics on sea fans in other parts of the Mediterranean have detected abrasions, an increase in epibionts (species that live on their surface), and increased mortality. Plastic contamination is considered to lead to the local disappearance of gorgonian underwater gardens.[22,27] The effect of plastic pollution on this habitat type adds to the impacts of other threats to marine habitats and species in the area. We found sea fans that were extensively covered by mucilage and filamentous algae, very possibly due to pollution. Various media outlets have reported the discharge of faecal water from the Pinedo sewage treatment plant in this area.[28,29,30]

Since green algal meadows have a sediment retention rate similar to sea fans, they also retain plastic waste at a high rate.[31] We also found that on coralligenous bottoms, plastics were a common occurrence, as well as other items related to fishing that had become hooked onto the reefs.[32] Coralligenous reef ecosystems are widely distributed in the area, and support a great diversity of species, including various species of sponges. These animals have been identified as ideal organisms for detecting the presence of microplastics at sea, due to their filtering activity.[33] In the case of the Mediterranean Sea, up to 72% of sponges on the IUCN Red List for threatened species are impacted by microplastics. [15,34]

Further away from the coast and in areas dominated by sandy or muddy bottoms, species that live in the sediments create galleries or burrows, and plastic finds its way into the small gaps and elevations that are features of these structures. The burrows of small fish like gobies (*Leuseurigobios* spp.) and angular crabs (*Goneplax rhomboides*), both characteristic of Valencian waters, were observed to be particularly affected by plastic in this way. This type of retention of plastic waste has been shown in other parts of the Mediterranean, where areas with bioturbations lie beyond 30-35 meters depth.

Large quantities of plastic waste were also concentrated around artificial structures, such as ports and breakwaters, which alter sea currents and retain sediments. Organisms such as bryozoans and polychaetes, which take advantage of those structures to settle and thrive, are most visibly affected by the plastic waste.

Seagrass meadows

Seagrass meadows that were once abundant in the area have almost totally disappeared, especially Posidonia meadows (*Posidonia oceanica*), apart from some smaller patches that are still intact. In some cases, Posidonia meadows have been replaced by green algae and invasive seaweeds.

Taking advantage of the deterioration and disappearance of seagrass meadows, the invasive species *Caulerpa cylindracea* has become the most common seaweed in the area, thus modifying the autochthonous seascapes.


© OCEANA / Enrique Talledo

Valencia, Spain. *Caulerpa cylindracea*, invasive species.

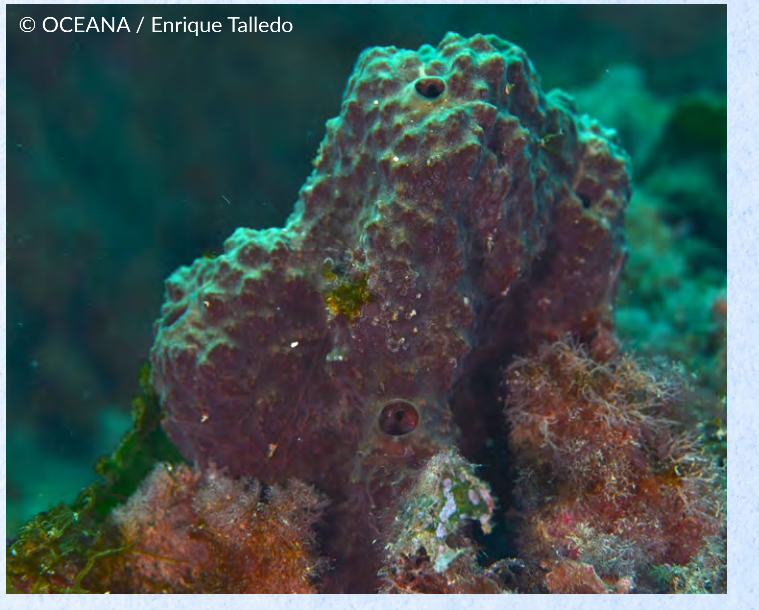
Coralligenous bottoms

Coralligenous bottoms are hard-bottom seafloors of biogenic origin, made of concretions of coralline red algae. They are common in the survey area and a wide variety of species is concentrated there, ranging from soft corals like sea fans to sponges, sea stars, sea urchins, and a variety of fishes. Also noteworthy is the abundance and variety of molluscs (including mussels, snails and bivalves), which take advantage of the abundant calcareous algal formations.


© OCEANA / Enrique Talledo

Valencia, Spain. Red calcareous algae.

Rock formations


© OCEANA / Enrique Talledo

Rock formations are often full of life. Although relatively scarce, they are more frequent in the southern part of the survey area. In the outer and deepest areas, some hard substrates house communities of sea fans, although they have been seriously impacted by coastal landfills, pipelines, and other human activity.

Valencia, Spain.
Rock covered with sponges and algae.

Muddy sands and muddy beds

Soft bottoms (muddy sands and muddy beds) cover large expanses of the seafloor within the survey area. They are characterised by bioturbations produced by crustaceans and fishes. The impact of marine plastic pollution is also visible in these habitats.


© OCEANA / Enrique Talledo

Valencia, Spain.
Sea star and piece of plastic.

5.4. Marine species impacted by plastic

Plastic produces many highly varied negative impacts on marine fauna and flora, ranging from effects on health (including asphyxiation, ingestion, dissolution of toxic chemicals, and physical damage) to behavioral changes in animals. Some such impacts were documented during our survey, and are detailed in Table 2.
Our observations included:

- **Species using plastics** instead of organic materials **to cover themselves.**
- **Fauna and flora overgrowing plastic remains,** which has also been widely documented in the scientific literature.[35,36]
- **Animals at risk of ingesting plastics.** Various species (including threatened species) were observed feeding in areas of plastic pollution, where they are likely to also ingest microplastics that are present in the water column or within the substrate.

