

Marine litter and biodiversity interactions in the Mediterranean Sea



BIODIVERSITY MANAGEMENT AND PROTECTION

This factsheet has been developed in the framework of the Working Group #1 "Biodiversity Management and Protection" of the MED Biodiversity Protection Community featured by the PANACeA Project, an Interreg MED Programme's initiative. The WG #1 is coordinated by MedCities, ETC-UMA and Plan Blue.

INTERNATIONAL AND REGIONAL CONTEXT

There is growing evidence of global marine ecosystems being impacted by marine litter pollution resulting from modern lifestyles shaped by the "plastic revolution". The Mediterranean Sea is no exception. The replacement of traditional goods, made of naturally recyclable materials, with others made of synthetic polymers (plastics), unsustainable growth in production and consumption, and poor waste management and recycling technologies (and solid waste in general) have directly and indirectly led to the use of oceans and seas as garbage receptacles and dumping areas. Recognising that marine ecosystems constitute biodiversity reserves and provide ecosystem services of great value for current and future generations, many international campaigns, at all stakeholder levels, are underway to raise the alarm that the continuation of this unsustainable conduct, from individuals up to socio-economic and political spheres, must be addressed and urgent actions taken.

REGIONAL POLICY CONTEXT

This contemporary threat posed by pollution to the conservation and sustainability of marine biodiversity, habitats and healthy and functional ecosystems is a focus of governments and international organisations worldwide. In the Mediterranean region the UN Environment/

Barcelona Convention adopted a Regional Plan on Marine Litter Management back in 2013 and is running an operational and collaborative platform to coordinate efforts at the basin scale, as well as implementing the Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast (UN Environment/Barcelona Convention IMAP), including the monitoring and assessment of marine litter (its Ecological Objective 10). In addition, the European countries bordering the northern part of the Mediterranean Sea are combating plastic pollution through the EU Marine Strategy Framework Directive (EU MSFD) and other recent policies, such as the European Strategy for Plastics in a Circular Economy. The EU MSFD includes the monitoring and assessment of marine litter in its Descriptor 10 of Good Environmental Status (GES).

It is worth mentioning that several other international organisations and conventions are also playing a role in taking on the challenge to reduce marine litter (i.e. the UN Convention on Biological Diversity, the UN Stockholm Convention, the International Maritime Organization, etc.) through their Strategic Action Plans and targeted programmes, applied at a global scale.

METHODOLOGY

Part of the contribution of the Interreg MED Biodiversity Protection Community, featured by PANACeA, is to increase evidence and

understanding of marine litter concerns and biodiversity threats in the Mediterranean region. Through a series of thematic projects, the Biodiversity Protection Community is compiling knowledge and information on monitoring, measures and actions in Marine Protected Areas (MPAs), thereby allowing for the transfer of added value knowledge from individual projects'

outcomes to streamlined tools supporting local stakeholders' fulfilment of international policies in the Mediterranean region. Information on projects addressing marine litter policy, management, pressures, occurrence and impacts, and best practices to combat litter in the marine environment, is presented in Table 1 below.

Thematic project	Goal	Marine litter-related objectives
ACT4LITTER	Devising joint measures to preserve natural ecosystems from marine litter in Mediterranean Protected Areas	MPA management, action plans and governance. Synthesis of measures to tackle and combat litter pollution, including beach monitoring
MEDSEALITTER	Developing Mediterranean-specific protocols to protect biodiversity from litter impact at basin and local MPAs scales	Combined monitoring and assessment protocols for quantities and biodiversity interactions in the sea
AMAre	Actions for Marine Protected Areas	Novel approaches to monitoring, providing georeferenced information on distribution and the amount of marine litter in MPAs
PLASTIC BUSTERS MPAs	Preserving biodiversity from plastics in Mediterranean Marine Protected Areas	The development of novel scientific approaches, and understanding the impact on biodiversity and MPAs
PHAROS4MPAs	Blue Economy and Marine Conservation: Safeguarding Mediterranean MPAs to achieve Good Environmental Status	Study of drivers, activities and pressures in the marine environment related to pollution and the maritime sectors

Table 1. The Biodiversity Protection Community's objectives related to marine litter in their respective Marine Protected Areas (MPAs).



Key message: “5 out of 11 thematic projects within the Interreg MED Biodiversity Protection Community are related to marine litter pollution aspects, offering coordinated knowledge and practices in the Mediterranean region and helping to tackle the international marine litter reduction challenge”

The work of PANACeA aims to bolster both knowledge and practices within the Interreg MED Biodiversity Protection Community, focusing on marine litter issues at the regional level. Streamlining, integrating and transferring the projects’ diverse findings related to current knowledge on macro and micro litter (i.e. floating marine litter, beach litter and seabed litter) in and outside MPAs, and their potential interactions beyond targeted ecological groups (mainly, fish, mammals and reptiles), is also an important part of the Biodiversity Protection Community’s action plan.