SPECIES IMPACTED	PLASTIC IMPACTS
Sea urchins (*Sphaerechinus granularis* and *Paracentrotus lividus*)	Behavioral change. Plastics have become so common that sea urchins were observed using plastics to cover themselves, instead of biogenic (organic) remains.
Various species of flora and fauna	Growth on plastic pieces. For example, species were observed using plastics used as substrate. An overgrowth of marine species on plastic means that the waste is integrated into the ecosystem and its degradation can cause a prolonged supply of microplastics.[37]
Red algae (*Laurencia* sp.)	Settlement on moving plastic pieces. Such pieces are transported with currents and can be displaced to areas where the species would not usually be found.
Oysters (*Ostrea edulis*)	Settlement on moving plastic pieces. In the case of the common European oyster, the association with plastic waste is especially worrying given that the species has suffered severe population declines, habitat losses and severe mortality throughout Europe.[38]
Mediterranean madreporian coral (*Cladocora caespitosa*)	Threatened species at risk of ingesting plastic pieces. This sessile benthic species was observed in plastic-polluted areas.
Stingray (*Dasyatis pastinaca*)	Threatened species at risk of ingesting plastic pieces. This benthic species was observed feeding in plastic-polluted areas.
Brown meagre (*Sciaena umbra*)	Vulnerable species at risk of ingesting plastic pieces. This benthic species was observed feeding in plastic-polluted areas.
Mullet (*Mullus* spp.)	At risk of ingesting plastic. Since these animals search for prey within the sediment, they are highly likely to also ingest other residues, such as plastics.
Sand steenbras (*Lithognathus mormyrus*)	At risk of ingesting plastic. Since these animals search for prey within the sediment, they are highly likely to also ingest other residues, such as plastics.

Table 2: Species impacts observed in relation to seafloor plastic pollution on the Valencian coast.

6. Plastic on the seafloor in Mallorca

Mallorca, Spain. Single-use plastics in the seabed.

The Balearic Islands have advanced legislation to reduce the consumption of single-use plastics and improve waste collection. However, holidaymakers tend to use more disposable products than they do in their daily life, and they are not always aware of local waste management systems. Even if many hotels in Mallorca have started to reduce their use of single-use plastics drastically, tourists buy other throw-away products in local shops. To this, it must be added marine pollution coming from mainland Spain, France or northern Africa.[39]

The island of Mallorca is a tourism hotspot in the Mediterranean, and the second most populous island in Spain. It has around 900,000 inhabitants with arrivals of over 10 million tourists in a normal year.[40]

Mainly due to tourism, Mallorca's beaches are full of single-use plastic waste during the tourist season and need to be cleaned every day.[41]

6.1. The survey area

The iconic Balearic Islands – Mallorca, Menorca, Ibiza, and Formentera – are home to a great diversity of marine animals, including marine mammals, birds, and hundreds of species of fishes and invertebrates.[42] This rich biodiversity has been recognised with the creation of several marine protected areas in the Balearic archipelago, including 12 marine reserves and a national park. One of the most important ecosystems that is protected in shallow coastal waters of the Balearics is formed by the plant *Posidonia oceanica*; meadows of this seagrass provide protection and food to many species and enrich the water with oxygen.

The total area surveyed in Mallorca (Figure 5) was 481 880.42 m^2, and it included waters adjacent to the tourist areas of Palmanova and Magaluf (Figure 4). Figure 4 shows the distribution of the main habitat types in this specific survey area. It is dominated by large seagrass meadows with rich ecosystems formed by *P. oceanica* and sandy bottoms that are characterized by bioturbations and galleries formed by various marine species.

Mallorca, Spain. Cala Figuera lighthouse.

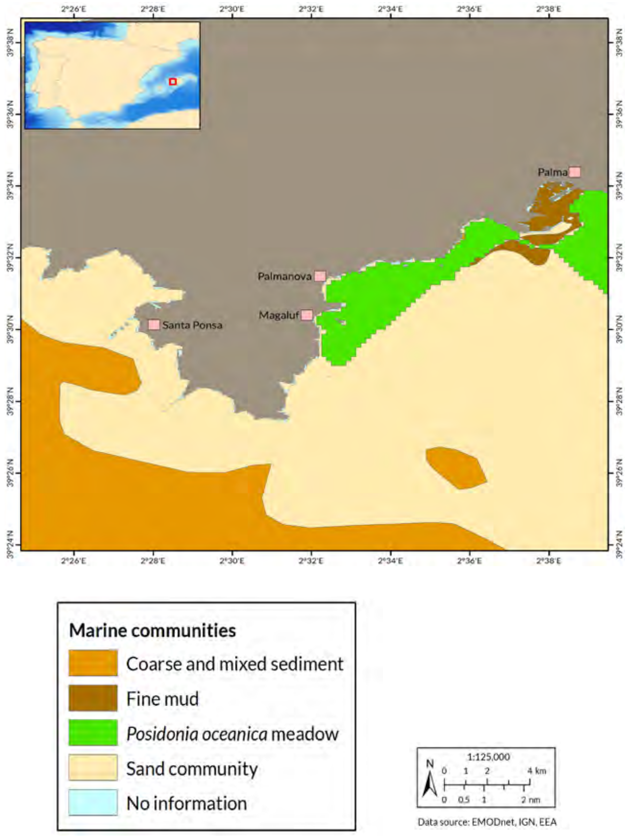


Figure 4: Bottom habitats in the area surveyed close to the coast of Magaluf, Mallorca.[13, 14, 18,43]

6.2. Amount and types of plastic found

In the survey area we found a total of 146 plastic items, in 11 out of 21 points surveyed. In total, 66% of the marine litter found in the area is plastic.

The estimated density of plastic waste on the sea bottom in the survey area was 330 pieces of plastic per square kilometer, an indication of the large amount of plastic garbage that ends up on the seabed.

As in the Valencia area, almost all of the plastics documented on seafloor habitats and species were single-use plastic items. Of these, most were parts of plastic film or sheets (54%), which may have been parts of packaging or bags. The second most

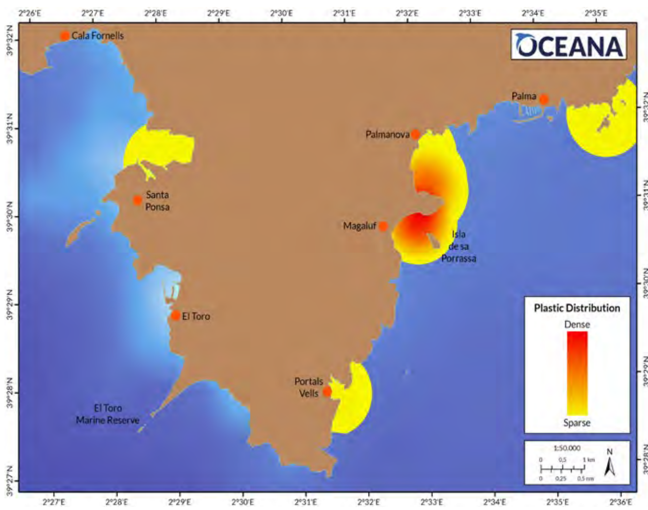
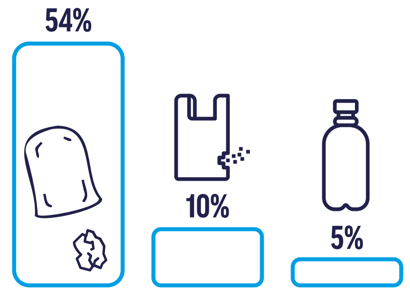


Figure 5: Plastic distribution and density on the seafloor in the Mallorcan survey area.[13-14]

documented items were plastic bags (10%), followed by plastic objects that could not be identified (10%), and plastic bottles (5%).

ITEMS	MATERIALS	NUMBER OF ITEMS
Film sheets	Plastic	87
Bags	Plastic	16
Other plastic objects	Plastic	15
Bottles	Plastic	8
Food cans / wrappers	Metal / Plastic	6
Plastic cups	Plastic	4
Beverage containers	Plastic / Paper	1
Healthcare items	Plastic	4
Plates	Plastic	4
Food wrappers	Plastic	3
Beverage cans	Metal / Plastic	1
Forks	Plastic	3
Other (gloves, shoes, etc.)	Plastic	2
Large plastic objects	Plastic	2
Clothing (clothes, shoes)	Natural fibres / Plastic	1
TOTAL PLASTIC ITEMS		**159**
Bottles	Glass/ Ceramic	50
Anchors / Anchorage	Metals	6
Ropes	Natural fibres	4
Large metallic objects	Metals	1
Unspecified	Unspecified	1
TOTAL OTHER ITEMS		**62**

Table 3: Plastic and other waste items found on the seafloor in the Mallorcan survey area.



Like in Valencia, the plastic items observed on the seafloor included those typically used in seaside restaurants and take-aways in Mallorca: plastic bags, bottles, cups, plates, and cutlery.

Table 3 summarizes the items recorded.

6.3. Marine habitats impacted by plastic

In Mallorca, we documented visible plastic impacts in six seafloor habitats. These habitats included meadows of *Posidonia oceanica*, *Cymodocea nodosa*, *Caulerpa prolifera*, and *Halimeda incrassata*, as well as soft and rocky bottoms.

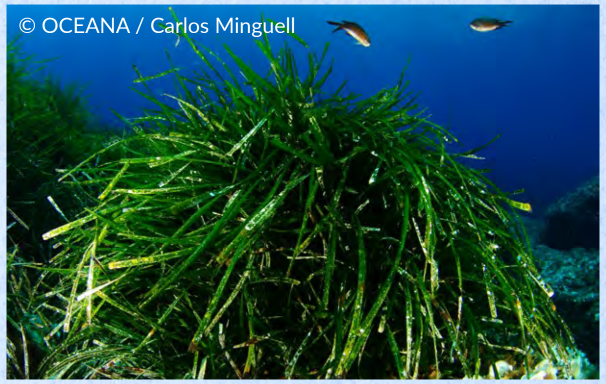
We found the highest concentration of plastics in *P. oceanica* and *C. nodosa* seagrass meadows. Seagrass meadows are very rich and highly valuable ecosystems.

We also observed areas covered by seaweeds with different species of green algae (*H. incrassata*, *C. prolifera*) polluted with plastic. In fact, the highest rates of plastic debris were found in degraded algal and seagrass meadows.

On some dotted areas with rocky beds, we found red algae (*Liagora* sp., *Ceramium* sp.) and brown algae (*Cystoseira balearica*) species affected by plastic.

Posidonia

Posidonia oceanica, also known as Neptune grass, is a real plant with flowers and fruit. This seagrass species is only found in the Mediterranean Sea and forms large underwater meadows that are among the richest ecosystems on the seafloor. Thousands of species live, feed, and breed there. Seagrass meadows are also important because they produce oxygen, improve water quality, and decrease wave energy, thereby protecting coastal areas and reducing beach erosion.[44] Posidonia meadows are protected under the European Union's Habitats Directive, but despite that, pollution and other disturbances are responsible for their decline in many coastal areas.[45] The plant is also crucially important for lessening the effects of climate change because it has a very high carbon absorption capacity. Posidonia's annual primary production is estimated at between 45 and 542 grams of carbon per square meter.[46] A significant proportion of this carbon (approximately 21%) is sequestered within the sediment; among seagrass species, *P. oceanica* appears to be the most effective at fixing and storing carbon.[47] Posidonia meadows have been shown to store carbon for thousands of years in their sediments, and are thus considered a long-term carbon sink.[48]