This is achieved by integrating and combining the thematic projects’ outcomes with other external data sources as the basis for a metadata analysis linked to a georeferenced Mediterranean basin database containing the evidence available on the registered impacts of marine litter on biota. The main results of this work are included in this factsheet.

UNDERSTANDING BIODIVERSITY INTERACTIONS

The interactions between marine litter and organisms specified in the work developed on geo-referenced data, spatial assessment and meta-analysis from literature and data sources, are classified by PANACeA in four categories: ingestion, entanglement, colonisation and others. This classification mimics the original approach by the AWI-LITTERBASE Project (<https://litterbase.awi.de>) at the Alfred Wegener Institute (AWI, Germany), which coincides with international frameworks in general terms, such as the categories proposed in the review and synthesis work undertaken by the Convention on Biological Diversity (CBD, 2012 and 2016).

These categories are used to highlight the direct and indirect forms of interactions with biota and are spatially situated in their geographical areas of occurrence (Figure 1). Direct interactions include ingestion and entanglement with marine litter, including microlitter (ca. microplastics), and the indirect interactions relate, for example, to the dispersal, via rafting, of colonised marine litter items (i.e. colonisation), including the potential to facilitate the transport of invasive species, the provisioning of new habitats, and indirect, ecosystem-level effects. All this information may be found on the Interreg MED Biodiversity Protection Knowledge Platform.¹

These ecosystem-level effects are the result of continued, cumulative pressures and impacts on key species and populations inhabiting specific ecosystems. Interactions with organisms have been reported to cause different levels of harm (ca. sub-lethal) and death (ca. lethal effects), despite the lack of harmonized monitoring and assessment protocols, which is impeding concrete actions to comprehensively protect biodiversity. Within the frameworks of the EU MSFD and UN Environment/Barcelona Convention IMAP and their components, Descriptor 10, and Ecological objective 10, several approaches and relevant publications have been produced related to biodiversity monitoring and assessment methods (Werner et al., 2016 and Veiga et al., 2016; UNEP/ MAP SPA/RAC, 2018).

ADDRESSING REGIONAL GAPS

In the Mediterranean Sea, scientific research has identified over 100 species interacting with marine litter, across all common ecological categories, though the type of interactions and their impact on species are not yet completely known, or even quantified, differing largely depending on the geographical area within the region. Therefore, the combination of the outcomes from different surveys on selected marine protected

¹ https://panaceacatalogue.adabyron.uma.es/gvsigon-line/core/public_project_load/marinelitter/