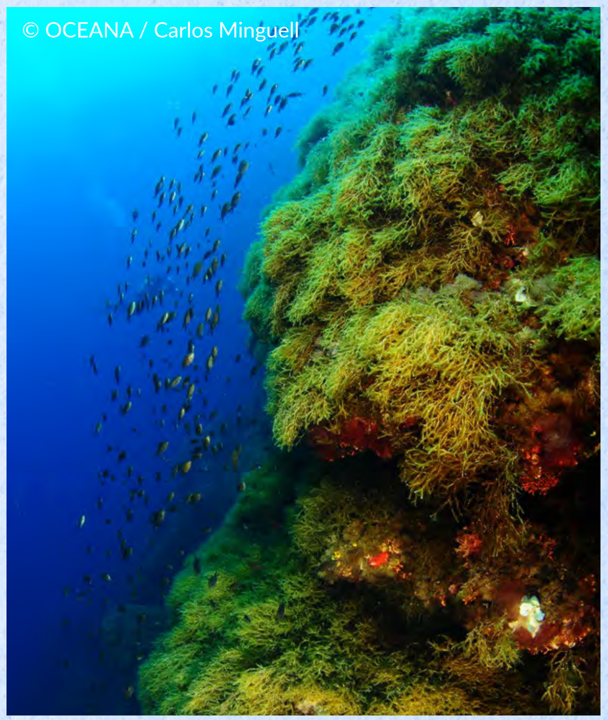


Balearic Islands, Spain. Posidonia.

Rocky beds

Rocky beds in shallow waters around Mallorca and in other Mediterrenan sites are commonly covered by a wide diversity of seaweeds. Some of the most common are the Dictyotales, like *Dictyota* spp., *Dictyopteris polypodioides* and *Padina pavonica*. Nevertheless, the Fucales are the ones that form the densest canopies,[49] mainly comprising species of the genus *Cystoseira*.

Cystoseira balearica is a Mediterranean endemic species with a limited distribution in the Western Mediterranean[50] and their canopies are important as nursery habitat for several fish species.[51] *Cystoseira* spp. have experienced massive declines in several areas in the Mediterranean Sea and Atlantic Ocean.[52,53]

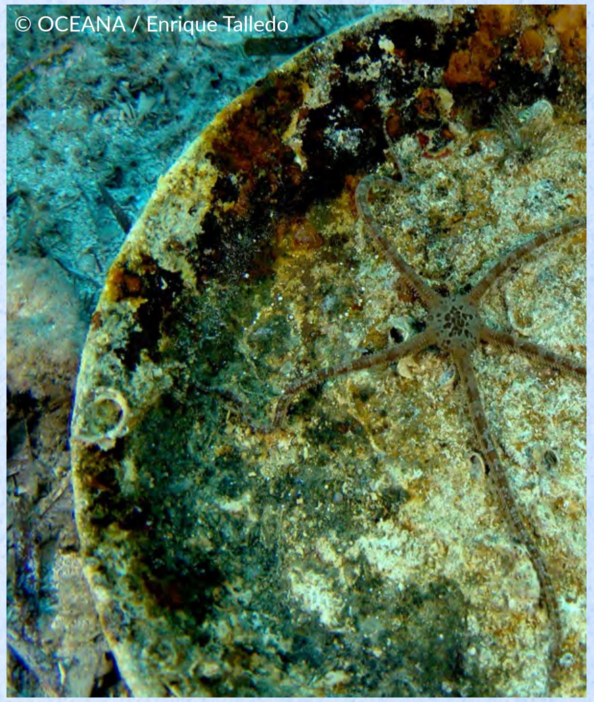


Balearic Islands, Spain. Rocky bed with algae.

Soft bottoms

Bottom currents, sediment movements, and the action of burrowing species living on soft bottoms can introduce plastic pollution into the sediments. This slows the rate of plastic deterioration and increases the time it stays in the environment.

In addition to this, healthy benthic ecosystems are more resilient to the settlement and expansion of invasive species.[54] Plastic can accumulate in large quantities in seagrass[15] enabling the spread of non-native species.[55] The alien species *Halimeda incrassata* already covers extensive areas in the sites researched in Mallorca, especially in the more heavily deteriorated soft bottoms.



Mallorca, Spain. Brown brittle star in plastic piece

6.4. Marine species impacted by plastic

Mallorca, Spain. Red starfish and toy flyer.

As noted previously, plastics affect marine flora and fauna in many ways (see Section 5.4). In the waters of Mallorca, we documented apparent such impacts from plastic items on more than 41 marine species. Table 4 provides an overview of these observations.

It should be noted that plastic and plastic debris can be difficult to see within algal or seagrass meadows, or in habitats and communities with high densities, because the plastic is hidden from view as organisms begin to grow over the plastic remains.[56] This means that estimates of the plastic within these ecosystems are very likely to underrepresent the full scale of the problem.

Table 4: Examples of species impacts observed in relation to seafloor plastic pollution in Mallorca.

SPECIES IMPACTED	PLASTIC IMPACTS
Mediterranean madreporian coral (*Cladocora caespitosa*)	Threatened species at risk of ingesting plastic pieces. This sessile benthic species was observed in plastic-polluted areas.
Green wrasse (*Labrus viridis*)	Threatened species at risk of ingesting plastic pieces. This benthic species was observed feeding in plastic-polluted areas.
Fan shell (*Pinna nobilis*)	Threatened species at risk of ingesting plastic pieces. This sessile benthic species was observed in a plastic-polluted area.
Red algae (*Phymatholithon* sp.)	Growth on plastic pieces. Red algae were observed growing over plastic debris, with echinoderms feeding upon them. This poses a risk of ingestion by the echinoderms, and fragmentation into microplastics.
Brown algae (*Cystoseira balearica*)	Growth on plastic pieces. Brown algae were observed growing over plastic debris, which poses a risk of fragmentation into microplastics and ingestion by other species.
Sea urchins (*Sphaerechinus granularis, Paracentrotus lividus*) and **sea stars** (*Asteroidea*)	At risk of ingesting microplastics when feeding. These species were observed feeding upon red algae that was growing over plastic debris (see above).
Bryozoans, corals and **algae**	Entanglement in plastics. Plastic pieces were observed to be entangled in various species with complex and tridimensional shapes.
Amberjacks (*Seriola dumerili*)	At risk of ingesting plastic. These animals were observed feeding in areas with high plastic pollution, and are thus likely to be ingesting plastic particles.
Seabreams (*Diplodus* spp.)	At risk of ingesting plastic. These animals were observed feeding in areas with high plastic pollution, and are thus likely to be ingesting plastic particles.
Picarels (*Spicara smaris*)	At risk of ingesting plastic. These animals were observed feeding in areas with high plastic pollution, and are thus likely to be ingesting plastic particles.
Seabasses (*Dicentrarchus labrax*)	At risk of ingesting plastic. These animals were observed feeding in areas with high plastic pollution, and are thus likely to be ingesting plastic particles.


© OCEANA / Enrique Talledo

7. Conclusions

Oceana carried out two expeditions to document plastic on the seafloor of the Mediterranean Sea, in locations known to be important for both biodiversity and tourism. In the waters of Mallorca and of the Gulf of Valencia, we found plastic pollution in every type of sea bottom and habitat surveyed.

Plastic waste was widespread, and in the areas we researched, we estimated densities of 330 pieces per square kilometer of seabed (in Mallorca) and 447 pieces per square kilometer (in the Gulf of Valencia).

Plastics represented a visible threat to biodiversity in the surveyed areas. We observed apparent impacts on a range of species, some of which are threatened. We documented cases of marine life that had become entangled in plastic, had modified behavior in response to plastic, or was at risk of directly ingesting plastic. Fauna and flora were also seen growing on moving plastic pieces, which can eventually be displaced by currents far away from their usual areas. Among the habitats surveyed, we found that those with complex structures (such as sea fans and algal meadows) were among the most heavily impacted. Seagrass meadows were also heavily polluted with plastics, which is particularly worrying given their important role in sequestering carbon and lessening the impacts of climate change.


© OCEANA / Enrique Talledo

Almost all the plastics documented were single-use items, such as bags, food wrappers, packaging, cutlery, and drinking containers. Most of the items found were typical of those used by hotels, restaurants, and take-outs, located close to the beach in tourist areas.

© OCEANA / Enrique Talledo

It should be noted, in the case of our research in the Gulf of Valencia, that our surveys were carried out during the height of the Covid-19 pandemic in the autumn of 2020, when most of the hotels, restaurants, and shops in the area were closed. As a result, our findings are likely to underestimate typical levels of marine plastic pollution in the area. Tourism is the main driver of plastic pollution in the Mediterranean, and so we would expect both the number of plastic items found and the range of impacts on species in the Gulf of Valencia to be much greater in years with normal levels of tourism. Nevertheless, the types of impacts studied and described are emblematic, and would also be expected during a more typical period.

8. Oceana's recommendations

Oceana's recommendations to curb single-use plastic pollution in Spain are aligned with an ambitious transposition[57] of EU Directive 2019/904 on the reduction of the impact of certain plastic products on the environment;[58] EU Directive 2018/852 on packaging and packaging waste;[59] current European policies related to the EU Green Deal;[60] the European Strategy for Plastics in a Circular Economy;[61] and the European Plastic Pact,[62] to which Spain is a signatory.[63] They are also in line with the Spanish Climate Emergency Declaration[64] regarding the target to reach 'zero waste' by 2050.

Oceana urges Spanish and regional authorities to address marine plastic pollution in the most efficient way, by shifting away from the throw-away culture and from the focus on merely cleaning up waste, to instead encouraging reusable choices and preventing the generation of waste. More specifically, Oceana recommends to:

1. **Adopt restrictive measures against products that heavily impact marine fauna and habitats**, such as setting binding reduction targets for wet wipes and phasing out single-dose packets and 6-pack plastic rings.

2. **Introduce bans on single-use products (such as beverage and food containers) in hotels, bars, and restaurants**, and promote, similar initiatives in environments associated with the heavy use of single-use plastic, such as beach bars, festivals, and street parties, especially in coastal areas.

3. **Introduce compulsory deposit return schemes**, to increase waste collection rates and reduce littering.

4. **Set targets for refillable beverage containers** so that they account for at least 50% of the market by 2025. Current refillable systems have a loss rate (broken or unreturned bottles) of less than 5%.[65] Recycling is not enough to reduce the consumption of raw materials, as only a limited number of cycles is possible before the material loses its properties.

5. **Raise awareness among citizens about the invisible impacts of pollution in the marine environment**, particularly in deep areas. It is urgent to publicly showcase the damages to vulnerable and lesser-known wildlife, to convey the true extent of the harm caused by marine pollution.

6. **Develop a protocol for removing marine litter**. Specify the cases where this is not appropriate due to the potential impact (for example, because of the vulnerability of the species affected).

7. **Levy a green tax on non-healthcare single-use plastic products.** To help curb marine pollution, this tax should be targeted and used to finance measures such as those listed above.