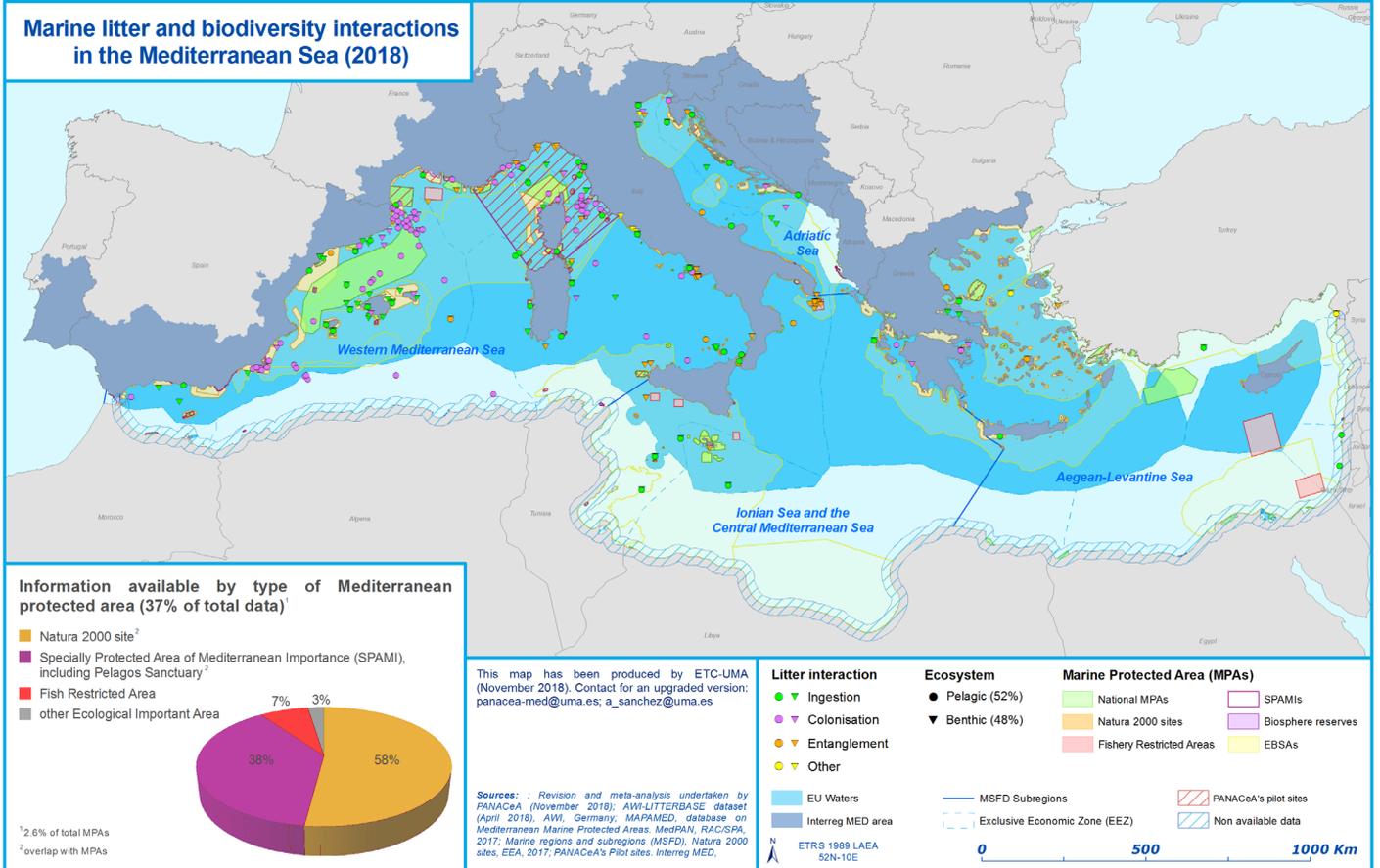


Figure 1. Spatial distribution of monitored sites with reported marine litter and biodiversity interactions in four categories (ingestion, entanglement, colonisation and others) created after the meta-analysis performed by PANACeA in December 2018.

areas participating in Interreg MED Biodiversity Protection thematic projects addressing marine litter and biodiversity interactions, and focusing on marine mammals, reptiles and fish (PLASTIC BUSTERS MPAs and MEDSEALITTER projects) in some 60 MPAs, offers unique information to improve a regional assessment, and is further supported by external scientific sources. According to the literature reviewed, up to 134 species are reported to be affected by marine litter (Deudero et al., 2015), and a recent study confirmed records of 91 species affected by ingestion in different habitats, with most available studies having been conducted on demersal (32.9%) and pelagic (27.7%) species,

followed by benthic (14.7%), benthopelagic (16.5%), neritic (5.3%) and mesopelagic (2.9%) ones (Fossi et al., 2018 and references therein). Entanglement and colonisation interactions (diverse blockage forms and physical function impairment, as well as rafting, or the provisioning of new habitats, to mention a few) have also been investigated. Entanglement should be addressed by future policy (Galgani et al., 2018).

Few in-depth scientific studies on the colonisation of floating plastic materials in the Mediterranean Sea have been undertaken (Masó et al., 2016 and Dussud et al., 2018), so

their implications for marine ecosystems are still uncertain. Yet, like climate change, and ocean acidification, the inertia of the situation requires the urgent development of a harmonised and region-wide, science-based fundamental knowledge system, as well as future projections and potential scenarios upon which policymakers and decision-makers can plan priority actions.

To understand the problem of marine litter's effects on biodiversity and to address regional gaps bioindicator species must be selected and routinely monitored, enabling the assessment of the status of the different marine ecosystems in terms of marine litter pollution. This work was initially spearheaded by the PLASTIC BUSTERS MPAs project and continues to be tackled by the Interreg MED Biodiversity Protection Community, through PLASTIC BUSTERS MPAs and MEDSEALITTER. It is particularly important to monitor and control long-lived species, such as marine mammals and reptiles, and solutions are being found by these two projects (Fossi et al., 2018b; Camana et al., 2018). Additionally, species providing natural resources and ecosystem services, such as fish, crustaceans and mollusks (i.e. fisheries and aquaculture sectors) should also be investigated, as in the case of MEDSEALITTER for fish species. It should be mentioned here that the Mediterranean Sea is recognised as overexploited for many fish species, and marine litter is placing additional pressure (ca. cumulative) on the sustainability of these natural resources.

Regional gaps in knowledge are prominent in the Eastern and Southern Mediterranean basin. As maybe observed in Figure 1, almost all the scientific literature available corresponds to the northern part of the Mediterranean Sea, particularly the Western Mediterranean Sea and the Adriatic Sea ecoregions, where all the categories of interactions can be found. Additionally, it should be noted that almost all the results obtained correspond to research monitoring (i.e. sampling operations are performed to test scientific hypothesis) or sporadic sampling, as a starting

point for future investigations. Few countries have developed routine monitoring networks on the Mediterranean Sea, or have programmes in place to do so, and very few have started to report consistently. Where they have, this has mostly been to comply with the obligations of the EU Marine Strategy Directive. This has been perceived by the Interreg MED community, which has detected Biodiversity Protection gaps that need to be urgently filled at the regional level to make possible the generation of a solid and regularly updated set of knowledge containing the evidence available on marine litter's effects on Mediterranean biodiversity.