© OCEANA / Carlos Minguell

9. References

1 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, 20326. https://doi.org/10.1038/s41598-020-77225-5

2 Sherrington, C. (2016). *Plastics in the marine environment*. Eunomia Research & Consulting Ltd. https://www.eunomia.co.uk/reports-tools/plastics-in-the-marine-environment/

3 Haegerbaeumer, A., Mueller, M.-T., Fueser, H., & Transpurger, W. (2019). Impacts of micro- and nano-sized plastic particles on benthic invertebrates: A literature review and gap analysis. *Frontiers in Environmental Science*, 7, 17. https://doi.org/10.3389/fenvs.2019.00017

4 de Wit, W., Hamilton, A., Freschi, A., & Dalberg Advisors. (2019). *Stop the flood of plastic. How Mediterranean countries can save their sea*. WWF Mediterranean Marine Initiative. https://wwfeu.awsassets.panda.org/downloads/wwfmmi_stop_the_flood_of_plastic_mediterranean.pdf

5 Dirección General de Sostenibilidad de la Costa y el Mar. (2021, September). *Ecocartografía de Valencia*. Ministerio para la Transición Ecológica y el Reto Demográfico. https://www.miteco.gob.es/es/costas/temas/proteccion-costa/ecocartografias/ecocartografia-valencia.aspx

6 Boucher, J., & Bilard, G. (2020). *The Mediterranean: Mare plasticum*. Interational Union for Conservation of Nature. https://portals.iucn.org/library/sites/library/files/documents/2020-030-En.pdf

7 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

8 Van Acoleyen, M., Laureysens, I., Lambert, S., Raport, L., Van Sluis, C., Kater, B., Van Onselen, E., Veiga, J., & Ferreira, M. (2014). *Marine litter study to support the establishment of an initial quantitative headline reduction target*. Directorate General for the Environment, European Commission. https://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/final_report.pdf

9 Cózar A., Sanz-Martín M., Martí E., González-Gordillo J. I., Úbeda B., Gálvez J. Á., et al. (2015). *Plastic Accumulation in the Mediterranean Sea*. PLoS ONE 10(4): e0121762. https://doi.org/10.1371/journal.pone.0121762

10 Hanke, G. 2016. *Marine beach litter in Europe – Top items*. Joint Research Centre, European Commission. https://mcc.jrc.ec.europa.eu/documents/Marine_Litter/MarineLitterTOPitems_final_24.1.2017.pdf

11 ICF & Eunomia. (2018). *Assessment of measures to reduce marine litter from single use plastics*. Part of European Commission Study Contract 'Plastics: Reuse, recycling and marine litter'. Directorate General for the Environment, European Commission. https://ec.europa.eu/environment/pdf/waste/Study_sups.pdf

12 Changing Markets Foundation & Eunomia. (2021). *More trash, more cash. Who is really behind the plastic crisis in Spain?* http://changingmarkets.org/wp-content/uploads/2021/03/MoreTrashMoreCash.pdf

13 EMODnet. 2020. *Bathymetry*. https://emodnet.ec.europa.eu/en/portals

14 Instituto Geográfico Nacional. (2020). *Base Topográfica Nacional*. http://centrodedescargas.cnig.es/CentroDescargas/index.jsp

15 Global Seafloor Geomorphic Features Map. (2019). https://www.arcgis.com/home/item.html?id=342d8cbfac074a53afa5e49bd0c53773

16 Maestro, A., Bohoyo, F., López-Martínez, J., Acosta, J., Gómez-Ballesteros, M., Llave, E., Muñoz, A., Terrinha, P. G., Dominguez, M., & Fernández-Sáez, F. (2015). Influencia de los procesos tectónicos y volcánicos en la morfología de los márgenes continentales ibéricos. *Boletín Geológico y Minero*, 126 (2-3), 427-482.

17 MITECO. (2007). *Ecocartografía de Valencia. https://www.miteco.gob.es/es/costas/temas/proteccion-costa/ecocartografias/ecocartografia-valencia.aspx*

18 European Environment Agency. 2019. *Datasets*. https://www.eea.europa.eu/data-and-maps/data/

19 Dirección General de la Costa y el Mar. (2020). *Programa de seguimiento de basuras marinas en playas informe de resultados* – 2020. Ministerio para la Transición Ecológica y el Reto Demográfico. https://www.miteco.gob.es/es/costas/temas/proteccion-medio-marino/informefinal2020_tcm30-523316.pdf

20 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., Ivar do Sul, J. A., Lavers, J. L., Lazar, B.L., Lebreton, W. J. Nichols, C. A., Ribic, P. G., Ryan, Schuyler, Q. A., Smith, S. D. A., Takada, H., Townsend, K. A., Wabnitz, C. C. C., Wilcox, C., Young, L. C., & Hamann, M. (2014). Global research priorities to mitigate plastic pollution impacts on marine wildlife. *Endangered Species Research*, 25(3), 225-247. https://doi.org/10.3354/esr00623

21 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(1), 1-7. https://doi.org/10.1038/s41598-020-79370-3

22 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*, 104, 184-207. https://doi.org/10.1016/j.dsr2.2013.06.016

23 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. https://doi.org/10.1016/j.biocon.2014.01.011

24 Bo, M., Angiolillo, M., Bava, S., Betti, F., Canese, S., Cattaneo-Vietti, R., Cau, A., Sandulli, A., Santangelo, G., Tunesi, L., & Bavestrello, G. (2014). *Fishing impact on Italian coral gardens and management of Vulnerable Marine Ecosystems*. In: Proceedings of the Symposia on the conservation of the Mediterranean Marine Key Habitats (Portorož, Slovenia, 31 October 2014). UNEP/MAP–RAC/SPA. Tunis, pp. 21-26.