ADDRESSING MARINE LITTER CONCERNS IN MARINE PROTECTED AREAS

Greater knowledge of interactions between marine litter and biodiversity in Marine Protected Areas (MPAs) is needed. Figure 1 maps facts obtained as a result of PANACeA's meta-analysis of revised literature datasets, such as the limited knowledge available on interaction in MPAs, using spatial assessments by overlapping the projects' results through their participating sites and the general layers for protected areas [European Environmental Agency (EEA) for Natura 2000 Sites, and the MedPAN layer for a complete map of protected areas in the Mediterranean Sea]. Figure 2 shows the knowledge distribution on interactions among protected area types for the Mediterranean region after the analysis of available scientific information; however, the interactions reported account for just 2.6% of all protected areas in the Mediterranean Sea. Therefore, although studies on marine litter pollution occurrence, distribution and dispersal are increasing in the Mediterranean, research on the interactions between marine litter and marine life, of all taxa, in and beyond MPAs, is still generally lacking, such that further efforts are necessary to assess the overall environmental impact and status, to be able to facilitate remedial actions.



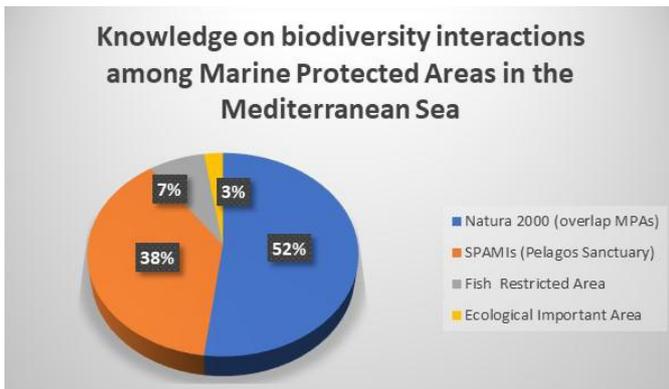


Figure 2: Distribution of monitoring data by type of protected area in the Mediterranean Sea. The metadata analysis was performed based on a review of research publications from major scientific databases and represents 37% of the geo-referenced data available on interactions in the Mediterranean Sea.

Key message: “Only 15% of the MPAs involved in the Interreg MED Biodiversity Protection Community have underpinning knowledge related to the interactions between marine litter and protected biodiversity”

Key message: “Information on biodiversity interactions is only available for 2.6% of the total protected areas (by MedPAN) in the Mediterranean Sea”

Key message: “Enhanced efforts on monitoring species and habitats are needed in MPAs to optimize management efforts and measures to protect their biodiversity and ecosystem functions”

Hence, both MPA monitoring and management plans require further evidence and knowledge of marine litter’s interactions with protected species in the coastal water column and benthic habitats. It should be mentioned that the data presented in Figure 2 is from 11 pilot sites (listed below), among the 61 protected areas engaged in the Interreg MED Biodiversity Protection Community, which accounts for approximately 15% of the total.

List of Mediterranean protected areas and participating sites in the Interreg MED Biodiversity Protection Community with information available

on marine litter and biodiversity interactions (note: FR-France, MC-Monaco, IT-Italy, ES-Spain, SL-Slovenia, CR-Croatia, MT-Malta):

1. Parc National des Calanques (FR)
2. Cap Rossu, Scandola, Pointe de la Reveletta (Canyon de Calvi) – Natura 2000 (Corsica, FR)
3. Costa de l’Oest d’Eivissa – Natura 2000 (ES)
4. Costa Viola (Messina Strait) – Natura 2000 (ES)
5. Canal de Menorca (Espacio Marino del Sureste de Menorca) – Natura 2000 (ES)
6. Kaprije – Habitats Directive Sites (CR)
7. Zona fil-Bahar Bejn Rdum Majjiesa u Ras ir-Rahed – Natura 2000 (MT)
8. Sistema de cañones submarinos occidentales del Golfo de León – Habitats Directive Sites (ES)
9. Espacio Marino de l’Empordà – Bird Directive Sites (ES)
10. Porto/Scandola/Revellata/Calvi/Calanches de Piana – Natura 2000 (Corsica, FR)
11. Espacio Marino del poniente de Mallorca – Bird Directive Sites (ES)
12. Selva Pisana – Natura 2000 (IT)
13. Secoveljskesoline – Bird Directives Site (SL)
14. Espacio Marino del Delta de l’Ebre-Illes Columbretes – Bird Directive Site (ES)
15. Lastovski i Mljetskikanal – Natura 2000 (CR)
16. Plateau du Cap de Corse – Natura 2000 Site (Corsica, FR)
17. Récifs du mount sous-marin de l’Agriate – Habitats Directive Site (offshore nord Corsica, FR)
18. Iles Marseillaises-Cassidaigne – Natura 2000 (FR)
19. Espacio Marino del Baix Llobregat-Garraf – Natura 2000 (ES)

20. Archipelago delle Eolie - Natura 2000 (IT)
21. Valles submarinos del Escarpe de Mazarrón - Natura 2000 (ES)

Protected areas in the Biodiversity Protection Community (with marine litter interaction data):

1. Pelagos Sanctuary (FR, MC, IT)
2. Îles d'Hyères (Port Cross National Park, FR) - Bird Directive Site
3. Fondali Monte Portofino (IT) - Habitats Directive Site
4. Delta de l'Ebre - Natura 2000 (ES)
5. Muntanyes d'Artà - Natura 2000 (ES)
6. Cap de Creus - Habitats Directive Sites (ES)
7. Badies de Pollença i Alcúdia - Habitats Directive Site (ES)
8. Fondali marini di Punta Campanella e Capri - Natura 2000 (IT)
9. Espacio Marino del sur de Mallorca y Cabrera - Natura 2000 (ES)
10. Iles Lavezzi, Bouches de Bonifacio - Natura 2000 (Corsica, FR)
11. Espacio Marino de Tabarca-Cabo de Palos - Bird Directive Site (ES)

In addition, in Figure 2, and based on the improved spatial meta-analysis of scientific literature where data has been georeferenced, it can be observed that the coincidences between the available monitoring sites information and protected geographical areas are greater for the Natura 2000 Sites designated under the EU Bird and Habitats Directives, followed by the data localized at the Pelagos Sanctuary, with a remaining 10% distributed between targeted areas that have not yet been legally or formally defined. The list enumerates Mediterranean protected areas where information on marine litter interactions can be found, and includes

several protected areas involved in the Interreg MED Biodiversity Protection Community featured by PANACeA, where ongoing knowledge is still being generated.

RESEARCH GAPS IN KEY MARINE ORGANISMS

The Interreg MED Biodiversity Protection Community of projects is contributing new research on the interactions between marine litter and different marine species in almost all marine habitats and across commonly known ecological groups. Thus, the MEDSEALITTER project is studying the ingestion of microplastics by pelagic fish (*Boops boops*) in Greece, Italy and Spain, and evaluating the likelihood of plastic ingestion by the loggerhead turtle (*Caretta caretta*) in the Tyrrhenian Sea in the Western Mediterranean subregion, after several surveys combining measurements of marine organisms' consumption amounts and prevalence. Similarly, the PLASTIC BUSTERS MPAs project is leading a study on the impacts of marine litter on mammal species, such as the fin whale (*Balaenoptera physalus*), sperm whale (*Physeter macrocephalus*) and other groups across the Mediterranean, particularly in the Pelagos Sanctuary and several MPAs.

In this regard, this factsheet summarises the meta-analysis undertaken based on a review of various literature sources (and the initial compilation by the AWI-LITTERBASE Project), and identifies the species affected by interactions with marine litter, and their common ecological groups (Figure 3) considering new knowledge. The Interreg MED Biodiversity Protection Community is currently identifying the key marine species to be protected, according to their long biological cycles, and elevated risks to their survival. However, scientific knowledge of the number of species affected by interactions with marine litter is greater and increasing, especially concerning planktonic organisms, as shown in Figure 3, affected mostly by colonisation and rafting.



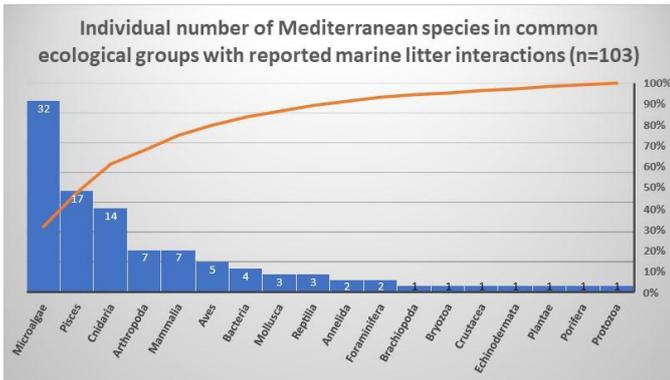


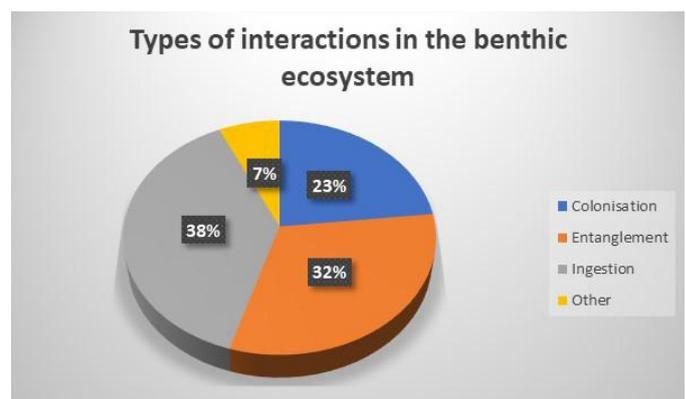
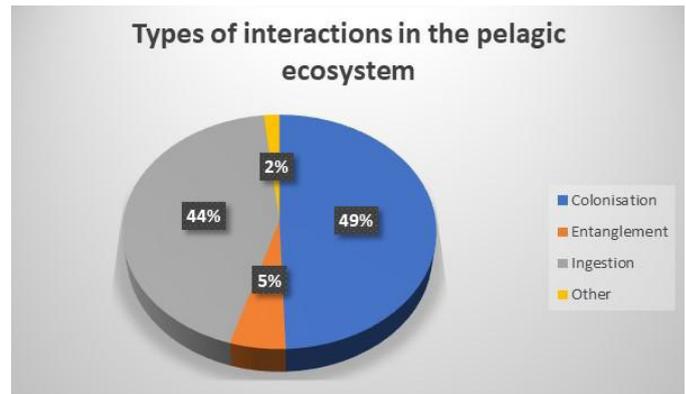
Figure 3: Distribution of known species affected by marine litter interactions in the main common ecological groups in the Mediterranean. The metadata analysis has been performed based on research publications from major scientific databases (note: in some cases, kingdom, phylum, class or subclass are shown for simplicity).