25 Angiolillo, M., di Lorenzo, B., Farcomeni, A., Bo, M., Bavestrello, G., Santangelo, G., Cau, to., 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. https://doi.org/10.1016/j.marpolbul.2014.12.044

26 Angiolillo, M., & Canese, S. (2018). Deep gorgonians and corals of the Mediterranean Sea. In: Duque, & E., Tello Camacho, E. (Eds), *Corals in a changing world*. Intech Open Book Series. https://doi.org/ 10.5772/intechopen.69686

27 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, 110928. https://doi.org/10.1016/j.marpolbul.2020.110928

28 Cadena Ser. (2020, September 19). *La depuradora de Pinedo vertió aguas fecales al mar 61 veces en el último año, según el PP*. https://cadenaser.com/emisora/2020/09/19/radio_valencia/1600522459_335718.html

29 El Periòdic. (2020, September 19). *La depuradora de Pinedo vertió aguas fecales al mar 61 veces en el último año*. https://www.elperiodic.com/valencia/depuradora-pinedo-vertio-aguas-fecales-veces-ultimo_701734

30 R. V. (2020, September 20). *El PP denuncia 61 vertidos fecales al mar de la depuradora de Pinedo*. Las Provincias. https://www.lasprovincias.es/comunitat/denuncia-vertidos-fecales-20200920000735-ntvo.html

31 Hendricks, I. E., Bouma, T. J., Morris, E. P., & Duarte, C. M. (2010). Effects of seagrasses and algae of the Caulerpa family on hydrodynamics and article-trapping rates. *Marine Biology*, 157, 473-481. https://doi.org/10.1007/s00227-009-1333-8

32 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 the Marine Biological Association of the United Kingdom*, 98, 1–10. https://doi.org/10.1017/S0025315417001096

33 Girard, E., Lasut, M., & Wörheide, G. (2018, September 5-7). *Microplastic mapping in sponges: Potential bioindicators?* [Conference poster]. 5th Young Reef Scientists Meeting, Munich, Germany. https://doi.org/10.13140/RG.2.2.32931.40482

34 Deudero, S. & Alomar, C. (2014). *Revising interactions of plastics with marine biota: Evidence from the Mediterranean*. In: CIESM Workshop Monographs No. 46. Marine litter in the Mediterranean and Black Seas. pp. 79-85.

35 Ramakritinan, C. M., Ramkumar, B., & Kumaraguru, A. K. (2015). Growth of sponges around nylon rope and E-waste in the coastal water of Veedhalai, Gulf of Mannar, India. *International Journal of Current Microbiology and Applied Sciences*, 4 (8), 61-65.

36 Valderrama Ballesteros, L., Matthews, J. L., & Hoeksema, B. W. (2018). Pollution and coral damage caused by derelict fishing gear on coral reefs around Koh Tao, Gulf of Thailand. *Marine Pollution Bulletin*, 135, 1107-1116. https://doi.org/10.1016/j.marpolbul.2018.08.033

37 Porter, A., Smith, K. E., & Lewis, C. (2019). The sea urchin *Paracentrotus lividus* bioeroder of plastic. *Science of the Total Environment*, 693, 133621. https://doi.org/10.1016/j.scitotenv.2019.133621

38 Global Invasive Species Database. (2021, January 28). *Ostrea edulis*. International Union for Conservation of Nature. http://www.iucngisd.org/gisd/species.php?sc798

39 Van Adrichem, C., Ayeri, T., Barneveld, C., Bernardin, N., Biekart, R., Bonicelli, P. L., Bouman, M., Busuttil, E., Dorrestijn, L., Giampoaoletti, R., Havinga, F., Hu, M., Hu, H., Keller, E., Kiers, A., Lopetegui Eguren, L., Nizamali, J., Noriega Hoyos, C., Olivier, P., Ommerborn, N., Peeters, E., Schadt, K., Slegersma, T., Slegt, M., Thomas, S., Zhang, C., Zhang, Y., van Zuijlen, J., & Zwart, M. (2020). *Final synthesis report EUW Mallorca*. European Workshop. Environmental Sciences and Management. University of Wageningen.

40 Agència de Turisme de les Illes Balears. (2017). *Balearic Islands regional context survey*. https://www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1508251726.pdf

41 Mallorca Daily Bulletin. (2021, February 2). *Eighty per cent of beach rubbish is plastic*. https://www.majorcadailybulletin.com/news/local/2020/02/19/62895/eighty-per-cent-beach-rubbish-mallorca-plastic.html

42 Deudero, S., Vallespir, J., & Obrador, M. (2011). *Atlas de biodiversidad marina del Mar Balear*. http://www.ba.ieo.es/bioatlasmarino/

43 EMODnet. (2019). *Seabed Habitats*. https://www.emodnet.eu/portals

44 United Nations Environment Programme. (2020). *Out of the blue. The value of seagrasses to the environment and to people*. UNEP. https://www.grida.no/publications/479

45 European Environment Agency. (2013). *Posidonia beds* [Factsheet]. Interpretation manual of European Union habitats. https://eunis.eea.europa.eu/habitats/10004

46 Mateo M.A., Cebrián J., Dunton K., & Mutchler, T. (2006). Carbon flux in seagrass ecosystems. In: Larkum, A.W.D., Orth, R.J., & Duarte, C.M. (Eds). *Seagrass: Biology, Ecology and Conservation*. Springer. pp. 157-191.

47 Pergent-Martini, C., Pergent, G., Monnier, B., Boudouresque, C.-F., Mori, C., & Valette-Sansevin, A. (2021). Contribution of *Posidonia oceanica* meadows in the context of climate change mitigation in the Mediterranean Sea. *Marine Environmental Research*, 165, Article 105236. https://doi.org/10.1016/j.marenvres.2020.105236

48 Bazairi, H., Bianchi, C. N., Boudouresque, C-F, Buia, M. C., Clabaut, P., Harmelin-Vivien, M. L, Mateo, M. A., Montefalcone, M., Morri, C., Orfanidis, S., Pergent, G., Pergent-Martini, C., Seimour, R., Serrano, O., & Verlaque, M. (2012) *Mediterranean seagrass meadows: Resilience and contribution to climate change mitigation, a short summary*. International Union for Conservation of Nature. https://www.iucn.org/node/20761

[49] Piazzi, L., Bonaviri, C., Castelli, A., Ceccherelli, G., Costa, G., Curini-Galletti, M., Langeneck, J., Manconi, R., Montefalcone, M., Pipitone, C., Rosso, A., & S. Pinna. (2008). Biodiversity in canopy-forming algae: Structure and spatial variability of the Mediterranean Cystoseira assemblages. *Estuarine, Coastal and Shelf Science*, 207, 132-141. https://doi.org/10.1016/j.ecss.2018.04.001

[50] Rodríguez-Prieto, C., Ballesteros, E., Boisset, F., & Afonso-Carrillo, J. (2013). *Guía de las macroalgas y fanerógamas marinas del Mediterráneo Occidental*. Ediciones Omega.