In terms of the absolute number of species and their ecosystem functions, more research efforts are needed to assess marine litter pollution effects in additional species, including careful studies of those with economic value, i.e. commercial fish species that are already impacted by overexploitation, in order to fully comprehend the dimension of the problem in Mediterranean marine ecosystems at the species, habitat and ecosystem level, with a view to the long-term management and conservation of healthy ecosystems and ecosystem services in the region. Moreover, research efforts need to be particularly intensified in the southern part of the Mediterranean (see Figure 1).

TYPES OF CATEGORIES BY PELAGIC AND BENTHIC ECOSYSTEMS

Figures 4 and 5 show clear differences in terms of interaction type, depending on species belonging to pelagic (water column) or benthic (deep and sea bottom) ecosystems. In line with major international policies, three main categories of interactions are considered: ingestion, entanglement and colonisation. There is an additional category (Others) that groups studies with experimental information on interactions,

such as forced field experiments, or information that is difficult to classify under other categories. An in-depth analysis of these categories might indicate further distinctive features, such as colonisation, where drifting and rafting could be considered as a primary effect and should not be overlooked for some species interacting with floating litter.



Figures 4 and 5: Distribution of knowledge on interaction type in pelagic and benthic ecosystems in the Mediterranean. The metadata analysis was performed based on a review of research publications from major scientific databases

A similar proportion is noticed for ingestion interactions between pelagic and benthic ecosystems (Figures 4 and 5), where a main difference noted is the large number of datasets recorded for colonisation in the pelagic ecosystem, with a low incidence in the entanglement category. This, however, is a direct consequence of the inclusion in the database of the higher number of individual species from the planktonic realm, such

as cyanobacteria and microalgae, colonising and inhabiting floating litter.

LINKING SPATIAL DATA TO MARINE ENVIRONMENT HABITAT FEATURES

The spatial meta-analysis of the data can be mapped, similarly to Figure 1, differentiating between pelagic and benthic ecosystems, and including additional layers of complementary information for each ecosystem. In Figure 6, the pelagic interactions dataset in the Mediterranean has been overlaid on the general bathymetric features of the whole basin, including a classification set of marine protected areas. Overall, knowledge is available in near-coastal areas, including MPAs, rather than offshore, except for the Pelagos Sanctuary. It can be observed that in the Aegean Sea and Levantine Sea there is no information on biodiversity interactions with marine litter, despite some entanglement records

in the coastal area of the Aegean. The situation in the Adriatic Sea is very similar, with very few studies reporting on interaction with marine organisms, though there is more data on ingestion than on entanglement and colonisation. In the Western Mediterranean, the highest number of datasets on interactions are found primarily in two places: the North-western Mediterranean with the Gulf of Lion, and the Pelagos Sanctuary. Most studies are performed in commercial fishing areas and in coastal and near-coastal areas, whereas offshore information is related to marine mammals and turtles, and the colonisation of floating litter by planktonic species.

Similarly, the dataset corresponding to the interactions with benthic species has been combined with the knowledge available on benthic habitats and the geomorphology of the Mediterranean Sea provided by the EUNIS layer (EEA).

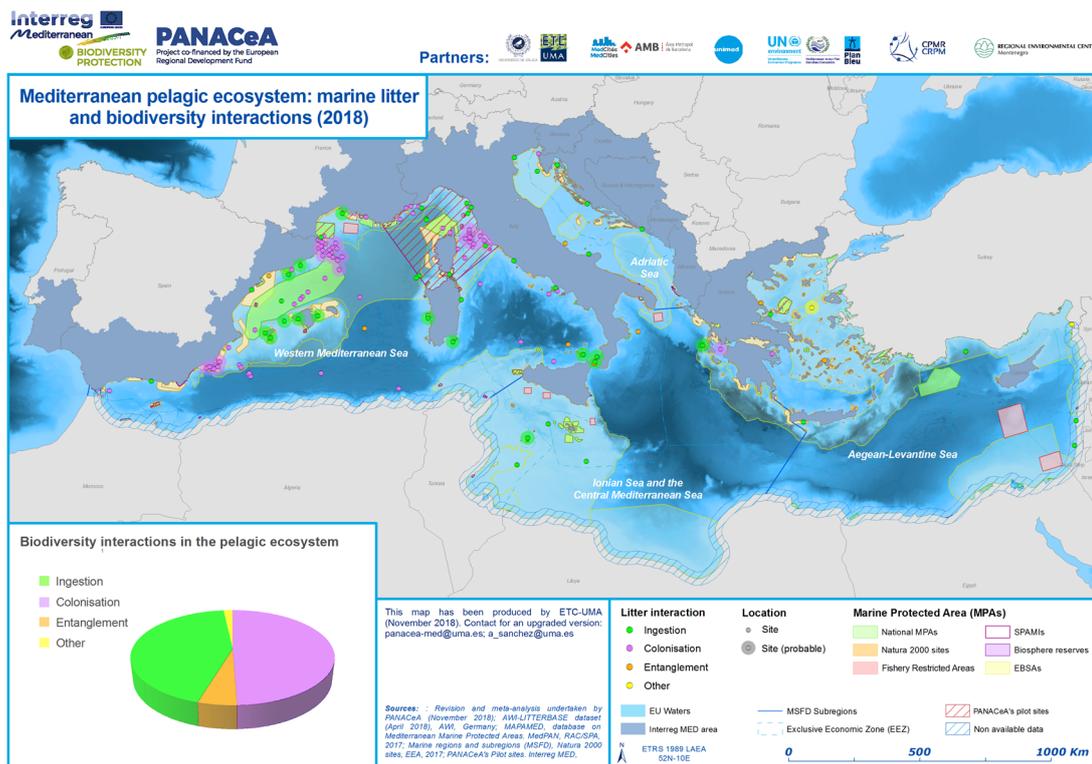


Figure 6. The map shows a selection of the data available on benthic biota interactions with marine litter using European Nature Information System (EUNIS) information for a better understanding of current research efforts and future needs.