[51] Cuadros-Casado, A., Cheminée, A., Vidal, E.M., Thiriet, P., Bianchimani, O., Basthard-Bogain, S., Francour, P., & Moranta, J. (2013). Effect of depth and canopy height on the nursery value of *Cystoseira balearica* forests for Mediterranean rocky reef fishes. *Rapport du Congrès de la Commission Internationale Pour l'Exploration Scientifique de la Mer Méditerranée*, 40, 663. http://hdl.handle.net/10508/10009

[52] Valdazo, J., Viera-Rodriguez, A., Espino, F., Haroun, R., & Tuya, F. (2017). Massive decline of *Cystoseira abies-marina* forests in Gran Canaria Island (Canary Islands, eastern Atlantic). *Scientia Marina*, 81(4), 499-507. https://doi.org/10.3989/scimar.04655.23A

[53] Thibaut, T., Pinedo, S., Torras, X., & Ballesteros, E. (2005). Long-term decline of the populations of Fucales (*Cystoseira* spp. and *Sargassum* spp.) in the Albères coast (France, North-western Mediterranean). *Marine Pollution Bulletin*, 50(12), 1472-1489. https://doi.org/10.1016/j.marpolbul.2005.06.014

[54] Bernardeau-Esteller, J., Marín-Guirao, L., Sandoval-Gil, J. M., García-Muñoz, R., Ramos-Segura, A., & Ruiz, J. M., (2020). Evidence for the long-term resistance of *Posidonia oceanica* meadows to *Caulerpa cylindracea* invasion. *Aquatic Botany*, 160, 103167. https://doi.org/10.1016/j.aquabot.2019.103167

[55] Menicagli, V., Balestri, E., Vallerini, F., De Battisti, D., & Lardicci, C. (2021). Plastics and sedimentation foster the spread of a non-native macroalga in seagrass meadows. *Science of The Total Environment*, 757, 143812. https://doi.org/10.1016/j.scitotenv.2020.143812

[56] Canals, M., Pham, C. K., Bergmann, M., Gutow, L., Hange, G., van Sebille, E., Angiolillo, M., Buhl-Mortensen, L., Cau, A., Oiakenimidis, C., Kammann, U., Ludsten, L., Papatheodorou, G., Purser, A., Sanchez-Vidal, A., Schulz, M., Vinci, M., Chiba, S., Galgani, F., Langenkamper, D., Moller, T., Nattkemper, T. W., Ruiz, M., Suikkanen, S., Woodall, L., Fakiris, E., Molina Jack, M. E., & Giorgetti, A. (2021). The quest for seafloor macrolitter: A critical review of background knowledge, current methods and future prospects. *Environmental Research Letters*, 16 (2021) 023001. https://doi.org/10.1088/1748-9326/abc6d4

[57] Oceana. (2020). *Batalla contra el plástico en los mares de España. La Directiva 2019/904, un arma contra la crisis del plástico* [Factsheet]. https://europe.oceana.org/sites/default/files/2020_03_fs_policy_plastics_-_def2.pdf

[58] Directive (EU) 2019/904. *The reduction of the impact of certain plastic products on the environment*. European Parliament, Council of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32019L0904

[59] Directive (EU) 2018/852 amending Directive 94/62/EC. *Packaging and packaging waste*. European Parliament, Council of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32018L0852

[60] Communication 2019/640. The European Green Deal. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640

[61] Communication 2018/028. A European strategy for plastics in a circular economy. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0028

[62] European Plastic Pact. (2020). https://europeanplasticspact.org/

[63] Ministerio para la Transición Ecológica y el Reto Demográfico. (2020, March 6). *España se suma al Pacto Europeo de los Plásticos con otros 12 países europeos y 90 multinacionales y asociaciones* [Press release]. https://www.miteco.gob.es/es/prensa/ultimas-noticias/espa%C3%B1a-se-suma-al-pacto-europeo-de-los-pl%C3%A1sticos-con-otros-12-pa%C3%ADses-europeos-y-90-multinacionales-y-asociaciones/tcm:30-507968

[64] Gobierno de España. 2020. Acuerdo de consejo de ministros por el que se aprueba la declaración del gobierno ante la emergencia climática y ambiental. https://www.miteco.gob.es/es/prensa/declaracionemergenciaclimatica_tcm30-506551.pdf

[65] Albrecht, P., Brodersen, J., Horts, D., Scherf, M., & PricewaterhouseCoopers AG WPG. (2011). *Reuse and recycling systems for selected beverage packaging from a sustainability perspective*. https://cooplesvaloristes.ca/v2/wp-content/uploads/2015/04/reuse-and-recycling-systems-for-selected-beverage-packaging-from-a-sustainability-perspective.pdf

Contact

Central Office - Madrid, Spain
Email: europe@oceana.org

EU Office - Brussels, Belgium
Email: brussels@oceana.org

North Sea and Baltic Office - Copenhagen, Denmark
Email: copenhagen@oceana.org

UK Office - London, UK
Email: oceanauk@oceana.org

Follow **@OceanaEurope** on

Facebook Instagram Twitter

OCEANA Protecting the World's Oceans