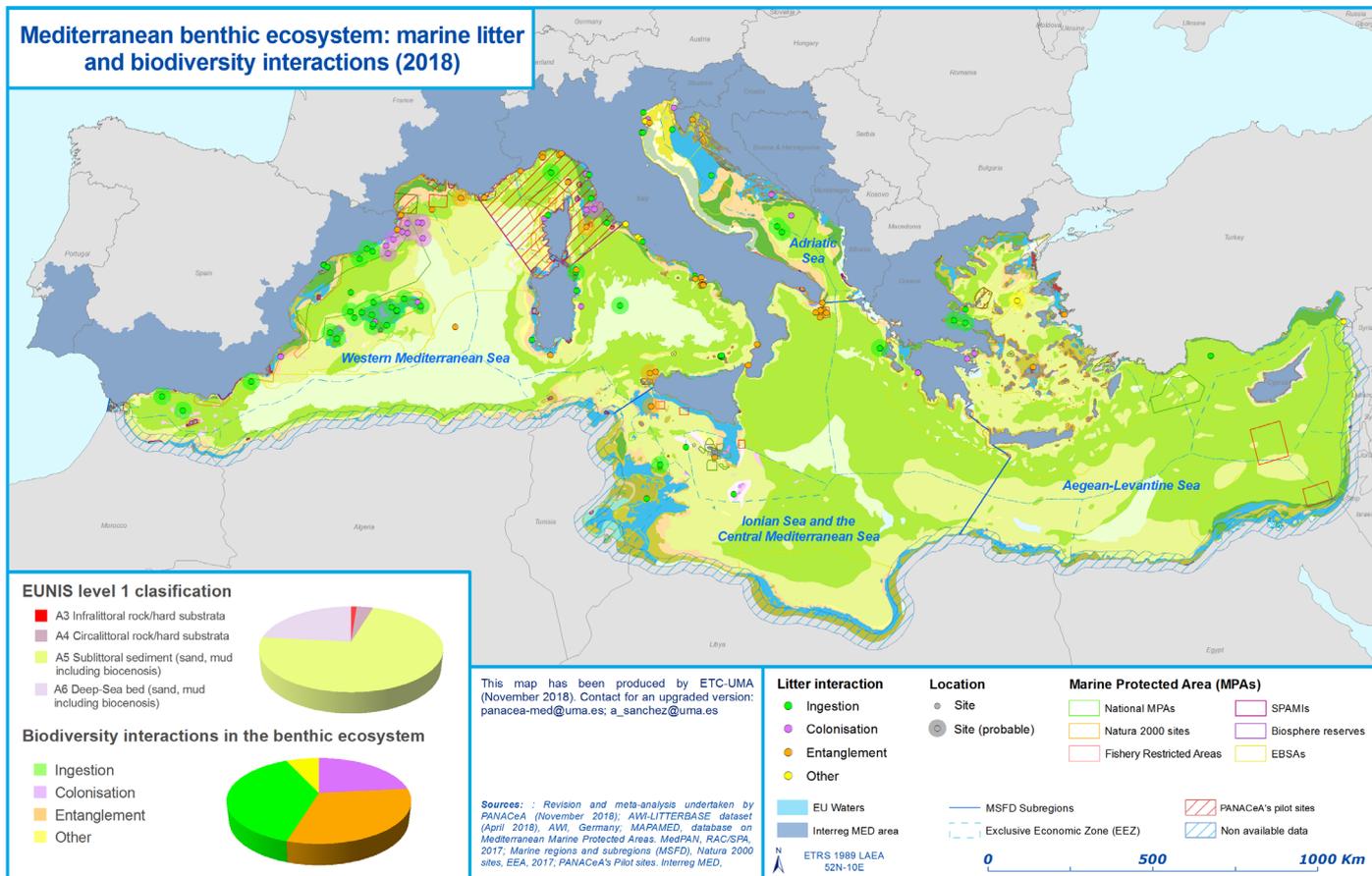


Figure 7. The map features a selection of the data available on interactions between marine litter and benthic biota using the European Nature Information System (EUNIS) classification, allowing for a better comprehension of bottom geomorphology and litter pollution in the Mediterranean Sea.

Despite the massive efforts and uncertainties hampering the development of a harmonised EUNIS layer on the characteristics of the Mediterranean's seabed, this map served to overlay georeferenced data with 4 main characteristic habitat groups (Figure 8). Few subclassifications have been observed for A4, A5 and A6 (EUNIS system), pointing at times to specific substrates and habitat characteristics, such as *Mediterranean coralligenous communities moderately exposed to or sheltered from hydrodynamic action (A4.26 or A4.32)*, *Mediterranean communities of shelf-edge detritic bottoms (A5.47)*, *Posidonia beds*

(A5.535) and *Facies of sandy muds with *Thenea muricata* (A6.511)*, the latter belonging to deep-sea Mediterranean habitats. Further refinement of these types of analyses could allow for the identification of potentially threatened marine protected areas and other targets for protection.

Worthy of mention here are the regional similarities resulting from the spatial analysis of deep-sea habitats impacted by marine litter included in A6 (*Deep-sea bed sand, and mud, including biocenosis*), which represent almost 25% of the available data in Mediterranean

areas, such as submarine canyons and deep-sea bottoms in the Gulf of Lion (NW Mediterranean), the Fish Restricted Area (FRA) of Santa Maria de Leuca (Southern Italy), the Portofino Promontory (Ligurian Sea), and the deep-sea bottom of the Sicilian Strait area in the central Mediterranean, to mention few, where species (*Madrepora oculata*, *Lophelia pertusa*, *Paramuricea clavata*) representative of what have been called “Cold-Water-Corals (CWC)” are being regularly impacted by entanglement (Bavestrello et al., 1997; Fabri et al., 2014; Taviani et al., 2017; D’Onghia et al., 2017; Consoli et al., 2018; Cau et al., 2018)

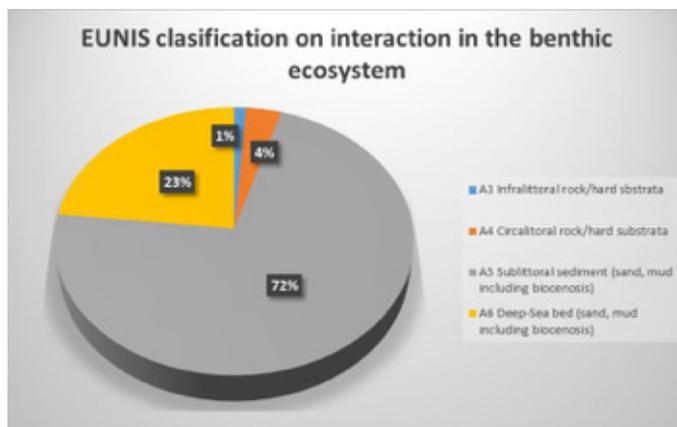


Figure 8: Percentage of available data according to the type of benthic bottom habitats and substrates from literature sources’ meta-analysis and spatial assessment in the Mediterranean.

Key message: “Cold-Water Coral assemblages are continually being impacted by litter entanglement all over the Mediterranean region, mainly due to fishing activities. Major protection and other legal measures are needed in these areas”

FUTURE WORK

Supplementary reviews of scientific literature, combined with future, detailed outcomes of the Interreg MED Biodiversity Protection Community in different areas of the Mediterranean and their MPAs, could serve to complete and update this meta-analysis and spatial assessment, including

additional external sources, where relevant. The combination of these research efforts aims to provide the basis for the development of significant knowledge of Interreg MED Biodiversity Protection project activities related to new findings on biodiversity interactions in the Mediterranean Sea, along with spatial information maps and gaps, which could include data related to pressures at different regional, sub-regional and national scales.

The database compiled, and metadata analysis based on georeferenced information are accessible through the Interreg MED Biodiversity Protection Knowledge Platform, which features the results of the community of projects individually and is available online to allow for transfer to other regional and international researchers, decision-makers and interested parties.

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